

UTH Guideline
Technical Specifications



UTH Standard Specification

SECTION 07 22 16

ROOF BOARD INSULATION

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Roof Insulation
- B. Roof Insulation Fasteners and Adhesive
- C. Tapered Insulation
- D. Tapered Edge

1.02 RELATED WORK

- A. Section 06 10 00 - Rough Carpentry
- B. Section 07 51 13 –Built-Up Asphalt Roofing
- C. Section 07 52 00 – Modified Bituminous Membrane Roofing
- D. Section 07 62 00 - Sheet Metal Flashing and Trim

1.03 REFERENCES

- A. National Roofing Contractors Association (NRCA) Roofing and Waterproofing Manual
- B. Underwriters Laboratories (UL)
 - 1. Roofing Materials and Systems Directory
 - 2. Fire Resistance Directory
- C. ASTM D41 - Asphalt Primer Used in Roofing
- D. ASTM D312 - Asphalt Used in Roofing
- E. ASTM C 728 - Perlite Thermal Insulation Board
- F. ASTM C 1289 - Faced Rigid Cellular Polyisocyanurate Thermal Insulation Board
- G. ASTM C 208 - Cellulosic Fiber Insulating Board
- H. ASTM C 552 - Cellular Glass Thermal Insulation

- I. ASTM C 578 - Rigid, Cellular Polystyrene Thermal Insulation
- J. ASTM C 726 - Mineral Fiber Roof Insulation Board
- K. ASTM C 984 - Perlite Board and Rigid Cellular Polyisocyanurate Composite Roof Insulation

1.04 SUBMITTALS

- A. Submit under provisions of **SPECIAL CONDITIONS** requirements and Division 1 Section **01 21 00** Submittal Procedures.
- B. Prior to pre-roofing meeting, submit the following:
 - 1. Manufacturer's Certification: Letter from manufacturer, on letterhead, and signed by authorized representative that roof insulation meets requirements for required warranties and is compatible with roof membrane products.
 - 2. Product Literature: Submit product literature on roof system and accessory components.
- C. Asphalt Fume Control Plan: Submit equipment data, and proposed loading and heating procedures to limit ground-level asphalt fumes.
- D. Shop Drawings: Submit shop Drawings for approval prior to Pre-roofing Conference and start of Work. Include the following Drawings:
 - 1. Roof Plan(s):
 - a) Include on roof plan tapered insulation locations at field, perimeter, and roof curbs. Indicate insulation thickness at high and low points, crickets pattern, and drain or scupper sumps.
 - b) Outline roof dimensions, including all levels.
 - 2. Provide scaled insulation attachment plan for each roof area indicating perimeter and corner requirements to achieve specified wind uplift resistance. Provide insulation fastening pattern Drawing for corner, perimeter, and field zones.
- E. Product data:
 - 1. Insulation products: Submit manufacturer's data sheets for each component required including insulation boards, adhesives, fasteners, plates and bitumen or adhesive. Provide roofing system manufacturer's written acceptance of proposed insulation board, adhesives, fasteners, and procedures for installation. Coordinate with roof membrane Specification Section(s).
 - 2. Material Safety Data Sheets: Provide manufacturer's MSDS information for all materials proposed for use.

3. Provide evidence of specified fire and wind uplift ratings for proposed insulation.
4. ASTM Compliance Sheet: Submit product material list with corresponding ASTM standard(s) each product complies with. Include Specification paragraph reference number that relates to each product.

1.05 QUALIFICATIONS

- A. Installer: Company specializing in performing the Work of this Section and approved by roof manufacturer for installation of specified roof system.
- B. Minimum 5 years documented successful experience with installation of products specified in this Section.

1.06 REGULATORY REQUIREMENTS

- A. Fire Resistance:
 1. UL Class A Fire Hazard Classification.
 2. UL Roof Ceiling Assembly Rating.

1.07 TOLERANCES

- A. Comply with tolerances listed in this Section.
- B. Where tolerances are not expressly stated in these Specifications, or by the manufacturer, perform Work within tolerances specified in the NRCA Roofing and Waterproofing Manual.

1.08 PRE-ROOFING CONFERENCE

- A. Schedule meeting to discuss roof Work before start of Work onsite.
- B. Comply with requirements of roof membrane Specification Section(s).

1.09 DELIVERY, STORAGE, AND HANDLING

- A. Deliver, store, and handle products according to manufacturer's recommendations.
- B. Deliver products in original containers, dry, undamaged, with seals and labels intact.
- C. Storage:
 1. Roof-top storage of weather-sensitive material is not permitted. Material stored overnight on roof-top will be considered defective.
 2. Store weather-sensitive products in enclosed storage trailers.
Store weather-sensitive products on pallets, clear of ground, and cover with

secure breathable canvas tarps.

Store weather-sensitive products in an enclosed warehouse, or in storage trailers off-site. Deliver products in quantity that can be used each day, without roof-top storage. Products must be returned to warehouse, or storage trailer, each day.

- D. Store related materials within temperature ranges recommended by the manufacturer(s) of each product.

1.10 ENVIRONMENTAL REQUIREMENTS

- A. Comply with manufacturer's environmental requirements for storage and application of products.
- B. Verify existing and forecasted weather conditions and determine when conditions are acceptable for roof Work within the guidelines as follows:
 1. Do not proceed with Work when ambient air temperature falls below 40° F.
 2. Do not proceed with roof application when excessive moisture is present. Excessive moisture is that which may be detected by sight or touch, or that which results in visible foaming of hot asphalt.
- C. Do not expose materials sensitive to water, or sunlight, damage in quantities greater than can be weatherproofed during each day.

1.11 COORDINATION

- A. Coordinate Work with installation of associated metal flashings as the Work of this Section proceeds.

1.12 INSPECTION BY MANUFACTURER

- A. Comply with requirements of roof membrane Specification Section(s).
- B. Provide manufacturer's field inspection reports within **five days** of each site visit.

1.13 ROOF SYSTEM WARRANTY

- A. Provide manufacturer's roof system warranty according to roof membrane Specification Section(s).
- B. Warranty shall include coverage for roof insulation, either as part of original warranty language, or by attachment.

1.14 INSTALLER WARRANTY

- A. Roof Installer Warranty: provide under provisions of Section **01 70 50 – Project Closeout**.
- B. Coordinate with requirements of roof membrane Specification Section(s).

PART 2 PRODUCTS

2.01 GENERAL

- A. Roof Insulation: Obtain written approval from roof membrane manufacturer for use of insulation products incorporated into roof system, which are not supplied by roof membrane manufacturer.
- B. Substitutions:
 - 1. Where specific products are listed in this Specification, the referenced manufacturer's systems are to establish a level of quality.
 - 2. Requests for substitutions to listed products shall be submitted during the bidding phase per requirements of Section 01 21 00.
 - 3. Consideration of requests for substitution is at the sole discretion of the A/E and Owner, and approvals shall be issued in writing by the A/E with Owner concurrence.

2.02 BITUMINOUS MATERIALS

- A. Asphalt Bitumen: ASTM D312, Type IV, special steep, as supplied or specifically approved by membrane manufacturer.
- B. Asphalt Primer: ASTM D41, as supplied or specifically approved by insulation manufacturer.

2.03 INSULATION

- A. First Layers: two (2) layers, 2.3 inch thick polyisocyanurate, non-organic fiberglass facers top and bottom, as supplied by, or approved by roof membrane manufacturer for use in their warranted roof system, mechanically fastened to roof deck.
- B. Insulation Fasteners: ensure plates and screws meet wind uplift rating and warranty requirements.
 - 1. Plates: Galvalume-coated steel, in size, type, and configuration to meet uplift requirements.
 - 2. Screws: Stainless-steel or polymer-coated steel shank, meeting Factory Mutual 4470 corrosion-resistance. Length sufficient to penetrate $\frac{3}{4}$ inch through top flute of roof deck.
- C. Coverboard: ASTM C728, one layer, $\frac{3}{4}$ inch thick perlite, supplied, or recommended by roof membrane manufacturer, set in hot asphalt.

2.04 TAPERED CRICKETS AND TAPERED EDGE

- A. Tapered Crickets:
 1. First course: ASTM C728, perlite tapered edge, minimum 12 inches wide, in thickness to match butt edge of tapered insulation, set in hot asphalt.
 2. Remaining courses: ASTM C728, perlite, ½ inch per foot tapered, set in hot asphalt.
- B. Tapered Edge: ASTM C728, perlite. Provide in widths and thicknesses indicated on Drawings.
- C. Roof Drain & Scupper Sumps: minimum 1 ½ inch to 0, 24" wide tapered perlite.

2.05 SPECIAL BITUMEN HEATING EQUIPMENT

- A. Provide ground-level filtering, or after-burning asphalt fume system equipment.
- B. Equip kettle with carton loader device.
- C. Ensure positive seals at kettle lid, loader, and piping, to ensure containment of ground-level asphalt fumes.

PART 3 – EXECUTION

3.01 GENERAL

- A. Work of this Section shall be performed in accordance with quality workmanship standards as defined by NRCA.
- B. The roof systems manufacturer's technical specifications shall be considered a part of this Section and shall be used as a minimum standard in conjunction with this Section. If this Section conflicts with, or exceeds manufacturer's minimum requirements the more rigid standard shall apply and be enforced.

3.02 COORDINATION

- A. Ensure proper sequencing of roof insulation and to allow installation of roof and flashings as detailed, without damage.
- B. Coordinate activities to prevent damage to roof assemblies.

3.03 EXAMINATION & PREPARATION

- A. Do not store, stage activities, or allow construction traffic over roof areas, unless protection plan is approved in advance by A/E.
- B. Contractor is responsible for maintaining insulation in good condition.

- C. Verify that surfaces and site conditions are ready to receive Work. Verify that debris has been completely removed from roof area and broom clean the deck immediately prior to insulation application.
- D. Verify deck is clean, sound, smooth, and dry enough for covering with roof insulation. Report decking not serviceable for covering with roof insulation. Do not install finish application of roof insulation over unserviceable roof deck area(s).
- E. Verify roof openings, curbs, pipes, sleeves, ducts, and vents through roof are solidly set, and wood components are in place.
- F. Install nailers and blocking immediately prior to application of roof insulation.
- G. Construct and install nailers and blocking under provisions of Section 06 10 00.

3.04 TEMPORARY WATERPROOFING

- A. Provide water stops and temporary tie-ins daily to prevent moisture penetration into building interior or installed assemblies.
- B. Seal roofing temporarily to the deck where leakage could penetrate installed assemblies. Remove upon resumption of Work.
- C. Provide permanent, or temporary, counter flashing daily.
- D. Install membrane assemblies complete with strip-in plies each day. Use mastic seals only in such a manner that mastic does not remain between finished modified bitumen plies at cant strips and membrane terminations. Provide seal at all terminations, both vertical and horizontal.
- E. Provide temporary seals which do not soil finished Work surfaces or contaminate surfaces intended to receive sealants.
- F. Remove temporary seals from completed Work.

3.05 BITUMEN HEATING

- A. Comply with manufacturer's requirements for heating, and applying bitumen.
- B. Heat asphalt bitumen to achieve EVT at point of application, as stamped on asphalt carton, plus or minus 25° F.
- C. Use insulated tubing and luggers during cold weather to maintain correct temperature at the point of application.
- D. Verify accurate temperature readings at point of application to ensure compliance. Establish proper temperature at kettle, hold time on roof, and substrate type and temperature to achieve proper application temperature.

- E. Measure temperature periodically, minimum one reading every two hours or when conditions change. Contractor to provide accurate temperature measuring device for verification.
- F. Adjust temperature, equipment, or procedure to maintain proper application temperature.
- G. Do not heat bitumen above finished blowing temperature for more than 3 hours, unless bitumen is under continuous use.
- H. Provide fume control equipment to minimize asphalt fumes during the Work. Comply with fume control requirements of this Specification and submitted Fume Control Plan.

3.06 APPLICATION IN COLD WEATHER

- A. Comply with manufacturer's special recommendations for membrane application during cold weather.
- B. Discontinue installation if asphalt temperature cannot be maintained at EVT at point of application.

3.07 INSULATION APPLICATION- GENERAL

- A. Apply insulation in accordance with insulation and insulation and membrane manufacturer's recommendations.
- B. Install so that boards are in moderate and continuous contact with adjacent boards, but not jammed or forced.
- C. Ensure that starter row is straight. Realign boards if perceptible gaps or spaces occur. Fill ¼ inch and greater gaps with loose perlite insulation before covering.
- D. Cut individual boards if necessary, to conform to humps or depressions in deck. Miter edges to prevent open joints at penetrations, Projections, and terminations.
- E. Install boards with joints staggered in the cross direction.
- F. Protect installed insulation from damage and moisture infiltration.

3.08 FIRST LAYER(S) INSULATION APPLICATION

- A. Position boards to ensure bottom board edges bear on top flange of metal deck, minimum 1 inch, at areas where board is directly over metal deck. Cut, and realign boards which do not bear sufficiently on top flange of metal deck.
- B. Stagger board joints from gypsum board joints minimum 6 inches in both directions, where insulation is installed over gypsum board.
- C. Install boards with joints staggered in the cross direction.

- D. Fasten first layer insulation with screw and plates to metal deck. Ensure fasteners engage top of deck flute, and penetrate deck minimum 3/4 inch.
- E. Ensure screws engage deck properly. Remove unengaged screws and reposition new screws to engage deck.

3.09 SECOND LAYER INSULATION APPLICATION

- A. Set second layer insulation into full bed of asphalt over first layer insulation.
- B. Install one layer cover board over first layer insulation where roof deck is sloped.
- C. Install tapered insulation over first layer insulation in areas where roof deck is not sloped.
- D. Stagger joints, minimum 6 inches, in both directions, from first layer insulation. Remove and replace insulation with improper staggering of joints.
- E. Step-in each board, while asphalt is still molten, to ensure full embedment.
- F. Set loose, cut boards, at overnight tie-ins, to provide uninterrupted staggering of insulation joints, upon resumption of Work.

3.10 APPLICATION OF TAPERED EDGE

- A. Apply tapered edge into solid moppings of asphalt and step in completely.
- B. Make straight, neat cuts and miter corners without perceptible gaps, or open joints.
- C. Stagger joints minimum 6 inches between layers.
- D. Cut, shave, modify and combine various sized tapered materials, to provide smooth, uniform transitions.
- E. Install 1.5 inch to 0 inch, 2 foot square tapered edge at scupper and 4 foot square roof drain sumps.

3.11 PROTECTION

- A. Protect stored insulation prior to installation according to provisions of this Section. Do not install improperly stored materials into the Work.
- B. Cover roof insulation with waterproof roof membrane daily. Install according to roof membrane Specification Section(s).
- C. Do not expose roof insulation overnight. Remove and replace roof insulation exposed overnight.
- D. Remove and replace roof insulation that has been wetted, damaged or is otherwise unserviceable.

- E. Include removal and replacement of wet roof insulation in roof membrane warranty.

END OF SECTION

UTH Standard Specification

SECTION 07 31 13

ASPHALT SHINGLE ROOFING

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Asphalt shingles
- B. Asphalt shingle underlayment and accessories

1.02 RELATED WORK

- A. Section 06 10 00 - Rough Carpentry
- B. Section 07 62 00 - Sheet Metal Flashing and Trim

1.03 REFERENCES

- A. National Roofing Contractors Association (NRCA) Roofing and Waterproofing Manual
- B. Underwriters Laboratories (UL)
 - 1. Roofing Materials and Systems Directory
 - 2. Fire Resistance Directory
 - 3. UL 2218 -Impact Resistance of Prepared Roof Covering Material.
- C. ASTM D1970 - Self-Adhering Polymer Modified Bituminous Sheet Materials Used as Steep Roofing Underlayment for Ice Dam Protection
- D. ASTM D3161 - Standard Test Method for Wind-Resistance of Asphalt Shingles (Fan-Induced Method)
- E. ASTM D3462 - Specification for Asphalt Shingles Made from Glass Felt and Surfaced with Mineral Granules
- F. ASTM D4586 - Standard Specification for Asphalt Roof Cement, Asbestos Free
- G. ASTM D4869 - Standard Specification for Asphalt-Saturated Organic Felt Shingle Underlayment Used in Roofing
- H. ASTM D6757 – Standard Specification for Inorganic Underlayment for Use with Steep Slope Roofing Products

1.04 SUBMITTALS

- A. Submit under provisions of **SPECIAL CONDITIONS** requirements and Division 1 **Section 01 21 00** Submittal Procedures.
- B. Prior to pre-roofing meeting, submit the following:
 - 1. Manufacturer's Certification: Letter from manufacturer, on letterhead, and signed by authorized representative, stating:
 - a) Materials and components **conform with ASTM D3462** and that materials furnished are compatible.
 - b) Asphalt shingles with underlayment over roof deck meet UL Class A Fire Resistance.
 - c) Asphalt shingles attached according to this Section meet **ASTM D3161 Class F** wind resistance.
 - d) Asphalt shingles and underlayment over roof deck qualifies for specified warranty.
 - e) Installer is authorized to install manufacturer's warranty roof systems minimum five (5) years prior to the Project NTP.
 - 2. Sample manufacturer, and installer, warranties meeting Specification requirements.
 - 3. Product Literature: Submit product literature on roof system and accessory components.
 - 4. Shop drawings.
- C. Roof Protection Plan: Submit written roof protection plan for A/E and Owner approval that describes type and layout of roof protection during construction activities on or above roof area.
- D. Pre-Roofing Meeting Notes: Submit Pre-Roofing Meeting Notes within 5 business days of meeting date.
- E. Manufacturer's Field Reports: Submit copies of manufacturer's field reports to A/E during the Work, and at final completion.
- F. Shop drawings: Submit shop drawings for approval prior to Pre-roofing Conference and start of Work. Include the following Drawings:
 - 1. Roof Plan(s): Prepare scaled roof plan locating roof details and penetrations.
 - 2. Location and type of penetrations. Illustrate edge, wall, vent curb and penetrations flashing. Scale details at 1½" or larger. Manufacturer's standard pre-printed details are not acceptable for shop drawings

3. Indicate deck type on each drawing.
4. Indicate location of proposed staging areas and material storage on site plan.

G. Product data:

1. Submit manufacturer's data sheets for each product being installed. Include manufacturer's installation instructions.
2. Material Safety Data Sheets: Provide manufacturer's MSDS information for all materials proposed for use.
3. ASTM Compliance Sheet: Submit product material list with corresponding ASTM standard(s) each product complies with. Include Specification paragraph reference number that relates to each product.
4. Asphalt shingle color sample board. Provide to A/E for color selection prior to ordering asphalt shingles.
5. Board Insulation products: Submit manufacturer's data sheets for each component required including venting method, insulation board, fasteners and accessories. Provide roofing system manufacturer's written acceptance of proposed venting method, insulation, fasteners, and procedures for installation. **Coordinate with Section 07 22 16.**

1.05 QUALIFICATIONS

- A. Installer: Company specializing in performing the work of this Section and approved by roof manufacturer for installation of specified roof system.
- B. Minimum 5 years documented successful experience with asphalt shingle roofing.

1.06 REGULATORY REQUIREMENTS

- A. Fire Resistance:
 1. UL Class A Fire Hazard Classification
 2. **UL** Roof Ceiling Assembly Rating
- B. Wind Uplift Resistance: design and certify that asphalt shingle roofing meets wind uplift loads as shown on Structural Drawings.
- C. Hail Resistance – UL 2218, Class 4 (2 inch diameter hail test)

1.07 TOLERANCES

- A. Comply with tolerances listed in this Section.

- B. Where tolerances are not expressly stated in these Specifications, or by the manufacturer, perform Work within tolerances specified in the NRCA Roofing and Waterproofing Manual.

1.08 PRE-ROOFING CONFERENCE

- A. Schedule meeting to discuss roof Work before start of work onsite. Notify attending parties prior to commencing work of this Section.
- B. Pre-roofing conference attendees shall include Owner, A/E, A/E's roofing consultant, General Contractor representatives, roofing subcontractor project manager and superintendent/foreman, related subcontractors and roof manufacturer's technical representative.
- C. Review Specifications, Submittals, installation procedures and coordination required with related Work. Agenda shall include:
 1. Schedule of daily roofing operations and daily production anticipated.
 2. Designation of key personnel and their respective responsibilities.
 3. Review of staging and material storage locations.
 4. Coordination of work with other trades.
 5. Emergency rain protection procedures.
 6. Protection of completed roofing and Roof Protection Plan.
 7. Manufacturer's scheduled inspections and acceptance procedures.
 8. Warranty period process for leak repairs and inspections.
- D. Keep meeting notes and provide copies to those in attendance according to Submittal requirements.

1.09 DELIVERY, STORAGE, AND HANDLING

- A. Deliver, store, and handle products according to manufacturer's recommendations.
- B. Deliver products in original containers, dry, undamaged, with seals and labels intact.
- C. Storage:
 1. Roof-top storage of weather-sensitive material is not permitted. Material stored overnight on roof-top will be considered defective.
 2. Store weather-sensitive products in enclosed storage trailers.
Store weather-sensitive products on pallets, clear of ground, and cover with secure breathable canvas tarps.

Store weather-sensitive products in an enclosed warehouse, or in storage trailers off-site. Deliver products in quantity that can be used each day, without roof-top storage. Products must be returned to warehouse, or storage trailer, each day.

3. Store roll goods on end. Do not use rolls with damaged ends. Cut and remove portion of roll damaged, and use undamaged portion.
- D. Store related materials, within temperature ranges, recommended by the manufacturer(s) of each product.

1.10 ENVIRONMENTAL REQUIREMENTS

- A. Comply with manufacturer's environmental requirements for storage and application of products.
- B. Verify existing and forecasted weather conditions and determine when conditions are acceptable for roof Work within the guidelines as follows:
1. Do not proceed with work when ambient air temperature falls below 40 ° F.
 2. Do not proceed with roof application when excessive moisture is present.
- C. Do not expose materials sensitive to water, or sunlight, damage in quantities greater than can be weatherproofed during each day.

1.11 COORDINATION

- A. Coordinate Work with installation of associated metal flashings as the Work of this Section proceeds.

1.12 INSPECTION BY MANUFACTURER

- A. Coordinate inspection of the Work, by an authorized technical representative of the asphalt shingle manufacturer.
1. Manufacturer is required to inspect work a minimum of three (3) visits per Project.
 2. Manufacturer's visits to consist of:
 - a) Attendance at Pre-Roofing Meeting
 - b) One visit at Project commencement
 - c) Interim visits for each 10 work days of roof work, and one visit at Project completion
- B. Provide manufacturer's field inspection reports within **five days** of each site visit.

1.13 ASPHALT SHINGLE MANUFACTURER WARRANTY

- A. Provide manufacturer's **ten (10) year** asphalt shingle material and workmanship warranty. Warranty shall include material, labor, disposal and other associated costs to repair or replace asphalt shingles due to workmanship or material deficiencies.
- B. Provide manufacturer's **thirty (30) year** asphalt shingle material warranty. Warranty shall include manufacturer providing replacement shingles for defective materials, including shipping and delivery costs.
- C. Warranty shall be issued on the manufacturer's form as submitted by Contractor and reviewed by A/E.
- D. If special maintenance of the roof is required by the manufacturer during the Warranty term(s), such requirements shall be provided to the Owner with the Warranty.

1.14 INSTALLER WARRANTY

- A. Roof Installer Warranty: provide two (2) year installer warranty under provisions of **Section 01 70 50 – Project Closeout**.
- B. Provide on Midwest Roofing Contractors Association Form 2002B - Roofing Contractor Workmanship Warranty. Warranty shall be issued on form submitted, and reviewed, prior to Work commencement.
- C. Installer Warranty to be co-signed by General Contractor.

PART 2 PRODUCTS

2.01 GENERAL

- A. Roof System: **plywood** roof deck, **board insulation as specified in Section 07 22 16**, one ply underlayment and asphalt shingles.
- B. Obtain written approval from asphalt shingle manufacturer for use of products incorporated into roof system, which are not supplied by asphalt shingle manufacturer.
- C. Substitutions:
 1. Where specific products are listed in this Specification, the referenced roofing manufacturer's systems are to establish a level of quality.
 2. Requests for substitutions to listed products shall be submitted during the bidding phase per requirements of **Section 01 21 00**.
 3. Consideration of requests for substitution is at the sole discretion of the A/E and Owner, and approvals shall be issued in writing by the A/E with Owner concurrence.

2.02 MATERIALS

- A. Field Shingles: ASTM D3462, UL Class A, minimum 300 pounds per 100 square feet, fiberglass reinforced, laminated, algae and fungus resistant coating. Color chosen by A/E.
- B. Starter Shingles: as supplied by, or specially recommended by asphalt shingle manufacture, meeting warranty requirements.
- C. Ridge and Hip Shingles: match color of field shingles, heavyweight, as supplied by, or specially recommended by asphalt shingle manufacture, meeting warranty requirements.
- D. Underlayment: ASTM D4869, Type II, No. 15, non-perforated, asphalt-saturated organic felt.
- E. Self-Adhering Underlayment: ASTM D1970, self-adhering rubberized asphalt membrane, as provided by, or specifically approved by asphalt shingle manufacture, meeting warranty requirements.
- F. Shingle Nails: Hot-dipped galvanized, barbed roofing nails, minimum 3/8 inch head, of sufficient length to penetrate 1 inch into, or 1/4 inch through roof deck. Staples are not acceptable.
- G. Underlayment Fasteners: 1 inch roofing nails, as described above, through minimum 32 gage, 1 5/8 inch diameter tin tabs.
- H. Plastic Cement: ASTM D4586, non-asbestos reinforced, as supplied and recommended by asphalt shingle manufacturer.
- I. Sheet metal flashings: according to provisions of Section 07 62 00.
- J. Ridge Vent: as supplied by, or specifically approved by, asphalt shingle manufacturer, meeting warranty requirements.
- K. Board Insulation: Comply with requirements of Section 07 22 00.

PART 3 – EXECUTION

3.01 GENERAL

- A. Work of this Section shall be performed in accordance with quality workmanship standards as defined by NRCA. Detailing shall be performed in accordance with standards as defined by NRCA and SMACNA.
- B. Asphalt shingle manufacturer's technical specifications shall be considered a part of this specification and shall be used as a minimum standard in conjunction with this specification. If this Specification conflicts with, or exceeds manufacturer's minimum requirements the more rigid standard shall apply and be enforced.

3.02 COORDINATION

- A. Ensure proper sequencing of roofing and to allow installation of roof and flashings as detailed, without damage.
- B. Coordinate activities to prevent damage to roof assemblies.

3.03 EXAMINATION & PREPARATION

- A. Do not store, stage activities, or allow construction traffic over roof areas, unless protection plan is approved in advance by A/E.
- B. Contractor is responsible for maintaining roof in good condition, and shall restore to manufacturer's warrantable state upon completion of activities.
- C. Verify that surfaces and site conditions are ready to receive Work. Verify that debris has been completely removed from roof area and broom clean the deck immediately prior to roofing application.
- D. Verify deck is sound, smooth, and dry enough for covering with roofing. Report decking not serviceable for covering with roof system.
- E. Verify roof openings, curbs, pipes, sleeves, ducts, and vents through roof are solidly set, and wood components are in place.
- F. Construct and install decking, nailers and blocking under provisions of **Section 06 10 00**.

3.04 TEMPORARY WATERPROOFING

- A. Provide water stops and temporary tie-ins daily to prevent moisture penetration into building interior or installed assemblies.
- B. Seal roofing temporarily to the deck where leakage could penetrate installed assemblies. Remove upon resumption of Work.
- C. Provide permanent, or temporary, counter flashing daily.
- D. Provide temporary seals which do not soil finished work surfaces or contaminate surfaces intended to receive sealants.
- E. Remove temporary seals from completed Work.

3.05 EXAMINATION OF SITE

- A. Inspect and verify pre-existing conditions and appearance of building surfaces, components and grounds. Submit findings prior to starting Work.
- B. Verify deck is clean, dry, smooth and ready to receive roofing.
- C. Verify sheet metal flashings are complete and installed in accordance with Sheet Metal Flashings **07 62 00**.

3.06 BOARD INSULATION APPLICATION

- A. Comply with requirements of Section 07 22 16.
- B. Only install insulation that can be covered with watertight underlayment the same day.
- C. Protect installed insulation from damage, and moisture.
- D. Comply with asphalt shingle manufacturer's ventilation requirements above at areas to receive board insulation.

3.07 UNDERLAYMENT INSTALLATION

- A. Comply with shingle manufacturer's application instructions.
- B. Install one ply, shingle fashion, with minimum 12 inch endlaps.
- C. Fasten underlayment felt using asphalt shingle manufacturer-approved fasteners driven through metal discs.
- D. Fastening Pattern:
 - 1. Field: 18 inches on center staggered pattern
 - 2. Laps: 9 inches on center

3.08 SELF-ADHERED UNDERLAYMENT APPLICATION

- A. Install one ply of self-adhered underlayment at areas indicated on Drawings.
- B. Install self-adhered underlayment in areas required by asphalt shingle manufacturer for specified Warranty.
- C. Lap shingle-fashion with standard underlayment. Install underlayment according to manufacturer's recommendations.
- D. Do not allow excessive exposure before covering with asphalt shingles. Comply with manufacturer's exposure limits.

3.09 SHINGLE INSTALLATION

- A. Starter Shingles:
 - 1. Standard three tab starter: Neatly trim tabs from shingle, to allow self-sealing strip to be positioned at lower edge of roof. Trimming tabs is not necessary if manufacturer's provided starter strip has adhesive at bottom-edge.
 - 2. Fasten maximum 12 inches on center, in row 4 inches above bottom edge. Ensure minimum 5 inch staggering of laps and fasteners from joints in first course shingles above.

- B. Offset each shingle course, minimum 5 inches, in pattern recommended by shingle manufacturer to obtain desired aesthetic appearance. Ensure joints are staggered from previous course's fasteners.
- C. Neatly trim shingles at rakes. Do not use less than a 12 inch long shingle at rakes.
- D. Fasten shingles with 4 fasteners per shingle, evenly spaced, placement of fasteners recommended by the manufacturer. Do not fasten into, or above, factory-applied sealant strip. Remove and replace shingles with fasteners improperly placed.
- E. Drive fasteners flush, but do not cut into shingles. Remove and replace shingles damaged by improperly driven fasteners.
- F. Shingle exposure: 5 inches.
- G. Install shingles straight, with uniform exposure. Utilize chalk lines as necessary to maintain alignment. Remove and replace shingles improperly installed.
- H. Prepare and fasten ridge shingles according to manufacturer's recommendations. Utilize chalk lines to provide straight application.
- I. Prepare deck and install ridge vent according to manufacture's instructions at locations indicated on Contract Documents.
- J. Install vent and pipe flashings laced into shingles shingle fashion. Bed concealed flanges in bed of plastic cement. Fasten bottom edge with wood screws minimum 6 inches on center, and at each corner.

3.10 PROTECTION

- A. Remove debris, trash, and extra materials from grounds and roof areas daily.
- B. Comply with submitted Roof Protection Plan.:
- C. Protect roof system from damage. Repair or remove and replace damaged asphalt shingles according to methods approved by roof manufacturer and A/E. A/E and Owner's decision on corrective procedure will be final.
- D. Repair minor scars, cuts, scraps, tears, using methods approved by manufacturer. Severe roof damage to be corrected by removal and replacement with new asphalt shingles.
- E. Ensure roof warranty is not voided due to membrane damage.

END OF SECTION

UTH Standard Specification

SECTION 07 32 13

CLAY ROOF TILES

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Clay roof tiles
- B. Clay roof tile underlayment and accessories

1.02 RELATED WORK

- A. Section 06 10 00 - Rough Carpentry
- B. Section 07 62 00 - Sheet Metal Flashing and Trim

1.03 REFERENCES

- A. National Roofing Contractors Association (NRCA) Roofing and Waterproofing Manual
- B. Tile Roofing Institute - Concrete and Clay Roof Tile Installation Manual for Moderate Climate Regions
- C. Underwriters Laboratories (UL)
 - 1. Roofing Materials and Systems Directory
 - 2. Fire Resistance Directory
- D. ASTM C270 - Specification for Mortar for Unit Masonry
- E. ASTM C1167 - Clay Roof Tiles
- F. ASTM D1970 - Self-Adhering Polymer Modified Bituminous Sheet Materials Used as Steep Roofing Underlayment for Ice Dam Protection
- G. ASTM D4586 - Standard Specification for Asphalt Roof Cement, Asbestos Free
- H. ASTM D 2626 - Specification for Asphalt-Saturated and Coated Organic Felt Base Sheet Used in Roofing
- I. ASTM D4869 - Standard Specification for Asphalt-Saturated Organic Felt Shingle Underlayment Used in Roofing
- J. ASTM D6164 - Specification for Styrene Butadiene Styrene (SBS) Modified Bituminous Sheet Materials Using Polyester Reinforcements

- K. ASTM D6757 – Standard Specification for Inorganic Underlayment for Use with Steep Slope Roofing Products

1.04 SUBMITTALS

- A. Submit under provisions of **SPECIAL CONDITIONS** requirements and Division 1 Section **01 21 00** Submittal Procedures.
- B. Prior to pre-roofing meeting, submit the following:
1. Manufacturer's Certification: Letter from manufacturer, on letterhead, and signed by authorized representative, stating:
 - a) Clay roof tile comply **with ASTM C1167 Grade 1** and that materials furnished are compatible.
 - b) Clay roof tile, fasteners and accessories attached according to this Section meet Project-specific wind resistance requirements.
 - c) Clay roof tile, tile accessories and underlayment over roof deck qualifies for specified warranty.
 - d) Installer is authorized to install manufacturer's warranty roof systems minimum five (5) years prior to the Project NTP.
 2. Sample manufacturer, and installer, warranties meeting Specification requirements.
 3. Product Literature: Submit product literature on roof system and accessory components.
 4. Approved tile blend color selection criteria. Coordinate with construction of Mockup a subsequent approval of A/E and Owner.
 5. Shop drawings.
- C. Roof Protection Plan: Submit written roof protection plan for A/E and Owner approval that describes type and layout of roof protection during construction activities on or above roof area.
- D. Pre-Roofing Meeting Notes: Submit Pre-Roofing Meeting Notes within 5 business days of meeting date.
- E. Manufacturer's Field Reports: Submit copies of manufacturer's field reports to A/E during the Work, and at final completion.
- F. Shop drawings: Submit shop drawings for approval prior to Pre-roofing Conference and start of Work. Include the following Drawings:
1. Roof Plan(s): Prepare scaled roof plan locating roof details and penetrations.

2. Location and type of penetrations. Illustrate edge, wall, vent curb and penetrations flashing. Scale details at 1½" or larger. Manufacturer's standard pre-printed details are not acceptable for shop drawings
3. Indicate deck type on each drawing.
4. Indicate location of proposed staging areas and material storage on site plan.
5. Roof Plan indicating clay roof tile fastening types and zones. Depict attachment types(s) and areas on roof plan for each attachment type.

G. Product data:

1. Submit manufacturer's data sheets for each product being installed. Include manufacturer's installation instructions.
2. Material Safety Data Sheets: Provide manufacturer's MSDS information for all materials proposed for use.
3. ASTM Compliance Sheet: Submit product material list with corresponding ASTM standard(s) each product complies with. Include Specification paragraph reference number that relates to each product.
4. Tile samples exhibiting available tile colors. Coordinate with Mockup construction.
5. Board Insulation products: Submit manufacturer's data sheets for each component required including insulation board, fasteners and accessories. Provide roofing system manufacturer's written acceptance of proposed, insulation, fasteners, and procedures for installation. **Coordinate with 07 22 16.**

H. Clay Tile Roof System Mockup: Construct tile blend mockup and have blend approved prior to ordering tile. Construct tile mockup to allow adequate lead time in ordering roof tile.

1. Construct **10 foot by 10 foot**, ¾ inch thick plywood deck, at ground level, sloped to match predominate Project roof deck slope. Install nailer at mockup ridge. Adequately support and anchor Mockup structure to prevent collapse and wind damage.
2. Install complete clay tile roof system components above Mockup roof deck.
3. Install 4 foot long samples of eave flashings, gutter, closures, ridge tile, pigmented mortar, wind clips and tile fasteners to demonstrate installation and materials.
4. Provide **6 different field tile colors blend chosen by A/E from clay roof tile manufacturer's color selections.** Coordinate installation of mockup tiles with A/E and Owner's Representative.

5. Obtain tile color blend approval of A/E and Owner prior to ordering clay roof tiles.

1.05 QUALIFICATIONS

- A. Installer: Company specializing in performing the work of this Section and approved by roof manufacturer for installation of specified roof system.
- B. Minimum 5 years documented successful experience with clay tile roofing.

1.06 REGULATORY REQUIREMENTS

- A. Fire Resistance:
 1. UL Class A Fire Hazard Classification.
 2. UL Roof Ceiling Assembly Rating.
- B. Wind Uplift Resistance: design and certify that clay roof tiles meet wind uplift loads as shown on Structural Drawings.

1.07 TOLERANCES

- A. Comply with tolerances listed in this Section.
- B. Where tolerances are not expressly stated in these Specifications, or by the manufacturer, perform Work within tolerances specified in the NRCA Roofing and Waterproofing Manual.

1.08 PRE-ROOFING CONFERENCE

- A. Schedule meeting to discuss roof Work before start of work onsite. Notify attending parties prior to commencing work of this Section.
- B. Pre-roofing conference attendees shall include Owner, A/E, A/E's roofing consultant, General Contractor representatives, roofing subcontractor project manager and superintendent/foreman, related subcontractors and roof manufacturer's technical representative.
- C. Review Specifications, Submittals, installation procedures and coordination required with related Work. Agenda shall include:
 1. Schedule of daily roofing operations and daily production anticipated.
 2. Designation of key personnel and their respective responsibilities.
 3. Review of staging and material storage locations.
 4. Coordination of work with other trades.

5. Emergency rain protection procedures.
 6. Protection of completed roofing and Roof Protection Plan.
 7. Manufacturer's scheduled inspections and acceptance procedures.
 8. Warranty period process for leak repairs and inspections.
- D. Keep meeting notes and provide copies to those in attendance according to Submittal requirements.

1.09 DELIVERY, STORAGE, AND HANDLING

- A. Deliver, store, and handle products according to manufacturer's recommendations.
- B. Deliver products in original containers, dry, undamaged, with seals and labels intact.
- C. Storage:
 1. Roof-top storage of weather-sensitive material is not permitted. Material stored overnight on roof-top will be considered defective.
 2.
 - Store weather-sensitive products in enclosed storage trailers.
 - Store weather-sensitive products on pallets, clear of ground, and cover with secure breathable canvas tarps.
 - Store weather-sensitive products in an enclosed warehouse, or in storage trailers off-site. Deliver products in quantity that can be used each day, without roof-top storage. Products must be returned to warehouse, or storage trailer, each day.
 3. Store rolls goods on end. Do not use rolls with damaged ends. Cut and remove portion of roll damaged, and use undamaged portion.
- D. Store related materials, within temperature ranges, recommended by the manufacturer(s) of each product.

1.10 ENVIRONMENTAL REQUIREMENTS

- A. Comply with manufacturer's environmental requirements for storage and application of products.
- B. Verify existing and forecasted weather conditions and determine when conditions are acceptable for roof Work within the guidelines as follows:
 1. Do not proceed with work when ambient air temperature falls below 40 ° F.
 2. Do not proceed with roof application when excessive moisture is present.
- C. Do not expose materials sensitive to water, or sunlight, damage in quantities greater than can be weatherproofed during each day.

1.11 COORDINATION

- A. Coordinate Work with installation of associated metal flashings as the Work of this Section proceeds.

1.12 INSPECTION BY MANUFACTURER

- A. Coordinate inspection of the Work, by an authorized technical representative of the clay roof tile manufacturer.
 - 1. Manufacturer is required to inspect work a minimum of three (3) visits per Project.
 - 2. Manufacturer's visits to consist of:
 - a) Attendance to Pre-Roofing Meeting.
 - b) One visit at Project commencement.
 - c) Interim visits for each 10 work days of roof work, and one visit at Project completion.
- B. Provide manufacturer's field inspection reports within **five days** of each site visit.

1.13 MANUFACTURER WARRANTY

- A. Provide manufacturer's **fifty (50) year** clay roof tile material warranty. Warranty shall include manufacturer providing replacement tiles for defective materials, including shipping and delivery costs.
- B. Warranty shall be issued on the manufacturer's form as submitted by Contractor and reviewed by A/E.
- C. If special maintenance of the roof is required by the manufacturer during the Warranty term(s), such requirements shall be provided to the Owner with the Warranty.

1.14 INSTALLER WARRANTY

- A. **Roof Installer Warranty: provide two (2) year installer warranty under provisions of Section 01 70 50 – Project Closeout.**
- B. Provide on Midwest Roofing Contractors Association Form 2002B - Roofing Contractor Workmanship Warranty. Warranty shall be issued on form submitted, and reviewed, prior to Work commencement.
- C. Installer Warranty to be co-signed by General Contractor.

PART 2 PRODUCTS

2.01 GENERAL

- A. Roof System: $\frac{3}{4}$ inch thick plywood roof deck, board insulation as specified in Section 07 22 16, one shingled ply of underlayment and clay roof tiles.
- B. Obtain written approval from clay roof tile manufacturer for use of products incorporated into roof system, which are not supplied by clay roof tile manufacturer.
- C. Substitutions:
 - 1. Where specific products are listed in this Specification, the referenced roofing manufacturer's systems are to establish a level of quality.
 - 2. Requests for substitutions to listed products shall be submitted during the bidding phase per requirements of Section 01 21 00.
 - 3. Consideration of requests for substitution is at the sole discretion of the A/E and Owner, and approvals shall be issued in writing by the A/E with Owner concurrence.

2.02 MATERIALS

- A. Field Tile: ASTM C1167, Grade 1, Spanish Tile, color blend chosen by A/E.
- B. Tile Closures: eave and headwall closures, clay tile matching color of field tile, as supplied by clay roof tile manufacture.
- C. Ridge and Hip Tiles: match color of field tiles, as supplied by clay roof tile manufacture. Provide clay roof tile manufacture-produced ridge and hip terminations and transitions.
- D. Tile Nails: Copper or stainless-steel, ring-shank roofing nails, minimum $\frac{3}{8}$ inch head, of sufficient length to penetrate 1 inch into, or $\frac{1}{4}$ inch through roof deck.
- E. Tile Wind Clips: brass or stainless steel, as supplied by, or recommended by clay roof tile manufacturer for use with specified tile profile.
- F. Underlayment: ASTM D1970, modified bituminous waterproofing sheet, self-adhering, high temperature resistant, Vycor Ultra by W.R. Grace, or approved substitute.
- G. Mortar: ASTM C270, Type M, color pigmented as approved by A/E.
- H. Plastic Cement: ASTM D4586, non-asbestos reinforced, as supplied and recommended by clay roof tile manufacturer.
- I. Sheet metal flashings: according to provisions of Section 07 62 00.
- J. Board Insulation: Comply with requirements of Section 07 22 16.

PART 3 – EXECUTION

3.01 GENERAL

- A. Work of this Section shall be performed in accordance with quality workmanship standards as defined by NRCA. Detailing shall be performed in accordance with standards as defined by NRCA and SMACNA.
- B. Clay roof tile manufacturer's technical specifications shall be considered a part of this specification and shall be used as a minimum standard in conjunction with this specification. If this Specification conflicts with, or exceeds manufacturer's minimum requirements the more rigid standard shall apply and be enforced.

3.02 COORDINATION

- A. Ensure proper sequencing of roofing and to allow installation of roof and flashings as detailed, without damage.
- B. Coordinate activities to prevent damage to roof assemblies.

3.03 EXAMINATION & PREPARATION

- A. Do not store, stage activities, or allow construction traffic over roof areas, unless protection plan is approved in advance by A/E.
- B. Contractor is responsible for maintaining roof in good condition, and shall restore to manufacturer's warrantable state upon completion of activities.
- C. Verify that surfaces and site conditions are ready to receive Work. Verify that debris has been completely removed from roof area and broom clean the deck immediately prior to roofing application.
- D. Verify deck is sound, smooth, and dry enough for covering with roofing. Report decking not serviceable for covering with roof system.
- E. Verify roof openings, curbs, pipes, sleeves, ducts, and vents through roof are solidly set, and wood components are in place.
- F. Construct and install decking, nailers and blocking under provisions of Section 06 10 00.
- G. Install sheet metal components, according to provisions of Section 07 62 00.

3.04 TEMPORARY WATERPROOFING

- A. Provide water stops and temporary tie-ins daily to prevent moisture penetration into building interior or installed assemblies.
- B. Seal roofing temporarily to the deck where leakage could penetrate installed assemblies. Remove upon resumption of Work.
- C. Provide permanent, or temporary, counter flashing daily.

- D. Provide temporary seals which do not soil finished work surfaces or contaminate surfaces intended to receive sealants.
- E. Remove temporary seals from completed Work.

3.05 EXAMINATION OF SITE

- A. Inspect and verify pre-existing conditions and appearance of building surfaces, components and grounds. Submit findings prior to starting Work.
- B. Verify deck is clean, dry, smooth and ready to receive roofing.
- C. Verify sheet metal flashings are complete and installed in accordance with Sheet Metal Flashings Section 07 62 00.

3.06 BOARD INSULATION APPLICATION

- A. Comply with requirements of Section 07 22 16.
- B. Only install insulation that can be covered with watertight underlayment the same day.
- C. Protect installed insulation from damage, and moisture.

3.07 UNDERLAYMENT INSTALLATION

- A. Comply with tile manufacturer's application instructions.
- B. Install one ply, shingle fashion, with minimum 4 inch laps.
- C. Install strip-in ply at ridges, hips, valleys, transitions, eaves and rise walls.
- D. Lap shingle-fashion with field underlayment.
- E. Do not allow excessive exposure before covering with clay roof tiles. Comply with manufacturer's exposure limits. Remove and replace underlayment that is over-exposed.

3.08 TILE INSTALLATION

- A. Apply in accordance with tile manufacturer's recommendations.
- B. Match approved Mockup blend pattern and layout.
- C. Ensure tile courses are straight and uniform distribution. Use string lines to ensure straight courses.
- D. Fasten each tile to roof deck with 2 fasteners per tile. Drive fasteners flush without damaging tile.
- E. Install tile wind clips at first course of roof tile at eave.

- F. Replace broken tiles. Remove tile in its entirety, seal nail holes in underlayment with sealant or plastic cement. Install replacement tile.
- G. Install flashings to provide watertight construction.

3.09 HIP & RIDGE TILE INSTALLATION

- A. Cover wood nailer with self-adhering strip-in ply. Lap over underlayment minimum 6 inches. Ensure shingle-fashion application.
- B. Install field tile and apply mortar to head of wetted field tile.
- C. Moisten ridge tile and set in mortar bed. Ensure positive embedment.
- D. Fasten hip tile to nailer. Apply plastic cement at overlap with adjacent hip tile.

3.10 CLEANING & PROTECTION

- A. Clean roof surfaces, metal flashings, walls, windows, walks, and other surfaces, which become soiled or discolored due to the work of this Section.
- B. Utilize cleaning agents which are approved by the applicable manufacturer.
- C. Protect completed Work during construction activities.
- D. Remove debris, trash, and extra materials from grounds and roof areas daily.
- E. Comply with submitted Roof Protection Plan.:
- F. Protect roof system from damage. Repair or remove and replace damaged clay roof tiles according to methods approved by roof manufacturer and A/E. A/E and Owner's decision on corrective procedure will be final.

END OF SECTION

UTH Standard Specification

SECTION 07 41 13

METAL ROOF PANELS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Metal Roof Panels
- B. Metal Roof Accessories

1.02 RELATED WORK

- A. Section 06 10 00 - Rough Carpentry
- B. Section 07 22 16 – Roof Board Insulation
- C. Section 07 62 00 - Sheet Metal Flashing and Trim
- D. Section 07 92 00 – Sealants

1.03 REFERENCES

- A. SMACNA - Architectural Sheet Metal Manual, 2003 Edition
- B. Metal Building Manufacturers Association (MBMA) - Metal Roofing Systems Design Manual, 2000 Edition
- C. ASTM A167 - Stainless and Heat-Resisting Chromium-Nickel Steel Plate
- D. ASTM A653 - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
- E. ASTM A792 - Standard Specification for Steel Sheet, 55% Aluminum-Zinc Alloy-Coated by the Hot-Dip Process
- F. ASTM B209 - Aluminum and Aluminum-Alloy Sheet and Plate
- G. ASTM B370 - Copper Sheet and Strip for Building Construction
- H. Underwriters Laboratories – wind uplift classifications

1.04 SUBMITTALS

- A. Submit under provisions of SPECIAL CONDITIONS requirements and Division 1 Section 01 21 00 Submittal Procedures.
- B. Prior to pre-roofing meeting, submit the following:

1. Manufacturer's Certification: document that certifies metal roof panels and accessories meet requirements.
 2. Product Literature: Submit product literature on metal roof panels and accessory components.
 3. Wind Uplift Resistance: design and certify that roof panels meet wind uplift loads as shown on Structural Drawings.
 4. Sample installer and manufacturer watertightness and finish warranties.
- C. Shop drawings: Submit shop drawings for approval prior to Pre-roofing Conference and start of Work. Include the following Drawings:
1. Indicate on Shop Drawings material profiles, jointing patterns, jointing details, fastening methods, and installation instructions.
 2. Indicate location of sealants, tapes and gaskets.
 3. Indicate material type, finish and gage.
 4. Submit roof plan showing panel layout.
 5. Provide details of rake, ridge, valley, sidewall, and headwall flashings and other applicable flashings. Indicate locations of field applied sealant.
- D. Product data:
1. Submit manufacturer's data sheets for each material Coordinate with roof Specification Section(s).
 2. Material Safety Data Sheets: Provide manufacturer's MSDS information for all materials proposed for use.
 3. ASTM Compliance Sheet: Submit product material list with corresponding ASTM standard(s) each product complies with. Include Specification paragraph reference number that relates to each product.
- E. Samples:
1. Submit color samples on metal of roof panel manufacturer's **standard color options**, for Architect's selection.
 2. Submit two samples, 12" long, full width panel, showing metal gage, seam and finish.

1.05 QUALIFICATIONS

- A. Installer: Company specializing in performing the work of this Section and approved by roof manufacturer for installation of specified roof system.

- B. Minimum 5 years documented successful experience with installation of products specified in this Section.

1.06 REGULATORY REQUIREMENTS

- A. Fire Resistance:
 - 1. UL Class A Fire Hazard Classification
 - 2. UL _____ Roof Ceiling Assembly Rating

1.07 TOLERANCES

- A. Comply with tolerances listed in this Section.
- B. Where tolerances are not expressly stated in these Specifications, or by the manufacturer, perform Work within tolerances listed in the SMACNA Architectural Sheet Metal Manual.

1.08 PRE-ROOFING CONFERENCE

- A. Schedule meeting to discuss roof Work before start of work onsite.
- B. Comply with requirements of roof Specification Section(s).

1.09 DELIVERY, STORAGE, AND HANDLING

- A. Deliver, store, and handle products according to manufacturer's recommendations.
- B. Deliver products in original containers, dry, undamaged, with seals and labels intact.
- C. Storage:
 - 1. Roof-top storage of weather-sensitive material is not permitted. Material stored overnight on roof-top will be considered defective.
 - 2. Store weather-sensitive products in enclosed storage trailers. Store weather-sensitive products on pallets, clear of ground, and cover with secure breathable canvas tarps. Store weather-sensitive products in an enclosed warehouse, or in storage trailers off-site. Deliver products in quantity that can be used each day, without roof-top storage. Products must be returned to warehouse, or storage trailer, each day.
- D. Store related materials, within temperature ranges, recommended by the manufacturer(s) of each product.
- E. Stack sheet metal to prevent twisting, bending, or abrasion, and to provide ventilation.
- F. Do not stack products on roof surfaces without properly securing to prevent blow-off and sliding-off roof.

- G. Deliver panels to jobsite properly packaged to provide protection against transportation damage.
- H. Exercise care in unloading, storing and erecting panels to prevent bending, warping, twisting, and surface damage.
- I. Store all material and accessories above ground on well skidded platforms. Store under waterproof covering. Provide proper ventilation to panels to prevent condensation build-up between each panel.
- J. Remove from site panels which are damaged, or become water-stained during storage and handling. Remove, and replace materials, which are installed damage, or stained.

1.10 ENVIRONMENTAL REQUIREMENTS

- A. Comply with manufacturer's environmental requirements for storage and application of products.
- B. Verify existing and forecasted weather conditions and determine when conditions are acceptable for roof Work within manufacturer's recommended guidelines:
- C. Do not expose materials sensitive to water, or sunlight, damage in quantities greater than can be weatherproofed during each day.

1.11 COORDINATION

- A. Coordinate Work, with installation of other associated Work, to ensure quality application.
- B. Coordinate Work with installation of associated metal flashings, manufactured fascia panels, soffit, and building walls.
- C. Coordinate Work to minimize foot traffic and construction activity on installed finished surfaces.
- D. Coordinate location of pipe penetrations to allow centering of pipe in panel.
- E. Coordinate location of roof curbs, to allow proper integration with roof panel seams.

1.12 INSPECTION BY MANUFACTURER

- A. Comply with requirements of roof membrane Specification Section(s).
- B. Provide manufacturer's field inspection reports within **five days** of each site visit.

1.13 SUBSTITUTIONS

- A. Where specific products are listed in this Specification, the referenced manufacturer's systems are to establish a level of quality.

- B. Requests for substitutions to listed products shall be submitted during the bidding phase per requirements of 01 21 00.
- C. Consideration of requests for substitution is at the sole discretion of the A/E and Owner, and approvals shall be issued in writing by the A/E with Owner concurrence.

1.14 QUALITY ASSURANCE

- A. Installer Qualifications: Installer ("roofer") to perform the Work of this Section, which firm has no fewer than 5 years of successful experience with installation metal roof systems similar to those required for this Project, and is certified, or licensed, by the roof panel manufacturer, for installation of manufacturer-warranted systems.
- B. Field Measurements: Prior to fabrication of panels, take field measurements of structure or substrates to receive panel system. Allow for trimming panel units, where final dimensions cannot be established prior to fabrication.
- C. Install a 20 foot wide, quality control area of metal roofing on Project's roof, for review by the Architect, to establish the quality of installation for the roof, and have reviewed prior to installing additional area.

1.15 WARRANTIES

- A. Roof Installer Warranty: provide under provisions of Section 01 70 50 – Project Closeout.
- B. Panel Finish Warranty: Furnish manufacturer's 20-year coating warranty:
- C. Metal Roof System Warranty: Provide manufacturer's watertightness warranty. Warranty must include the following:
 1. 20 year term. Term starts at completion of roof. Years 1, through 20, are fully covered by Warranty, including years under Contractor's Warranty.
 2. Coverage to include metal roof panels, and metal roof accessories provided by metal roof panel manufacturer.
- D. Installer Warranty: Provide 2 year Installer Workmanship Warranty covering sheet metal roof workmanship.

PART 2 PRODUCTS

2.01 ROOF PANEL SYSTEM

- A. Roof Panels: BattenLok panel manufactured by MBCI, JSM 200 as manufactured by American Building Components, Inc., SDP 200 by Centria, or acceptable substitute, meeting the following requirements:
 1. Galvalume ASTM 792 or Galvanized G90, 24 gage sheet steel, with full-strength Kynar 500 coating, in color chosen by A/E from standard color selections.

2. Factory-formed panel width of 16 inches, with continuous 2 inch high, interlocking standing seam. Field-formed panels are not acceptable, unless performed by panel manufacturer's trained full-time employees on approved equipment.
3. Panels fabricated in full length from ridge to eave. Include costs to ship oversized panels under special permit, or provide factory roll formed panels. Field panel endlaps are not permitted.
4. Factory-applied continuous sealant at standing seam.

B. Roof Accessories

1. Underlayment: high-temperature-resistant, modified bituminous sheet membrane, with adhesive backing, non-slip walking surface, Vycor by W.R. Grace, or MiraDRi 300HT, or approved substitute.
2. Panel Clip Screw – corrosion-resistant, provided by roof panel manufacturer, as required in wind uplift rating, and meeting warranty requirements.
3. Roof Panels Clip: **Floating clip** bearing the UL classification marking meeting wind uplift requirements of this Section.
4. **Roof Panel Clip Bearing Plate**: heavy gage steel, corrosion-resistant coating, in size, profile, and gage to meet wind uplift requirements and prevent deformation of roof insulation.
5. Metal Trim and Metal Closures: meeting requirements of Section 07 62 00.
6. Concealed supports, angles, plates, accessories and brackets: As recommended, and furnished by manufacturer.
7. Accessory Screw: Size and screw type as provided by panel manufacturer for each use, with prefinished hex washer head in color to match panels where exposed to view.
8. Rivets: non-magnetic stainless steel, including mandrel, in size to match application.
9. Field Sealant: Color coordinated primerless silicone or high grade, non-drying butyl as supplied by panel manufacturer.
10. Sealant Tape: non-drying, 100 percent solids, high grade butyl tape, as supplied by panel manufacturer, in sizes to match application.
11. Pipe Penetration Flashings: flexible boot type, with stainless steel compression ring, and stainless steel pipe strap, Dektite by Buildex, or approved substitute. Use silicone type at hot pipes.
12. Metal Roof Curbs: welded aluminum, or stainless steel, factory-insulated, with integral cricket, and designed to fit roof panel module, sized to meet application,

by L.M. Curbs, or approved substitute.

13. Insulation: according to provisions of Section 07 22 16.

PART 3 – EXECUTION

3.01 GENERAL

- A. The roof manufacturer's technical specifications shall be considered a part of this Section and shall be used as a minimum standard in conjunction with this Section.
- B. If this Section conflicts with, or exceeds manufacturer's minimum requirements the more rigid standard shall apply and be enforced.

3.02 EXAMINATION

- A. Ensure metal roof deck is ready to receive metal roofing.
- B. Ensure surface of deck is free from objectionable warp, wave, and buckle.

3.03 UNDERLAYMENT INSTALLATION

- A. Install insulation board according to provisions of Section 07 22 16.
- B. Install one layer underlayment, shingle fashion, over insulation.
- C. Extend up vertical surfaces 2 inches at sidewalls, and headwalls, and down over roof edges 1 inch.
- D. Apply one layer with metal roof with 6 inch endlaps and 3 inch sidelaps.
- E. Ensure underlayment is bonded to substrate to prevent blow-off, prior to roof panel installation.
- F. Install underlayment to provide watertight installation prior to roof panel installation.
- G. Cover underlayment, within maximum 30 days, with new sheet metal roof system at insulated areas. Remove and replace underlayment exposed longer than 30 days.
- H. Repair torn, cut, buckled, or weathered underlayment prior to roof panel application.

3.04 INSTALLATION OF ROOF PANELS

- A. Comply with manufacturer's instructions for assembly, installation and erection, in order to achieve weathertight installation.
- B. Install field panels in continuous lengths, without endlaps.
- C. Install clips, over bearing plates at roof insulation, in pattern to meet wind uplift rating requirements.

- D. Allow for 1 inch panel clearance at penetrations.
- E. Install concealed supports, angles and brackets as furnished by manufacturer to form complete assemblies.
- F. Field-apply sealant at penetrations, transitions, and other locations necessary (not standing seams) for airtight, waterproof installation.
- G. Ensure sealant beads and tape is applied prior to sheet metal installation to achieve a concealed bead. Neatly trim exposed portions of sealant without damaging painted finish.
- H. Align pipe penetrations to occur at center of roof panel. Report and have corrected improperly-placed penetrations. Remove and replace roof panels which have improperly-placed penetration flashings.
- I. Align roof curbs to fit roof panel module and overlap standing seam(s). Allow for proper drainage on both sides of curb.
- J. Install sheet metal flashings according to manufacturer's recommendations, and in accordance with provision of Section 07 62 00.

3.05 CLEANING & PROTECTION

- A. Clean exposed surfaces of Work promptly after completion of installation.
- B. Clean mud, dirt, and construction-related debris from panels before panels are scratched or marred.
- C. Protect Work as required to ensure roofing will be without damage at time of final completion.
- D. Do not allow excessive foot traffic over finished surfaces.
- E. Do not track mud, dirt, or construction-related debris onto panel surfaces.
- F. Clean metal roof surfaces using methods and materials approved by roof panel manufacturer.
- G. Replace damaged Work before final completion.

END OF SECTION

UTH Standard Specification

SECTION 07 51 13

ASPHALT BUILT-UP ROOFING

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Asphalt built-up roof membrane
- B. Membrane flashings and accessories

1.02 RELATED WORK

- A. Section 06 10 00 - Rough Carpentry
- B. Section 07 22 16 – Roof Board Insulation
- C. Section 07 62 00 - Sheet Metal Flashing and Trim

1.03 REFERENCES

- A. National Roofing Contractors Association (NRCA) Roofing and Waterproofing Manual
- B. Underwriters Laboratories (UL)
 - 1. Roofing Materials and Systems Directory
 - 2. Fire Resistance Directory
- C. ASTM D41 - Asphalt Primer Used in Roofing
- D. ASTM D312 - Asphalt Used in Roofing. Use if hot asphalt is used in roof system.
- E. ASTM D2178 - Asphalt Glass Felt Used in Roofing and Waterproofing
- F. ASTM D4586 - Standard Specification for Asphalt Roof Cement, Asbestos-Free
- G. ASTM D6221 - Standard Specification for Reinforced Bituminous Flashing Sheets for Roofing and Waterproofing
- H. ASTM D4601- Standard Specification for Asphalt-Coated Glass Fiber Base Sheet Used in Roofing
- I. ASTM D4897 - Standard Specification for Asphalt-Coated Glass-Fiber Venting Base Sheet Used in Roofing

1.04 SUBMITTALS

- A. Submit under provisions of **SPECIAL CONDITIONS** requirements and Division 1 **Section 01 21 00** Submittal Procedures.
- B. Prior to pre-roofing meeting, submit the following:
 - 1. Manufacturer's Certification: Letter from manufacturer, on letterhead, and signed by authorized representative, stating:
 - a) Materials and components conform with specification requirements and that materials furnished are compatible.
 - b) Roof membrane system, membrane flashings, and roof insulation, qualifies for specified warranty.
 - c) Installer is authorized to install manufacturer's warranty roof systems and was approved prior to minimum five (5) years prior to the Project NTP.
 - d) Roof system meets specified regulatory requirements.
 - 2. Sample manufacturer, and installer, warranties meeting Specification requirements.
 - 3. Product Literature: Submit product literature on roof system and accessory components.
 - 4. Manufacturer's cold weather application recommendations.
 - 5. Shop drawings.
- C. Roof Protection Plan: Submit written roof protection plan for A/E and Owner approval that describes type and layout of roof protection during construction activities on or above roof area.
- D. Pre-Roofing Meeting Notes: Submit Pre-Roofing Meeting Notes within 5 business days of meeting date.
- E. Manufacturer's Field Reports: Submit copies of manufacturer's field reports to A/E during the Work, and at final completion.
- F. Asphalt Fume Control Plan: Submit equipment data, and proposed loading and heating procedures to limit ground-level asphalt fumes.
- G. Shop drawings: Submit shop drawings for approval prior to Pre-roofing Conference and start of Work. Include the following Drawings:
 - 1. Roof Plan(s):
 - a) Prepare scaled roof plan locating roof details and penetrations.

- b) Include on roof plan tapered insulation locations at field, perimeter, and roof curbs. Indicate insulation thickness at high and low points, crickets pattern, and drain sumps.
 - c) Outline roof dimensions, including all levels.
 - 2. Location and type of penetrations. Illustrate perimeter flashings, equipment flashings and penetrations flashing. Scale details at ½” or larger. Manufacturer’s standard pre-printed details are not acceptable for shop drawings
 - a. Indicate deck type on each drawing.
 - 3. Provide scaled insulation attachment plan for each roof area indicating perimeter and corner requirements to achieve specified wind uplift resistance. Provide insulation fastening pattern drawing for corner, perimeter, and field zones.
 - 4. Indicate location of proposed staging areas and material storage on site plan.
- H. Product data:
 - 1. Roofing membrane products: Submit manufacturer’s data sheets for each product being installed. Include manufacturer’s installation instructions.
 - 2. Insulation products: Submit manufacturer’s data sheets for each component required including insulation boards, adhesives, fasteners, plates and bitumen or adhesive. Provide roofing system manufacturer’s written acceptance of proposed insulation board, adhesives, fasteners, and procedures for installation. **Coordinate with Section 07 22 16.**
 - 3. Material Safety Data Sheets: Provide manufacturer’s MSDS information for all materials proposed for use.
 - 4. Laboratory Testing: Provide evidence of specified fire and wind uplift ratings for proposed roof system.
 - 5. ASTM Compliance Sheet: Submit product material list with corresponding ASTM standard(s) each product complies with. Include Specification paragraph reference number that relates to each product.
- I. Surfacing Sample: Submit approximately 2 pound sample of roof membrane surfacing in metal container.
- J. Roof Maintenance Data: Submit manufacturer’s complete recommended maintenance procedures for roofing system, including precautions and warnings to prevent damage and deterioration to the roofing system. Information shall include maintenance guidelines indicating materials and methods to be used for emergency and minor repairs.

1.05 QUALIFICATIONS

- A. Installer: Company specializing in performing the work of this Section and approved by roof manufacturer for installation of specified roof system.

- B. Minimum 5 years documented successful experience with asphalt built-up roofing.

1.06 REGULATORY REQUIREMENTS

- A. Fire Resistance:
 - 1. UL Class A Fire Hazard Classification
 - 2. **UL** Roof Ceiling Assembly Rating
- B. Wind Uplift Resistance: design and certify that asphalt built-up roofing meets wind uplift loads as shown on Structural Drawings.

1.07 TOLERANCES

- A. Comply with tolerances listed in this Section.
- B. Where tolerances are not expressly stated in these Specifications, or by the manufacturer, perform Work within tolerances specified in the NRCA Roofing and Waterproofing Manual.

1.08 PRE-ROOFING CONFERENCE

- A. Schedule meeting to discuss roof Work before start of work onsite. Notify attending parties prior to commencing work of this Section.
- B. Pre-roofing conference attendees shall include Owner, A/E, A/E's roofing consultant, General Contractor representatives, roofing subcontractor project manager and superintendent/foreman, related subcontractors and roof manufacturer's technical representative.
- C. Review Specifications, Submittals, installation procedures and coordination required with related Work. Agenda shall include:
 - 1. Schedule of daily roofing operations and daily production anticipated.
 - 2. Designation of key personnel and their respective responsibilities.
 - 3. Review of staging and material storage locations.
 - 4. Coordination of work with other trades.
 - 5. Emergency rain protection procedures.
 - 6. Protection of completed roofing and Roof Protection Plan.
 - 7. Manufacturer's scheduled inspections and acceptance procedures.
 - 8. Warranty period process for leak repairs and inspections.
 - 9. Review Fume Control Plan.

- D. Keep meeting notes and provide copies to those in attendance according to Submittal requirements.

1.09 DELIVERY, STORAGE, AND HANDLING

- A. Deliver, store, and handle products according to manufacturer's recommendations.
- B. Deliver products in original containers, dry, undamaged, with seals and labels intact.
- C. Storage:
 1. Roof-top storage of weather-sensitive material is not permitted. Material stored overnight on roof-top will be considered defective.
 2. Store weather-sensitive products in enclosed storage trailers.
Store weather-sensitive products on pallets, clear of ground, and cover with secure breathable canvas tarps.
Store weather-sensitive products in an enclosed warehouse, or in storage trailers off-site. Deliver products in quantity that can be used each day, without roof-top storage. Products must be returned to warehouse, or storage trailer, each day.
 3. Store roll goods on end. Do not use rolls with damaged ends. Cut and remove portion of roll damaged, and use undamaged portion for strip-in ply, or completely remove roll from site.
- D. Store related materials within temperature ranges recommended by the manufacturer(s) of each product.

1.10 ENVIRONMENTAL REQUIREMENTS

- A. Comply with manufacturer's environmental requirements for storage and application of products.
- B. Verify existing and forecasted weather conditions and determine when conditions are acceptable for roof Work within the guidelines as follows:
 1. Do not proceed with work when ambient air temperature falls below 40 degrees F.
 2. Do not proceed with roof application when excessive moisture is present. Excessive moisture is that which may be detected by sight or touch, or that which results in visible foaming of hot asphalt.
- C. Do not expose materials sensitive to water, or sunlight, damage in quantities greater than can be weatherproofed during each day.

1.11 COORDINATION

- A. Coordinate Work with installation of associated metal flashings as the Work of this Section proceeds.

1.12 INSPECTION BY MANUFACTURER

- A. Coordinate inspection of the Work, by an authorized technical representative of the roof system manufacturer.
 - 1. Manufacturer is required to inspect work a minimum of three (3) visits per Project.
 - 2. Manufacturer's visits to consist of:
 - a) Attendance to Pre-Roofing Meeting.
 - b) One visit at Project commencement.
 - c) Interim visits for each 10 work days of roof work, and one visit at Project completion.
- B. Provide manufacturer's field inspection reports within **five days** of each site visit.

1.13 ROOF SYSTEM WARRANTY

- A. Provide manufacturer's twenty **(20) year, no penal sum limit**, roof system warranty.
- B. Warranty shall include all material and labor costs
- C. Warranty shall include coverage for **roof insulation, as specified in Section 07 22 16**, either as part of original warranty language, or by attachment. Manufacturer's warranty shall include the full roofing system including membranes, flashings, insulation, fasteners/adhesives, rigid roof boards, accessories and all related roof system components.
- D. Warranty shall be issued on the manufacturer's form as submitted by Contractor and reviewed by A/E.
- E. If special maintenance of the roof is required by the manufacturer during the Warranty term(s), such requirements shall be provided to the Owner with the Warranty.

1.14 INSTALLER WARRANTY

- A. Roof Installer Warranty: provide under provisions of **Section 01 70 50 – Project Closeout**.
- B. Provide on Midwest Roofing Contractors Association Form 2002B - Roofing Contractor Workmanship Warranty. Warranty shall be issued on form submitted, and reviewed, prior to Work commencement.
- C. Installer Warranty to be co-signed by General Contractor.

PART 2 PRODUCTS

2.01 GENERAL

- A. Roof System: [REDACTED] deck, insulation as specified in Section 07 22 16, four plies fiberglass felt set in hot asphalt, with gravel aggregate surfacing.
- B. Provide roof membrane, and membrane base flashing materials from single manufacturer.
- C. Obtain written approval from roof membrane manufacturer for use of products incorporated into roof system, which are not supplied by roof membrane manufacturer.
- D. Substitutions:
 - 1. Where specific products are listed in this Specification, the referenced roofing manufacturer's systems are to establish a level of quality.
 - 2. Requests for substitutions to listed products shall be submitted during the bidding phase per requirements of Section 01 21 00.
 - 3. Consideration of requests for substitution is at the sole discretion of the A/E and Owner, and approvals shall be issued in writing by the A/E with Owner concurrence.

2.02 ROOF MEMBRANE & BASE FLASHING

- A. Membrane Ply Sheet: ASTM D2178, Type VI , premium fiberglass ply sheet.
- B. Membrane Base Flashing: strip-in ply is required, regardless of roof membrane manufacturer minimum requirements, with modified bitumen membrane base flashing sheet top ply.
 - 1. Strip-In Ply: meet, or exceed, roof membrane ply sheet requirements.
 - 2. Second Ply: ASTM D 6221, polyester or glass reinforced, modified bitumen sheet, meeting roof warranty requirements.
- C. Metal Flashing Strip-In Ply: meet, or exceed, roof membrane ply sheet requirements.

2.03 BITUMINOUS MATERIALS

- A. Asphalt Bitumen: ASTM D312, Type III, steep, as supplied or specifically approved by membrane manufacturer.
- B. Asphalt Primer: ASTM D41, as supplied or specifically approved by membrane manufacturer.
- C. Cold Adhesive: type supplied by, or specifically recommended by roof membrane manufacturer, meeting requirements of warranty.
- D. Plastic Cement: ASTM D4586, non-asbestos reinforced, as supplied and recommended by roof membrane manufacturer.

2.04 INSULATION

- A. Board Insulation: Comply with requirements of Section 07 22 16.
- B. Tapered Crickets:
 - 1. First course: ASTM C728, perlite tapered edge, minimum 12 inches wide, in thickness to match butt edge of tapered insulation, set in hot asphalt.
 - 2. Remaining courses: ASTM C728, perlite, 1/2 inch per foot tapered, set in hot asphalt.

2.05 TAPERED EDGE & CANTS

- A. Tapered Edge: ASTM C728, perlite.
- B. Cant Strip: ASTM C728, perlite minimum 3 1/2 inch face.
- C. Wood Cant: treated southern pine, cut to size, according to provisions of Section 06 10 00.

2.06 SURFACING AND ACCESSORIES

- A. Gravel Surfacing: ASTM D1863, light-color, clean, washed, opaque, gravel aggregate.
- B. Membrane Flashing Fasteners: hot-dipped galvanized Simplex cap nails, with minimum 15/16 inch wide head.
- C. Sheet metal flashings: according to provisions of Section 07 62 00.
- D. Membrane Edge Sealant: As required by membrane roof manufacturer.
- E. Mineral Granules: as supplied by membrane manufacturer to match color of membrane base flashing sheet surface.
- F. Traffic Pad: as supplied by membrane manufacturer, and meeting their warranty requirements.

2.07 SPECIAL BITUMEN HEATING EQUIPMENT

- A. Provide ground-level filtering, or after-burning asphalt fume system equipment.
- B. Equip kettle with carton loader device.
- C. Ensure positive seals at kettle lid, loader, and piping, to ensure containment of ground-level asphalt fumes.

PART 3 – EXECUTION

3.01 GENERAL

- A. Work of this Section shall be performed in accordance with quality workmanship standards as defined by NRCA. Detailing shall be performed in accordance with standards as defined by NRCA and SMACNA.

- B. The roof systems manufacturer's technical specifications shall be considered a part of this specification and shall be used as a minimum standard in conjunction with this specification. If this Specification conflicts with, or exceeds manufacturer's minimum requirements the more rigid standard shall apply and be enforced.

3.02 COORDINATION

- A. Ensure proper sequencing of roofing and to allow installation of roof and flashings as detailed, without damage.
- B. Coordinate activities to prevent damage to roof assemblies.

3.03 EXAMINATION & PREPARATION

- A. Do not store, stage activities, or allow construction traffic over roof areas, unless protection plan is approved in advance by A/E.
- B. Contractor is responsible for maintaining roof in good condition, and shall restore to manufacturer's warrantable state upon completion of activities.
- C. Verify that surfaces and site conditions are ready to receive Work. Verify that debris has been completely removed from roof area and broom clean the deck immediately prior to roofing application.
- D. Verify deck is sound, smooth, and dry enough for covering with roofing. Report decking not serviceable for covering with roof system.
- E. Verify roof openings, curbs, pipes, sleeves, ducts, and vents through roof are solidly set, and wood components are in place.
- F. Install nailers and blocking immediately prior to application of roofing. Do not cut nailers in after membrane application.
- G. Construct and install nailers and blocking under provisions of Section 06 10 00.

3.04 TEMPORARY WATERPROOFING

- A. Provide water stops and temporary tie-ins daily to prevent moisture penetration into building interior or installed assemblies.
- B. Seal roofing temporarily to the deck where leakage could penetrate installed assemblies. Remove upon resumption of Work.
- C. Provide permanent, or temporary, counter flashing daily.
- D. Install membrane assemblies complete with strip-in plies each day. Use mastic seals only in such a manner that mastic does not remain between finished roof plies at cant strips and membrane terminations. Provide seal at all terminations, both vertical and horizontal.
- E. Provide temporary seals which do not soil finished work surfaces or contaminate surfaces intended to receive sealants.

- F. Remove temporary seals from completed Work.

3.05 CANT STRIP APPLICATION

- A. Apply fiber cant strip into solid mopping of asphalt, and step-in completely.
- B. Install wood cant at through-wall scupper intersections and to support vertical “L” nailers.
- C. Securely fasten wood cant to substrate. Ensure smooth transitions with fiber cant.
- D. Make straight, neat cuts and miter corners without perceptible gaps or open joints.
- E. Cut, shave, modify and combine various sized tapered materials to provide smooth, uniform transitions.

3.06 BITUMEN HEATING

- A. Comply with manufacturer’s requirements for heating, and applying bitumen.
- B. Heat asphalt bitumen to achieve EVT at point of application, as stamped on asphalt carton, plus or minus 25 degrees F.
- C. Use insulated tubing and luggers during cold weather, to maintain correct temperature, at the point of application.
- D. Verify accurate temperature readings at point of application to ensure compliance. Establish proper temperature at kettle, hold time on roof, and substrate type and temperature to achieve proper application temperature.
- E. Measure temperature periodically, minimum one reading every two hours, or when conditions change. Contractor to provide accurate temperature measuring device for verification.
- F. Adjust temperature, equipment, or procedure to maintain proper application temperature.
- G. Do not heat bitumen above finished blowing temperature for more than 3 hours, unless bitumen is under continuous use.
- H. Provide fume control equipment to minimize asphalt fumes during the Work. Comply with fume control requirements of this Specification and submitted Fume Control Plan.

3.07 APPLICATION IN COLD WEATHER

- A. Comply with manufacturer's special recommendations for membrane application during cold weather.
- B. Discontinue installation if asphalt temperature cannot be maintained at EVT at point of application.
- C. Pre-heat adhesive, and store to allow proper application temperatures.

3.08 ROOF INSULATION APPLICATION

- A. Comply with requirements of Section 07 22 16.
- B. Only install insulation that can be covered with watertight roof membrane the same day.
- C. Protect installed insulation from damage, and moisture.

3.09 TAPERED CRICKET APPLICATION

- A. Commence cricket installation at edge of drain and scupper sumps.
- B. Establish straight, uniform, cricket valley.
- C. Set tapered edge strip along valley line, in full bed of hot asphalt.
- D. Butt first layer of tapered insulation to thick edge of tapered edge, and set in full bed of hot asphalt.
- E. Install remaining layers of tapered and fill insulation to achieve uniform, positive slope.
- F. Step-in each board, while asphalt is still molten, to ensure good embedment.

3.10 ROOF MEMBRANE APPLICATION

- A. Coordinate activities so foot traffic does not occur on or across plies while bitumen is fluid.
- B. Use only hand-mopping, or bitumen dispensers that do not displace bitumen between roof plies.
- C. Install one additional layer of ply felt at valleys, hips, and ridges, minimum 12 inch wide, set in hot asphalt.
- D. Begin at the lowest point of the roof.
- E. Apply plies together in shingle fashion without phasing.
- F. Apply and lap felts in accordance with membrane product manufacturer's recommendations, to obtain minimum four (4) shingled plies, irregardless of membrane manufacturer's minimum roof warranty requirements.
- G. Apply felts straight, without buckles or voids, and broom lightly as necessary to result in full embedment without voids.
- H. Extend plies to the top edge of cants or to the point required by the membrane products manufacturer.
- I. Do not place items on installed membranes which could cause displacement of interply bitumen.

- J. Protect installed membranes.
- A. Repair voids, wrinkles, and other defects, daily to prevent water from entering roof system.
- B. Install metal flashings under provisions of **Section 07 62 00**.

3.11 ROOF DRAIN INSTALLATION

- A. Install tapered insulation sump. Ensure smooth transition at roof drain. Readjust insulation, or roof drain elevation to obtain smooth transition.
- B. Extend membrane plies onto drain bowl flange. Cut felts off and dress cut edge of membrane with roof cement.
- C. Brush both sides of the lead drain flashing with a wire brush to remove wax and score surfaces. Prime both sides, and allow to dry thoroughly.
- D. Set the lead flashing in a solid bed of roof cement and apply 3 strip-in plies in roof cement. Extend the flashing onto the drain bowl flange.
- E. Install clamp ring. Allow clamp ring to seat for several days and retighten at least once.
- F. Install a stainless steel gravel stop around drains, 30 inches square. Set the primed gravel stop flange in a bed of roof cement and strip-in with three plies glass felt and roof cement.
- G. Apply bitumen flood coat and embed gravel to outer edge of gravel stop.
- H. Coat exposed felts between gravel stop flange and roof drain with heavy-body aluminum coating.

3.12 APPLICATION OF MEMBRANE FLASHING

- A. Apply in accordance with manufacturer's recommendations.
- B. Install base sheet over nailable surfaces. Fasten base sheet according to manufacturer's recommendations.
- C. Prime roof and masonry surfaces to receive flashing sheet, allow primer to dry completely.
- D. Comply with manufacture's high base flashing application instructions and materials where base flashing exceeds maximum standard height recommended by manufacturer.
- E. Apply first ply membrane flashing sheets in maximum 5 foot lengths, set in cold adhesive or hot asphalt. Ensure full embedment of membrane flashing.
- F. Set top ply over first ply. Set in asphalt, cold adhesive, or heat weld second ply, ensuring good embedment. Install in width of sheet with selvage edge. Cut, remove, and repair voids and other defects.

- G. Cut, miter, and wrap around corners with no loose tails or large flaps.
- H. Fasten top edge according to manufacturer's recommendations.
- I. Apply neatly and provide uniform, symmetrical appearance.
- J. Fasten top edge minimum 6 inches on center with nails, or screws, driven through minimum 1 inch diameter metal caps, or cap nails.

3.13 INSTALLATION OF SOIL PIPE FLASHINGS

- A. Clean roof flange and apply asphalt primer to topside and underside, and allow to dry.
- B. Embed roof flange in solid bed plastic cement over fiberglass roof membrane, apply strip-in ply. Fold flashing into top of pipe.
- C. Strip-in roof flange with three strip-in plies set in hot asphalt or plastic cement.

3.14 MEMBRANE SURFACING

- D. Load and spread gravel using methods that do not damage the membrane. Keep loose gravel swept clean in unsurfaced areas.
- E. Obtain membrane manufacturer's approval of installed membrane before applying gravel.
- F. Apply bitumen at the membrane manufacturer's recommended rate.
- G. While bitumen is still hot apply gravel at the approximate rate of 400 pounds per square, embedding not less than 200 pounds per square in asphalt flood coat. Broadcast additional surfacing material to completely cover exposed asphalt flood coat.
- H. Provide a finished appearance free of uneven or ridged areas. Broom or rake gravel to provide a smooth, uniform surface.

3.15 INSTALLATION OF ROOF PADS

- A. Install roof pads according to recommendations of membrane manufacturer.
- B. Install around roof-mounted equipment that is greater than 3 foot wide, and at foot and top of roof access ladder(s) and roof hatch(s).
- C. Install roof pads underneath lightning protection cable over roof membrane.

3.16 CLEANING

- A. Clean roof surfaces, metal flashings, walls, windows, walks, etc. which become soiled or discolored due to the Work of this Section.
- B. Utilize cleaning agents and procedures which are approved by manufacturer.

3.17 PROTECTION

- A. Comply with submitted Roof Protection Plan.
- B. Protect roof system from damage. Repair or remove and replace damaged roof membrane according to methods approved by roof manufacturer and A/E. A/E and Owner's decision on corrective procedure will be final.
- C. Repair minor scars, cuts, scraps, tears, using methods approved by manufacturer. Severe roof damage to be corrected by removal and replacement with new roof membrane and insulation.
- D. Ensure roof warranty is not voided due to membrane damage.

3.18 ROOF SIGNS

- A. Provide a 30 inch x 30 inch metal sign notifying maintenance, and service personnel of the guaranteed roof system. Coordinate placement of signs with Owner.
- B. Professionally letter sign using 2 coats of high quality exterior enamel with black lettering on white background; containing the following information:

<p>NOTICE: GUARANTEED ROOF SYSTEM DO NOT INSTALL NEW EQUIPMENT ON, OR THROUGH THIS ROOF, WITHOUT SPECIFIC AUTHORIZATION.</p> <p>REPORT CHANGES OR DAMAGE IMMEDIATELY TO OWNER.</p> <p>Owner - _____ Phone: _____ . Contractor: _____ Phone: _____ . Manufacturer: _____ Phone: _____ .</p>

END OF SECTION

UTH Standard Specification

SECTION 07 52 00

MODIFIED BITUMINOUS ROOFING

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Modified bituminous roof membrane
- B. Membrane flashings and accessories

1.02 RELATED WORK

- A. Section 06 10 00 - Rough Carpentry
- B. Section 07 22 16 – Roof Board Insulation
- C. Section 07 62 00 - Sheet Metal Flashing and Trim

1.03 REFERENCES

- A. National Roofing Contractors Association (NRCA) Roofing and Waterproofing Manual.
- B. Underwriters Laboratories (UL)
 - 1. Roofing Materials and Systems Directory.
 - 2. Fire Resistance Directory.
- C. ASTM D41 - Asphalt Primer Used in Roofing.
- D. ASTM D312 - Asphalt Used in Roofing. Use if hot asphalt is used in roof system. .
- E. ASTM D4586 - Standard Specification for Asphalt Roof Cement, Asbestos-Free
- F. ASTM D6164 - Standard Specification for Styrene Butadiene Styrene (SBS) Modified Bituminous Sheet Materials Using Polyester Reinforcements.
- G. ASTM D6298 - Standard Specification for Fiberglass Reinforced Styrene-Butadiene-Styrene (SBS) Modified Bituminous Sheet with a Factory Applied Metal Surface.
- H. ASTM D2178 – Standard Specification for Asphalt Glass Felt Used in Roofing and Waterproofing.
- I. ASTM D4601- Standard Specification for Asphalt-Coated Glass Fiber Base Sheet Used in Roofing.

- J. ASTM D4897 - Standard Specification for Asphalt-Coated Glass-Fiber Venting Base Sheet Used in Roofing.
- K. ASTM D6162 - Standard Specification for Styrene Butadiene Styrene (SBS) Modified Bituminous Sheet Materials Using a Combination of Polyester and Glass Fiber Reinforcements.
- L. ASTM D6163 - Standard Specification for Styrene Butadiene Styrene (SBS) Modified Bituminous Sheet Materials Using Glass Fiber Reinforcements.
- M. ASTM D6222 - Standard Specification for Atactic Polypropylene (APP) Modified Bituminous Sheet Materials Using Polyester Reinforcements.
- N. ASTM D6223 - Standard Specification for Atactic Polypropylene (APP) Modified Bituminous Sheet Materials Using a Combination of Polyester and Glass Fiber Reinforcements.
- O. ASTM D6509 Standard Specification for Atactic Polypropylene (APP) Modified Bituminous Base Sheet Materials Using Glass Fiber Reinforcements.

1.04 SUBMITTALS

- A. Submit under provisions of **SPECIAL CONDITIONS** requirements and Division 1 **Section 01 21 00** Submittal Procedures.
- B. Prior to pre-roofing meeting, submit the following:
 - 1. Manufacturer's Certification: Letter from manufacturer, on letterhead, and signed by authorized representative, stating:
 - a) Materials and components conform with specification requirements and that materials furnished are compatible.
 - b) Roof membrane system, membrane flashings, and roof insulation, qualifies for specified warranty.
 - c) Installer is authorized to install manufacturer's warranty roof systems minimum five (5) years prior to the Project NTP.
 - d) Roof system meets specified regulatory requirements.
 - 2. Sample manufacturer, and installer, warranties meeting Specification requirements.
 - 3. Product Literature: Submit product literature on roof system and accessory components.
 - 4. Manufacturer's cold weather application recommendations.
 - 5. Shop drawings.

- C. Roof Protection Plan: Submit written roof protection plan for A/E and Owner approval that describes type and layout of roof protection during construction activities on or above roof area.
- D. Pre-Roofing Meeting Notes: Submit Pre-Roofing Meeting Notes within 5 business days of meeting date.
- E. Manufacturer's Field Reports: Submit copies of manufacturer's field reports to A/E during the Work, and at final completion.
- F. Asphalt Fume Control Plan: Submit equipment data, and proposed loading and heating procedures to limit ground-level asphalt fumes.
- G. Shop drawings: Submit shop drawings for approval prior to Pre-roofing Conference and start of Work. Include the following Drawings:
 - 1. Roof Plan(s):
 - a) Prepare scaled roof plan locating roof details and penetrations.
 - b) Include on roof plan tapered insulation locations at field, perimeter, and roof curbs. Indicate insulation thickness at high and low points, crickets pattern, and drain sumps.
 - c) Outline roof dimensions, including all levels.
 - 2. Location and type of penetrations. Illustrate perimeter flashings, equipment flashings and penetrations flashing. Scale details at ½" or larger. Manufacturer's standard pre-printed details are not acceptable for shop drawings
 - a. Indicate deck type on each drawing.
 - 3. Provide scaled insulation attachment plan for each roof area indicating perimeter and corner requirements to achieve specified wind uplift resistance. Provide insulation fastening pattern drawing for corner, perimeter, and field zones.
 - 4. Indicate location of proposed staging areas and material storage on site plan.
- H. Product data:
 - 1. Roofing membrane products: Submit manufacturer's data sheets for each product being installed. Include manufacturer's installation instructions.
 - 2. Insulation products: Submit manufacturer's data sheets for each component required including insulation boards, adhesives, fasteners, plates and bitumen or adhesive. Provide roofing system manufacturer's written acceptance of proposed insulation board, adhesives, fasteners, and procedures for installation. **Coordinate with Section 07 22 16.**
 - 3. Material Safety Data Sheets: Provide manufacturer's MSDS information for all materials proposed for use.

4. Laboratory Testing: Provide evidence of specified fire and wind uplift ratings for proposed roof system.
 5. ASTM Compliance Sheet: Submit product material list with corresponding ASTM standard(s) each product complies with. Include Specification paragraph reference number that relates to each product.
- I. Roof Maintenance Data: Submit manufacturer's complete recommended maintenance procedures for roofing system, including precautions and warnings to prevent damage and deterioration to the roofing system. Information shall include maintenance guidelines indicating materials and methods to be used for emergency and minor repairs.

1.05 QUALIFICATIONS

- A. Installer: Company specializing in performing the work of this Section and approved by roof manufacturer for installation of specified roof system.
- B. Minimum 5 years documented successful experience with modified bituminous roofing.

1.06 REGULATORY REQUIREMENTS

- A. Fire Resistance:
 1. UL Class A Fire Hazard Classification
 2. UL Roof Ceiling Assembly Rating
- B. Wind Uplift Resistance: design and certify that modified bituminous roofing meets wind uplift loads as shown on Structural Drawings.

1.07 TOLERANCES

- A. Comply with tolerances listed in this Section.
- B. Where tolerances are not expressly stated in these Specifications, or by the manufacturer, perform Work within tolerances specified in the NRCA Roofing and Waterproofing Manual.

1.08 PRE-ROOFING CONFERENCE

- A. Schedule meeting to discuss roof Work before start of work onsite. Notify attending parties prior to commencing work of this Section.
- B. Pre-roofing conference attendees shall include Owner, A/E, A/E's roofing consultant, General Contractor representatives, roofing subcontractor project manager and superintendent/foreman, related subcontractors and roof manufacturer's technical representative.
- C. Review Specifications, Submittals, installation procedures and coordination required with related Work. Agenda shall include:

1. Schedule of daily roofing operations and daily production anticipated.
 2. Designation of key personnel and their respective responsibilities.
 3. Review of staging and material storage locations.
 4. Coordination of work with other trades.
 5. Emergency rain protection procedures.
 6. Protection of completed roofing and Roof Protection Plan.
 7. Manufacturer's scheduled inspections and acceptance procedures.
 8. Warranty period process for leak repairs and inspections.
 9. Review Fume Control Plan.
- D. Keep meeting notes and provide copies to those in attendance according to Submittal requirements.

1.09 DELIVERY, STORAGE, AND HANDLING

- A. Deliver, store, and handle products according to manufacturer's recommendations.
- B. Deliver products in original containers, dry, undamaged, with seals and labels intact.
- C. Storage:
- D.
 1. Roof-top storage of weather-sensitive material is not permitted. Material stored overnight on roof-top will be considered defective.
 2.
 - Store weather-sensitive products in enclosed storage trailers.
 - Store weather-sensitive products on pallets, clear of ground, and cover with secure breathable canvas tarps.
 - Store weather-sensitive products in an enclosed warehouse, or in storage trailers off-site. Deliver products in quantity that can be used each day, without roof-top storage. Products must be returned to warehouse, or storage trailer, each day.
 3. Store roll goods on end. Do not use rolls with damaged ends. Cut and remove portion of roll damaged, and use undamaged portion for strip-in ply, or completely remove roll from site.
- E. Store related materials, within temperature ranges, recommended by the manufacturer(s) of each product.

1.10 ENVIRONMENTAL REQUIREMENTS

- A. Comply with manufacturer's environmental requirements for storage and application of products.

- B. Verify existing and forecasted weather conditions and determine when conditions are acceptable for roof Work within the guidelines as follows:
 - 1. Do not proceed with work when ambient air temperature falls below 40 ° F.
 - 2. Do not proceed with roof application when excessive moisture is present. Excessive moisture is that which may be detected by sight or touch, or that which results in visible foaming of hot asphalt.
- C. Do not expose materials sensitive to water, or sunlight, damage in quantities greater than can be weatherproofed during each day.

1.11 COORDINATION

- A. Coordinate Work with installation of associated metal flashings as the Work of this Section proceeds.

1.12 INSPECTION BY MANUFACTURER

- A. Coordinate inspection of the Work, by an authorized technical representative of the roof system manufacturer.
 - 1. Manufacturer is required to inspect work a minimum of three (3) visits per Project.
 - 2. Manufacturer's visits to consist of:
 - a) Attendance at Pre-Roofing Meeting
 - b) One visit at Project commencement
 - c) Interim visits for each 10 work days of roof work, and one visit at Project completion
- B. Provide manufacturer's field inspection reports within **five days** of each site visit.

1.13 ROOF SYSTEM WARRANTY

- A. Provide manufacturer's twenty **(20) year, no penal sum limit**, roof system warranty.
- B. Warranty shall include all material and labor costs.
- C. Warranty shall include coverage for **roof insulation, as specified in 07 22 16**, either as part of original warranty language, or by attachment. Manufacturer's warranty shall include the full roofing system including membranes, flashings, insulation, fasteners/adhesives, rigid roof boards, accessories and all related roof system components.
- D. Warranty shall be issued on the manufacturer's form as submitted by Contractor and reviewed by A/E.

- E. If special maintenance of the roof is required by the manufacturer during the Warranty term(s), such requirements shall be provided to the Owner with the Warranty.

1.14 INSTALLER WARRANTY

- A. Roof Installer Warranty: provide under provisions of **Section 01 70 50 – Project Closeout**.
- B. Provide on Midwest Roofing Contractors Association Form 2002B - Roofing Contractor Workmanship Warranty. Warranty shall be issued on form submitted, and reviewed, prior to Work commencement.
- C. Installer Warranty to be co-signed by General Contractor.

PART 2 PRODUCTS

2.01 GENERAL

- A. Roof System: deck, insulation as specified in Section 072216, one ply smooth-surfaced modified bitumen sheet set in hot asphalt, with one ply granular-surfaced modified bitumen sheet set in adhesive.
- B. Provide roof membrane, and membrane base flashing materials from single manufacturer.
- C. Obtain written approval from roof membrane manufacturer for use of products incorporated into roof system, which are not supplied by roof membrane manufacturer.
- D. Substitutions:
 1. Where specific products are listed in this Specification, the referenced roofing manufacturer's systems are to establish a level of quality.
 2. Requests for substitutions to listed products shall be submitted during the bidding phase per requirements of **Section 01 21 00**.
 3. Consideration of requests for substitution is at the sole discretion of the A/E and Owner, and approvals shall be issued in writing by the A/E with Owner concurrence.

2.02 ROOF MEMBRANE & BASE FLASHING

- A. First Ply Modified Bitumen Sheet: ASTM D6164, Type II , Grade S, SBS modified bitumen, polyester reinforced, set in asphalt.
- B. Second Ply Modified Bitumen Sheet: ASTM D 6164, Type II, Grade G, SBS modified bitumen, polyester reinforced, fire-rated sheet for use in Class A assemblies, set in adhesive.
- C. Membrane Base Flashing: strip-in ply is required, regardless of roof membrane manufacturer minimum requirements, with aluminum foil-faced SBS modified bitumen membrane top ply.

1. Strip-In Ply: meet, or exceed, first ply modified bitumen sheet requirements.
 2. Second Ply: ASTM D 6298, Aluminum-clad, modified bitumen sheet.
- D. Metal Flashing Strip-In Ply: meet, or exceed, first ply modified requirements.

2.03 BITUMINOUS MATERIALS

- A. Cold Adhesive: type supplied by, or specifically recommended by roof membrane manufacturer, meeting requirements of warranty.
- B. Asphalt Bitumen: ASTM D312, Type IV, special steep, as supplied or specifically approved by membrane manufacturer.
- C. Asphalt Primer: ASTM D41, as supplied or specifically approved by membrane manufacturer.
- D. Plastic Cement: ASTM D4586, non-asbestos reinforced, as supplied and recommended by roof membrane manufacturer.

2.04 INSULATION

- A. Board Insulation: Comply with requirements of [Section 07 22 16](#).
- B. Tapered Crickets:
 1. First course: ASTM C728, perlite tapered edge, minimum 12 inches wide, in thickness to match butt edge of tapered insulation, set in hot asphalt.
 2. Remaining courses: ASTM C728, perlite, [1/2 inch per foot tapered](#), set in hot asphalt.

2.05 TAPERED EDGE & CANTS

- A. Tapered Edge: ASTM C728, perlite
- B. Cant Strip: ASTM C728, perlite minimum 3 1/2 inch face
- C. Wood Cant: treated southern pine, cut to size, according to provisions of [Section 06 10 00](#)

2.06 ACCESSORIES

- A. Membrane Flashing Fasteners: hot-dipped galvanized Simplex cap nails, with minimum 15/16 inch wide head.
- B. Sheet metal flashings: according to provisions of [Section 07 62 00](#).
- C. Membrane Edge Sealant: As required by membrane roof manufacturer.
- D. Mineral Granules: as supplied by membrane manufacturer to match color of membrane cap sheet surface.

- E. Traffic Pad: as supplied by membrane manufacturer, and meeting their warranty requirements.

2.07 SPECIAL BITUMEN HEATING EQUIPMENT

- A. Provide ground-level filtering, or after-burning asphalt fume system equipment.
- B. Equip kettle with carton loader device.
- C. Ensure positive seals at kettle lid, loader, and piping, to ensure containment of ground-level asphalt fumes.

PART 3 – EXECUTION

3.01 GENERAL

- A. Work of this Section shall be performed in accordance with quality workmanship standards as defined by NRCA. Detailing shall be performed in accordance with standards as defined by NRCA and SMACNA.
- B. The roof systems manufacturer's technical specifications shall be considered a part of this specification and shall be used as a minimum standard in conjunction with this specification. If this Specification conflicts with, or exceeds manufacturer's minimum requirements the more rigid standard shall apply and be enforced.

3.02 COORDINATION

- A. Ensure proper sequencing of roofing and to allow installation of roof and flashings as detailed, without damage.
- B. Coordinate activities to prevent damage to roof assemblies.

3.03 EXAMINATION & PREPARATION

- A. Do not store, stage activities, or allow construction traffic over roof areas, unless protection plan is approved in advance by A/E.
- B. Contractor is responsible for maintaining roof in good condition, and shall restore to manufacturer's warrantable state upon completion of activities.
- C. Verify that surfaces and site conditions are ready to receive Work. Verify that debris has been completely removed from roof area and broom clean the deck immediately prior to roofing application.
- D. Verify deck is sound, smooth, and dry enough for covering with roofing. Report decking not serviceable for covering with roof system.
- E. Verify roof openings, curbs, pipes, sleeves, ducts, and vents through roof are solidly set, and wood components are in place.

- F. Install nailers and blocking immediately prior to application of roofing. Do not cut nailers in after membrane application.
- G. Construct and install nailers and blocking under provisions of Section 06 10 00.

3.04 TEMPORARY WATERPROOFING

- A. Provide water stops and temporary tie-ins daily to prevent moisture penetration into building interior or installed assemblies.
- B. Seal roofing temporarily to the deck where leakage could penetrate installed assemblies. Remove upon resumption of Work.
- C. Provide permanent, or temporary, counter flashing daily.
- D. Install membrane assemblies complete with strip-in plies each day. Use mastic seals only in such a manner that mastic does not remain between finished modified bitumen plies at cant strips and membrane terminations. Provide seal at all terminations, both vertical and horizontal.
- E. Provide temporary seals which do not soil finished work surfaces or contaminate surfaces intended to receive sealants.
- F. Remove temporary seals from completed Work.

3.05 CANT STRIP APPLICATION

- A. Apply fiber cant strip into solid mopping of asphalt, and step-in completely.
- B. Install wood cant at through-wall scupper intersections and to support vertical "L" nailers.
- C. Securely fasten wood cant to substrate. Ensure smooth transitions with fiber cant.
- D. Make straight, neat cuts and miter corners without perceptible gaps or open joints.
- E. Cut, shave, modify and combine various sized tapered materials to provide smooth, uniform transitions.

3.06 BITUMEN HEATING

- A. Comply with manufacturer's requirements for heating, and applying bitumen.
- B. Heat asphalt bitumen to achieve EVT at point of application, as stamped on asphalt carton, plus or minus 25 ° F.
- C. Use insulated tubing and luggers during cold weather, to maintain correct temperature, at the point of application.
- D. Verify accurate temperature readings at point of application to ensure compliance. Establish proper temperature at kettle, hold time on roof, and substrate type and temperature to achieve proper application temperature.

- E. Measure temperature periodically, minimum one reading every two hours, or when conditions change. Contractor to provide accurate temperature measuring device for verification.
- F. Adjust temperature, equipment, or procedure to maintain proper application temperature.
- G. Do not heat bitumen above finished blowing temperature for more than 3 hours, unless bitumen is under continuous use.
- H. Provide fume control equipment to minimize asphalt fumes during the Work. Comply with fume control requirements of this Specification and submitted Fume Control Plan.

3.07 APPLICATION IN COLD WEATHER

- A. Comply with manufacturer's special recommendations for membrane application during cold weather.
- B. Discontinue installation if asphalt temperature cannot be maintained at EVT at point of application.
- C. Pre-heat adhesive, and store to allow proper application temperatures.

3.08 ROOF INSULATION APPLICATION

- A. Comply with requirements of Section 07 22 16.
- B. Only install insulation that can be covered with watertight roof membrane the same day.
- C. Protect installed insulation from damage, and moisture.

3.09 TAPERED CRICKET APPLICATION

- A. Commence cricket installation at edge of drain and scupper sumps.
- B. Establish straight, uniform, cricket valley.
- C. Set tapered edge strip along valley line, in full bed of hot asphalt.
- D. Butt first layer of tapered insulation to thick edge of tapered edge, and set in full bed of hot asphalt.
- E. Install remaining layers of tapered and fill insulation to achieve uniform, positive slope.
- F. Step-in each board, while asphalt is still molten, to ensure good embedment.

3.10 ROOF DRAIN INSTALLATION

- A. Ensure tapered insulation sump is in place, prior to drain flashing application.
- B. Clean and prime drain bowl roof flange.

- C. Extend first ply membrane onto drain flange.
- D. Clean and prime both sides of lead flashing sheet.
- E. Set metal flashing in solid bed of membrane adhesive. Form metal flashing into drain bowl flashing. Form to contours of sump, and extend into roof drain bowl, trim excess to allow complete drainage.
- F. Strip-in metal flashing with minimum 12 inch wide sheet, set in cold adhesive.
- G. Install top ply sheet into drain bowl, and extend up sump slope 18 inches.
- H. Prime 6 inch wide top edge of membrane flashing, and overlap with top ply roofing membrane, to achieve shingle-fashion application.

3.11 APPLICATION OF FIRST MEMBRANE PLY

- A. Apply in accordance with manufacturer's recommendations.
- B. Use roof manufacturer's approved sidelap and endlap measurements.
- C. Apply into solid asphalt moppings, not to exceed 25 pounds per square.
- D. Install at cants and transitions according to manufacturer's recommendations.
- E. Apply sheet in lengths less than 5 feet long, where parallel to cants. Ensure continuous embedment, free of voids. Broom ply if necessary.
- F. Complete application of first ply and strip-in plies, before application of granular-surfaced sheet, if allowed by membrane manufacturer.
- G. Install metal flashings under provisions of Section 07 62 00.
- H. Repair voids, wrinkles, and other defects, daily to prevent water from entering roof system.

3.12 APPLICATION OF SECOND PLY MEMBRANE SHEET

- A. Apply sheet according to manufacturer's cold adhesive application recommendations.
- B. Stagger endlaps minimum 3 feet.
- C. Do not allow back-water laps.
- D. Broom sheet to provide finished membrane assembly free of voids or wrinkles.
- E. Repair voids, wrinkles, and other membrane defects using full width sheet to provide finished appearance.
- F. Embed mineral granules into adhesive bleed-out while still tacky.

- G. Apply sealant to seal edges of membrane where membrane terminates on horizontal surfaces (if required by manufacturer).
- H. Do not allow foot traffic over finished roof until adhesive has set-up to prevent tracking.

3.13 APPLICATION OF MEMBRANE FLASHING

- A. Apply in accordance with manufacturer's recommendations.
- B. Install base sheet over nailable surfaces. Fasten base sheet according to manufacturer's recommendations.
- C. Prime roof and masonry surfaces to receive flashing sheet, allow primer to dry completely.
- D. Comply with manufacture's high base flashing application instructions and materials where base flashing exceeds maximum standard height recommended by manufacturer.
- E. Apply first ply membrane flashing sheets in maximum 5 foot lengths, set in cold adhesive or hot asphalt. Ensure full embedment of membrane flashing.
- F. Heat weld second ply, ensuring good embedment. Install in width of sheet with selvage edge. Cut, remove, and repair voids and other defects.
- G. Cut, miter, and wrap around corners with no loose tails or large flaps.
- H. Fasten top edge according to manufacturer's recommendations.
- I. Apply neatly and provide uniform, symmetrical appearance.
- J. Fasten top edge minimum 8 inches on center with nails, or screws, driven through minimum 1 inch diameter metal caps, or cap nails.

3.14 INSTALLATION OF SOIL PIPE FLASHINGS

- A. Clean roof flange and apply asphalt primer to topside and underside, and allow to dry.
- B. Embed roof flange in solid bed plastic cement over fiberglass roof membrane, apply strip-in ply. Fold flashing into top of pipe.
- C. Strip-in roof flange with strip-in ply set in hot asphalt.
- D. Neatly trim granular-surfaced sheet at pipe. Cover exposed cuts with a granular surfaced sheet target.

3.15 INSTALLATION OF ROOF PADS

- A. Install roof walk pads according to recommendations of membrane manufacturer.
- B. Install around roof-mounted equipment that is greater than 3 foot wide, and at foot and top of roof access ladder(s) and roof hatch(s).

- C. Install roof pads underneath lightning protection cable over roof membrane.

3.16 CLEANING

- A. Clean roof surfaces, metal flashings, walls, windows, walks, etc. which become soiled or discolored due to the Work of this Section.
- B. Utilize cleaning agents and procedures which are approved by manufacturer.

3.17 PROTECTION

- A. Comply with submitted Roof Protection Plan.:
- B. Protect roof system from damage. Repair or remove and replace damaged roof membrane according to methods approved by roof manufacturer and A/E. A/E and Owner’s decision on corrective procedure will be final.
- C. Repair minor scars, cuts, scraps, tears, using methods approved by manufacturer. Severe roof damage to be corrected by removal and replacement with new roof membrane and insulation.
- D. Ensure roof warranty is not voided due to membrane damage.

3.18 ROOF SIGNS

- A. Provide a 30 inch x 30 inch metal sign notifying maintenance, and service personnel of the guaranteed roof system. Coordinate placement of signs with Owner.
- B. Professionally letter sign using 2 coats of high quality exterior enamel with black lettering on white background; containing the following information:

<p>NOTICE: GUARANTEED ROOF SYSTEM DO NOT INSTALL NEW EQUIPMENT ON, OR THROUGH THIS ROOF, WITHOUT SPECIFIC AUTHORIZATION.</p> <p>REPORT CHANGES OR DAMAGE IMMEDIATELY TO OWNER.</p> <p>Owner - _____ Phone: _____ . Contractor: _____ Phone: _____ . Manufacturer: _____ Phone: _____ .</p>
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END OF SECTION

UTH Standard Specification

SECTION 07 62 00

SHEET METAL FLASHING AND TRIM

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Sheet metal flashings
- B. Gutters and downspouts
- C. Collectorheads

1.02 RELATED WORK

- A. Section 06 10 00 - Rough Carpentry
- B. Section 07 31 13 – Asphalt Shingle Roofing
- C. Section 07 32 13 – Clay Roof Tile
- D. Section 07 41 13 – Metal Roof Panels
- E. Section 07 51 13 – Asphalt Built-Up Roofing
- F. Section 07 52 00 – Modified Bituminous Roofing
- G. Section 07 92 00 – Joint Sealants

1.03 REFERENCES

- A. SMACNA - Architectural Sheet Metal Manual, 2003 Edition
- B. ASTM A167 - Stainless and Heat-Resisting Chromium-Nickel Steel Plate
- C. ASTM A653 - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
- D. ASTM A792 - Standard Specification for Steel Sheet, 55% Aluminum-Zinc Alloy-Coated by the Hot-Dip Process
- E. ASTM B32 - Solder Metal
- F. ASTM B209 - Aluminum and Aluminum-Alloy Sheet and Plate
- G. ASTM B370 - Copper Sheet and Strip for Building Construction
- H. Federal Specification FS 0-F-506 - Flux, Soldering, Paste, and Liquid

- I. ANSI/SPRI ES-1 - Wind Design Standard for Edge Systems Used with Low Slope Roofing Systems

1.04 SUBMITTALS

- A. Submit under provisions of **SPECIAL CONDITIONS** requirements and Division 1 Section **01 21 00** Submittal Procedures.
- B. Prior to pre-roofing meeting, submit the following:
 - 1. Manufacturer's Certification: document that certifies metal products meet requirements.
 - 2. Product Literature: Submit product literature on sheet metal and accessory components.
 - 3. Perimeter Flashing Certification: document that certifies roof perimeter edge sheet metal flashing meets ANSI/SPRI ES-1 Design Standard.
- C. Shop drawings: Submit shop drawings for approval prior to Pre-roofing Conference and start of Work. Include the following Drawings:
 - 1. Indicate on Shop Drawings material profiles, jointing patterns, jointing details, fastening methods, and installation instructions.
 - 2. Indicate location of sealants, tapes and gaskets.
 - 3. Indicate material type, finish and gage.
- D. Product data:
 - 1. Sheet metal products: Submit manufacturer's data sheets for each material Coordinate with roof Specification Section(s).
 - 2. Material Safety Data Sheets: Provide manufacturer's MSDS information for all materials proposed for use.
 - 3. ASTM Compliance Sheet: Submit product material list with corresponding ASTM standard(s) each product complies with. Include Specification paragraph reference number that relates to each product.

1.05 QUALIFICATIONS

- A. Installer: Company specializing in performing the work of this Section and approved by roof manufacturer for installation of specified roof system.
- B. Minimum 5 years documented successful experience with installation of products specified in this Section.

1.06 REGULATORY REQUIREMENTS

- A. Wind Uplift Resistance: Perimeter sheet metal edge to comply with ANSI/SPRI ES-1.

1.07 TOLERANCES

- A. Comply with tolerances listed in this Section.
- B. Where tolerances are not expressly stated in these Specifications, or by the manufacturer, perform Work within tolerances listed in the SMACNA Architectural Sheet Metal Manual.

1.08 PRE-ROOFING CONFERENCE

- A. Schedule meeting to discuss roof Work before start of work onsite.
- B. Comply with requirements of roof Specification Section(s).

1.09 DELIVERY, STORAGE, AND HANDLING

- A. Deliver, store, and handle products according to manufacturer's recommendations.
- B. Deliver products in original containers, dry, undamaged, with seals and labels intact.
- C. Storage:
 1. Roof-top storage of weather-sensitive material is not permitted. Material stored overnight on roof-top will be considered defective.
 2. Store weather-sensitive products in enclosed storage trailers.
Store weather-sensitive products on pallets, clear of ground, and cover with secure breathable canvas tarps.
Store weather-sensitive products in an enclosed warehouse, or in storage trailers off-site. Deliver products in quantity that can be used each day, without roof-top storage. Products must be returned to warehouse, or storage trailer, each day.
- D. Store related materials, within temperature ranges, recommended by the manufacturer(s) of each product.
- E. Stack sheet metal to prevent twisting, bending, or abrasion, and to provide ventilation.
- F. Do not stack products on roof surfaces without properly securing to prevent blow-off and sliding-off roof.
- G. Slope metal sheets to ensure drainage

1.10 ENVIRONMENTAL REQUIREMENTS

- A. Comply with manufacturer's environmental requirements for storage and application of products.
- B. Verify existing and forecasted weather conditions and determine when conditions are acceptable for roof Work within manufacturer's recommended guidelines:

- C. Do not expose materials sensitive to water, or sunlight, damage in quantities greater than can be weatherproofed during each day.

1.11 COORDINATION

- A. Coordinate Work with installation of associated metal flashings as the Work of this Section proceeds.

1.12 INSPECTION BY MANUFACTURER

- A. Comply with requirements of roof membrane Specification Section(s).
- B. Provide manufacturer's field inspection reports within **five days** of each site visit.

1.13 MANUFACTURER WARRANTY

- A. Provide manufacturer's roof system warranty according to roof Specification Section(s). Include sheet metal flashings provided by roof manufacturer for incorporation into their roof system.
- B. Provide 20 year material warranty(s) for ASTM A792 and prefinished sheet metal coating(s).

1.14 SUBSTITUTIONS

- A. Where specific products are listed in this Specification, the referenced manufacturer's systems are to establish a level of quality.
- B. Requests for substitutions to listed products shall be submitted during the bidding phase per requirements of Section **01 21 00**.
- C. Consideration of requests for substitution is at the sole discretion of the A/E and Owner, and approvals shall be issued in writing by the A/E with Owner concurrence.

1.15 INSTALLER WARRANTY

- A. **Roof Installer Warranty:** provide under provisions of Section **01 70 50 – Project Closeout**.
- B. Coordinate with requirements of roof membrane Specification Section(s).

PART 2 PRODUCTS

2.01 SHEET MATERIALS

- A. Stainless Steel: ASTM A167; **24 gage** sheet steel; Type 304; non-magnetic.
- B. Copper Sheet Metal: Sheet copper, ASTM B370, **16 ounce and 20 ounce**.
- C. Galvanized Sheet Metal: Sheet steel, ASTM A653, G90 coating, in **various gages**.

- D. Galvalume® Sheet Metal: Sheet steel with aluminum-zinc alloy coating, ASTM A792, in various gages.
- E. Prefinished Sheet Metal: Sheet steel, Galvalume according to ASTM A792, with full-strength Kynar 500 coating, 24 gage, in color chosen by A/E.
- F. Aluminum Sheet and Plate: ASTM B209, anodized color, form alloy, gage and temper appropriate for use, color chosen by A/E.

2.02 FASTENERS

- A. Flashing Nails: threaded nails;
 - 1. Non-Ferrous Metal: non-magnetic stainless steel slater's nails, minimum 3/8 inch head.
 - 2. Ferrous Metal: hot-dipped galvanized; minimum 3/8 inch head.
- B. Screws: thread design to meet application, add minimum 5/8 inch diameter EPDM integral washer where exposed to weather.
 - 1. Non-Ferrous Metal: #12, non-magnetic stainless-steel screws.
 - 2. Ferrous Metal: #12, galvanized or polymer coating steel screw, with head designed to meet application.
- C. Masonry Screws: 1/4 inch diameter, galvanized, with polymer finish; slotted hex washer head with minimum 5/8 inch EPDM washer; Tapcon by Buildex, or approved substitute.
- D. Pop Rivets: full stainless steel, including mandrel; in size to meet application.
- E. Fastener lengths as required to penetrate:
 - 1. Minimum 1 inch, maximum 1-1/2 inch into masonry
 - 2. Minimum 1-1/4 inch, or through wood receiving members
 - 3. Minimum 1/2 inch through sheet metal and steel receiving members

2.03 ACCESSORIES

- A. Solder: ASTM B32 - 50/50 type
- B. Flux: FS 0-F-506
- C. Bituminous Products: According to provisions of membrane roofing Specification.
- D. Sealants: according to provisions of Section 07 92 00.
- E. Sealant Tape: butyl tape, 100 percent solids, in width and thickness to meet application.

- F. Roof Penetration Flashing Sealer: ASTM C-920, Type S, Grade P, class 25, use TM; one-part self leveling polyurethane sealer.
- G. Asphalt Primer: ASTM D41, as supplied or specifically approved by insulation manufacturer.

PART 3 – EXECUTION

3.01 GENERAL

- A. Work of this Section shall be performed in accordance with standards as defined in SMACNA Architectural Sheet Metal Manual.
- B. The roof manufacturer's technical specifications shall be considered a part of this Section and shall be used as a minimum standard in conjunction with this Section.
- C. If this Section conflicts with, or exceeds manufacturer's minimum requirements the more rigid standard shall apply and be enforced.

3.02 COORDINATION

- A. Coordinate installation of sheet metal components to ensure quality installation.
- B. Strip-in metal flanges built into roof membrane daily. Remove, and reinstall flanges left overnight.
- C. Coordinate installation of through-wall flashings with masonry, and dampproofing, to achieve required quality.
- D. Ensure proper sequencing to allow installation of roof and flashings as detailed, without damage.
- E. Coordinate activities to prevent damage to adjacent surfaces.

3.03 EXAMINATION & PREPARATION

- A. Do not store, stage activities, or allow construction traffic over roof areas, unless protection plan is approved in advance by A/E.
- B. Contractor is responsible for maintaining sheet metal and accessories in good condition during delivery, storage, installation and Final Completion.
- C. Verify that surfaces and site conditions are ready to receive Work. Verify that debris has been completely removed from roof area and broom clean immediately prior to sheet metal application.
- D. Verify flashing substrate is clean, sound, smooth, and dry enough for covering. Report substrate not serviceable. Do not install finish application sheet metal over unserviceable area(s).

- E. Verify roof openings, curbs, pipes, sleeves, ducts, and vents through roof are solidly set, and wood components are in place.
- F. Ensure nailers and blocking are properly attached and ready for application of sheet metal.
- G. Construct and install nailers and blocking under provisions of Section 06 10 00.
- H. Field-measure site conditions prior to fabricating work. Note variances; adjust dimensions to accommodate site conditions.
- I. Pre-prime top surface of metal flanges which will be built-into roof membrane, except where field soldering is required.
- J. Provide separation of dissimilar metals by back-painting concealed contact surfaces with asphalt primer, both surfaces.

3.04 TEMPORARY WATERPROOFING

- A. Provide water stops and temporary tie-ins daily to prevent moisture penetration into building interior or installed assemblies.
- B. Seal roofing temporarily to the deck where leakage could penetrate installed assemblies. Remove upon resumption of Work.
- C. Provide permanent, or temporary, counter flashing daily.
- D. Install membrane assemblies complete with strip-in plies each day. Use mastic seals only in such a manner that mastic does not remain between finished modified bitumen plies at cant strips and membrane terminations. Provide seal at all terminations, both vertical and horizontal.
- E. Provide temporary seals which do not soil finished work surfaces or contaminate surfaces intended to receive sealants.
- F. Remove temporary seals from completed Work.

3.05 FABRICATION

- A. Fabricate flashings and components true to shape, accurate in size, square, and free from distortion or defect.
- B. Ensure symmetrical layout of running lengths of sheet metal.
- C. Fabricate corners, intersections and terminations of "running" flashing fixed as components, separate from other lengths of flashings. Fabricate such components with maximum 18 inch legs.
- D. Partially assemble sub-components of corner intersections, and termination components; set partially assembled components in place to verify fit and that each seats properly before soldering or joining the finished assembly.

- E. Form a slight kick-down to edges of metal flanges to be built into roof membranes, maximum 1/4 inch wide, maximum 10 degree brake.
- F. Hem exposed edges 1/2 inch.
- G. Obtain prior approval from Engineer to adjust dimensions and configurations of sheet metal flashings, to allow more effective yield of material, or to facilitate fabrication. Ensure that adjustments comply with design intent.

3.06 SOLDERING

- A. Solder only fixed components, which have maximum 18 inch legs.
- B. Pre-tin both sides of edges to be soldered, using flux and solder to full anticipated width of joint.
- C. Join sub-components together before soldering. For flat seams, and whenever possible, form flat-lock seams, binding sheets tightly. Where flat-lock seams are impractical, provide tabs, partially interlocked, if possible, and join with pop-rivets at 1 inch on center.
- D. Do not solder over nail heads.
- E. Apply flux to surface of joint, and solder slowly with well heated irons. Heat sheets as necessary to sweat solder to full width of seam, or minimum 3/4 inch. Ensure an even flow of solder without excess build-up.
- F. Solder joints in a horizontal position whenever possible. When soldering on slopes steeper than 45°, apply a second bead, neatly laced.
- G. Neutralize flux from surfaces immediately after soldering, using cloth saturated with 10% solution of washing soda and water, and wipe again using separate cloth and clean water.

3.07 JOINTING

- A. Form joints in running flashings to accommodate thermal movement equally throughout all joints.
- B. Provide "slip"-type joints each side of soldered or joined components, except where total length of intersecting lengths is less than 5 feet.
- C. Provide joints aligned with joints in walls. Overlap, notch, and loosely interlock adjoining sections at lower hem. Fasten only one side of joint.
- D. Form rigid, fixed joints only when constructing fixed components. Provide minimum 3/4 inch tabs, interlocked where possible. Join sections with tabs concealed.
- E. Solder fixed joints in galvanized and stainless steel. Rivet and seal fixed joints in prefinished sheet metal.

- F. Expansion Joint Covers: apply two beads of concealed sealant, 6 inch lap, shingle fashion.
- G. Counter Flashing:
 - 1. Form minimum 3 inch lap joint. Apply single bead of sealant, concealed inside lap. Notch and interlock lower hem, allowing for 1/4 inch movement. Do not fasten through lap.
 - 2. Tab corners, seal between tabs with sealant (or solder corner) and rivet 1 inch on center.
 - 3. Align, or add joints, to counter flashing at wall panel joints.
- H. Concealed Continuous Cleats: Leave 1/2 inch space between lengths.
- I. Exposed Cleats:
 - 1. Form minimum 3 inch lap joint. Apply single bead of sealant, concealed inside lap. Notch and interlock lower hem, allowing 1/4 inch movement. Do not fasten through lap.
 - 2. Tab corners, seal between tabs with sealant (or solder corner), and rivet 1 inch on center.

3.08 INSTALLATION

- A. Comply generally with recommendations in the "Architectural Sheet Metal Manual", by SMACNA, except where otherwise specified.
- B. Provide uniform, symmetrical layout of flashing sections, seams, joints, and fasteners.
- C. Prime, and embed, sheet metal flanges built-into roof membrane in solid 1/8 inch bed of plastic cement. Fasten to wood nailer 3 inches on center, in staggered pattern. Apply strip-in plies on the same day.
- D. Roughen prefinish paint finish on metal flanges built into roof membrane, and apply primer.
- E. Ensure proper fit and positioning of flashings. Make adjustments necessary to accommodate variances and imperfections in receiving surfaces.
- F. Install flashings free of warp or distortion, and without stress on fixed components.
- G. Stagger joints between components.

3.09 GUTTERS

- A. Fabricate from 10 foot lengths, except maximum 5 foot lengths at corners.
- B. Install gutter straps 18 inches on center. Fasten with rivets.

- C. Rivet 1 inch on center between double beads at front, back and bottom.
- D. Solder joints together. Install gutter expansion joint maximum 40 feet on center.
- E. Miter, tab, rivet, and solder corners.

3.10 DOWNSPOUTS

- A. Fabricate downspout drops with minimum $\frac{3}{4}$ inch tabs and 4 inch long vertical section. Solder drops together as a single unit.
- B. Insert drops through properly sized opening in floor of gutter. Rivet and solder to floor of gutter. Locate drops away from gutter joints. Connect downspout to drop with rivets 2 inches on center.
- C. Fabricate downspouts to 5 inch by 4 inch, with double-lock concealed seam.
- D. Connect downspout sections together with 4 inch overlap and rivet sections together.
- E. Fasten downspout to wall with 1 inch, wide straps spaced 5 feet on center.
- F. Fasten straps to wall and to downspout. Locate straps to conceal downspout joints.
- G. Install splash pan diverters where downspouts empty onto asphalt shingle roofing.

3.11 PROTECTION

- A. Protect stored sheet metal and accessories prior to installation according to provisions of this Section. Do not install improperly stored materials into the Work.
- B. Remove and replace sheet metal that has been water-stained, damaged or is otherwise unserviceable.

3.12 SCHEDULE

ITEM	FINISH	GAGE	FASTENER	PATTERN
Asphalt Shingle Roof Flashings				
Headwall Flashing	Prefinished	24	Neoprene-Head Screw	12 inches on center
Step Shingles	Galvanized	24	Threaded Nail	1 each
Counter Flashing	Prefinished	24	Neoprene-Head Screw	12 inches on center
Soldered Curb Flashing	Galvanized	24	Screws	4 each
Cleat	Galvanized	22	Threaded Nail	12 inches on center
Metal Roof and Siding Flashings				
Counter Flashing	Prefinished	24	Screw	12 inches on center
Pocket Receiver	Prefinished	24	Screw	12 inches on center
Ridge	Prefinished	24	Neoprene-Head Screw	6 inches on center
Ridge Closure	Galvanized	16	Neoprene-Head Screw	6 inches on center
Ridge Plate	Galvanized (Prime & Paint)	16	Screw	24 inches on center

Gutter	Prefinished	24	Wood Screw & Washer	16 inches on center
Gutter Strap	Galvanized	18	Rivets	3 each strap
Outlet Tube	Stainless Steel	24	Pop Rivets	2 inches on center
Downspouts	Prefinished	24	Straps	5 feet on center
Straps	Prefinished	24 (x2)	Wall: Screw Downspout: Rivet	one each side one each side
Zee Purlin at Eave	Galvanized	16	Screws	12 inches on center
Eave Closure	Galvanized	16	Screws	4 each
Eave Support Angle	Galvanized	16	Screws	12 inches on center
Wall Panel Closure	Galvanized	22	Screws	12 inches on center
Rake Flashing	Prefinished	24	Neoprene-Head Screw	12 inches on center
Concealed Rake Support	Galvanized	16	Screws	12 inches on center
Asphalt Built-Up Roof & Modified Bituminous Roof Flashings				
Counter Flashing	Prefinished	24	Screw	12 inches on center
Pocket Receiver	Prefinished	24	Screw	12 inches on center
Roof Drain Flashing	Sheet Lead	4 lb.	Set in Plastic Cement	Full bed
Overflow Scupper Liner	Copper	16 oz	Threaded Nail Hem to Collectorhead	3 inches on center Continuous
Scupper Face Plate	Copper	16 oz	Hem to Scupper	Continuous
Scupper Counter Flashing	Copper	16 oz	Screws	16 inches on center or one each stud
Termination Bar	Alum.	3/16"	Screw	12 inches on center
Soldered Sheet Metal Hood	Galvanized	24	Neoprene-Head Screw	2 each
Louver Counter Flashing	Copper	16 oz	Clips	12 inches on center
Louver Counter Flashing Clips	Copper	20 oz	Screws	One each
Louver Cover Plates (Alternate No. 3)	Copper	16 oz	Neoprene-Head Screw	12 inches on center
Clay Roof Tile Flashings				
Metal Edge	Copper	16 oz	Threaded Nail Hem to Cleat	12 inches on center Continuous
Metal Edge Cleat	Copper	20 oz	Threaded Nail	12 inches on center
Expansion Joint Cover	Copper	16 oz	Neoprene-Head Screw Cleat	16 inches on center Continuous
Expansion Joint Cleat	Copper	20 oz	Neoprene-Head Screw	16 inches on center
Sheet Lead Flashing	Lead (Prime & Paint)	2.5 lb.	Threaded Nail Embed in Mastic	12 inches on center Continuous
Sidewall Flashing	Copper	16 oz	Cleat	12 inches on center
Sidewall Cleat	Copper	20 oz	Threaded Nail	One each
Valley Flashing	Copper	20 oz	Cleat	12 inches on center
Valley Cleat	Copper	20 oz	Threaded Nail	One each
Headwall Flashing	Copper	16 oz	Cleat	12 inches on center
Headwall Clip	Copper	20 oz	Screw	One each

Gutter	Copper	20 oz	Wood Screw & Washer	16 inches on center
Gutter Strap	Copper Bar	1/8"	Rivets	3 each strap
Outlet Tube	Copper	20 oz	Rivets	2 inches on center
Downspouts	Copper	16 oz	Straps	5 feet on center
Straps	Copper Bar	1/8"	Wall: Screw Downspout: Rivet	one each side one each side

END OF SECTION

26 00 00
BASIC ELECTRICAL REQUIREMENTS

PART 1 GENERAL

1.1 WORK INCLUDED

A. General Requirements specifically applicable to Division 26.

B. The Contractor shall be responsible for:

1. The work included consists of furnishing all materials, supplies, equipment and tools, and performing all labor and services necessary for installation of a completely functional power, lighting, fire alarm and signaling systems. Complete systems in accordance with the intent of Contract Documents.
2. Coordinating the details of facility equipment and construction for all Specification Divisions, which affect the work covered under this Division.
3. Furnishing and installing all incidental items not actually shown or specified, but which are required by good practice to provide complete functional systems.
4. Temporary power service and lighting for construction. Coordinating all shutdown dates and schedules with Owner's Representative and obtain all work-permits required by Owner.

C. Intent of Drawings:

1. The Drawings are necessarily diagrammatic by their nature, and are not intended to show every connection in detail or every device or raceway in its exact location, unless specifically dimensioned. The Contractor shall carefully investigate structural and finish conditions and shall coordinate the work in order to avoid interference between the various phases of work. The Contractor shall be responsible for the proper routing of raceway, subject to prior review by the Owner and Engineer. Work shall be organized and laid out so that it will be concealed in furred chases and suspended ceilings, etc., in finished portions of the building, unless specifically noted to be exposed. All work shall be installed parallel or perpendicular to the lines of the building unless otherwise noted.
2. The intent of the Drawings is to establish the type of systems and functions, but not to set forth each item essential to the functioning of the system. The drawings and specifications are cooperative, and work or materials called for in one and not mentioned in the other shall be provided. Review pertinent drawings and adjust the work to conditions shown. In case of doubt as to work intended, or here discrepancies occur between drawings, specifications, and actual conditions, immediately notify the Architect/Engineer and the Owner's representative, and propose a resolution.

1.2 RELATED WORK

- A. This Section shall be used in conjunction with the following other specifications and related Contract Documents to establish the total general requirements for the project electrical systems and equipment.
 - 1. Division 01 Sections included in the project specifications.
 - 2. The contract.

1.3 DESIGN CRITERIA

- A. Equipment and devices to be installed outdoors or in enclosures where the temperatures are not controlled shall be capable of continuous operation under such conditions per manufacturer's requirements.
- B. Compliance by the Contractor with the provisions of this Specification does not relieve him of the responsibilities of furnishing equipment and materials of proper design, mechanically and electrically suited to meet operating guarantees at the specified service conditions.
- C. Electrical components shall be UL listed and labeled.

1.4 REFERENCE CODES AND STANDARDS, REGULATORY REQUIREMENTS

- A. Standards of the following organizations as well as those listed in Division 01, may be referenced in the specification. Unless noted otherwise, references are to standards or codes current at the time of bidding.
 - 1. Association of Edison Illuminating Companies (AEIC)
 - 2. American National Standards Institute (ANSI)
 - 3. Institute of Electrical and Electronics Engineers (IEEE)
 - 4. Insulated Cable Engineers Association (ICEA)
 - 5. National Electrical Code (NEC)
 - 6. National Electrical Manufacturers Association (NEMA)
 - 7. Electrical Safety in the Workplace
 - 8. National Fire Protection Association (NFPA)
 - 9. Underwriter's Laboratories (UL)
 - 10. ASHRAE/IES 90.1 – Energy Standard for Buildings Except Low-Rise Residential Buildings
- B. Work, materials and equipment must comply with the latest rules and regulations of the following.
 - 1. National Electrical Code (NEC)
 - 2. Electrical Safety in the Workplace
 - 3. Occupational Safety and Health Act (OSHA)
 - 4. American with Disability Act (ADA)
 - 5. American Society for Testing and Materials (ASTM)

6. University of Texas (UT) System
 7. Applicable state and federal codes, ordinances and regulations
- C. Discrepancies. The drawings and specifications are intended to comply with listed codes, ordinances, regulations and standards. Where discrepancies occur, immediately notify the Owner's representative in writing and ask for an interpretation. Should installed materials or workmanship fail to comply, the Contractor is responsible for correcting the improper installation. Additionally, where sizes, capacities, or other such features are required in excess of minimum code or standards requirements, provide those specified shown.
- D. Contractor shall obtain permits and arrange inspections required by codes applicable to this Section and shall submit written evidence to the Owner and Engineer that the required permits, inspections and code requirements have been secured.

1.5 SUBMITTALS

- A. Submit the following in addition to and in accordance with the requirements of Division 01 for submittal requirement.
1. Include inspection and permit certificates and certificates of final inspection and acceptance from the authority having jurisdiction.
 2. Manufacturer's standardized schematic diagrams and catalog cuts shall not be acceptable unless applicable portions of it are clearly indicated and non-applicable portions clearly deleted or crossed out.
 3. All schematic, connection and/or interconnection diagrams in accordance with the latest edition of NEMA.
 4. Provide submittals as required by individual specification Section.
- B. Provide the following with each submittal:
1. Catalog cuts with manufacturer's name clearly indicated. Applicable portions shall be circled and non-applicable portions shall be crossed out.
 2. Line-by-line specification review by equipment manufacturer and contractor with any exceptions explicitly defined.
- C. Equipment Layout Drawing: 1/8-inch scale minimum drawings indicating electrical equipment locations. Dimensions for housekeeping pads should be indicated on these drawings. Indicate routing of conduit 2 inches and over on these drawings.
- D. Within the specified time window after award of contract, submit list of equipment and materials to be furnished.
1. Itemize equipment and material by specification Section number; include manufacturer and identifying model or catalog numbers.
 2. Replace rejected items with an acceptable item within 2 weeks after notification of rejection.

3. If a satisfactory replacement is not submitted within a two-week period, owner will notify contractor as to equipment manufacturer or type and make or material to be furnished. Provide designated items at no additional cost to owner.
- E. As-Built Record Drawings: The Contractor shall maintain a master set of As-Built Record Drawings that show changes and any other deviations from the drawings. The markups must be made as the changes are done. At the conclusion of the job, these As-Built Record Drawings shall be transferred to AutoCad electronic files, in a format acceptable to the Owner, and shall be complete and delivered to the Owner's Representative prior to final acceptance. Refer to 01210 Project Administration for other requirements.

1.6 SAFETY

- A. The Contractor shall follow the safety procedures in addition to, and in accordance with, the requirements of Project Safety Manual (PSM).
1. The Contractors shall be responsible for training all personnel under their employ in areas concerning safe work habits and construction safety. The Contractor shall continually inform personnel on hazards particular to this project and update the information as the project progresses.
 2. The Contractor shall secure all electrical rooms, to limit access, prior to energizing any high voltage (2.4KV or higher) switchgear and shall control access during the project after energization. The Contractor shall post and maintain warning and caution signage in areas where work is on going near energized equipment. The Contractor shall cover all energized live parts when work is not being done in the equipment. This includes lunch and breaks.
 3. The Contractor shall strictly enforce OSHA lock out/tag out procedures. Initial infractions shall result in a warning; a second infraction shall result in the removal of the workman and his foreman from the site. Continued infractions shall result in removal of the Contractor from the site.

1.7 SHORING AND EQUIPMENT SUPPORTS

- A. The Contractor shall provide all permanent and temporary shoring, anchoring, and bracing required to make all parts absolutely stable and rigid; even when such shoring, anchoring, and bracing are not explicitly called for.
- B. The Contractor shall adequately support all freestanding panels, motor control centers, enclosures, and other equipment. This shall include bolting to the floor or solid structural steel to prevent tipping. Install free-standing electrical equipment on 4" thick concrete housekeeping pads that are provided by others. Under no condition shall equipment be fastened to non-rigid building steel (i.e., removable platform steel gratings, handrails, etc.).
- C. The Contractor shall provide racks and supports, independently mounted at structure, to support electrical equipment and systems supplied and installed under this contract. At no time shall the Contractor mount or suspend equipment from other disciplines' supports.

1.8 TEMPORARY POWER REQUIREMENTS

- A. Provide power distribution system sufficient to accommodate construction operations requiring power, use of power tools, electrical heating, lighting, and start-up/testing of permanent electric-powered equipment prior to its permanent connection to electrical system. Provide proper overload protection. Ground fault circuit interrupters (GFCI) are to be used on all 120-volt, single-phase, 15 and 20 amp receptacle outlets where portable tools and equipment are used. Ground fault circuit interrupters shall be tested weekly by the Contractor.
- B. Temporary power feeders shall originate from a distribution panel. The conductors shall be multi-conductor cord or cable per NEC for hard and extra-hard service multi-conductor cord.
- C. Branch circuits shall originate in an approved receptacle or panelboard. The conductors shall be multi-conductor cord or cable per NEC for hard and extra-hard service multi-conductor cord. Each branch circuit shall have a separate equipment grounding conductor.
- D. All receptacles shall be of the grounding type and electrically connected to the grounding conductor.
- E. Provide temporary lighting by factory-assembled lighting strings or by manually-assembled units. All lamps for general lighting shall be protected from accidental contact or breakage. Protection shall be provided by installing the lights a minimum of 7 feet from the work surface or by lamp holders with guards. Branch circuits supplying temporary lighting shall not supply any other load. Provide sufficient temporary lighting to ensure proper workmanship by combined use of day lighting, general lighting, and portable plug-in task lighting. Comply with OSHA required foot-candle levels and submit plan for approval by the owner.
- F. For temporary wiring over 600 volts, suitable fencing, barriers, or other effective means shall be provided to prevent access of anyone other than authorized and qualified personnel.
- G. Temporary power cords shall be kept off the ground or floor. The Contractor shall provide temporary supports as required to keep temporary cords off the ground or floor.

1.9 SUBSTITUTION OF MATERIALS AND EQUIPMENT:

- A. Refer to Uniform General Conditions and Supplementary General Conditions for substitution of materials and equipment.
- B. The intent of the Drawings and/or Specifications is neither to limit products to any particular manufacturer nor to discriminate against an "APPROVED EQUAL" product as produced by another manufacturer. Some proprietary products are mentioned to set a definite standard for acceptance and to serve as a reference in comparison with other products. When a manufacturer's name appears in these Specifications, it is not to be construed that the manufacturer is unconditionally acceptable as a provider of equipment for this project. The successful manufacturer or supplier shall meet all of the provisions of the appropriate specification(s).

- C. The specified products have been used in preparing the Drawings and Specifications and thus establish minimum qualities with which substitutes must at least equal to be considered acceptable. The burden of proof of equality rests with the Contractor. The decision of the designer is final.
- D. When requested by the Architect/Engineer, the Contractor shall provide a sample of the proposed substitute item. In some cases, samples of both the specified item and the proposed item shall be provided for comparison purposes.
- E. Timeliness: The burden of timeliness in the complete cycle of submittal data, shop Drawings, and sample processing is on the Contractor. The Contractor shall allow a minimum of six (6) weeks time frame for review of each submission by the office of the design discipline involved after receipt of such submissions by that design discipline. The Contractor is responsible for allowing sufficient time in the construction schedule to cover the aforementioned cycles of data processing, including time for all resubmittal cycles on unacceptable materials, equipment, etc. covered by the data submitted. Construction delays and/or lack of timeliness in the above regard are the responsibility of the Contractor and will not be considered in any request for scheduled construction time extensions and/or additional costs to the Owner.
- F. All equipment installed on this project shall have local representation; local factory authorized service, and a local stock of repair parts.
- G. Acceptance of materials and equipment will be based on manufacturer's published data and will be tentative subject to the submission of complete shop Drawings indicating compliance with the contract documents and that adequate and acceptable clearances for entry, servicing, and maintenance will exist. Acceptance of materials and equipment under this provision shall not be construed as authorizing any deviations from the Specifications, unless the attention of the Architect/Engineer has been directed in writing to the specific deviations. Data submitted shall not contain unrelated information unless all pertinent information is properly identified.
- H. Certification: The Contractor shall carefully examine all data forwarded for approval and shall sign a certificate to the effect that the data has been carefully checked and found to be correct with respect to dimensions and available space and that the equipment complies with all requirements of the Specifications.
- I. Physical Size of Equipment: Space is critical; therefore, equipment of larger sizes than shown, even though of specified manufacturer, will not be acceptable unless it can be demonstrated that ample space exists for proper installation, operation, and maintenance.
- J. Should a substitution be accepted, and should the substitute material prove defective, or otherwise unsatisfactory for the service intended within the guarantee period, this material or equipment shall be replaced with the material or equipment specified at no additional cost to the Owner.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

SECTION 26 00 00
BASIC ELECTRICAL REQUIREMENTS

- A. Materials and Equipment: Labeled and/or listed as acceptable to the authority having jurisdiction as suitable for the use intended. Materials shall be of a standard industrial quality if no specifications or specific model numbers are given.
- B. Where two or more units of the same class of material are required, provide products of a single manufacturer. Component parts of materials or equipment need not be products of the same manufacturer.
- C. All materials shall be new and unused.
- D. Provide non-metallic material in corrosive areas or as otherwise specified.

PART 3 EXECUTION

3.1 WORKMANSHIP

- A. Install work in compliance with NEC latest edition.
- B. Install material and equipment in accordance with manufacturers' instructions. Provide calibrated torque wrenches and screwdrivers and tighten all terminals, lugs, and bus joints using it.
- C. Comply with startup procedures as defined by Construction Manager and Owner.
- D. Arrange electrical work in a neat, well-organized manner. Do not block future connection points of electrical service. Install all electrical work parallel or perpendicular to building lines unless noted otherwise, properly supported with purpose-designed apparatus, in a neat manner.
- E. Apply, install, connect, erect, use, clean, adjust, and condition materials and equipment as recommended by the manufacturers in their published literature.
- F. Make opening through masonry and concrete by core drilling in acceptable locations. Restore openings to original condition to match remaining surrounding materials.

3.2 SERVICE CONTINUITY

- A. Maintain continuity of electric service to all functioning portions of process or buildings during the hours of normal use. Phase construction work to accommodate Owner's occupancy requirements.
- B. Arrange temporary outages for cutover work with the Owner. Keep the outages to a minimum number and minimum length of time.
- C. All service outages shall be requested in writing a minimum of two weeks prior to the date. Owner reserves the right to postpone shutdowns up to 24 hours prior to the shutdown at no additional cost. Outage requests shall include a schedule of the work to be performed and the time requirements.
- D. The Contractor shall obtain all appropriate Owner permits for working in equipment.

3.3 HAZARDOUS LOCATIONS

- A. Equipment, wiring, devices, and other components located within hazardous areas to be of appropriate type per NFPA requirements.

- B. Ground exposed non-current carrying parts of entire electrical system in hazardous areas, in accordance with NEC and as instructed by Owner.

3.4 SLEEVES AND SEALS

- A. Provide sealing and/or fire stopping where electrical equipment passes through walls, ceilings, and floors. Seals shall be watertight and/or fire rated as applicable.

3.5 CONSTRUCTION REVIEW

- A. The Engineer or Owner's representative will review and observe installation work to insure compliance by the Contractor with requirements of the Contract Documents.
- B. Review, observation, assistance, and actions by the Engineer or Owner's representative shall not be construed as undertaking supervisory control of the work or of methods and means employed by the Contractor. The review and observation activities shall not relieve the Contractor from the responsibilities of these Contract Documents.
- C. The fact that the Engineer or Owner's representative do not make early discovery of faulty or omitted work shall not bar the Engineer or Owner's representative from subsequently rejecting this work and insisting that the Contractor make the necessary corrections.
- D. Regardless of when discovery and rejection are made, and regardless of when the Contractor is ordered to correct such work, the Contractor shall have no claim against the Engineer or Owner's representative for an increase in the Contract price, or for any payment on account of increased cost, damage, or loss.

3.6 WARRANTY

- A. Provide warranties in accordance with the requirements of Uniform General and Supplementary Conditions (UGC).

END OF SECTION

26 00 00.01
ELECTRICAL DEMOLITION

PART 1 -- GENERAL

1.1 WORK INCLUDED

- A. Electrical demolition for remodeling.
- B. Electrical/control portion of HVAC work covered by Division 23 pertaining electrical demolition shall follow the requirement set forth by this specification.

1.2 RELATED WORK

- A. This Section shall be used in conjunction with the following other specifications and related Contract Documents to establish the total requirements for minor electrical demolition for remodeling.
 - 1. Section 26 00 00.UT - Basic Electrical Requirements.
- B. In the event of conflict regarding minor electrical demolition requirements between this Section and any other Section, the provisions of this Section shall govern.

PART 2 -- PRODUCTS

2.1 MATERIALS AND EQUIPMENT

- A. Materials and equipment for patching and extending work: as specified in individual Sections.
- B. Provide all materials necessary for work.

PART 3 -- EXECUTION

3.1 EXAMINATION

- A. All demolitions or modifications to existing systems shall be coordinated through Owner's Representative. Demolition drawings are based on casual field observation and existing record documentations. Therefore the accuracy or exactness of the drawings is not guaranteed. The Contractor shall verify that field measurements and circuiting arrangements are as shown on Drawings and abandoned wiring and equipment serve only abandoned facilities. The Contractor shall be responsible for reporting discrepancies to Engineer before disturbing existing installation.
- B. Beginning of demolition means Contractor accepts existing conditions.

3.2 PREPARATION

- A. Disconnect electrical systems in walls, floors, and ceilings scheduled for removal. Provide temporary wiring and connections to maintain remaining systems in service during demolition and/or modification. Owner reserve the right up to 24 hours prior to any scheduled event to delay or suspend shutdowns or outages to more convenient times at no additional cost.

- B. Existing Electrical Service: Maintain existing system in service until new system is complete and ready for service. No work shall begin without proper permits and authorizations. Disable system only to make switchovers and connections. Obtain permission from Owner at least (2) weeks before partially or completely disabling system. Minimize outage duration. Make temporary connections to maintain service in areas adjacent to work area.
- C. Existing Fire Alarm System: Maintain existing system in service until new system is accepted. Disable system only to make switchovers and connections. Notify Owner at least (2) weeks before partially or completely disabling system. Minimize outage duration. Provisions for manual fire watch shall be provided in areas where services are interrupted. Make temporary connections to maintain service in areas adjacent to work area.
- D. Existing Telephone System: Maintain existing system in service until new system is complete and ready for service. Disable system only to make switchovers and connections. Notify Owner at least (2) weeks before partially or completely disabling system. Minimize outage duration. Make temporary connections to maintain service in areas adjacent to work area.

3.3 DEMOLITION AND EXTENSION OF EXISTING ELECTRICAL WORK

- A. Remove, relocate, and extend existing installations to accommodate new plan drawings.
- B. Remove exposed abandoned conduit, including abandoned conduit above accessible ceiling finishes full length from source to device. Cut embedded or concealed conduit flush with walls and floors, and patch surfaces.
- C. Disconnect abandoned outlets and remove devices. Remove abandoned outlets if conduit servicing them is abandoned and removed. Provide blank cover for abandoned outlets that are not removed.
- D. Disconnect and remove abandoned panelboards and distribution equipment.
- E. Disconnect and remove electrical devices and equipment serving utilization equipment that has been removed.
- F. Disconnect and remove abandoned luminaires. Remove brackets, stems, hangers, and other accessories.
- G. Repair adjacent construction and finishes damaged during demolition and extension work.
- H. Maintain access to existing electrical installations that remain active. Modify installation or provide access panel as appropriate.
- I. Extend existing installations using materials and methods compatible with existing electrical installation or as specified.
- J. The level of completion shall be demonstrated to Owner's Representative.
- K. Where equipment is indicated to be demolished and returned to Owner, the Contractor shall include the delivery of this equipment to the Owner's site storage

area. Remove with care all equipment to be relocated. Repair or replace of newly damaged equipment is the responsibility of the Contractor.

3.4 CLEANING AND REPAIR

- A. The Contractor shall follow Owner's clean work policy and shall include the removal of trash and demolished material from the building or work area at the end of the each day and removal from the site once a week.
- B. The Contractor shall be responsible for repairing adjacent construction and finishes damaged during demolition and/or modification. The Contractor shall be responsible for the removal of ceiling tiles required in the demolition work. The Contractor shall be responsible for the replacement of damaged tiles and reinstallation of the ceiling prior to final acceptance.
- C. Panelboards: Clean exposed surfaces and check tightness of electrical connections. Replace damaged circuit breakers and provide closure plates for vacant positions. Provide typed circuit directory showing revised circuiting arrangement.
- D. Luminaires: Remove existing luminaires for cleaning. Use mild detergent to clean all exterior and interior surfaces; rinse with clean water and wipe dry. Replace lamps, ballasts, and broken electrical parts.

3.5 DISPOSITION OF MATERIAL AND EQUIPMENT

- A. Review with the Owner materials that have been removed and are no longer required, to determine any which the Owner may desire to keep. Deliver those materials that the Owner desires to the Owner's specified location.
- B. For those materials not required by the Owner, dispose of them in accordance with applicable regulations.

END OF SECTION

26 05 00
BASIC ELECTRICAL MATERIALS AND METHODS

PART 1 GENERAL

1.1 WORK INCLUDED

- A. Hinged cover enclosures and cabinets
- B. Contactors
- C. Control relays
- D. Push buttons, and selector switches
- E. Terminal blocks and accessories
- F. Penetration sealing systems (fire stops)
- G. Electrical/control portion of HVAC work covered by Division 23 pertaining basic electrical materials and methods shall follow the requirement set forth by this specification.

1.2 APPLICABLE CODES AND STANDARDS

- A. NFPA 70, National Electrical Code (latest edition)
- B. American National Standard, National Electrical Safety Code, (latest edition)
- C. Applicable publications of NEMA, ANSI, IEEE, and ICEA
- D. Underwriters Laboratories, Inc. Standards (UL)
- E. Federal, city, state, and local codes and regulations having jurisdiction
- F. OSHA requirements
- G. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum)
- H. NEMA WD 1 – General-Purpose Wiring Devices
- I. UL 98 - Enclosed Switches

1.3 INTENT

- A. This Section is not, and shall not be interpreted to be, a complete listing of all materials or equipment that is Contractor furnished and erected. It is intended to clarify and further define the Contractor scope of work, procurement, and responsibilities for those incidental materials that are not specified by other specifications, but important to a complete and operational system.
- B. The Contractor shall furnish all equipment and materials, whether or not specified in other Sections of specification and on drawings, for installation and connection required to place equipment into satisfactory operating service. The Contractor shall review the Drawings and specifications for clarification of his responsibility in the handling and installation of equipment and material. Where applicable, and

not in contradiction with the Drawings and specifications, the Contractor shall install and connect the equipment in accordance with the manufacturer's recommendations and instructions.

- C. All materials and equipment shall be of types and manufacturer specified wherever practical. Should materials or equipment so specified be unattainable, the Contractor shall submit the description and manufacturer's literature, reason for substitution request and shall secure the approval of the Engineer before substitution of other material or equipment is purchased. This Section establishes performance requirements and the quality of equipment acceptable for use and shall in no way be construed to limit procurement from other manufacturer.

1.4 SUBMITTALS

- A. Provide submittals in addition and in accordance with Section 26 00 00.UT, Basic Electrical Requirements, and Division 01 for submittal requirement.
- B. Submit manufacturer's literature and specification data sheets for each type of basic material, which is applicable to the project.

1.5 DELIVERY, STORAGE AND HANDLING

- A. Provide factory-wrapped waterproof flexible barrier material for covering materials, where applicable, to protect against physical damage in transit. Damaged materials shall be removed from project site.
- B. In their factory-furnished coverings, store materials in a clean, dry indoor space, which provides protection against the weather.

PART 2 PRODUCTS

2.1 ENCLOSURES AND CABINETS

- A. Enclosures and cabinets for all Contractor furnished electrical equipment and devices shall be suitable for the location and environmental conditions and shall be of the NEMA type as shown in Table 16050-1. Exceptions shall be specifically designated on the Drawings.

Table 16050-1 Enclosures		
Location	Environment	Enclosure Type
Indoor Utility	Dry, subject to dust, falling dirt and dripping non-corrosive liquids	NEMA 12
Indoor	Clean, Dry	NEMA 1
Outdoor	Subject to windblown dust and rain, splashing water, and hose-directed water	NEMA 4

Indoor	Wet, subject to hose-directed water	NEMA 4
Outdoor	Subject to falling rain, sleet, and external ice formation	NEMA 3R
Indoor or Outdoor	Subject to corrosion, windblown dust and rain, splashing water and hose-directed water	NEMA 4X

B. Enclosures shall have the following properties:

1. Hinged Cover Enclosures: NEMA 250.
 - a. Type 1: Steel.
 - b. Type 4: Steel with gasket door, rain tight.
 - c. Type 4X: Stainless steel, (polycarbonate or fiberglass reinforced polyester (FRP) in corrosive areas).
 - d. Type 12: Steel with gasketed door, dust-tight.

C. Finish: Exterior, manufacturer's standard gray enamel finish; interior, white enamel finish.

D. Covers: Continuous hinge, held closed by flush latch operable by hasp and staple for padlock. Where required for NEMA ratings, gaskets shall be neoprene rubber.

E. Interior Panel for Mounting Terminal Blocks or Electrical Components: 14-gauge steel, white enamel finish.

F. Provide protective pocket inside front cover with schematic diagram, connection diagram, and layout drawing of control wiring and components within enclosure.

G. Forced Ventilation: Where indicated, provide 115V single-phase fan motor, filtered with air plenum, finger guard, and stainless steel grille. Washable aluminum filter, accessible for cleaning from outside the enclosure; 20,000-hour continuous operation without lubrication or service. Provide matching exhaust grille assembly. Mount fan in lower side corner, exhaust grille in opposite upper side corner.

2.2 CONTACTORS

A. Acceptable Manufacturers

1. General Electric Company
2. Square D Company
3. Other manufacturers equal in design and function will be considered upon A/E approval following substitution procedure in 26 00 00.UT and Division 01 for substitution requirement.

B. Contactors: NEMA ICS 2; electrically held or mechanically held as indicated on Drawings. Two-wire control for electrically held contactors and three-wire control for mechanically held contactors.

- C. Enclosure: NEMA 1 unless indicated otherwise on Drawings.
- D. Control Transformer: Provide when indicated on Drawings. Minimum capacity shall be 100 VA. Provide primary and secondary fuse protection.
- E. Coil operating voltage; 110 volts, 60 Hz or as per drawings.
- F. Size: NEMA ICS 2; size as indicated on Drawings.
- G. Contacts: As indicated on Drawings; 600 Volts, 60 Hz.
- H. Provide solderless pressure wire terminals on bus terminals suitable for mounting in panelboard as indicated on Drawings.

2.3 CONTROL RELAYS

- A. Acceptable Manufacturers
 - 1. General Electric Type CR120A
 - 2. Cutler-Hammer Type M-300
 - 3. Square D Company
 - 4. Allen-Bradley
 - 5. Other manufacturers equal in design and function will be considered upon A/E approval following substitution procedure in 26 00 00.UT and Division 01 for substitution requirement.
- B. Provide magnetic control relays, NEMA Class A: A300 (300 volts, 10 amps continuous, 7,200 VA make, 720 VA break), industrial control type with field-convertible contacts, and meeting the requirements of NEMA ICS 2.
- C. Where time delay relays are specified or required, unless otherwise noted, provide magnetic control relays with a solid-state timer attachment adjustable from 0.2 to 60 seconds (minimum) or with range as indicated. Provide with field convertible from ON delay to OFF delay and vice versa.
- D. Where latching (mechanically held) relays or motor thermal detector relays are specified, provide magnetic control relays with mechanical latch attachment with unlatching coil and coil clearing contacts.

2.4 PUSH BUTTONS, AND SELECTOR SWITCHES

- A. Acceptable Manufacturers
 - 1. Allen-Bradley
 - 2. Square D
 - 3. Cutler Hammer
 - 4. Seimens
 - 5. Other manufacturers equal in design and function will be considered upon A/E approval following substitution procedure in 26 00 00.UT and Division 01 for substitution requirement.

- B. For non-hazardous, indoor, dry locations, including control panels, and individual stations, provide heavy duty, NEMA 13, oil tight type pushbuttons, indicating lights, selector switches, and stations for these devices.
- C. For non hazardous, outdoor, or normally wet locations, or where otherwise indicated, provide heavy duty corrosion resistant, NEMA 4, watertight type pushbuttons, indicating lights, or selector switches mounted in NEMA 4 watertight enclosures. Provide special gasketing required to make complete station watertight.
- D. For hazardous locations, provide control station listed by UL for Class I, Divisions 01 and 02, Groups C and D; Class II, Division 01 and 02, Groups E, F, and G. Specific type shall be in accordance with area classification as indicated on the Drawings.
- E. For corrosive locations, provide nonmetallic components and enclosures meeting NEMA Type 4X.
- F. Provide devices meeting the requirements of NEMA ICS 2, and having individual, extra large nameplates indicating their specific function. Provide push-button stations with laminated plastic nameplates indicating the drive they control. Provide contacts with NEMA designation rating A600. Install provisions for locking pushbuttons and selector switches in the OFF position wherever lockout provisions are indicated. Nameplates shall be as specified in Section 16195.
- G. Utilize selector switches having standard operating levers. All indicating lights shall be LED type, push-to-test type. Provide ON or START pushbuttons colored black. Provide OFF or STOP pushbuttons colored red.

2.5 TERMINAL BLOCKS AND ACCESSORIES

A. Signal And Control Terminals

1. Acceptable Manufacturers

- a. Phoenix Contact
- b. Buchanan
- c. Weidmüller
- d. Entrelec
- e. Other manufacturers equal in design and function will be considered upon A/E approval following substitution procedure in 23 00 00 and Division 01 for substitution requirement.

- 2. Signal and Control Terminals: Modular construction type, DIN 46 277/3 channel mounted; screw clamp compression connectors, rated 300 volts. Minimum terminal width of 0.24-inch, capable of holding two No. 12 or two No. 14 AWG conductors in each connector. Terminal identification numbers shall be thermoset characters (black) on a white background. Provide 25 percent spare terminals.

B. Power Terminals

1. Acceptable Manufacturers

- a. Buchanan
- b. IlSCO
- c. Square D Company
- d. Burndy
- e. Other manufacturers equal in design and function will be considered upon A/E approval following substitution procedure in 26 00 00 and Division 01 for substitution requirement.

2. Power Terminals: Unit construction type, closed-back type, with tubular pressure screw connectors, rated 600 volts, size as required. Provide 25 percent spare terminals.

2.6 PENETRATION SEALING SYSTEMS (FIRE STOPS)

- A. Provide penetration sealing where conduit, cable tray, etc. pass through rated walls, ceilings, and floors. See Section 07840, Fire Stopping, and Section 07900, Joint Sealants, for sealing requirements and systems.

2.7 UL LISTING

- A. All equipment and materials shall be new and conform to the requirements of this Section. All equipment and materials shall be UL listed, and shall bear their label whenever standards have been established and level service is regularly furnished. All equipment and materials shall be of the best grade of their respective kind for the purpose.

PART 3 EXECUTION

3.1 FABRICATION - CONTROL ENCLOSURES AND CABINETS

- A. Shop assemble enclosures and cabinets housing terminal blocks or electrical components in accordance with NEMA ICS 6.

3.2 INSTALLATION - ENCLOSURES AND CABINETS

- A. Install cabinets and enclosures plumb; anchor securely to wall and structural supports at each corner, minimum. Direct attachment to dry wall is not permitted.
- B. Provide accessory feet for freestanding equipment enclosures.
- C. Install trim plumb.

3.3 ERECTION OF EQUIPMENT

- A. Manufacturer's Installation Instructions: Where furnished or called for by the manufacturer equipment manufacturer's installation instructions shall be considered a part of this specification and fully complied with. Where the Contractor damages the finishing coat of paint in existing or completed areas, he shall refinish with matching paint.

- B. Mounting Heights: Individual safety switches and buttons and devices shall normally be installed at the following mounting heights, when not specified on the Drawings.
1. Safety Switches: 6 feet 0 inches (to top).
 2. Pushbuttons: 4 feet 0 inches (to center).
 3. Control Panels: 6 feet 0 inches (to top).
- C. Mounting: Equipment and control devices shall be supported independent of conduit connections. Panels or cabinets shall be mounted on metal frame supports independently of equipment. Control devices and metal enclosures shall be bolted or welded to steel channel or steel plate. All electrical equipment and devices not covered by the above, such as miscellaneous switches, thermostats, duct switches, temperature switches, floats, photoelectrical devices, and similar electrical devices shall be located and set as suitable for the application. Where control panels are provided as part of the equipment racks mounted on the floor, they shall be provided to support conduits and flexible connections to control panels.
- 3.4 COORDINATION
- A. Exact location of all electrical equipment, devices and fixtures shall be determined in field by contractor and verified by Engineer's field representative prior to installation.

END OF SECTION

SECTION 26 05 13
CABLE AND TERMINATIONS (MEDIUM VOLTAGE)

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

- A. The extent of medium voltage cable work is indicated by drawings and by the requirements of this Section.

1.2 REFERENCES

- A. AEIC CS6-96 – Specifications for Ethylene Propylene Rubber Insulated Shielded Power Cables Rated 69 kV
- B. ASTM B8-04 - Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
- C. ICEA S-93-639/NEMA WC74 – Shielded Power Cables Rated 5 – 46 kV
- D. ICEA S-97-682 – Utility Shield Power Cables Rated 5 - 46 kV
- E. IEEE 48 – Standard Test Procedures and Requirements for Alternating-Current Cable Terminations 2.5 kV through 765 kV
- F. UL 1072 – Medium-Voltage Power Cables
- G. IEEE 400 – Guide for Field Testing and Evaluation of the Insulation of Shielded Power Cable Systems

1.3 QUALITY ASSURANCE

- A. Manufacturer shall be a firm specializing in manufacturing medium voltage cable and accessories with minimum ten years documented experience.
- B. Installer shall be a firm with at least five years of successful installation experience on projects with electrical work similar to that required for this project.
- C. NEC Compliance: Comply with the National Electrical Code (NFPA 70) as applicable to construction and installation of electrical cable, and terminations required for this project.
- D. Product Delivery, Storage Handling:
 - 1. Provide factory wrapped waterproof flexible barrier materials for covering cable on wooden reels. Cable ends shall be properly sealed to prevent water propagation.
 - 2. Store cable in factory finished covering and in clean, dry place which provides protection against weather.

1.4 SUBMITTALS

- A. Provide submittals in accordance with and in additional to Section 26 00 00, Basic Electrical Requirements, and Division 01 for submittal requirement.

- B. Submit evidence documenting manufacturer's ten-year experience in medium voltage cable and accessories manufacturing. Submit manufacturer's data on electrical cable and terminations.
- C. Submit a list of previous work evidencing at least five years experience in medium voltage cable installation of similar type.
- D. Submit name and experience record of each person to be engaged in medium voltage cable work. Only those persons accepted by the Owner will be permitted to engage in medium voltage cable work.
- E. Submit three copies of cable manufacturers' certified test report prior to installation of cable.
- F. Submit original and two copies of certified field test report.

PART 2 - PRODUCTS

2.1 CABLE (MEDIUM VOLTAGE)

- A. Provide cable and terminations of manufacturer's standard materials as indicated by published product information designed and constructed as recommended by the manufacturer and as required by the application.
- B. Power cable shall be single conductor copper, ethylene propylene rubber insulated, 133% insulation level with [copper drain wire shielding] [or] [copper tape shielding and overall PVC jacket. Cable shall conform to ICEA S-93-639, ICEA S-97-682, AEIC CS6-96, UL 1072, and shall be UL listed as Type MV-90. Voltage ratings and conductor sizes shall be as shown on the drawings.
- C. Cable reel shall bear a tag containing name of manufacturer, UL label, cable type and year and month of manufacture. Cable shall be imprinted with name of manufacturer, UL label, cable type and year and month of manufacture.
- D. Cable to be furnished in continuous length and shall be free of kinks and defects at time of delivery to jobsite.
- E. Provide #2 AWG TW stranded copper ground conductor minimum in each conduit with phase conductors. Size for ground conductor shall be as shown on the Drawings.

NOTE TO SPEC WRITER: REVISE TERMINATOR SELECTIONS IN PARAGRAPH "F" BELOW IF 500 MCM OR LARGER CABLE IS REQUIRED.

- F. Medium voltage terminations shall be as follows:
 - 1. Elbow Terminators:
 - a. 200 ampere, loadbreak, equal to Elastimold Type 165LR series with shield terminator with appropriate shield adapt kit.
 - b. 600 ampere, non-loadbreak, equal to Elastimold Type 655LR with shield terminator with appropriate shield adapt kit.

2. Indoor terminators shall be equal to Elastimold Type 35MSCI with shield terminator.
3. Outdoor terminators shall be equal to Elastimold 35MTG with shield terminator.

G. Electrical tapes shall be equal to those manufactured by 3M as follows:

1. Fire Retardant Electric Arc Proofing: Scotch 77
2. Glass Cloth: Scotch 69
3. Self-fusing Silicone Rubber: Scotch 70
4. Vinyl Plastic: Scotch 88

PART 3 - EXECUTION

3.1 INSPECTION

- A. Examine areas and conditions under which medium voltage cable terminations are to be installed and notify the Architect/Engineer in writing of conditions detrimental to the proper and timely completion of the work. Do not proceed with the work until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install medium voltage cable and terminations as indicated in accordance with the manufacturer's written instructions, the applicable requirements of NEC and the National Electrical Contractors Association's "Standard of Installation", and in accordance with recognized industry practices to ensure that products serve the intended functions.
- B. Conduit shall be swabbed to ensure debris free. Rubber duct swabs shall be sized to conduit used. Do not exceed cable pulling tensions and bending radius recommended cable manufacturer.
- C. Cable lubricant used on pulls shall be appropriate type or as specified by cable manufacturer. All conduits shall be pre-lubricated with lubricant placed in each conduit ahead of a rubber duct swab and pulled in just before each cable pull.
- D. Ground cable shield at each termination.
- E. Medium Voltage Cable Identification:
 1. Identify cables as to phase and circuit at each accessible location. Identification to be accomplished by means of brass tags permanently affixed to cable embossed in letters no less than 1/2" high.
 2. Arrange tags such that they can be read without moving cables.

NOTE TO SPEC WRITER: EDIT PARAGRAPH "F" BELOW.

- F. Fireproof exposed medium voltage cable at [transformers] [switchgear] [junction boxes] [manholes] as follows:

1. Apply one half-lapped wrap of fire retardant electric arc proofing tape over exposed areas of cable extended one inch into ducts.
 2. Secure ends of fireproofing tape with two wraps of glass cloth tape.
- G. Where cable terminates in a stress cone, wrap exposed insulation with half-lapped layer of self-fusing silicone tape applied without stretch. Secure ends of silicone tape with vinyl plastic tape to prevent ravel.
- H. Damaged cable jacket and/or insulation will be cause for rejection of cable. Do not install cable if jacket is damaged in any way. No kinks are permitted and the bends are to be kept in accordance with the minimums recommended by the manufacturer. Pull cables directly into the duct from the coil or reel on which they are received. Cable shall not be pulled off and laid on the ground prior to installation. Make pulls in one direction.
- I. Splices are not permitted for straight new pulls. Contractor shall pull all cables in continuous lengths unless splices are specified by the Engineer. Splices are permitted only where indicated on the Drawings for connections to existing underground medium voltage feeders. The installer shall be a trained and certified technician for such special installation with appropriate splicing kit and materials.
- J. Provide cable lengths with liberal allowances for slack for terminating. If pulling grips are used, sufficient excess cable shall be allowed so that damage due to the pulling grips can be removed prior to terminating. Use rubber tape to seal cable ends. Cable shall not be pulled with the ends open. Where cable requires more than one pull, the Contractor shall lay down new 6-mil PVC plastic sheathing on the ground in the lay down area. The cable shall not be dragged across this surface, but will be permitted to be laid on the surface between pulls. Cable ends shall be moisture proofed at all times until terminations are installed.
- K. Provide pull-in guides, cable feeders or draw-in protectors to prevent damage to the cable at the duct mouths. Pull cable by grips on the conductors with proper taping of the insulation to prevent pushback. Short lengths may be pulled with cable grips around the entire group; however, care should be taken to ensure equal distribution of tension and any damaged ends must be cut off and discarded before terminating the cable.
- L. Stop pulling instantly if undue tension occurs. Lubricant shall be used to facilitate pulling and shall be compatible with the type of cable used.
- M. Identify individual phases of each power circuit at points near each end of the cables. Before connections are made at cable terminals, check by ringing out or talking over each conductor by means of a portable hand telephone set. Identify circuits before terminal connections are made by one of the methods specified above.

3.3 PRIMARY CABLE TESTING

- A. The cable manufacturer shall perform non-destructive factory tests on all cable in accordance with ICEA standards and shall furnish three copies of certified test report.

- B. Cables shall be field tested prior to energization. Notify the Architect/Engineer at the proper time during construction that the cables are ready for field testing. Cables shall not be energized prior to testing.
- C. Each circuit shall be rung-out or talked-out with proper signaling devices and with all equipment disconnected at each end to indicate that it is a continuous circuit where the operating requirements are that it shall be continuous.
- D. Insulation resistance of each cable shall be measured with a 500 volt megohm meter. Cable will be rejected if resistance is less than 25 megohms.
- E. All power cables shall be given d-c high potential tests after potheads or other terminations have been made, but before connections have been made to busses or apparatus according to IEEE 400 and manufacturer's recommendation.
 - 1. Apply test voltage to conductors in at least five equal increments to maximum test voltage. Duration at each step should be long enough for the current to reach steady value.
 - 2. Record leakage current at each increment, allowing for charging current decay. Hold maximum test voltage for 15 minutes. Current magnitudes should be recorded at 2 minutes and 15 minutes after the maximum test voltage has been reached.
 - 3. Record results of test in tabular form and in plots of current versus time for incremental voltages, and current versus time at maximum voltage.
- F. Adequate means shall be taken to insure safety during the tests and all safety instructions of the test operator shall be carried out.
- G. If a cable fails, the fault shall be located, and all cables in that conduit between the nearest pulling points on each side of the failure shall be withdrawn. If, in the opinion of the Owner, the other cables in the same conduit have not been damaged, they may be reinstated, but the cable which failed shall be replaced by new cable. After the replacement of the faulted cable, and any other damaged cables, all cables of the circuit in that conduit shall be retested.
- H. During the period of warranty any failure in primary cable, terminations or splices shall require immediate correction. In the event of a failure creating interruption in electrical service, furnish and install all labor and materials for temporary services to get the electrical system back in service. Work shall begin immediately upon notification of a failure, regardless of time.

END OF SECTION

SECTION 26 05 19
CABLE, WIRE AND CONNECTORS, 600 VOLT

PART 1 GENERAL

1.1 WORK INCLUDED

- A. Building wire.
 - 1. Power distribution circuitry.
 - 2. Control system circuitry.
 - 3. Lighting circuitry.
 - 4. Appliance and equipment circuitry.
 - 5. Motor-branch circuitry.
 - 6. Outdoors lighting and power.
 - 7. Other systems circuitry as designated.
- B. Cable.
- C. Wiring connections and terminations.
- D. Electrical/control portion of HVAC work covered by Division 23 pertaining 600 volt cable, wire and connectors shall follow the requirement set forth by this specification.

1.2 REFERENCES

NOTE TO SPEC WRITER: INCLUDE ONLY REFERENCE STANDARDS THAT ARE TO BE INDICATED WITHIN THE TEXT OF THIS SECTION. EDIT THE FOLLOWING, ADDING AND DELETING AS REQUIRED FOR PROJECT AND PRODUCT SELECTION.

- A. NEMA WC 3 - Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.
- B. NEMA WC 5 - Thermoplastic-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.
- C. ANSI/UL 83 – Thermoplastic-Insulated Wire and Cables
- D. NFPA 70 – National Electrical Code, latest edition
- E. NEFA – Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems.
- F. Where application of National Electrical Code, trade association standards or publications appears to be in conflict with the requirements of this Section, the Architect/Engineer shall be asked for an interpretation.

1.3 SUBMITTALS

- A. Provide submittals in accordance with and in addition to Section 26 00 00, Basic Electrical Requirements, and Division 01 for submittal requirement.
- B. Submit manufacturer's literature and specification data sheets for each item of cable, wire connectors.
- C. Qualification of cable and wire manufacturer: Company specializing in manufacturing products specified in this Section with minimum ten years experience.

1.4 DELIVERY, STORAGE AND HANDLING

- A. Provide factory-wrapped waterproof flexible barrier material for covering wire and cable wood reels, where applicable; and weather resistant fiberboard containers for factory packaging of cable, wire and connectors, to protect against physical damage in transit. Damaged cable, wire or connectors shall be removed from project site.
- B. Store cable, wire and connectors in a clean, dry indoor space in their factory-furnished coverings, which provides protection against the weather.

PART 2 PRODUCTS

2.1 GENERAL REQUIREMENTS

- A. Generally, cable, wire and connectors shall be of manufacturer's standard materials, as indicated by published product information.
- B. Provide factory-fabricated wire of the size, rating, material and type as indicated for each service. Where not indicated, provide proper selection as required to comply with installation requirements and with NEC standards. The minimum size wire to be used for power or lighting circuits shall be #12 copper with insulation as noted below. Minimum size for control shall be #14 copper.
- C. The conductors of wires and cables shall be of copper (tinned where specified), and have conductivity in accordance with the standardization rules of the IEEE. The conductor and each strand shall be round and free of kinks and defects.
- D. Grounding conductors, where insulated, shall be colored solid green or identified with green color as required by the NEC. Conductors intended as a neutral shall be colored solid white, or identified as required by the NEC. All motor or equipment power wiring shall be colored according to Section 26 05 53.UT, Electrical Identification.
- E. All cable specified for use in tray shall be multiconductor and shall have an outer jacket of flame-retardant, moisture and sunlight resistant polyvinyl chloride (PVC) and shall be UL and NEC approved type for tray installation. Cable installed in cable tray outdoors shall have a jacket that is UV resistant chlorinated polyethylene (CPE) or polyvinyl chloride (PVC), rated 90°C per UL Standard 1277.
- F. All low voltage power and control cable installed in open cable tray above ceilings used for return air shall be plenum rated. Where tray cable is not available in size and type required, conductors shall be installed in conduit.

- G. Use compression lugs for all wiring termination's, except on breakers or terminal strips in panel boards.

2.2 BUILDING WIRE

- A. Thermoplastic-insulated Building Wire: NEMA WC 5.
- B. Rubber-insulated Building Wire: NEMA WC 3.
- C. Feeders and Branch Circuits Larger Than 10 AWG: 98% conductivity copper, soft-drawn, stranded conductor, 600 volt insulation, THHN/THWN Use XHHW conductors where installed in conduit underground.
- D. Feeders and Branch Circuits 10 AWG and Smaller: 98% conductivity copper, soft-drawn, stranded conductor, 600-volt insulation, THWTHHN/THWN.

2.3 REMOTE CONTROL AND SIGNAL CABLE

- A. 600 Volt Insulation Control Cable for Class 1 Remote Control and Signal Circuits, Type TC:
 - 1. Individual Conductors: 14 AWG, stranded copper, XHHW insulation. Rated 90 degrees C dry, 75 degrees C wet, color-coded per ICEA Method 1 plus one green equipment grounding conductor.
 - 2. Assembly: Bundle wrapped with cable tape and covered with an overall PVC jacket. Cable shall pass IEEE-1202 vertical tray ribbon-burner flame test (210,000 BTU) VW-1.
- B. Instrumentation Cable
 - 1. 300 Volt Instrumentation Cable, Multiple Pairs, Overall Shield, Type PLTC:
 - a. Individual Conductors: 18 AWG, stranded, tinned copper, flame retardant polyethylene or PVC insulated, rated 105 degrees C, black and white numerically printed and coded pairs.
 - b. Assembly: Individual twisted pairs having a 100 percent coverage aluminum-polyester shield and 20 AWG stranded tinned copper drain wire. Conductor bundle shall be shielded with 100 percent coverage overall aluminum-polyester shield complete with 20 AWG drain wire. All group shields completely isolated from each other. Bundle wrapped with cable tape and covered with an overall flame retardant PVC jacket. Cable shall pass IEEE-383 vertical tray flame test (70,000 BTU) UL1581.
- C. Life Safety Systems Cable
 - 1. All life safety system wiring shall be installed in dedicated conduit or raceway with adequate separation/shielding from all other systems.
 - 2. Life safety systems wiring shall be as specified in the Section 28 31 00.UT - Fire Alarm and Smoke Detection Systems.
- D. Security/Access Control/CCTV Cable
 - 1. All security/access control wiring shall be installed in dedicated conduits.

2. Security/access control wiring shall be rated and as specified below:

Circuit Type	No. of Conductors	Conductor Specifications	Cable Specifications
20 mA Current Loop	2	18-gauge, stranded copper	2 cables, 1 twisted pair each required
Card Reader Coaxial	--	18-gauge, solid copper, center conductor	Schlage Model No. SE9284PL or Anicom 5910PL
Contact Circuits	2	18-gauge, stranded copper	Nonshielded, twisted
CCTV Coaxial	--	--	Belden 89259 plenum rated, or approved equal

3. All security/access control power circuit wiring shall comply with paragraph 2.2. Building Wire of this Section.

E. Plenum Cable for Class 3 Remote Control and Signal Circuits: 98% conductivity copper conductor, 300 volt insulation, rated 60 degree C, UL listed for use in air handling ducts, hollow spaces used as ducts, and plenums.

2.4 WIRING CONNECTIONS AND TERMINATIONS

A. Provide factory-fabricated, metal connectors of the size, rating, material, type and class as indicated for each service. Where not indicated, provide proper selection as required to comply with installation requirements and with NEC standards. Select from only following types, classes, kinds and styles.

1. Type:

- a. Solderless pressure connectors
- b. Crimp.
- c. Threaded.
- d. Insulated spring wire connectors with plastic caps for 10 AWG and smaller.

2. Class: Insulated.

3. Material: Copper (for CU to CU connection).

4. Style:

- a. Insulated terminals. Use ring-terminal for control wiring. Use flange (fork) spade compression terminal for termination of stranded conductors at wiring devices, including ground connection.
- b. Split bolt-parallel connector.
- c. Pigtail connector.

- d. Pre-insulated multi-tap connector.

PART 3 EXECUTION

3.1 INSPECTION

- A. Installer must examine the areas and conditions under which cable, wire and connectors are to be installed and notify the Contractor in writing of conditions detrimental to the proper and timely completion of the work. Inspect wire and cable for physical damage. Do not proceed with the work until unsatisfactory conditions have been corrected.

3.2 GENERAL WIRING METHODS

- A. Install electrical cable, wire and connectors as indicated, in accordance with the manufacturer's written instructions, the applicable requirements of NEC and the National Electrical Contractors Association's "Standard of Installation", and as required to ensure that products serve the intended functions.
- B. Coordinate cable and wire installation work with electrical raceway and equipment installation work, as necessary for proper interface. Do not install the conductors until raceway system is complete and properly cleaned.
- C. Cables shall be selected on the basis of their purpose and UL listing. Generally, use Types THWN and THHN in building interiors and other dry locations. Outdoors and underground in raceways, use Type RHW. Conductors subject to abrasion, such as in lighting poles, shall be Type THWN or THHN.
- D. No conductor smaller than No. 12 wire shall be used for lighting purposes. In the case of "home runs" over 50' in length (100' for 277 volt) no conductor smaller than a No. 10 wire shall be used. The sizing of all wire except remote control wire shall be accomplished in the case of both feeder and branch circuits by conforming to the following provisions. Separate neutral conductors shall be provided for each phase of the same size for 120V/277V single-phase application for heavy electrical loads, computer loads, loads fed from isolated transformers, lab equipment, clinic equipment, dedicated circuits, unless noted otherwise on drawings. Voltage drop on feeders and branch circuits shall not exceed NEC requirement.
- E. Remote control wires shall be no smaller than No. 14 conductors. Control wires shall be run in separate conduits. Departures from the sizes so determined shall be made only in those cases in which the National Electrical Code requires the use of larger conductors. The sizes as determined from these tables shall be regarded as the acceptable minimum under all other circumstances. In no case, however, shall there be a voltage drop greater than that specified in any feeder or branch circuit. The Contractor may, if he deems it necessary or advisable, use larger sized conductors than those shown. Under no circumstances, however, shall the Contractor use any conductors sized in a manner which does not conform to the above mentioned tables without having first secured the written approval of the Owner's duly authorized representative.
- F. Install exposed wire and cable, parallel and perpendicular to surface or exposed structural members and follow the surface contours, where possible.

- G. Splice branch circuits only in accessible junction or outlet boxes. Control cable shall never be spliced except the final connection to field devices. Where terminations of cables that are installed under this Section are to be made by others, provide pigtail of adequate length for neat, trained and bundles connections, minimum 5 feet at each location, unless noted otherwise on drawings.
- H. Wiring Within An Enclosure: Contractor shall bundle ac and dc wiring separately within an enclosure. The Contractor shall utilize panel wire-ways when they are provided. Where wireways are not provided the Contractor shall neatly tag, bundle wires and secure to sub-panel at a minimum of every three inches with T&B Type TC5355 heavy duty mounting bases.
- I. Do not band any conductor either permanently or temporarily during installation to radii less than four times the outer diameter of 600-volt insulated conductors.

3.3 WIRING INSTALLATION IN RACEWAYS

- A. Wire and cable shall be pulled into clean dry conduit. Do not exceed manufacturer's recommended values for maximum pulling tension.
- B. Pull conductors together where more than one is being installed in a raceway.
- C. Use UL listed pulling compound or lubricant, when necessary; compound must not deteriorate conductor and insulation.
- D. Do not use a pulling means, including fish tape, cable or rope, which can damage the raceway.
- E. Install wire in raceway after interior of building has been physically protected from the weather and all mechanical work likely to injure conductors has been completed.
- F. Place an equal number of conductors for each phase of a circuit in same raceway.
- G. Provide separate conduit or raceway for line and load conductors of motor starters, safety disconnect switches, and similar devices. Those devices shall not share the same raceway.
- H. All conduits shall contain a green grounding conductor. Conduit, wireways, or boxes shall not be used as the equipment grounding conductor.

3.4 CABLE INSTALLATION

- A. Provide protection for exposed cables where subject to damage during construction. Do not install cable before the completion of raceway system.
- B. Cable above ceilings shall be in conduit or raceways. Cables, conduits and raceways shall not be laid on ceiling tiles or strapped to ceiling wire.
- C. Use suitable cable fittings and connectors.
- D. It shall be the Contractor's responsibility to accurately measure all cable runs before the cable is cut. The Contractor shall furnish all tools and equipment, have sufficient properly trained personnel and shall exercise necessary care to ensure that the cable is not damaged during installation. Cable found to be damaged before installation shall not be installed. Cable damage during installation shall be

removed and replaced. Repairs to cables can only be done with written permission from the Owner's Representative and only under special circumstances.

- E. Care shall be exercised with cables entering or leaving cable trays that all cable bend radii shall not be less than the recommended minimum and that cables are not left to rest unprotected on any sharp edge or corner.
- F. PVC jacketed cable shall not be installed or worked in any way at temperatures below 32 degrees F, unless cable has been previously stored in a heated area 48 hours prior to being pulled and transported to a heated pulling area.
- G. Each cable entering an enclosure shall have its conductors bundled together and identified with the cable number. All groups of conductors within an enclosure shall be shaped and formed to provide a neat appearance to facilitate future additions or rework. All control conductors shall be numbered and shall be labeled at each termination with this number, using markers designed for the application.
- H. Multi-Conductor Cable Installation: Power and 120V control cable shall be installed in the same tray. When cables leave trays, they shall be protected between the trays and the cable terminal points by drawing them through conduits. Do not route 600V cables (power cable and 120V control cable) in the same conduit or cable tray as low voltage cables (less than 50V, communications, security systems, or control conductors). Do not route security systems, or control cables through communications rooms. Fire alarm cable shall be routed in a separate conduit only.
- I. Instrument Cable: Instrument cable shall, when conduit installation is required be installed in rigid steel conduit. They shall not be spliced at any point. The shields and drain wires of shielded signal cables shall be grounded only at one point as indicated on the Drawings.

3.5 WIRING CONNECTIONS AND TERMINATIONS

- A. Install splices, taps and terminations, which have equivalent-or-better mechanical strength and insulation as the conductor. Make splices, taps and terminations to carry full ampacity of conductors without perceptible temperature rise.
- B. Keep conductor splices and taps accessible and to a minimum, and in junction boxes only. Control circuit conductors shall terminate at terminal blocks only. Splices below grade shall only be in handholes or manholes and shall be made watertight with epoxy resin type splicing kits similar to Scotchcast.
- C. Use splice, tap and termination connectors, which are compatible with the conductor material.
- D. Thoroughly clean wires before installing lugs and connectors.
- E. Terminate spare conductors with electrical tape and label as spare.
- F. Power and Lighting Circuits: Use solderless pressure connectors with insulating covers for copper wire splices and taps, 8 AWG and larger. For 10 AWG and smaller, use insulated spring wire connectors with plastic caps on lighting and receptacle circuits.

- G. Use split bolt connectors for copper wire splices and taps, 6 AWG and larger. Tape un-insulated conductors and connectors with electrical tape to 150 percent of the insulation value of conductor.
- H. Connections for all wire sizes in motor terminal boxes where the motor leads are furnished with crimped-on lugs shall be made by installing ring type compression terminals on the motor branch circuit ends and then bolting the proper pairs of lugs together. First one layer of No. 33 scotch tape reversed (sticky side out), then a layer of rubber tape, then two layers of No. 33 half-lapped.
- I. Identify conductors per Section 26 05 53.UT - Electrical Identification.

3.6 FIELD QUALITY CONTROL

- A. Torque test conductor connections and terminations to manufacturer's recommended values.
- B. Perform continuity test on all power and equipment branch circuit conductors. Verify proper phasing connections.
- C. Conductors in vertical conduits or raceways shall be supported in the manner set forth in the appropriate section of the latest revision of the National Electrical Code. Lighting fixtures shall not be used for raceways for circuits other than parallel wiring of fixtures.
- D. Conductors may be run in parallel on sizes 1/0 to 500 MCM inclusive provided all paralleled conductors are the same size, length, and type of insulation. Except as otherwise shown on drawings, no more than three conductors may be run in parallel, and they shall be so arranged and terminated as to insure equal division of the total current between all conductors involved. Where parallel connection is contemplated, approval of the Owner's representative must be obtained before installation is made.

3.7 TESTING AND ACCEPTANCE

- A. Before final acceptance, the Contractor shall make voltage, insulation, and load tests, necessary to demonstrate to the Owner's representative the satisfactory installation and proper performance of all circuits.
- B. Test feeder conductors clear of faults. Insulation-resistance test shall be conducted per NETA – Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems. Test results below 50 megohms shall be cause for rejection of the wiring installation. Replace and retest all such rejected conductor.
- C. At the completion of this project, the Contractor shall provide for the Owner three (3) complete and finally corrected sets of working drawings. These sets of working drawings shall be new, unused and in good condition, and shall include the nature, destination, path, size and type of wire and all other characteristics for complete identification of each and every conduit and circuit.

END OF SECTION

SECTION 26 05 26
GROUNDING

PART 1 -- GENERAL

1.1 WORK INCLUDED

- A. Power system grounding.
- B. Communication system grounding.
- C. Electrical equipment and raceway grounding and bonding.

1.2 RELATED WORK

- A. Lightning protection.

1.3 REFERENCES

- A. NFPA 70 – National Electrical Code, latest edition
- B. ANSI/UL 467 – Electrical Grounding and Bonding Equipment
- C. ANSI/IEEE STD 142 – Recommended Practice for Grounding of Industrial and Commercial Power Systems
- D. IEEE 81 – Guide for Measuring Earth Receptivity, Ground Impedance and earth Surface Potential of a ground System
- E. IEEE 1100 – Recommended Practice for Powering and Grounding Sensitive Electronic Equipment
- F. ANSI/TIA/EIA 607 – Commercial Building Grounding and Bonding Requirements for Telecommunications

1.4 SYSTEM DESCRIPTION

- A. Ground the electrical service system neutral at service entrance equipment to grounding electrodes. Electrical systems that are grounded shall be connected to earth in a manner that will limit the voltage imposed by lightning, line surges, or unintentional contact with higher-voltage lines and that will stabilize the voltage to earth during normal operations. Concrete encased electrodes shall be connected as the most effective grounding electrodes. Provide a completely grounded system in accordance with Article 250 of the NEC.
- B. Ground each separately-derived system neutral to separate ground buses that are installed in nearest electrical rooms. Transformer, UPS systems, power conditioners, inverters, or other power supplies are separately derived systems. Standby or emergency generators are separately derived systems if the neutral is bonded to the generator frame and if there is no direct connection of the generator neutral conductor to the service neutral conductor.
- C. Provide communications system grounding conductor connected to separate electrode (ground bus) that is installed in each IT room.

- D. Bond together system neutrals, service equipment enclosures, exposed non-current carrying metal parts of electrical equipment, metal raceway systems, cable trays, auxiliary gutters, meter fittings, boxes, cable armor, cable sheath, ground bus in electrical rooms and IT rooms, metal frame of the building or structure, ground ring, lightning down lead conductor, grounding conductor in raceways and cables, receptacle ground connectors, and metal underground water pipe.
- E. Bonding jumpers shall be installed around non-metal fittings or insulating joints to ensure electrical continuity. Bonding shall be provided where necessary to ensure electrical continuity and the capacity to conduct safely any fault current likely to be imposed.

NOTE TO SPEC WRITER: THE NATIONAL ELECTRICAL CODE IS SPECIFIC ABOUT WHAT IS REQUIRED FOR USE AS GROUNDING ELECTRODES. EDIT THE FOLLOWING PARAGRAPH TO CONFORM TO THE PARTICULAR PROJECT.

- F. Supplementary Grounding Electrode: [Use driven ground rod [on exterior of building.] [in main service equipment area.]] [Install ground rod in suitable recessed well; fill with gravel after connection is made.] [Use effectively grounded metal frame of the building.] [Use minimum of 20 feet No. 4 bare copper wire embedded in concrete foundation.]
- G. Use minimum 6 AWG copper conductors for communications service grounding conductor. Leave 10 feet slack conductor at termination [board.] [cabinet.]

1.4 SUBMITTALS

- A. Provide submittals in accordance with and in additional to Section 26 00 00, Basic Electrical Requirements, and Division 01 for submittal requirement.

PART 2 -- PRODUCTS

2.1 MATERIALS AND EQUIPMENT

- A. Grounding system components shall be as required to comply with the design and construction of the system indicated. Components shall be as indicated in manufacturer's submittal data.
- B. Ground conductors shall be stranded tinned, annealed copper cable of the sizes indicated on drawings. Bond grounding conductors at both ends of metallic conduit.
- C. Grounding clips shall be Steel City Type G, or equal.
- D. Ground Rods shall be copper-encased steel, 3/4" diameter, minimum length 10 feet.

PART 3 -- EXECUTION

3.1 INSTALLATION

- A. Install ground system as indicated, in accordance with the applicable requirements of the National Electrical Code and the National Electrical Contractors Association's "Standard of Installation".
- B. Install grounding conductors continuous, without splice or connection, between

- equipment and grounding electrodes. Install test wells as required per drawings.
- C. In feeder and branch circuits, provide a separate, insulated equipment grounding conductor. Terminate each end on a grounding lug, bus, or bushing.
 - D. Connect grounding electrode conductors to metal water pipe where metal pipe is available and accessible using suitable ground clamp. Make connections to flanged piping at street side of flange. Provide bonding jumper around water meter.
 - E. Install fusion welded ground connectors where they are concealed or inaccessible.
 - F. Ground each outlet by the use of an approved grounding clip attached to the junction box in such a position to be readily inspected on removal of the cover plate; or by the use of an approved grounding yoke type receptacle.
 - G. No strap grounding clamps shall be used; connections requiring bolting shall be made up with monel metal bolts, washers and nuts. Connections shall be made only after surfaces have been cleaned, or ground to expose virgin metal.
 - H. Install external ground wire on liquid tight flexible metal conduit with grounding bushings.
 - I. Conductor connections shall be made by means of solderless connectors such as serrated bolted clamps or split bolt and nut type connectors. .
 - J. The neutral of each transformer shall be bonded to system ground at one point only. This point shall be ahead of the first secondary protective device.
 - K. Connect grounding conductors to ground rods at the upper end of the rod with the end of the rod and the connection points below finished grade. Below grade connection shall be exothermic-welded type connectors as manufactured by Cadweld, Thermoweld. In manhole, install ground rods with 4 to 6 inches above the floor with connections of grounding conductors fully visible and accessible.

NOTE TO SPEC WRITER: USE THE FOLLOWING PARAGRAPH WHERE REQUIRED FOR COMPUTERS OR OTHER ELECTRONIC EQUIPMENT.

- L. Isolated Grounding Systems: Use insulated equipment grounding conductor and connect only to separate grounding bus.

NOTE TO SPEC WRITER: USE THE FOLLOWING PARAGRAPH FOR PROJECTS WHICH INCLUDE A UTILITY SERVICE.

- M. Provide grounding and bonding at Utility Company's metering equipment and pad-mounted transformer in accordance with Utility Company's requirements.

3.2 FIELD QUALITY CONTROL

- A. Inspect grounding and bonding system conductors and connections for tightness and proper installation.
- B. Measure ground resistance from system neutral connection at service entrance to convenient ground reference point using suitable ground testing equipment.

Resistance shall not exceed 10 ohms. Provide additional ground rod as required until resistance reading is 10 ohms or less.

END OF SECTION

SECTION 26 05 29
SECURING AND SUPPORTING METHODS

PART 1 GENERAL

1.1 WORK INCLUDED

- A. Raceway, cable tray, and equipment supports
- B. Fastening hardware
- C. Coordinate location of concrete equipment pads

1.2 QUALITY ASSURANCE

- A. Support systems shall be adequate for weight of equipment and conduit, including wiring, which they carry. Support systems shall be sized adequately to support an additional 25% for future loads

1.3 COORDINATION

- A. Coordinate with other trades where conduit and cable tray supports are in the same location as piping, ductwork, and work of other trades and where supports are furnished and installed under other Divisions. Supporting from the work or supports of other Contractors shall not be allowed except by express, written permission of the Owner.

1.4 SUBMITTALS

- A. Provide submittals in accordance with and in additional to Section 26 00 00, Basic Electrical Requirements, and Division 01 for submittal requirement.

PART 2 PRODUCTS

2.1 MATERIAL

- A. Support Channel:
 - 1. All non-corrosive locations: Hot-dip galvanized steel.
 - 2. Corrosive locations: Nonmetallic fiberglass.
- B. Hardware:
 - 1. All non-corrosive locations: Hot-dip galvanized steel.
 - 2. Corrosive locations: Stainless steel threaded rod, attachments and fasteners shall be used with fiberglass supports.
- C. Threaded Rod: used for rack support from structure above; 3/8-inch minimum diameter.

PART 3 EXECUTION

3.1 INSTALLATION

- A. Fasten hanger rods, conduit clamps, and outlet and junction boxes to building structure using precast insert system, expansion anchors, or beam clamps. Do not use spring steel clips and clamps. Provide necessary calculations to select proper support materials for electrical equipment, raceway, and cable tray supports. Provide cable tray supports for cable tray filled to 125 percent capacity per NEC.
- B. Install hangers, anchors, sleeves and seals as indicated, in accordance with manufacturer's written instructions and with recognized industry practices to insure supporting devices comply with requirements. Comply with requirements of NEC for installation of supporting devices. Install supports with spacing in compliance with NEC requirements.
- C. Use toggle bolts or hollow wall fasteners in hollow masonry, plaster, or gypsum board partitions and walls; expansion anchors in solid masonry walls; or concrete surfaces; sheet metal screws in sheet metal studs; and wood screws in wood construction.
- D. Do not fasten supports to piping, ductwork, mechanical equipment, or conduit.
- E. Do not use powder actuated anchors without written permission from the Engineer.
- F. Do not drill structural steel members without written permission from the Structural Engineer.
- G. Fabricate supports from structural steel or steel channel, rigidly welded or bolted to present a neat appearance. Use hexagon head bolts with spring lock washers under all nuts.
- H. Bridge studs top and bottom with channels to support recessed mounted cabinets and panelboards in stud walls.
- I. Install surface mounted cabinets and panelboards with a minimum of four anchors. Provide strut channel supports to stand cabinet 1-5/8 inches off wall. Utilize "Post Bases" where support channel is attached to structural floor.
- J. Provide extra care in supporting PVC conduit to protect it from potential damage.
- K. Use fiberglass for nonmetallic raceway systems supports in areas subject to corrosives.
- L. All supports in contact with floor using stanchion type support shall be solidly bolted to the permanent structural floor.
- M. Conduit supports shall have at a minimum, the bottom support member constructed of double strut. This horizontal member shall be double-nutted, and the supporting all-thread rod shall be trimmed to one inch below lowest nut.
- N. Conduit entering/exiting cable tray shall be attached to the tray rail by means of unistrut bolted to the rail and standard manufacturer's accessories. Conduit shall only enter/exit tray horizontally supported within three feet of the tray, and extended into the tray two inches. Conduit shall be terminated with a grounding bushing, and bonded to the tray ground wire. (The attachment to the tray shall not be considered a support.)

- O. Coordinate with other electrical work, including raceway and wiring work, as necessary to interface installation of supporting devices with other work.
 - P. Install freestanding electrical equipment on 4-inch concrete pads. Pad shall be a minimum four inches larger than equipment. No crevices shall be left around the pads. Equipment includes but not limited to the following:
 - 1. Motor Control Centers
 - 2. Static Transfer Switches
 - 3. Floor mounted VFDs
 - 4. Floor mounted transformers
 - 5. Switchboards, 1200A and larger
 - Q. Do not anchor supports to columns. Where panelboards, cables, or conduits are routed on the face of a column provide “column hugging” channel supports.
- 3.2 TOUCH-UP
- A. Touch-up all scratches on securing and supporting system, and paint the ends of channel after cutting with an approved zinc chromate or 90 percent zinc paint.

END OF SECTION

SECTION 26 05 33
RACEWAYS, CONDUITS AND BOXES

PART 1 GENERAL

1.1 WORK INCLUDED

A. Raceways:

1. Surface metal raceways.
2. Multi-outlet assemblies.
3. Wireways.
4. Indoor service poles.

B. Conduit:

1. Rigid metal conduit and fittings. (RGS)
2. Intermediate metal conduit and fittings. (IMC)
3. Electrical metallic tubing and fittings. (EMT)
4. Flexible metal conduit and fittings.
5. Liquid-tight flexible metal conduit and fittings.
6. Non-metallic conduit and fittings. (underground use only)
7. PVC coated rigid steel conduit.

C. Boxes:

1. Wall and ceiling outlet boxes.
2. Pull and junction boxes.

D. Electrical/control portion of HVAC work covered by Division 23 pertaining raceway, conduit and boxes shall follow the requirement set forth by this specification.

1.2 REFERENCES

- A. NFPA 70 – National Electrical Code, latest edition
- B. ANSI C80.1 - Rigid Steel Conduit, Zinc-Coated
- C. ANSI C80.3 - Electrical Metallic Tubing, Zinc-Coated
- B. ANSI/NEMA FB 1 - Fittings and Supports for Conduit and Cable Assemblies
- E. EMA TC 3 - PVC Fittings for Use with Rigid PVC Conduit and Tubing
- F. ANSI/NEMA OS 1 - Sheet-Steel Outlet Boxes, Device Boxes, Covers and Box Supports
- G. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum)
- H. ANSI/NEMA TC 2 – Electrical Plastic Tubing (EPT) and Conduit (EPC-40 and

EPC-80)

- I. ANSI/UL 1 – Flexible Metal Conduit
- J. ANSI/UL 5 – Surface Metal Raceways and Fittings
- K. ANSI/UL 360 – Liquid-tight Flexible Steel Conduit
- L. ANSI/UL 467 – Electrical Grounding and Bonding Equipment
- M. ANSI/UL 651 – Schedule 40 and 80 Rigid PVC Conduit (underground use only)
- N. ANSI/UL 797 – Electrical Metal Tubing
- O. ANSI/UL 870 – Wireways, Auxiliary Gutters and Fittings
- P. NEMA RN 1 – Polyvinyl Chloride (PVC) Externally Coated galvanized Rigid Steel Conduit and Intermediate Metal Conduit
- Q. NEMA VE 1 – Metallic Cable Tray Systems
- R. UL 6 – Rigid Metal Conduit
- S. ANSI/UL 5C – Surface Raceways and Fittings for Use with Data, Signal, and Control Circuits
- T. ANSI/UL 498 – Attachment Plugs and Receptacles
- U. ANSI/UL 943 – Ground Fault Circuit Interrupters

1.3 SUBMITTALS

- A. Provide submittals in accordance with and in additional to Section 26 00 00, Basic Electrical Requirements, and Section 01330, Submittal Procedures.
- B. Shop drawings consisting of a complete list of equipment and materials, which will be used for the project, including manufacturer's descriptive and technical literature, catalog cuts and installation instructions.
- C. Sealing/fire stopping materials and details.

1.4 STORAGE AND HANDLING

- A. Handle materials carefully to avoid damage, breaking, denting and scoring. Damaged equipment or materials shall not be installed.
- B. Store materials in a clean dry space and protected from the weather.

PART 2 PRODUCTS

2.1 SURFACE METAL RACEWAY

- A. Surface metal raceway shall be factory pre-assembled galvanized steel complete including bases, removable covers, receptacles, end plates, elbows, connectors and fittings, to exact length to match the length of the cabinets, casework, utility chases, and shelving as indicated on laboratory and furniture shop drawings, and work bench details, as applicable.
- B. Size shall be as shown on the Drawings. The length shown on electrical drawings is diagrammatic only and is not accurate for fabrication of raceway Sections. Refer to

shop drawings, architectural plans, elevations, and details.

- C. Finish shall be ANSI-61 gray enamel .
- D. Covers shall be field removable by use of a standard screwdriver, without marring the extrusion or cover finish. Raceway with two covers must allow each cover to be removed separately without access into the compartment(s) enclosed by the other cover.
- E. Provide a permanent, integral, grounded metallic dividing barrier to isolate the wiring compartments in the multi-outlet raceway system per drawing as applicable. Provide divider with fittings that maintain the separation of the raceway wiring compartments.
- F. Provide device brackets for mounting standard single-gang or two-gang devices within the raceway system. Devices shall have the capacity of mounting flush or in conjunction with device faceplates.
- G. Provide receptacles for the respective power systems as indicated on the drawings. Refer to Section 26 27 26.UT Wiring Devices for device specifications.

2.2 MULTI-OUTLET ASSEMBLY

- A. Multi-outlet assembly shall be two-piece sheet metal channel with fitted, removable cover suitable for use as a multi-outlet assembly.
- B. Size shall be as indicated on the Drawings.
- C. Provide receptacles mounted as shown on Drawings.
- D. Finish shall be ANSI-61 gray enamel.
- E. Provide couplings, elbows, outlet and device boxes, and connectors designed for use with multi-outlet system.

2.3 WIREWAYS

- A. Wireways shall be of steel construction general purpose for indoor spaces and rain tight for outdoor applications with knockouts.
- B. Size shall be as indicated on Drawings.
- C. Cover shall be hinged or screw applied as indicated on Drawings. Rain tight wireways shall be provided with full gasketing.
- D. Fittings shall be so constructed to continue the "lay-in" feature through the entire installation.
- E. Provide all sheet metal parts with a rust inhibiting phosphatizing primer coating and finished in gray enamel. All hardware shall be cadmium plated to prevent corrosion.

2.4 CONDUIT AND FITTINGS

- A. Conduit and fittings for all electrical systems on this project shall include the following:
 - 1. Service entrance

2. Electrical power and lighting feeders
 3. Electrical power and lighting circuits
 4. Telephone systems
 5. Control systems (other than HVAC)
 6. Fire alarm and signaling systems
 7. CCTV rough-in system
 8. Clock and bell system
 9. Computer system rough-in
 10. Sound system rough-in
 11. Other electrical systems
- B. For each electrical wireway system indicated, provide a complete assembly of conduit, tubing or duct with fittings including, but not necessarily limited to, connectors, nipples, couplings, locknuts, bushings, expansion fittings, other components and accessories as needed to form a complete system of the same type indicated.
- C. Conduit fittings shall be designed and approved for the specific use intended. Conduit fittings, including flexible, shall have insulated throats or bushings. Rigid conduits shall have insulated bushings, unless grounding bushings are required by N.E.C. Article 250. Grounding bushings shall have insulated throats.
- D. Rigid and intermediate metal conduit shall be hot-dipped galvanized. Fittings shall be threaded type. Expansion fittings shall be OZ Type DX.
- E. Electrical metallic tubing shall be galvanized. Fittings shall be all steel compression type. Expansion fittings shall be OZ Type TX.
- F. Flexible metal conduit and fittings shall be zinc-coated steel.
- G. Liquid-tight flexible conduit and fittings shall consist of single strip, continuous, flexible interlocked, double-wrapped steel, galvanized inside and outside, forming smooth internal wiring channel with liquid-tight covering of flexible polyvinyl chloride (PVC). It shall be furnished with a sealing O-ring where entering an enclosure subject to moisture. Where O-Rings are used, ground type bushings shall be used in the box or enclosure.
- H. Nonmetallic conduit and fittings shall be suitable for temperature rating of conductor but not less than 90°C. Nonmetallic conduit and fittings shall be molded of high impact PVC compound having noncombustible, nonmagnetic, non-corrosive and chemical resistant properties and shall be of the same manufacturer. Where located outdoors and above ground, the conduit and fittings shall be UV resistant. Solvent cement shall be of the same manufacturer as the conduit and shall be of the brush-on type. Spray solvents are prohibited. PVC coated metallic fittings shall not be permitted for PVC conduit connections.
- I. Crimp or set-screw type fittings are not acceptable.

- J. Minimum conduit size shall be 3/4 inch, except 1/2 inch flexible metallic conduit may be used as fixture whips.
- K. PVC coated rigid steel conduit shall be externally coated with a 40 mil PVC coating and internal phenolic coating over a galvanized surface.

2.5 WALL AND CEILING OUTLET BOXES

- A. Galvanized steel interior outlet wiring boxes of the type, shape and size, including depth of box, to suit each respective location and installation; constructed with stamped knockouts in back and sides, and with threaded holes with screws for securing box covers or wiring devices.
 - 1. Outlet box accessories as required for each installation, including mounting brackets, wallboard hangers, extension rings, fixture studs, cable clamps and metal straps for supporting outlet boxes, compatible with outlet boxes, compatible with outlet boxes being used and meeting requirements of individual situations.
 - 2. Provide multi-gang outlets of single box design. Sectional boxes are not acceptable. Provide outlet boxes of sufficient volume to accommodate the number of conductors entering the box in accordance with the requirements of NEC, and not less than 1 1/2 inch deep unless shallower boxes are required by structural conditions and are approved by the A/E.
- B. Provide deep type cast metal weatherproof exterior outlet wiring boxes of the type, shape and size, including depth of box, with threaded conduit ends, cast metal face plate with spring-hinged waterproof cap suitably configured for each application, including face plate gasket and fasteners. Provide PVC type outlet boxes only in corrosive areas rated as NEMA 13X.
- C. Outlet boxes in poured concrete shall be plenum type without any holes and with reset knockouts. Where extension rings are used to offset conduit between wall reinforcing steel, joint between extension ring and box shall be sealed to prevent concrete from entering box during pour.
- D. Provide 4-inch octagonal ceiling outlet boxes.

2.6 PULL AND JUNCTION BOXES

- A. Boxes shall be galvanized sheet metal conforming to ANSI/NEMA OS 1 with screw-on cover and welded seams, stainless steel nuts, bolts, screws and washers.
- B. Boxes larger than 12 inches in any dimension shall be panelboard code gauge galvanized steel with hinged cover.
- C. Boxes shall be sized in accordance with NEC.
- D. Provide cast-in-place, pre-cast concrete or die-molded fiberglass handholes/pull boxes as per design for underground installations. Cast-in-place and pre-cast boxes shall be provided with reinforcing bars with material compressive strength no less than 11,000 psi, and shall be approved by Owner/Structural Engineer.

2.7 CABLE TRAY AND FITTINGS

A. Ladder type cable trays

1. Tray: NEMA VE 1, Class 12C or as indicated on the drawings.
2. Material and Finish of Tray, Fittings, and Accessories: 6063-T6 aluminum extrusion or hot-dip galvanized after fabrication steel (ASTM A123) as indicated on Drawings.
3. Inside width: 12 inches minimum or as indicated on Drawings.
4. Inside depth: 4 inches minimum or as indicated on Drawings
5. Straight Section rung spacing: 12 inches on center.
6. Inside radii of fittings: as indicated on Drawings
7. Accessories and Fittings: Manufacturer's standard clamps, hangers, brackets, splice plates, reducer plates, blind ends, barrier strips, connectors, and grounding straps.
8. Provide covers on tray where exiting the top of control cabinets, communication/data cabinets, distribution panelboards and switchboards which covers vertical Sections of tray and 90 degree bend.

B. Perforated bottom cable trays

1. Tray: NEMA VE 1, Class 12C.
2. Material and Finish of Tray, Fittings, and Accessories: 6063-T6 aluminum extrusion or hot-dip galvanized steel (ASTM A123).
3. Inside Width: 12 inches minimum or as indicated on Drawings.
4. Inside depth: 4 inches or as indicated on Drawings.
5. Inside radii of fittings: 12 inches.
6. Accessories and Fittings: Manufacturer's standard clamps, hangers, brackets, splice plates, reducer plates, blind ends, barrier strips, connectors, and grounding straps.
7. Utilization: Data cables, control cables, telephone cables, fiber optics. Do not use for vertical sections. Vertical cables shall be installed vertical floor mounted racks.
8. Covers: Ventilated covers where indicated on the drawings.

C. Fiberglass cable trays

1. Tray: NEMA FG1
2. Material and finish of tray, fittings, and accessories: Glass fiber reinforced polyester.
3. Inside width: 12 inches minimum or as indicated on Drawings.
4. Inside depth: 4 inches minimum or as indicated on Drawings
5. Inside Radii of Fittings: 12 inches or as indicated on Drawings.

6. Accessories and Fittings: Manufacturer's standard clamps hangers, brackets, splice plates, reducer plates, blind ends, barrier strips, and connectors.
 7. Covers: Solid covers where indicated on the drawings.
- D. Warning signs for cable trays
1. 1/2-inch high black letters on yellow plastic with the following wording:
WARNING! DO NOT USE CABLE TRAY AS WALKWAY, LADDER,
OR SUPPORT. USE ONLY AS MECHANICAL SUPPORT FOR CABLES
AND TUBING!

PART 3 EXECUTION

3.1 INSTALLATION - CONDUIT

- A. Install products as indicated, in accordance with the applicable requirements of NEC, NEMA and the National Electrical Contractors Association's "Standard of Installation".
- B. Cut conduit square using a saw or pipe cutter. De-burr cut ends. Joints in steel conduit must be painted with T&B Kopr shield and drawn up tight. Threads for rigid metal conduit and IMC shall be deep and clean. Running threads shall not be used. Wipe plastic conduit clean and dry before joining. Apply full, even coat of cement with brush to entire area that will be inserted into fitting. Let joint cure for 20 minutes minimum. Spray type of cement is not acceptable. Install raceway and conduit system from point of origin in outlets shown, complete with support assemblies including all necessary hangers, beam clamps, hanger rods, turnbuckles, bracing, rolls, clips angles, through bolts, brackets, saddles, nuts, bolts, washers, offsets, pull boxes, junction boxes and fittings to ensure a complete functional raceway system. Where vertical drops of conduit are made to equipment in open space, the vertical conduit shall be rigidly supported from racks supported on the floor.
- C. Install rigid wall hot-dipped galvanized steel conduit or hot-dipped galvanized intermediate metal conduit for service entrance; feeders; wall or floor penetrations; mechanical rooms electrical rooms and exposed locations where there is a high potential subject to physical damage; exposed outdoor locations; damp locations or any location as per design drawing. The following exceptions permitted:
 1. EMT
 - a. In sizes up to and including 1-1/2 inch, may be used inside dry locations where not subject to mechanical damage. EMT may be used in air-conditioned spaces, such as accessible ceilings, dry wall partitions and exposed where 6 feet above the floor. EMT may not be used outside, in concrete, underground, in under floor spaces, in masonry walls, in locations likely to be damp, in electrical rooms subject to mechanical damage due to future installation, or exposed within 6 feet of the floor. EMT shall not be used for medium voltage circuits.

- b. Where used for feeder circuits receptacle branch circuits and motor branch circuits EMT shall also contain a NEC grounding conductor.
 - c. All conduits shall be concealed in walls or ceilings unless otherwise noted.
 - 2. PVC (underground use only)
 - a. Install PVC schedule 40 conduit where direct buried in earth.
 - b. Type EB, Utility Duct, encased in concrete.
 - 3. Liquid-tight
 - a. Install liquid-tight flexible metal conduit for connections to rotating, vibrating, moving or movable equipment, including dry-type transformers. Install external ground wire on flexible conduit with grounding bushings. Maximum length shall be 6 feet minimum of 2 feet.
 - 4. Flexible Metal Conduit
 - a. Install standard flexible metal conduit (not liquid-tight), which shall be only used for lighting fixture whips or motor vibrations, with internal ground wire. Install flexible conduit connection such that vibrations are not transmitted to adjoining conduit or building structure. Maximum length shall be 6 feet minimum of 3 feet; minimum size shall be 3/4; and minimum size shall be 1/2 inch for lay-in light fixture whips.
- D. Install conduits parallel and supported on Unistrut, or equal, trapezes and anchored with split ring hangers, conduit straps or other devices specifically designed for the purpose. No raceways or boxes shall be supported using wire. Arrange conduit to maintain headroom and present a neat appearance. Conduit routes shall follow the contour of the surface it is routed on. Route exposed conduit and tray above accessible ceilings parallel and perpendicular to walls and adjacent piping. Maintain 12-inch clearance between conduit and heat sources, such as flues, steam pipes, and heating appliances. Wire ties or "wrap lock" are not permitted to support or secure conduit system. Fasten conduit with the following material:
 - 1. Wood screws on wood
 - 2. Toggle bolts on hollow masonry
 - 3. Bolts and expansion anchors in concrete or brick
 - 4. Machine screws, threaded rods and clamps on steel
 - 5. Conduit clips on steel joists.
 - 6. 4 inch x 4 inch penta-treated pine installed in pitch pans on roof, spaced at intervals not to exceed 5 feet.
- E. Install conduits outside of building lines at a minimum depth of 30 inches below finished grade. Maintain twelve inches earth or two inches concrete separation between electrical conduits and other services or utilities underground. Encase all plastic service entrance conduits with concrete unless otherwise specifically detailed or noted on the drawings.

- F. Ducts in concrete encased ductbanks shall be independently supported by interlocking module spacers by Formex or equal. Spacers shall provide 3 inches separation between adjacent ducts. Spacers shall be installed at 6 feet maximum intervals.
- G. Ducts in concrete encased ductbanks shall be terminated in manholes, pull boxes, and vaults with interlocking terminators . A watertight tapered plug shall be furnished and installed in unused duct openings. Where terminators are installed in new work, they shall be poured-in-place.
- H. Install underground conduits with sealing glands equal to OZ Type FSK exterior to the conduit and OZ type CSB, or equal internally at the point where conduits enter the building to prevent water seepage into the building.
- I. Fittings shall be approved for grounding purposes or shall be jumpered with a copper grounding conductors of appropriate ampacity. Leave termination of such jumpers exposed.
- J. Install expansion fittings in metal and PVC conduit as follows:
 - 1. Conduit Crossing Building Expansion Joints:
 - a. EMT all sizes
 - b. IMC all sizes
 - c. RMC all sizes
 - d. PVC all sizes
 - 2. Conduits entering environmental rooms and other locations subject to thermal expansion and as required by NEC.
 - 3. Unless expansion fitting has an integral bonding braid, as in Crouse-Hinds Type XC, a green insulated grounding conductor shall be pulled in the conduit. Both ends of this green grounding conductors shall be accessible for inspection.
- K. Install conduit concealed in walls, partitions and above ceilings. Install conduit exposed in ceiling area (at structure) of boiler rooms, mechanical rooms and in other similar rooms where ceilings are not called for. Install conduit concealed in slab when finished areas below do not have ceiling. A written approval shall be obtained from Owner/Structural Engineer prior to construction.
- L. Avoid moisture traps where possible; where unavoidable, provide junction box with drain fitting at conduit low point.
- M. Use suitable conduit caps to protect installed conduit against entrance of dirt and moisture if cable or wire are not installed immediate after conduit run. Tape covering conduit ends is not acceptable.
- N. Provide 200 lb. nylon cord full length in empty conduit.
- O. Where conduit penetrates fire-rated walls and floors, provide pipe sleeve two sizes larger than conduit; pack void around conduit with oakum and fill ends of sleeve with fire-resistive compound or provide mechanical fire-stop fittings with UL listed

fire-rating or seal opening around conduit with UL listed foamed silicone elastomer compound equal to fire-rating of floor or wall.

- P. Install no more than the equivalent of three 90-degree bends between boxes. Where four 90 degree bends are required, prior approval by the Engineer is required. Use conduit bodies to make sharp changes in direction, as around beams. Conduit bodies shall be readily accessible and sized for the cables installed. Running or rolling offsets are not approved. Use factory long radius elbows for bends in conduit larger than 2-inch size. All parallel bends shall be concentric.
 - Q. Conduit entering / exiting cable tray shall be attached to the tray rail by means of strut bolted to the rail and standard manufacturer's accessories or by use of a UL listed conduit to tray connector. Conduit shall only enter / exit tray horizontally supported within 3 feet of the tray and extend into the tray 2 inches. Conduit shall be terminated with a grounding bushing and bonded to the ground conductor routed in the tray. (The attachment to the tray shall not be considered a ground.)
 - R. Pull string shall be provided full length in conduit designated for future use.
- 3.2 INSTALLATION - SURFACE METAL RACEWAY AND MULTI-OUTLET
- A. Use flathead screws to fasten channel to surfaces. Mount plumb and level.
 - B. Use suitable insulating bushings and inserts at connections to outlets and corner fittings on multi-outlet assembly.
 - C. Maintain grounding continuity between raceway components to provide a continuous grounding path in accordance with the requirement of NEC.
- 3.3 INSTALLATION - WIREWAYS
- A. Bolt wireways to steel channels fastened to the wall or in self-supporting structure.] Install level.
 - B. Gasket each joint in oil-tight wireway.
 - C. Mount rain tight wireway for exterior installation in horizontal position only.
- 3.4 INSTALLATION - BOXES
- A. Provide electrical boxes as shown on Drawings, and as required for splices, taps, wire pulling, equipment connections, and code compliance.
 - B. Provide outlet box accessories as required for each installation, including mounting brackets, wallboard hangers, extension rings, fixture studs, cable clamps and metal straps for supporting outlet boxes, compatible with outlet boxes being used and meeting requirements of individual situations.
 - C. Electrical box locations shown on Contract Drawings are approximate unless dimensioned. Verify location of outlets prior to rough-in.
 - D. Locate and install boxes to allow access, minimum 12 inches above ceiling except where space dimensions do not allow.
 - E. Do not install boxes back-to-back in walls. Provide minimum 6-inch separation. Provide minimum 24-inch separation in acoustic-rated walls. If boxes are

connected together, install flexible connection between the two and pack openings with fiberglass.

- F. Secure boxes rigidly to the substrate upon which they are being mounted, or solidly imbed boxes in concrete or masonry. Do not support junction boxes from the raceway systems. Boxes shall not be permitted to move laterally. Boxes shall be secured between two studs. Boxes connected to one stud are not permitted.
- G. Provide knockout plugs for unused openings.
- H. Use multiple-gang boxes where more than one device is mounted together. Do not use sectional boxes. Provide barriers to separate wiring of different voltage systems.
- I. Install boxes in walls without damaging wall insulation.
- J. Outlet boxes in plaster partitions shall be "shallow-type" set flush in wall so there is at least 5/8 inch plaster covering back of box.
- K. Outlet boxes for switch shall not be used as junction boxes.
- L. Coordinate mounting heights and locations of outlets mounted above counters, benches and backsplashes.
- M. In inaccessible ceiling areas, position outlets and junction boxes within 6 inches of recessed luminaire, to be accessible through luminaire ceiling opening.
- N. Outlet boxes supporting fixtures shall be securely anchored in place in an approved manner. Support outlet boxes and fixtures in acoustic ceiling areas from building structures, not from acoustic ceilings. Lighting fixture outlets shall be coordinated with mechanical and architectural equipment and elements to eliminate conflicts and provide a workable neat installation.
- O. Set floor boxes level and flush with finish flooring material.
- P. Provide tamper resistance receptacles in child care areas, psychiatric, and medical facilities.

3.5 INSTALLATION – CABLE TRAY

- A. Installation: In conformance with NEC and NEMA requirements and in accordance with manufacturer's instructions. Arrange cable tray to maintain headroom and present neat appearance. Cables shall be arranged in cable trays in a neat, workmanlike manner.
- B. Support cable tray at each connection point, at the end of each run, and at other points to maintain spacing between supports of 10 feet maximum. Trays shall be level with respect to grade plus or minus 1/8-inch per 10 feet or 1/2-inch cumulative. Unless otherwise noted cable trays shall be supported by rigid steel brackets or trapeze type hangers. Hanger materials, including threaded hanger rods, all brackets, and other structural support items shall be per 16190, Supporting Methods and shall have sufficient strength to support the load with a safety factor of at least 3 when all trays are filled to design capacity. Where multiple tiers of cable tray are installed, a minimum of 100-lbs./foot fill for each cable tray shall be

used to establish support requirements if limiting factor is the supporting material. In fabricating or installing cable tray supports, holes shall be drilled and cuts made with a saw. Hanger rods shall be of 1/2-inch or larger diameter, shall be double-nutted at the lowest cable tray support and the hanger rod shall be cut off one (1) inch below the bottom nut. Cable tray support spacing shall not exceed 10 feet for ladder type trays. Hanger rods shall be unspliced. Cable trays installed on trapeze type hangers shall be braced laterally at intervals not exceeding 50 feet. Refer to Section 26 05 29 for cable tray support methods.

- C. Where it is necessary to make field changes in the tray system, cuts shall be made with hacksaw or power saw. All sharp edges and burrs shall be removed.
- D. Install warning signs at 50 foot centers along route of cable tray, in locations visible from the floor.
- E. Where new cable trays are installed above, below or in-line with existing cable trays, the new cable tray shall be supported independently from the existing cable tray with new supports and framing unless approved by the Owner and the Structural Engineer. Maintain twelve-inch clearance between cable tray and surfaces with temperatures exceeding 104 degrees F, such as flues, steam pipes, and heating appliances. Maintain at least 6-inch clearance between cable tray and piping, ductwork or other interference. Any deviation from this must be approved by the Owner. It shall be the Contractor's responsibility to protect existing cable tray in the area of construction against damage throughout the construction period. Any damaged cable tray shall be replaced by the Contractor at no additional cost prior to final acceptance by the Owner.
- F. All power cable trays shall have a continuous; No. 4/0 insulated copper, (for aluminum tray) and bare copper (for galvanized steel tray) grounding conductor run inside the tray. Bond No. 4/0 to each section of tray and fitting with an OZ Gedney type CTGC ground clamp. All communication cable trays shall have a continuous, No. 6, green insulated copper grounding conductor run inside the tray. Connect to tray at each fitting or tray section per the Drawings.
- G. Maintain electrical continuity between sections of cable tray and bond cable trays at the both ends to building ground plates to provide a continuous grounding path. Install copper braided bonding jumpers around expansion joints and hinged adjustable splice plates where electrical discontinuity occurs.
- H. Cable tray in designated "Corrosive" areas shall be fiberglass.

3.6 INSTALLATION - INDOOR SERVICE POLES

- A. Verify that installation of ceiling suspension system and other work above finished ceiling is complete.
- B. Neatly cut openings in ceiling panels.
- C. Attach foot and top clamp in accordance with manufacturer's instructions.
- D. Install trim plate to enclose ceiling panel opening.
- E. Install poles plumb. Install grounding.

3.7 WALL AND FLOOR PENETRATIONS:

- A. Core drilling shall be approved in writing by the Structural Engineer prior to execution. Avoid anchor bolt on structural column by installing “column hugging” type of unistrut support for electrical installation. PVC shall not be used for wall and floor penetration.
- B. Wall penetrations for cable tray or under floor raceway shall be sealed in accordance with Specification Section 07840, Fire-stopping and Section 07900, Joint Sealers.
- C. Provide a 3 1/2 inch curb around block outs through concrete floors. Fire-stop per Architectural specification.
- D. Route conduit through roof openings for piping and ductwork where possible; otherwise, route through roof jack with pitch pocket. Coordinate roof penetrations with the roofing contractor.

END OF SECTION

SECTION 26 05 53
ELECTRICAL IDENTIFICATION

PART 1 GENERAL

1.1 WORK INCLUDED

- A. Nameplates and tape labels
- B. Wire and cable markers
- C. Conduit color coding and labeling

1.2 REFERENCES

- A. NFPA 70 – National Electrical Code (latest edition)

1.3 SUBMITTALS

- A. Provide submittals in accordance with and in addition to Section 26 00 00, Basic Electrical Requirements, and Division 01 for submittal requirement.
 - 1. Furnish nameplate identification schedules listing equipment type and nameplate data with letter sizes and nameplate material.

PART 2 PRODUCTS

2.1 MATERIALS

- A. Equipment Nameplates:
 - 1. For normal power electrical equipment, provide engraved three-layer laminated plastic nameplates, engraved white letters on a black background.
 - 2. For emergency equipment provide engraved three-layer laminated plastic nameplates with engraved white letters on a red background.
 - 3. For UPS powered equipment provide engraved three-layer laminated plastic nameplates with engraved white letters on an orange background.
 - 4. For fire alarm system provide engraved three-layer laminated plastic nameplates with white letters on a yellow background.
 - 5. For security and CCTV system panels, provide engraved three-layer laminated plastic nameplates with white letters on a blue background.
- B. Underground Warning Tape
 - 1. Manufactured polyethylene material and unaffected by acids and alkalines.
 - 2. 3.5 mils thick and 6 inches wide.
 - 3. Tensile strength of 1,750 psi lengthwise.
 - 4. Printing on tape shall include an identification note BURIED ELECTRIC LINE, and a caution note CAUTION. Repeat identification and caution notes over full length of tape. Provide with black letters on a red background.

- C. Conductor Color Tape and Heat Shrink:
 - 1. Colored vinyl electrical tape shall be applied perpendicular to the long dimension of the cable or conductor.
 - 2. In applications utilizing tray cable, heat shrinkable tubing shall be used to obtain the proper color coding for the length of the conductor in the cabinet or enclosure. Variations to the cable color coding due to standard types of wire or cables are not acceptable.
- D. Conduit Labels (5 kV and 15 kV Conduits Only): 2-inch black letters on yellow background reading "DANGER - 12,470 VOLTS" or "DANGER - 4,160 VOLTS". Labels shall have adhesive backing, and shall be installed at intervals not exceeding 50 feet and on all pull boxes located to be visible from floor.
- E. Warning labels: Provide warning labels with black lettering on red background with a minimum of 1/2" lettering.
- F. Tape Labels: Embossed adhesive tape, with minimum 1/4-inch letters for labeling receptacles, switches, control device stations, junction and pull boxes and manual motor starter units, etc.
 - 1. White letters on black background for normal power.
 - 2. White letters on red background for emergency/standby power.
 - 3. White letters on orange background for UPS power.
- G. J-Box and Cover plate Voltage Labels: Black stenciled letters 1/4" high. Adhesive back tapes may be used if a clear tape is applied over the label for protection.

PART 3 EXECUTION

3.1 INSTALLATION

- A. Degrease and clean surfaces to receive nameplates or tape labels.
- B. Install nameplates parallel to equipment lines.
- C. Secure plastic nameplates to equipment fronts using screws or rivets. Use of adhesives shall be per Owner's approval. Secure nameplate to outside face of flush mounted panelboard doors in finished locations.

3.2 WIRE IDENTIFICATION

- A. Provide wire markers on each conductor in panelboard gutters, pull boxes, outlet and junction boxes, and at load connection. Identify with branch circuit or feeder number for power and lighting circuits. Label control wire with number as indicated on schematic and interconnection diagrams or equipment manufacturer's shop drawings for control wiring.
- B. Conductors for power circuits to be identified per the following schedule.

NOTE TO SPEC WRITER: EDIT THE FOLLOWING DESCRIPTIVE SPECIFICATIONS FOR ANY CONFLICTS WITH THE EXISTING COLOR CODING.

Conductor	System Voltage			
	480/277V	208/120V	240/120V High Leg	Medium Voltage
Phase A	Brown	Black	Black	One White Band
Phase B	Purple	Red	Orange	Two White Bands
Phase C	Yellow	Blue	Blue	Three White Bands
Neutral	Gray	White	White	N/A
Grounding IG	Green N/A	Green Green w/Yellow	Green Green w/Yellow	Green N/A

3.3 NAMEPLATE ENGRAVING SCHEDULE

- A. Provide nameplates of minimum letter height as scheduled below. Nameplates shall be same as equipment names indicated on the Drawings.
- B. Individual Circuit Breakers in Distribution Panelboards, Disconnect Switches, Motor Starters, and Contactors: 1/4-inch; identify source to device and the load it serves, including location.
- C. Dry Type Transformers Not in Substations: 3/8-inch; identify equipment designation. 1/4-inch; identify primary and secondary voltages, primary source, and secondary load and location.
- D. Automatic Transfer Switches: 3/8-inch; white letters and red background; identify equipment designation 1/4-inch; identify voltage rating, normal source, standby source and load served including location.
- E. Panelboards: 3/8-inch; identify equipment designation. 1/4 -inch; identify source, voltage and bus rating.

3.4 ENCLOSURE COLOR CODING

- A. The following systems shall have each junction and pull box cover completely painted per the following:

NOTE TO SPEC WRITER: EDIT THE FOLLOWING DESCRIPTIVE SPECIFICATIONS FOR ANY CONFLICTS WITH THE EXISTING CONDITION.

System	Color of Box Cover
Ethernet Backbone	Blue
Telecommunications	Brown
FCMS	Green
Emergency Power	Red

Security**	White
Fire Alarm	Yellow
Clock	Fluorescent Violet
U.P.S.	Fluorescent Pink

**Security shall include, but not be limited to, the following systems:

- Card Access
- Duress Alarms
- Perimeter Door Alarms
- CCTV

END OF SECTION

SECTION 26 12 13
SECONDARY SUBSTATION TRANSFORMERS (LIQUID FILLED)

PART 1 – GENERAL

1.1 WORK INCLUDED

- A. Indoor or outdoor liquid filled secondary substation transformers (medium voltage) for rating and installation as indicated on Drawings.
- B. The indoor substation type liquid-filled transformers are part of unit substation that also consists of low-voltage metal-enclosed switchgear. All equipment in the unit substation shall be products of the same manufacturer who furnishes the low voltage metal-enclosed switchgear. The indoor liquid filled transformers shall be less-flammable.

1.2 RELATED WORK

- A. Section 26 24 13.UT - Switchboards
- B. Section 26 13 00.UT - Metal-Enclosed Switchgear (Medium Voltage)
- C. Section 26 05 26.UT - Grounding

1.3 REFERENCES

- A. IEEE C57.12.00 - General Requirements for Liquid-Immersed Distribution, Power and Regulating Transformers
- B. ANSI C57.12.10 – Requirements for Transformers 230 kV and Below
- C. IEEE C57.12.70 – Terminal Markings and Connections for Distribution and Power Transformers
- D. IEEE C57.12.90 - Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers
- E. IEEE C57.98 – Guide for Transformer Impulse Tests
- F. IEEE C57.109 – Guide for Liquid Immersed Transformer Through-Fault-Current Duration
- G. IEEE C57.111 – Guide for Acceptance of Silicon Insulating Fluid and Its Maintenance in Transformers
- H. IEEE C57.121 – Guide for Acceptance and Maintenance of Less Flammable Hydrocarbon Fluid in Transformers
- I. NEMA TR1: Transformers, Regulators, and Reactors

1.4 SUBMITTALS

- A. Provide submittals in accordance with and in addition to Section 26 00 00, Basic Electrical Requirements, and Division 01 for submittal requirement.

1. Outline dimensions including plan and elevation views, base plan, and conduit entry (top or bottom) opening dimensions.
 2. Support points, locations of all accessories, bushings, and terminal compartments.
 3. Transformer diagrammatic nameplate (each unit) including manufacturer, primary voltage and connections, secondary voltage and connections, rated KVA, number of phases, number and percent taps, frequency and percent impedance.
 4. Schematic and interconnection diagrams for control and monitoring devices.
 5. Location for floor channels, anchor bolts, drain valve, and ground pads.
 6. Total weight of unit (transformer and filling liquid).
 7. Transformer winding temperature rise.
 8. Filling liquid capacity in gallons.
 9. Bill of material showing components, ratings, and part numbers.
 10. Product descriptive literature including standard factory tests for each unit, and options for similar units.
 11. Short-circuit withstand capacities.
- B. Submit dimensioned drawings of transformers, including support points, lifting eyes and brackets.
- C. Submit the following information as a complete set in 3-ring binder after fabrication, assembly, delivery, installation, and field testing. Deliver to Owner no later than the training included in the contract.
1. Operation and Maintenance manual.
 2. Maintenance schedule for the first cycle of scheduled maintenance, not less than 12 months.
 3. Spare parts list, renewable parts list, and consumable list.
 4. As-built drawings including final fabrication drawings of items specified in 1.4, this Section.
 5. Certified test reports.

1.5 DELIVERY, STORAGE AND HANDLING

- A. Store in a clean dry location.
- B. Handle transformers using only lifting eyes and brackets provided for handling purposes. Protect units against damage from rain, sleet, or snow if handled in inclement weather.

PART 2 -- PRODUCTS

2.1 SECONDARY SUBSTATION TRANSFORMERS

NOTE TO SPEC WRITER: SELECT APPROPRIATE CONSTRUCTION IN PARAGRAPH "A" BELOW.

- A. Transformers shall be equipped with a [close-coupling] [air filled terminal compartment] on the high voltage side, and a [close-coupling] [air filled terminal compartment] on the low voltage side.

NOTE TO SPEC WRITER: COMPLETE TRANSFORMER RATINGS IN PARAGRAPH "B" BELOW.

- B. The ratings of each transformer shall be as follows:

KVA Rating: [_____] [_____ / _____] [OA] [OA/FA], 3PH, 60HZ

Temp. Rise: The average temperature rise of the windings measured by the resistance method, shall be [65°] [55°] C when the transformer is operated at rated KVA output in a 40° C ambient, without loss of life expectancy.

Impedance: 7-1/2% or per drawings.

H. Voltage: _____ [delta] [wye]

H.V. BIL: _____ KV

H.V. Taps: 2 - 2-1/2% full capacity above and below rated voltage

L. Voltage: _____ [delta] [wye]

L.V. BIL: _____ KV

NOTE TO SPEC WRITER: SELECT APPROPRIATE LIQUID IN PARAGRAPH "C" BELOW USE ONLY NON-FLAMMABLE LIQUID FOR INDOOR APPLICATIONS.

- C. The units shall be [silicone] [mineral oil] [high fire point hydrocarbon R-Temp fluid] filled and shall be in accordance with the latest edition of the NEC. The insulating liquid shall be shipped in the tank of the transformer.

NOTE TO SPEC WRITER: SELECT APPROPRIATE PARAGRAPH "D" BELOW.

- D. Transformers shall include all devices, wiring, fans and auxiliary equipment necessary for automatic temperature controlled forced-air cooling. Control power for fans shall be 230 volt AC, single phase, furnished from a control transformer in the secondary switchgear.

- E. The transformers shall be designed to carry short time emergency overloads in accordance with ANSI standards. Duration and magnitude of designed short circuit withstand capability shall be as outlined in IEEE C57.12.00.

- F. Transformer features and accessories shall include:

1. De-energized tap changer with cover mounted, externally operated, pad lockable handle;
2. Liquid temperature indicator with maximum indicating hand and alarm contacts;
3. Combination drain and filter valve and sampling device;
4. Manual gas pressure test connection;

5. 1" filling plug and filter press connection in cover;
6. Top liquid thermometer (dial type), with alarm contacts, connected to Building Automation System (BAS);
7. Magnetic liquid level gauge, with low level alarm contacts, connected to BAS;
8. Provision for lifting;
9. Provision for jacking on tank or base;
10. Base for skidding or rolling in two directions;
11. Automatic pressure relief device that automatically reseals after operation, with alarm contacts, connected to BAS;
12. Sudden pressure relay with tripping/alarm contacts, connected to BAS;
13. Ground pad;
14. Instruction and diagrammatic nameplate;
15. Pressure vacuum gauge;
16. Welded-on main tank cover and handhole in cover;
17. Bushings per ANSI Standards with copper conductors and terminals. Bushing may be [cover mounted] or [left/right] oriented.
18. Flexible bus braid connections, terminals, and fasteners for connecting the transformer secondary and the substation, rated for the maximum transformer ampacity configuration.

G. Windings shall be wound with [copper] [aluminum] conductors.

H. The main transformer tank and attached components shall be designed to withstand pressures 25% greater than the design value without permanent deformation. Construction shall be from carbon steel plate reinforced with external sidewall braces. All seams and joints shall be continuously welded.

I. Each radiator assembly shall be individually welded and receive a quality control pressurized check for leaks. The entire tank assembly shall receive a similar leak test before tanking. A final six-hour leak test shall be performed after the transformer is tanked, welded and completed to ensure that there are no leaks before shipment.

NOTE TO SPEC WRITER: EDIT PARAGRAPH "J" BELOW.

J. [Indoor units shall be painted ANSI NO. 61 (light gray) [and] [outdoor units shall be painted ANSI NO. 24 (dark grey)].

K. Manufacturer shall perform the following tests on all transformers:

1. Resistance measurements of all windings on the rated voltage connection and at the tap extremes.
2. Ratio tests on the rated voltage connection and on all tap connections.

3. Polarity and phase-relation tests on the rated voltage connections.
 4. No-load loss at rated voltage on the rated voltage connection.
 5. Exciting current at rated voltage on the rated voltage connection.
 6. Impedance and load loss at rated current on the rated voltage connection and on the tap extremes.
 7. Applied potential tests.
 8. Induced potential tests.
 9. Temperature Test:
 - a. Furnish temperature tests for each size and type transformer. Certified tests of a similar unit of identical size and type will be acceptable.
 - b. When a transformer is furnished with auxiliary cooling equipment to provide more than one KVA rating, temperature tests shall be made on both the lowest KVA OA rating and on the highest KVA FA rating.
 10. All tests shall be conducted in accordance with the latest revision of ANSI C57.12.90 and NEMA TR2.
 11. Furnish manufacturer's certified test report.
 12. Owner reserves right to witness tests. Provide four-week notice of testing schedule.
- L. Audible sound level shall comply with NEMA TR1.

PART 3 -- EXECUTION

3.1 EXAMINATION

- A. Verify that pads are ready to receive work.
- B. Verify field measurements are as shown on Drawings and as indicated by manufacturer's shop drawings.
- C. Verify that required utilities are available, in proper location, and ready for use.
- D. Beginning of installation means installer accepts conditions.

3.2 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install safety labels to NEMA requirements.
- C. Secondary containment for spill control maybe required. Coordinate and comply such requirement with the Owner.

3.3 FIELD QUALITY CONTROL

- A. Check for damage and tight connections prior to energizing transformers. Check primary, secondary, and ground connections.
- B. Clean and inspect bushings.

- C. Inspect bushing clamps and gaskets.
- D. Inspect cover and handhole gasket seals.
- E. Inspect tap change seals.
- F. Check fluid leaks and external damage to radiators.
- G. Check liquid level.
- H. Check accessory devices for condition and proper operation.
- I. Measure primary and secondary voltages and make appropriate tap adjustments within zero to two percent of rated voltage at no load.
- J. Check phase rotation and make appropriate changes in connection to match phase rotation between units connected in secondary-selective schemes.
- K. Insulation resistance test: Megger transformer windings high to low and ground, low to high and ground, and high and low to ground.
- L. Perform turns ratio test.
- M. Where auxiliary cooling has been provided, verify proper operation of such equipment.
- N. Field test reports shall be forwarded to the Owner.

END OF SECTION

SECTION 26 13 00
METAL ENCLOSED SWITCHGEAR (MEDIUM VOLTAGE)

PART 1 - GENERAL

1.1 WORK INCLUDED

- A. Metal enclosed medium voltage switchgear for rating and installation as indicated on Drawings.

1.2 REFERENCES

- A. ANSI C37.04 and 06 - Standard for Indoor AC Medium-Voltage Circuit Breakers used in Metal-Clad Switchgear
- B. ANSI C37.55 - American National Standard for Metal-Clad Switchgear Assemblies Conformance Test Procedures.
- C. ANSI C57.13 - Requirements for Instrument Transformers
- D. ANSI C37.90a - Surge Withstand Capability Test.
- E. ANSI 37.20.2 Standard for Metal-Clad Switchgear
- F. NFP-70 - Medium Voltage Switchgear.

1.3 SUBMITTALS

- A. Provide submittals in accordance with and in addition to Section 26 00 00, Basic Electrical Requirements, and Division 01 for submittal requirement.
- B. Provide certified shop drawings, literature, and samples upon request showing proposed for use. Use NEMA device designations and symbols for all electric circuit diagrams submitted.
- C. Submit dimensioned drawings of metal enclosed switchgear showing accurately scaled basic units including, but not necessarily limited to, front and side view elevations showing arrangement of all devices, auxiliary compartments, unit components and combination units, floor plan, top and bottom views showing entry and exit space for conduits. Submit schematic equipment schedules, and bill of materials.
- D. Submit assembly ratings including, but not limited to, short-circuit rating, voltage, continuous current, and basic impulse level for equipment over 600 volts.
- E. Submit major component rating including, but not limited to, voltage, continuous current, interrupting current, and coordination curves for each type and rating of circuit breaker.
- F. Submit schematics and wiring diagrams for metering and controls.
- G. Furnish, upon request, manufacturer's certification of rating of the basic switch and fusing components and the integrated metal-enclosed interrupter switchgear assembly.

- H. All device or equipment tag numbers that appear on shop drawings shall be consistent with design drawings.

1.4 PRODUCT DELIVERY, STORAGE AND HANDLING

- A. Deliver switchgear in factory fabricated water resistant wrapping.
- B. Maintain factory wrapping or provide an additional heavy canvas or plastic cover.
- C. Store switchgear in a clean and dry space and protected from weather in accordance with manufacturer's instructions.
- D. Shipping groups shall be designed to be shipped by truck, rail, or ship. Circuit breakers and accessories shall be packaged and shipped separately. Switchgear shall be equipped to be handled by crane. Where cranes are not available, switchgear shall be suitable for skidding in place on rollers using jacks to raise and lower the groups. Handle switchgear carefully to avoid damage to material components, enclosure and finish.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

- A. S&C Electric Company
- B. Cutler-Hammer
- C. GE Company
- D. Siemens
- E. Square D
- F. Other manufacturers equal in design and function will be considered upon A/E approval following substitution procedure in 26 00 00, and Division 01 for substitution requirement.

2.2 SWITCHGEAR CONSTRUCTION

- A. Switchgear shall be of the metal enclosed type complying with the design and function requirements of the project. Design characteristics shall be as noted in manufacturer's submittal data. The short circuit interrupting rating shall be as required by the result of the short circuit and coordination study, sealed by a Texas P.E.
- B. Provide metal enclosed switchgear assembly consisting of indoor or outdoor style as per Drawings self-supporting sections containing interrupter switches, power fuses and necessary accessory components, completely factory assembled and operationally checked.
- C. Complete assembly shall be constructed in accordance with minimum construction specifications of the switch and fuse manufacturer to provide adequate electrical clearances and adequate space for fuse handling, cable pulling and cable terminations.

NOTE TO SPEC WRITER: DELETE THE FOLLOWING PARAGRAPH IF OUTDOOR ASSEMBLY NOT USED.

- D. Outdoor units shall have drip-proof roof. Louvered rainproof ventilation openings shall be screened to prevent the entrance of small animals or insects. A minimum of one 250 watt, 120 volt, thermostat controlled space heater shall be provided in each cubicle. Power for the space heater shall be furnished as indicated on drawings or by a fused control transformer mounted within the switchgear.
- E. Enclosures shall be minimum 11-gauge panel-grade sheet steel with structural joints and butt joints welded and external seams ground flush and smooth. Each section containing high voltage components shall be a complete unit with full side sheets resulting in a double wall construction between sections. Sections shall consist of continuous 4" structural steel channel extending completely around all four sides of each section and welded or bolted at each corner. Provide removable lifting arms.
- F. Enclosure to be front accessible only. No access to high voltage through side or rear of the metal enclosed switchgear assembly and no front access to high voltage by means of externally removable panels.
- G. Doors shall be minimum 11-gauge panel-grade sheet steel of the bulkhead type construction full length with provisions for multiple padlocking. Each door shall have minimum of three concealed interlocking cam type high-strength latches. Each door shall have high impact safety glass viewing windows, which permit viewing of all three-switch blades through the closed door. Opening the fuse access door shall not be required to observe the blown fuse indicator or switch position.
- H. Provide a protective screen door, which will bolt closed to guard against inadvertent entry when the enclosure door is open for each section containing high-voltage components.
- I. Provide provisions to store spare fuses in each door access to fuses and fused voltage transformers.
- J. Main bus shall be made of 98 percent IACS conductivity copper bars with rounded edges, silver-plated and of bolted design. Rate the main bus not less than as shown on the drawings, based on continuous duty, including skin and proximity effect, insulation, steel enclosure, and a 65 degree C maximum temperature rise with an ambient temperature of 40 degree C. Brace bus components to amply resist forces due to short circuit currents equal to those specified for the circuit breakers. The bus shall be braced to withstand fault currents equal to the close and latch rating of the breakers. Insulate buses with epoxy-coated, flame-retardant and track-resistant material applied by fluidized bed process over the entire length. Rigidly support buses and provide flame-retardant, track-resistant, cycloaliphatic epoxy or glass polyester bus support for the duty required. Lugs shall be tin-plated copper.
- K. Interrupter switch and fuse mounting insulators and main bus supports shall be of a cycloaliphatic epoxy resin system or electrical grade porcelain with characteristics to ensure non-tracking properties and adequate leakage distance that withstand the

stresses associated with the short circuit rating of the switchgear, including proper allowance for transient conditions.

- L. Provide ground bus consisting of silver-plated copper bar in each section bolted to copper clad steel that is welded to the steel enclosure. Each individual ground connection, one per section, to have short circuit current capability consistent with the short circuit rating of integrated assembly. Extend ground bus through the entire length of the switchgear. Provide for future extension of ground bus at each end of switchgear.

NOTE TO SPEC WRITER: DELETE PARAGRAPH BELOW IF SURGE ARRESTERS ARE NOT REQUIRED IN SWITCHGEAR.

- M. Provide surge arresters, for type and rating as indicated on drawings. Surge arresters shall be solid-state type using metal oxide ceramic elements. Surge arresters shall be installed at the incoming terminations and securely grounded to the metal structure.

NOTE TO SPEC WRITER: DELETE PARAGRAPH BELOW IF NO KIRK KEY INTERLOCKS.

- N. Provide Kirk key interlocks as shown on the drawings.

NOTE TO SPEC WRITER: DELETE PARAGRAPH BELOW IF NO UTILITY COMPANY METERING IN SWITCHGEAR. CAMPUS KW DEMAND AND KWH METERING IS NORMALLY IN LOW VOLTAGE SWITCHGEAR.

- O. Metering cubicles shall contain current and potential transformers as required by the Utility Company and shall conform to the Utility Company metering standards including arrangement and size. It shall also conform to the general electrical and construction requirements of the fusible switch bays as specified.
- P. Make provisions for entrance of medium voltage conductors from the bottom of the switchgear. Make provisions for close coupling between the feeder circuit breaker in switchgear and the medium voltage transformer. Make provisions for entrance of medium voltage conductors from the bottom of the switchgear for each feeder breaker section designated for future. Incoming cable termination shall be compression type. Provide adequate room for indoor stress cones, six 500 kcmil per phase.
- Q. Barriers made of glass polyester meeting or exceeding the BIL of the bus insulation system shall be provided between fuse and switch compartments, between individual, and between outer phases and the enclosure. Finish in inaccessible areas shall have phosphatizing bath and iron oxide zinc-chromate anti-corrosion primer to ensure that all surfaces are protected.
- R. A conductive zinc coating shall be applied to interior and exterior surfaces to furnish cathodic protection for the steel, promote neutralization of atmospheric contaminants, improve finished covering at sharp edges and retard underfilm propagation of rust. The intermediate coat to be epoxy ester primer. Final coat of epoxy modified alkyd resin, color ANSI 61, gray.

- S. Ratings: The ratings for the integrated switchgear assembly shall be as follows:

Nominal Voltage Class Drawings	[4.16] [7.2] [13.8] [27.0] [34.5] KV as shown on Drawings
Maximum Design Voltage Drawings	[4.76] [8.25] [15.0] [27.0] [38.0] KV as shown on Drawings
Basic Impulse Level	[60] [95] [95] [125] [170] KV
Main Bus Drawings	[600] [1200] Amperes Continuous as shown on Drawings
Short Circuit Drawings	[] Ampere RMS Symmetrical as shown on Drawings

- T. Interrupter switches and interrupter switches with power fuses shall have a two-time duty-cycle fault-closing rating equal to or greater than the short circuit rating of the switchgear assembly. Switches shall have a single blade per phase for circuit closing including fault closing, continuous current carrying and circuit interrupting. Switches incorporating secondary flipper type interrupter blades are not acceptable.
- U. Interrupter switches intended for manual operation shall be operated by means of an externally mounted, non-removable handle. The handle shall have provisions for padlocking both the open and closed positions. Each switch shall be actuated by means of a quick-make, quick-break, manually operated, stored energy mechanism. The operating mechanism shall provide sufficient force to overcome the forces associated with closing the switch into a fault. Speed of opening or closing of contacts shall be independent of the operator. Mechanical linkages between the interrupter switchblades and operating mechanism shall be insulating material meeting or exceeding the BIL of the bus insulation system.
- V. Provide a traveling crane hoist mounted on a rail on top of each section of switchgear or a freestanding separate crane hoist cart, which shall be used for moving the breaker elements. Provide all accessories. Sufficient room space shall be provided to accommodate such operation.

2.3 MEDIUM VOLTAGE FUSES

- A. Furnish SM series standard speed fuse refills for metal enclosed switchgear as manufactured by S&C Electric Company, or equal.
- B. Fuses shall be capable of detecting and interrupting faults down to the minimum melting current with line-to-line or line-to-ground voltage across the fuse and capable of handling the full range of transient recovery voltage associated with these faults.
- C. Fuses shall have minimum melting time-current characteristics accurate to within +10%.
- D. Fuses shall be non-aging and non-damageable so that it is unnecessary to replace unburn fuses in single phase or three phase installations where one or more of the fuses have blown.
- E. Furnish six spare fuses of each size and type used on project.

2.4 CIRCUIT BREAKERS

- A. Provide horizontal drawout type vacuum circuit breakers designed for use in metal-clad switchgear. Make breakers of same current rating completely interchangeable. Provide circuit breakers capable of being withdrawn on rails. The circuit breakers shall be operated by a means of a stored energy mechanism, which is normally charged by a universal motor but can also be charged by the manual handle on each breaker for manual emergency closing or testing. The closing speed of the moving contacts shall be independent of both the control voltage and the operator. Provide a full front shield on the breaker.
- B. The racking mechanism to move the breaker between positions shall be operable with the front door closed and position indication shall be visible with door closed. A Mechanical interlocking system shall be provided to prevent racking a closed circuit breaker to or from any position. An additional interlock shall automatically discharge the stored energy operating mechanism springs upon removal of the breaker out of the compartment.
- C. Provide breakers with current ratings as shown on drawings. Provide breakers with maximum symmetrical interrupting rating as shown on drawings.
- D. Each circuit breaker shall contain three vacuum interrupters separately mounted in a self-contained, self-aligning pole unit, which can be removed easily. The vacuum interrupt pole unit shall be mounted on cycloaliphatic epoxy supports for rated voltage. An integral contact wear indicator indicating available contact life for each vacuum interrupter shall be easily visible when the breaker is removed from its compartment. Make primary, main and secondary contacts of silver-plated copper.
- E. Provide breakers operated by motor-charged-spring, stored-energy mechanisms. Additionally, provide a manual means of charging the mechanism and of slowly opening the contacts for inspection or adjustment. The circuit breaker control voltage shall be 125 volts AC or as indicated on drawings. When DC power is specified for control voltage, the control voltage shall match station battery. Secondary control circuit shall be connected automatically with a self-aligning, self-engaging plug and receptacle arrangement when the circuit breaker is racked into the connected position. Provide capacitor trip stored energy mechanism for each circuit breaker.
- F. Provide a mechanism for moving the breaker from the connected to the test/disconnected position and for removal from the compartment. Provide padlocking capability for both positions.
- G. Provide each breaker with six auxiliary MOC (Mechanism Operated Cell) contacts (3 normally open, and 3 normally closed) operated by the MOC auxiliary switch to indicate status of breaker in open or closed position. Provide each breaker with six auxiliary TOC (Truck Operated Cell) contacts (3 normally open, and 3 normally closed) operated by the TOC auxiliary switch to indicate status of breaker in connected or test/disconnected position.

2.5 PROTECTIVE RELAYS

- A. Provided factory installed microprocessor-based relays for overcurrent protection, in the metal clad switchgear. Relays shall be factory calibrated and blocked before shipment. All relays shall have integral test switches.
- B. The quantity, ANSI device function type and rating of protection relays shall be as indicated on the Drawings. Functions shall be adjustable.
- C. Protective relay shall be drawout type, with test switches and devices incorporated in the relay unit. Include hand reset tripping indicators. Provide RS-485 port for external communications.
- D. Relay shall have low burden characteristics, high thermal capacity and negligible temperature error. All settings shall be readily visible and accessible from the front of the relay.
- E. Specific characteristics and relay settings shall be in accordance with the Short Circuit and Device Coordination Study.

2.6 INSTRUMENT TRANSFORMERS

- A. Install and connect at the factory instrument transformers with primary/secondary ratio specified on drawings, 60 hertz, burden and accuracy consistent with connected metering and relay devices.
- B. Design instrument voltage transformers (PT) to fit into and coordinate with the complete switchgear units, including the instruments, relays, meters, and devices specified. Voltage transformers shall be per phase, drawout mounted, disconnecting type with integral primary and secondary fuses. Provide rails for each drawer to allow easy inspection, testing, and fuse replacement. Interlock with compartment access door to disconnect, ground and isolate from primary voltage when door is open.
- C. Design instrument current transformers (CT) for installation on bushings of primary disconnecting contacts in circuit breakers. The standard location for the current transformers on the bus side and line side of the medium voltage switchgear shall be front accessible to allow adding or changing current transformers without removing medium voltage insulation connections.
- D. Control transformers shall be 120V, 60 Hertz, 15 KVA minimum, single-phase, drawout mounted, disconnecting type with integral primary and secondary fuses. Provide 100amp 120V circuit breakers for control transformer secondary protection. Interlock with compartment access door to disconnect, ground and isolate from primary voltage when door is open.

2.7 LOW-VOLTAGE COMPONENTS

- A. All low-voltage components, including meters, instruments, and relays, shall be located in grounded, steel-enclosed compartments separate from high voltage to provide isolation and shall be arranged to allow complete accessibility for test and maintenance without exposure to high voltage.

NOTE TO SPEC WRITER: DELETE PARAGRAPH BELOW IF SPACE HEATERS ARE NOT REQUIRED ON PROJECT.

- B. Space heaters shall be enclosed with a grounded, perforated, galvanized steel guard.
- C. Low-voltage wiring shall be in grounded conduit or raceways where necessary to isolate from high voltage.

2.8 METERING

- A. Provide microprocessor-based power monitoring device for each switch or circuit breaker as indicated on drawings. Include associated instrument transformers.

2.9 ACCESSORIES

A. Interrupt switchgear

1. Furnish two 4 foot fiberglass single-head universal poles, equal to S&C Catalog No. 4451RZ-E.
2. Furnish two grappler-type fuse handling tools suitable for removing or installing fuse holders. Tools shall be equal to S&C Catalog No. 4423.
3. Furnish with each switch two, fire amp, 120 Vac auxiliary contact
4. Small wiring, fuse blocks and terminal blocks within the switch shall be furnished. All groups of control wires shall be labeled with wire markers and all wires leaving the switch shall be provided with terminal blocks having suitable numbering strips.

B. Circuit breaker switchgear

1. Tool for manually charging the breaker closing spring and manually opening.
2. Levering crank for moving the breaker between test and connected position.
3. Test jumper for electrically operating the breaker while out of its compartment.
4. Circuit breaker lifting device: Carriage and track on top of switchgear lineup with lifting device to serve drawout circuit breakers in switchgear, or manufacturer's standard device.
5. Circuit breaker control switch per breaker with red and green indicating lights, LED type.

C. Wiring and termination blocks

1. All control, metering, and instrumentation wiring shall be terminated on 600V heavy-duty terminal blocks. CT terminal blocks shall be separately mounted with all CT secondary terminated on 4-point shorting type terminal blocks.
2. Test blocks shall be provided per the Drawings and mounted on hinged instrument panels and fully wired. Provide test plugs (four potential and six current).
3. All control wiring shall be 14 AWG minimum, 600V 90-degree C, type SIS. All control conductors shall be terminated in crimp-on lugs. All conductor leads shall be T&B Sta-Kon spade type except current leads, which shall be Sta-Kon ring type.

4. Conductor and terminal block identification: All conductors shall have machine-lettered, PVC sleeve type wire markers. All terminal blocks shall be identified with phenolic nameplates as described herein. Individual terminals shall be clearly and neatly labeled with indelible, black marking pen.
 5. Both sides of all trip and close coils shall be wired to terminal blocks.
- D. Nameplates: Identification as per Section 26 05 53.UT. Inscription shall be as per the Drawings. All nameplates shall be attached with plastic pop-in rivets. Provide master nameplate on breaker cubicle or switch compartment indicating equipment name, voltage and service, and source of power. In addition, a "Danger High Voltage" sign shall be mounted on all doors providing access to high voltage.
- E. Mimic Bus: Provide a plastic mimic bus over the face of the switchgear. Mimic bus shall depict incoming lines, outgoing lines, breakers, voltage transformer and control power transformer. Mimic shall be medium blue in color and fastened with countersunk screws.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Installer shall examine the areas and conditions under which switchgear is to be installed and notify the Contractor in writing of conditions detrimental to the proper and timely completion of the work. Do not proceed with the work until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install switchgear as indicated in accordance with manufacturer's written instructions and applicable requirements of the NEC, ANSI, and NEMA. Secure the switchgear units rigidly on the concrete housekeeping pad with anchor bolts or other approved means recommended by the manufacturer.
- B. Provide the services of a qualified factory-trained manufacturer's representative to assist the Contractor in installation and start-up of the equipment specified under this Section for a period of 10 working days. The manufacturer's representative shall provide technical direction and assistance to the Contractor in general assembly of the equipment, connections, adjustments, and testing of the assembly and components contained herein.
- C. Properly set adjustable current, voltage, and time settings as indicated on shop drawing submittals. Trip setting shall be set in accordance with the recommendations and study performed as Short Circuit and Device Coordination.
- D. Prior to energization of switchgear, Megger Test phase-to-phase and phase-to-ground insulation resistance.
- E. Prior to energization, check metering and control wiring for correct polarity and proper interconnection.
- F. Subsequent to wire and cable hook-ups, energize switchgear and verify functioning of all features, metering, controls and protective relaying.

- G. Tighten all current-carrying bolted connections and all support framing and panels with a torque wrench to NEMA standards or manufacturer's recommendations.
- H. A complete test of all relays shall be performed by manufacturer's certified technician after installation and before acceptance by the Owner's representative. This test shall involve passing a primary current through the current sensor with a suitable, low-voltage test set and timer, which shall allow verification that the protective relays track their published curves and that they actually trip the devices on which they applied. This test shall also include the polarity of the current sensors and give an indication of satisfactory operations. The field test of protective relays shall include testing of relays at their final settings. Provide manufacturer's testing services using qualified personnel. Submit personnel qualifications, test equipment calibration reports, as well as final test reports to Owner and Architect/Engineer.
- I. Adjust operating mechanism for free mechanical movement. Touch-up scratched or marred surfaces to match original finish.

3.3 CERTIFICATION

- A qualified factory-trained manufacturer's representative shall certify in writing that the equipment has been installed, adjusted and tested in accordance with the manufacturer's recommendations. Provide three copies of certification.
- A. Provide the services of Professional Engineer, licensed in Texas, to certify in writing that the switchgear has been designed, manufactured, installed, and tested in full compliance with utility standards and requirements, with national standards, and with Owner's requirements. Provide three copies of certification.

3.4 TRAINING

- A. The Contractor shall provide a training session for up to (10) Owner's representatives for (1) normal workday at a jobsite location determined by the Owner.
- B. The training session shall be conducted by a qualified manufacturer's representative. Training program shall include instruction on the assembly, circuit breaker, protective devices, and other major components. Training program shall also include instructions on maintenance procedures and troubleshooting procedure for all switchgear components.

END OF SECTION

SECTION 26 22 13
DRY TYPE TRANSFORMERS

PART 1 – GENERAL

1.1 WORK INCLUDED

This Section includes enclosed dry type distribution transformers rated 600 volts and less, sizes up to 500 kVA.

- A. Dry type Two-Winding transformers.
- B. Dry type Buck and Boost transformers.
- C. Dry type Shielded Isolation transformers.
- D. Dry type, K-rated transformers.

1.2 REFERENCES

- A. NEMA ST 1 - Specialty Transformers (Except General Purpose Type)
- B. NEMA ST 20 - Dry Type Transformers for General Applications
- C. IEEE C57.12.01 - General Requirements for Dry-Type Distribution and Power Transformers.
- D. IEEE C57.12.91 - Test Code for Dry-Type Distribution and Power Transformers
- E. IEEE C57.96 – Guide for Loading Dry-Type Distribution and Power Transformers
- F. IEEE Std. 519 - Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems
- G. UL 506 – Specialty Transformers
- H. UL 1561 - Dry Type General Purpose and Power Transformers
- I. NEMA TP 1 – Guide for Determining Energy Efficiency for Distribution Transformers
- J. NEMA TP 2 – Standard Test Method for Measuring the Energy Consumption for Distribution Transformers

1.3 SUBMITTALS

- A. Provide submittals in accordance with and in additional to Section 26 00 00, Basic Electrical Requirements, and Division 01 for submittal requirement.
- B. Submit manufacturer's data on dry type transformers, vibration isolators and accessories.
- C. Include outline and support point dimensions of enclosures and accessories; unit weight; voltage; kVA; impedance ratings and characteristics; loss data; efficiency at 25, 50, 75 and 100 percent rated load; sound level; tap configurations; insulation system type, and rated temperature rise.

1.4 PRODUCT DELIVERY, STORAGE AND HANDLING

- A. Store transformers in a clean and dry space and protected from weather in accordance with manufacturer's instructions. Cover ventilating openings to keep out dust.
- B. Transformer shall not be used as work tables, scaffolds or ladders.
- C. Handle transformers carefully to avoid damage to material components, enclosure and finish. Use only lifting eyes and brackets provided for that purpose. Damaged transformers shall be rejected and not be installed on project.

PART 2 - PRODUCTS

2.1 MATERIALS AND EQUIPMENT

- A. Transformers shall be of dry type complying with the design function requirements of the project. Design characteristics shall be as noted in manufacturer's submittal data.
- B. Provide barrel type coils vacuum impregnated with high grade insulating varnish, non-hydroscopic thermo-setting type.
- C. Furnish [aluminum] [copper] windings, continuous without splice.
- D. Use non-aging silicon steel cores held together with steel channels or angles, with low flux density, quiet operating, and vibration isolated from enclosure and support channels.
- E. All transformers shall be designed, manufactured, and tested in accordance with all the latest applicable ANSI, NEMA, IEEE and UL standards, and shall be UL listed and bear the UL label.

2.2 DRY TYPE TWO-WINDING TRANSFORMERS

- A. Acceptable manufacturers
 - 1. Square D
 - 2. Cutler-Hammer
 - 3. General Electric Company
 - 4. Other manufacturers equal in design and function will be considered upon A/E approval following substitution procedure in 26 00 00, and Division 01 for substitution requirement.
- B. Dry type transformers shall be NEMA ST 20; factory-assembled, air cooled dry type transformers; ratings as shown on the Drawings.
- C. Insulation system and average winding temperature rise (in a 40 degree C maximum ambient) for rated kVA as follows:

kVA Rating	Insulation Class (degree C)	Temperature Rise (degree C)
1-15 kVA	185	115
25-500 kVA	220	115

- D. The maximum temperature of the top of the enclosure shall not exceed 50 degrees C rise above a 40 degree ambient.
- E. Winding Taps, Transformers 15 kVA and Less: Two 5 percent below rated voltage, full capacity taps on primary winding.
- F. Winding Taps, Transformers 25 kVA and Larger: Two 2.5 percent above rated voltage and four 2.5 percent below rated voltage, full capacity taps on primary.
- G. Sound Levels: Maximum sound levels are as follows:

kVA Rating	Sound Level
0-9	40 db
10-50	45 db
51-150	50 db
151-300	55 db
301-500	60 db

- H. Basic impulse level shall be 10 KV.
- I. Ground core and coil assembly to enclosure by means of a visible flexible copper grounding strap.
- J. Transformers 75 kVA and less shall be suitable for wall, floor, or trapeze mounting; transformers larger than 75 kVA shall be floor mounted.
- K. Enclosure shall be NEMA Type 2 or as shown on the Drawings. Provide lifting eyes or brackets.
- L. Nameplate on transformer shall include transformer connection data, kVA ratings, impedance, and overload capacity based on rated allowable winding temperature rise. Identify primary and secondary voltages.
- M. Isolate core and coil from enclosure using vibration absorbing mounts.
- N. Provide identification nameplate in accordance with Section 26 05 53 Electrical Identification.

2.3 DRY TYPE BUCK AND BOOST TRANSFORMERS

- A. Acceptable manufacturers
 - 1. Square D
 - 2. Cutler-Hammer
 - 3. General Electric Company
 - 4. Other manufacturers equal in design and function will be considered upon A/E approval following substitution procedure in 26 00 00, and Division 01 for substitution requirement.
- B. Dry Type Buck and Boost Transformers shall be NEMA ST 1; factory-assembled, dry type two winding buck and boost transformers; ratings as shown on the Drawings.

C. Insulation system and average winding temperature rise for rated kVA as follows:

kVA Rating	Insulation Class (degree C)	Temperature Rise (degree C)
0.25-2 kVA	185	115
3-7.5 kVA	185	115

D. Transformers shall be suitable for wall mount.

E. Enclosure shall be NEMA Type 3R or as shown on the Drawings.

F. Nameplate shall include transformer connection data.

2.4 DRY TYPE SHIELDED ISOLATION TRANSFORMERS

A. Acceptable manufacturers

1. Square D
2. Cutler-Hammer
3. General Electric Company
4. Other manufacturers equal in design and function will be considered upon A/E approval following substitution procedure in 26 00 00, and Division 01 for substitution requirement.

B. Dry Type Shielded Isolation Transformers shall be NEMA ST 20; factory-assembled, air cooled dry type shielded isolation transformers; ratings as shown on the Drawings.

C. Insulation system and average winding temperature rise (in a 40 degree C maximum ambient) for rated kVA shall be as 2.2 C.

D. The maximum temperature of the top of the enclosure shall not exceed 50 degrees C rise above a 40 degree ambient.

E. Winding Taps, Transformers 15 kVA and Less: Two 5 percent below rated voltage, full capacity taps on primary winding.

F. Winding Taps, Transformers 25 kVA and Larger: Two 2.5 percent above rated voltage and four 2.5 percent below rated voltage, full capacity taps on primary.

G. Maximum sound levels are as 2.2 G.

H. Basic Impulse Level shall be 10 KV.

I. Ground core and coil assembly to enclosure by means of a visible flexible copper grounding strap.

J. Transformers shall be supplied with quality, full width electrostatic shields in a maximum effective coupling capacitance between primary and secondary of 33 picofarads. With transformers connected under normal, loaded operating conditions, the attenuation of line noise and transients shall equal or exceed the following limits:

1. Common mode noise attenuation:

Frequency	Attenuation
0 - 1.5k Hz	120 db
1.5 -10k Hz	90 db
10 - 100k Hz	65 db
100k – 1M Hz	40 db

2. Transverse mode noise attenuation:

Frequency	Attenuation
1.5 -10k Hz	52 db
10 - 100k Hz	30 db
100k – 1M Hz	30 db

- K. Provide electrostatic shield between the primary and secondary winding and grounded to the transformer core.
- L. Transformers 75 kVA and less shall be suitable for wall, floor, or trapeze mounting; transformers larger than 75 kVA shall be floor mounted.
- M. Enclosure shall be NEMA Type 2 or as shown on the Drawings. Provide lifting eyes or brackets.
- N. Nameplate on transformer shall include transformer connection data, ratings, impedance, and overload capacity based on rated allowable winding temperature rise. Identify primary and secondary voltages.
- O. Isolate core and coil from enclosure using vibration absorbing mounts.
- P. Provide identification nameplate in accordance with Section 26 05 53 Electrical Identification.

2.5 DRY TYPE, K-RATED TRANSFORMERS

- A. K-rated transformers shall be NEMA ST 20; factory-assembled, air cooled dry type transformers meeting all the requirements as specified under paragraphs 2.2 and 2.4 of this Section; ratings as shown on the Drawings.
- B. Impedance range shall be 3 percent to 5 percent with a 2 percent minimum reactance in order to reduce neutral current when supplying loads with large amount of third harmonic current.
- C. Transformers shall be UL listed and labeled for K-4 or K-13; ratings as shown on the Drawings.
- D. Three-phase transformer secondary neutral terminal shall be sized for 200 percent of the rated secondary phase current.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Installer shall examine the areas and conditions under which dry type transformers are to be installed and notify the contractor in writing of conditions detrimental to the proper and timely completion of the work. Do not proceed with the work until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install dry type transformers as indicated, in accordance with the applicable requirements of the NEC and the National Electrical Contractors Association's "Standard of Installation".
- B. Check for damage and tight connections prior to energizing transformer.
- C. Measure primary and secondary voltages and make appropriate tap adjustments.
- D. Set transformer plumb and level.
- E. Use flexible liquid-tight conduit, 2 ft. minimum length, for connections to transformer case. Make conduit connections to side panel of enclosure.
- F. Mount transformers on vibration isolating pads suitable for isolating the transformer noise from the building structure.
 - 1. For floor or roof transformer installations, use one pad type Korfund Elasto-Grip, waffle, or equal, at each corner of the transformer, sized for load of 50 lbs./sq. in.
 - 2. For wall hung transformer installations, use spring type Korfund Series P, or equal. Provide sound pads at each corner of the transformer, sized for 1/2 inch deflection.
- G. Avoid mounting transformers in areas where tend to amplify noises, such as stairways, hall areas, and corners near ceilings. Avoid where possible, nearby reflecting object or enclosure that might resonate or echo.
- H. Ground transformers in accordance with Section 26 05 26 Grounding and NEC requirements.

END OF SECTION

SECTION 26 24 13
SWITCHBOARDS

PART 1 GENERAL

1.1 WORK INCLUDED

- A. Furnish and install switchboards as herein specified and shown on the associated electrical drawings.

1.2 REFERENCES

NOTE TO SPEC WRITER: INCLUDE ONLY REFERENCE STANDARDS THAT ARE TO BE INDICATED WITHIN THE TEXT OF THIS SECTION. EDIT THE FOLLOWING, ADDING AND DELETING AS REQUIRED FOR PROJECT AND PRODUCT SELECTION.

- A. ANSI C12.1 - Code for Electricity Metering
- B. ANSI C39.1 - Requirements for Electrical Analog Indicating Instruments
- C. ANSI C57.13 - Requirements for Instrument Transformers
- D. NEMA AB 1 - Molded Case Circuit Breakers
- E. NEMA KS 1 - Enclosed Switches
- F. NEMA KS 2 - Bolted Pressure Contact Switches
- G. NEMA PB 2 - Dead Front Distribution Switchboards
- H. NEMA PB 2.1 - Instructions for Safe Handling, Installation, Operation and Maintenance of Dead-front Switchboards Rated 600 Volts or Less

1.3 SUBMITTALS

- A. Provide submittals in accordance with and in addition to Section 26 00 00, Basic Electrical Requirements, and Division 01 for submittal requirement.
- B. Submit dimensioned drawings of switchboard showing accurately scaled basic units including, but not limited to, auxiliary compartments and components.
- C. Submit schematics and wiring diagrams for metering and controls.
- D. Line-by-line specification review by equipment manufacturer with any exception explicitly defined.

1.4 DELIVERY, STORAGE, AND HANDLING

- A. Deliver switchboards in factory-fabricated water-resistant wrapping, and mounted on shipping skids. All components and sections shall be identified by the Purchaser's equipment number or name, which shall be clearly indicated on Shop Drawings and shipping packages.
- B. Handle in accordance with NRMS PB2.1 to avoid damage to material components, enclosure, and finish. Switchboard shall be provided with adequate lifting means.

- C. Store in a clean, dry space and protected from the weather. Maintain factory wrapping or provide an additional heavy canvas or plastic cover to protect units from dirt, water, construction debris, and traffic. Switchboard shall be stored in a location where the relative humidity below required level for storage per manufacturer's recommendation. Heaters shall be energized in the switchboard section when relative humidity exceeds the requirement.
- D. Provide one (1) set of installation and maintenance instructions with each switchboard. Instructions are to be easily identified and affixed within the incoming or main section of the line-up.

PART 2 PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

- A. Cutler-Hammer
- B. General Electric Company
- C. Siemens
- D. Square D
- E. Other manufacturers equal in design and function will be considered upon A/E approval following substitution procedure in Section 26 00 00, and Division 01 for substitution requirement.

2.2 SWITCHBOARD CONSTRUCTION

- A. Switchboards shall be of the freestanding type complying with the design and function requirements of the project. Design characteristics shall be as noted in manufacturer's submittal data.
- B. Provide factory-assembled, dead-front, metal-enclosed, and self-supporting switchboard consisting of required vertical sections bolted together to form one rigid assembly.
- C. Enclosure shall be NEMA Type as per Drawings. Sections shall align at front and rear, or as per configurations shown on Drawings.
- D. Line and load terminations shall be accessible from front of the switchboard or as per Drawings.
- E. Main section devices shall be individually mounted.
- F. Distribution section devices shall be panel (group) mounted.
- G. Auxiliary section devices shall be individually mounted.
- H. Bus shall be copper. Bus connections shall be accessible from front of the switchboard or as per Drawings. All bussing shall be braced for the maximum available fault current as shown on drawings.
- I. Provide disconnecting means of all phases, neutral and grounds either in the form of a link, or similar conducting piece, designed to make connection between two suitable terminals or consisting of a terminal plate or stud provided with a suitable

wire connection. Simple removal of bolts from a single bus bar joint is not acceptable.

- J. Provide a 1 x 1/4 inch copper ground bus through the length of the switchboard.
- K. Bus Material: silver-plated copper. Neutral bars shall be full capacity rated.
- L. Lugs shall be tin-plated copper.
- M. Bus Arrangement: Phase A-B-C, left to right, top to bottom, and front to rear, as viewed from the front. Provided main horizontal bus with continuous current rating as shown on Drawings. Main bus shall be full capacity through each section and have provisions for future extension. Main bus and sub-main busses shall be sized to meet UL and NEMA standards for temperature rise.
- N. Exterior and interior steel surfaces shall be cleaned and finished with gray enamel over a rust inhibiting phosphatized coating. Color shall be ANSI 61 gray.
- O. Provide a mimic bus. Show bussing, connections and devices in single line form using black laminated plastic strips securely attached on the front panels of the switchboard.
- P. Switchboard electrical ratings and configurations as shown on Drawings.
- Q. Pull Box: Same construction as switchboard, size as shown on Drawings. Top and sides shall be removable. Insulating, fire-resistive bottom with separate openings for each circuit to pass into switchboard. Top or bottom entry as shown on Drawings, which shall be clearly indicated on shop drawings.
- R. Pull Section: Same construction as switchboard, size as shown on Drawings. Arrange as shown on Drawings.
- S. Future Provisions: Fully equip spaces for future devices with bussing and bus connections, suitably insulated and braced for short circuit currents. Continuous current rating as indicated on Drawings.

2.3 SWITCHING AND OVERCURRENT PROTECTIVE DEVICES

- A. Main and feeder protective devices shall be molded case circuit breakers.
 - 1. Breakers 400 ampere frame and less shall be manufacturer's standard industrial construction bolt-on type, integral inverse time delay thermal and instantaneous magnetic trip. Breakers 225 ampere through 400 ampere shall have continuously adjustable magnetic pick-ups of approximately five to ten times trip rating.
 - 2. Breakers 600 ampere frame and above shall be equipped with solid-state trip complete with built-in current transformers, solid-state trip unit and flux transfer shunt trip.
 - 3. Interrupting capacity shall be as noted on Drawings.

2.4 GROUND FAULT RELAYING

- A. Provide ground fault protection on each disconnect device, rated 1200 amps or above.

- B. Provide U.L. listed ground fault relay system with coordinated ground sensor with integral test winding and solid state relay to operate with protective device shunt trip circuit and monitor panel.
- C. Use time delay type relay with the following features:
 - 1. Continuously adjustable current pick-up settings of 100 to 1200 amperes.
 - 2. Continuously adjustable time delay setting from instantaneous (.03 seconds) to one second.
 - 3. Memory function to recognize and initiate tripping on intermittent ground faults.
- D. Install panel that indicates relay operation and provides means for testing the system with or without interruption of electric service and does not permit the ground fault system to be inadvertently left in an inactive or "off" state.
- E. Use zero sequence fault arrangement.

2.5 METERING

- A. Provide multi-function instruments as shown on Drawings or with the following electrical parameters. Voltmeter, phase to phase and phase to neutral.
 - 1. Current, per phase RMS and 3 phase average.
 - 2. Demand current, per phase.
 - 3. Power factor, per phase and 3 phase total.
 - 4. Real power, 3 phase total.
 - 5. Reactive power, 3 phase total.
 - 6. Apparent power, 3 phase total.
 - 7. Energy (MWH).
 - 8. Reactive energy (MVARH).
 - 9. Frequency.
 - 10. Average demand real power.
- B. Current Transformers: ANSI C57.13; 5-ampere secondary, window type with single secondary winding and secondary shorting device, primary/secondary ratio as shown on Drawings, burden and accuracy consistent with connected metering and relay devices, 60 Hertz.
- C. Voltage Transformers: ANSI C57.13; 120 volt secondary, disconnecting type with integral fuse mountings, primary/secondary ratio as shown on Drawings, burden and accuracy consistent with connected metering and relay devices, 60 Hertz.

PART 3 EXECUTION

3.1 INSTALLATION

- A. Install switchboards as indicated in accordance with manufacturer's written instructions and applicable requirements of the NEC, NEMA, ANSI and applicable requirement of the National Electrical Contractors Association's "Standard of Installation".
- B. Switchboard shall be bolted directly to floor without the use of floor sills.
- C. Tighten electrical bus connections with torque wrench to manufacturer's recommendations.
- D. Connect phase A, B and C, respectively to Bus No. 1, 2 and 3 from left to right or top to bottom.
- E. Adjust operating mechanisms for free mechanical movement.
- F. Touch-up scratched or marred surfaces to match original finish.

END OF SECTION

SECTION 26 24 16
PANELBOARDS

PART 1 - GENERAL

1.1 WORK INCLUDED

- A. Distribution panelboards.
- B. Branch circuit panelboards.

1.2 REFERENCES

- A. NEMA AB 1 - Molded Case Circuit Breakers and Molded Case Switches.
- B. NAME KS 1 - Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum).
- C. NEMA PB 1 - Panelboards.
- D. NEMA PB 1.1 - Instructions for Safe Installation, Operation and Maintenance of Panelboards Rated 600 Volts or Less.
- E. NEMA PB 1.2 - Application Guide for Ground-fault Protective Devices for Equipment.
- F. NEMA AB 3 – Molded Case Breakers and Their Application
- G. ANSI/UL 67 – Electric Panelboards
- H. ANSI/UL 50 – Cabinets and Boxes
- I. ANSI/UL 508 – Industrial Control Equipment

1.3 SUBMITTALS

- A. Provide submittals in accordance with and in addition to Section 26 00 00, Basic Electrical Requirements, and Division 01 for submittal requirement.
- B. Submit dimensioned drawings showing size, circuit breaker arrangement and equipment ratings including, but not limited to, voltage, main bus ampacity, integrated short circuit ampere rating, and temperature rating of circuit breaker terminations.

1.4 PRODUCT DELIVERY, STORAGE AND HANDLING

- A. Deliver distribution panelboards in factory-fabricated water-resistant wrapping.
- B. Handle panelboards carefully to avoid damage to material component, enclosure and finish.
- C. Store in a clean, dry space and protected from the weather.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

- A. Square D Company

- B. General Electric Company
- C. Other manufacturers equal in design and function will be considered upon A/E approval following substitution procedure in 26 00 00, and Division 01 for substitution requirement.

2.2 PANELBOARD CONSTRUCTION

- A. General: Provide flush or surface mounted, or surface mounted deadfront circuit breaker type distribution or branch circuit panelboards with electrical ratings and configurations, as indicated on the drawings and schedules. Load center type of panelboards are not acceptable.
- B. Enclosure:
 - 1. Enclosure shall be proper NEMA type as shown on the drawings.
 - 2. NEMA 1
 - a. Back box shall be galvanized steel for flush mounted branch circuit panelboards. Back box shall have gray enamel electro-deposited finish over cleaned phosphatized steel for all other type panelboards.
 - b. Provide panelboard fronts with screw cover and hinged door with flush lock.
 - c. Where power monitors or metering are specified on the Drawings, the manufacturer shall cut the doors for field mounting of the unit.
 - 3. NEMA 3R, 3S and 12
 - a. Enclosure and doors shall have gray enamel electro-deposited finish over cleaned phosphatized steel.
 - b. Doors shall be gasketed and equipped with tumbler type vault lock and two trunk latches where required by UL standard. Interior trim shall consist of four pieces, each covering one gutter top, bottom and both sides.
 - 4. Construct cabinet in accordance with UL 50. Use not less than 16-gauge galvanized sheet steel, with all cut edge galvanized. Provide a minimum 4-inch gutter wiring space on each side. Provide large gutter where required to accommodate the size and quantity of conductors to be terminated in the panel, and where required by code.
 - 5. Exterior and interior steel surfaces shall be cleaned and finished with gray enamel over rust inhibiting phosphatized coating. Color shall be ANSI 61 gray.
 - 6. Doors shall be equipped with flush-type combination catch and key lock. All locks shall be keyed alike.
 - 7. Branch circuit panelboards shall be 5 ¾ inches deep.
 - 8. A directory holder with heavy plastic plate, metal frame, and index card shall be mounted inside of each door.

9. Reinforce enclosure and securely support bus bars and overcurrent devices to prevent vibration and breakage in handling.
10. Rating: Minimum integrated short-circuit rating, voltage and current rating as shown on drawings.
11. Labeling: The Contractor shall furnish and install engraved, laminated plastic nameplates on the trim per Section 26 05 53, Electrical Identification

C Bus:

1. Provide panelboards with rounded edge phase, neutral and ground buses, rated full capacity as scheduled on drawings. Buses shall be full-length copper and braced for the maximum available fault current as shown on drawings. Neutral bus shall be 200% rated for those panels feeding non-linear loads.
2. Phase bussing shall be stacked front-to-back, A-B-C.
3. The neutral and ground bus bars shall have termination locations for each of the individual feeders and the lugs sized appropriately. In addition, space shall be provided to terminate the neutrals and grounds in two feeders equal to the largest size circuit breaker that can be installed in the panelboard. The ground bus shall be mounted in the panelboard, opposite the incoming line and neutral lugs and shall be accessible to allow easy installation of bolts, nuts and lock washers used to attach ground lugs. The neutral and ground buses in branch circuit panelboards shall have spaces to terminate 42 neutral and 42 ground wires.
4. Where isolated ground buses are specified or indicated, provide copper grounding bus bars mounted in the panelboard on insulated standoffs to ensure isolation from equipment ground potential. Isolated ground buses shall be drilled and tapped as appropriate for connection of the individual isolated grounding conductors.
5. All lugs for phase, neutral, and ground buses shall be tin-plated copper.
6. Panelboard shall be rated SE where required for service Entrance duty.

2.3 SWITCHING AND OVERCURRENT PROTECTIVE DEVICES

- A. Provide molded case circuit breakers with manufacturer's standard construction, bolt on type, with integral inverse time delay thermal and instantaneous magnetic trip in each pole. Circuit breakers shall be constructed using glass reinforced polyester insulating material providing superior dielectric strength. Provide circuit breakers UL listed as Type HACR for air-conditioning equipment branch circuits.
- B. Circuit breakers shall have an over center, trip-free, toggle operating mechanism that will provide a quick-make, quick-break contact action.
- C. Provide handle padlock attachments on circuit breakers where indicated on drawings. Device shall be capable of accepting a single padlock. All circuit breakers shall be capable of being individually padlocked in the off position.

- D. The circuit breakers shall be connected to the bus by means of solidly bolted connection. In multi-pole breakers, the phase connections on the bussing shall be made simultaneously without additional connectors or jumpers. Multi-pole breakers shall be two or three pole as specified. Handle ties are not permitted. The circuit breaker shall have common tripping for all poles.
- E. All circuit breakers shall be provided with visible ON and OFF indications.
- F. Provide GFI circuit breakers as indicated on drawing or per NEC requirement.
- G. Breaker voltage and trip rating shall be per drawings. Breaker faceplate shall indicate UL certificate standards with applicable voltage systems and corresponding short current rating as per drawings.
- H. Molded Case Circuit Breakers:
 - 1. Breakers 400 ampere frame and less shall be manufacturer's standard industrial construction, bolt-on type, integral inverse time delay thermal and instantaneous magnetic trip. Breakers 225 ampere through 400 ampere shall have continuously adjustable magnetic pick-ups of approximately five to ten times trip rating.
 - 2. Breakers 600 ampere frame and above shall be equipped with solid-state trip complete with built-in current transformers, solid-state trip unit and flux transfer shunt trip.
- I. Current Limiting Molded Case Circuit Breakers:
 - 1. Breakers 100 ampere frame shall be inverse time delay thermal and instantaneous magnetic trip.
 - 2. Breakers 250 ampere and 400 ampere frame shall be solid-state trip with built-in current transformers, solid-state trip unit and flux transfer shunt trip.
 - 3. Current limiting breakers shall protect downstream molded case breakers. Submit manufacturer's test data proving the protection, from both peak currents and I²T energy of downstream devices.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install panelboards in accordance with manufacturer's written instructions and the applicable requirements of the NEC, NEMA, ANSI and the National Electrical Contractors Association's "Standard of Installation".
- B. Anchor enclosed firmly to walls and structural surfaces, ensuring that they are permanently and mechanically secured. Direct attachment to dry wall is not permitted. Freestanding panelboards shall be installed on a concrete housekeeping pad with anchors per manufacturer's recommendation.
- C. Mounting height:
 - 1. Distribution Panelboards: As per Drawings, but such that highest operating handle is no greater than 79 inches above finished floor.

2. Branch Circuit Panelboards: As per Drawings, but such that highest operating handle is no greater than 79 inches above finished floor.
 3. Where panelboards occur in groups, the tops shall be aligned if it can be done without exceeding items 1 and 2 above.
- D. Install panelboards plumb. Adjust trim to cover all openings. Seal all conduit openings and cap all used knockout holes.
 - E. Provide blank plates for unused open spaces in panelboards. Keep the front door closed after work to protect from damage, dirt, and debris at all times.
 - F. Install identification nameplates in accordance with Section 26 05 53, Electrical Identification.

3.2 FIELD QUALITY CONTROL

- A. Visual and Mechanical Inspection: Inspect for physical damage, proper alignment, anchorage, and grounding. Check proper installation and tightness of connections for circuit breakers and lugs.
- B. Provide testing and start-up as indicated in Section 26 08 00 – Commissioning of Electrical Systems.

3.3 PANELBOARD SCHEDULE

- A. The Contractor shall provide engraved, laminated plastic nameplates for circuit identification as indicated on the Drawings for distribution panelboards.
- B. The Contractor shall fill the index directory inside the front door of branch circuit panelboards identifying each circuit as shown on Panel Schedule drawings. Where changes are made, the schedule shall reflect the changes. At the end of the job, these schedules shall reflect as-built record conditions.

END OF SECTION

SECTION 26 24 19
MOTOR CONTROL CENTERS, 600VOLTS

PART 1 - GENERAL

1.1 WORK INCLUDED

- A. Motor control centers for application at 600 volts and less.

1.2 REFERENCES

NOTE TO SPEC WRITER: INCLUDE ONLY REFERENCE STANDARDS THAT ARE TO BE INDICATED WITHIN THE TEXT OF THIS SECTION. EDIT THE FOLLOWING, ADDING AND DELETING AS REQUIRED FOR PROJECT AND PRODUCT SELECTION.

- A. ANSI/NEMA ICS 6 - Enclosures for Industrial Controls and Systems
- B. NEMA ICS 2 - Industrial Control Devices, Controllers, and Assemblies
- C. NEMA AB 1 - Molded Case Circuit Breakers
- D. NEMA KS 1 - Enclosed Switches
- E. NEMA PB 1.1 - Instructions for Safe Installation, Operation and Maintenance of Panelboards Rated 600 Volts or Less.
- F. UL 508 – Industrial Control Equipment
- G. UL 845 – Electric Motor Control Centers
- H. ANSI C19 – Industrial Control Apparatus

1.3 SUBMITTALS

- A. Provide submittals in accordance with and in additional to Section 26 00 00, Basic Electrical Requirements, and Division 01 for submittal requirement.
- B. Submit manufacturer's literature and specification product data sheets. Line item specifications review indicating compliance or itemized exceptions with each Section of the specification.
- C. Submit dimensioned drawings showing size, circuit breaker, fusible switch and combination starter arrangement and electrical characteristics, including but not limited to, voltage, bus ampacity, integrated short circuit ampere rating, frame size and trip ratings, and coordination curves on log-log paper of the main protective device and for the largest branch circuit devices. Include conduit entrance locations and requirements; nameplate legends; size and number of bus bars per phase, and ground.
- D. Submit product data on motor starters and combination motor starters, relays, pilot devices, and switching and overcurrent protective devices.
- E. Submit control and wiring diagrams for each starter or breaker unit.

1.4 PRODUCT DELIVERY, STORAGE AND HANDLING

- A. Deliver motor control centers in factory-fabricated water-resistant wrapping, and in 60-inch maximum width mounted on shipping skids.
- B. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.
- C. Handle motor control centers carefully to avoid damage to material components, enclosure and finish. Motor control centers shall be provided with adequate lifting means.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

- A. Cutler hammer
- B. General Electric Company
- C. Seimens
- D. Square D
- E. Other manufacturers equal in design and function will be considered upon A/E approval following substitution procedure in 26 00 00, and Division 01 for substitution requirement.

2.2 MOTOR CONTROL CENTER CONSTRUCTION

- A. Motor control centers shall be totally enclosed of one or more rigid, freestanding, vertical sheet metal cubicles bolted together to form a rigid, dead-front assembly. Use not less than 14 gauge, cold-rolled steel. Grind any imperfections smooth, such as welding splatter, sharp edges, burrs, etc., before finishing. Cleansing bath followed by single coat of phosphatized primer and a zinc-rich second coat, final coat ANSI 61 gray enamel inside and out, final paint thickness 3 mils on all surfaces, including corners. Provide a minimum of one pint of finish paint for touch-up after field installation.
- B. Make each vertical Section normally 20 inches wide, 20 inches deep and 90 inches high, unless noted otherwise. Enclosure shall be NEMA type as per drawings.
- C. Provide separate hinged compartment doors for each starter, feeder or other unit. Provide a mechanical interlock that prevents door from being opened when disconnecting means is in closed position. A defeater shall be provided to bypass this interlock. Provisions shall be provided to positively lock the disconnect in the OFF position with up to three padlocks.
- D. Unit Compartments: Individual compartments shall be separated by steel barriers for each starter, feeder or other unit; capable of being wired from front without unit removal; no wiring to be exposed on rear of unit. Doors shall be formed round corners, rolled edges, neoprene gaskets, and at least two heavy-duty hinges, held closed by means of quick-captive fasteners. Provide removable formed steel channel sills and removable lifting angles.

- E. Vertical Wiring Compartment: Full height, accessible from front, wire guards and grommets on openings for wire passage. Designed to allow wiring to be installed according to NEC.
- F. Horizontal Wiring Compartments: Full width top and bottom, accessible from front, wire guards and grommets on openings for wire passage. This shall include openings to the vertical wiring compartment. Openings to vertical wiring compartments shall have insulating material installed to prevent physical damage to conductors.
- G. Nameplates: provide identification of motor control center and individual control units in accordance with Section 26 05 53 - Electrical Identification.

2.3 BUS

- A. Horizontal bussing shall be minimum of 800A, tin or silver plated copper or as shown on the Drawings with a continuous current rating with no reduction in capacity for length of bus.
- B. Vertical bussing shall be tin or silver plated copper full height with a minimum continuous current rating of 300 amperes, or as shown on the Drawings.
- C. Ground Bus: Provide continuous 1 X 1/4-inch tin or silver plated copper ground bus solidly grounded to each structure near bottom and provide for connection to building grounding system at each end. Ground bus shall be accessible in each Section.
- D. Insulation/Isolation:
 - 1. Horizontal Bus: Isolated by grounded steel or insulating type barriers.
 - 2. Vertical Bus: Isolated from motor starter and feeder units by a full height insulating type barrier with openings for stabs. Provide shutter mechanism to cover stab openings upon removal of units.
- E. The buses shall be rated at 50 degree C temperature rise over a 40 degree C ambient in compliance with UL standards.
- F. Future provisions: Fully equip spaces for future devices with bussing and bus connections, braced for available short circuit currents as per drawings. Provide provision for extension of main horizontal bus on either end of the control center. Include ground bus entire length of control center.
- G. Make provision for top entry branch circuit installation.
- H. Integrated Equipment Short Circuit Rating: Starters, feeders, and bus bracing shall be rated as indicated on the drawings.

2.4 MOTOR STARTERS

- A. Draw-out combination type with tin-plated stab assembly for connection to the vertical bus, except where size and weight of equipment makes this impractical; readily interchangeable with starters of similar size. No wiring to those stabs shall extend into the bus compartment. Each combination starter or circuit breaker unit shall have a single hinged door, which opens up to reveal starter components.

Multiple doors per unit are not acceptable unless specifically approved in writing by the Owner or Engineer. Unit shall be equipped with side-mounted, positive latch pull-apart type control terminal blocks rated 600 volts. Knockouts shall be provided for the addition of future terminal blocks. All control wire shall be minimum AWG 14 copper.

- B. Motor starters shall be combination type, full voltage non-reversing equipped with thermal magnetic circuit breakers sized as indicated on drawings. Starters shall be 480 volts, three-phase, four-wire, 60 Hz, unless otherwise indicated on drawings.
- C. A cast metal handle operator must be provided on each disconnect. With the unit stabs engaged into the vertical phase bus and the unit door closed, the handle mechanism shall allow complete ON/OFF control of the unit disconnect with clear indication of the disconnect status. All circuit breaker operators shall include a separate TRIPPED position to clearly indicate a circuit breaker trip condition. It shall be possible to reset a tripped breaker without opening the control unit door.
- D. Overload relay: Provide three-phase, solid state overload relays for trip current, phase loss, and phase unbalance protection with a power LED indication. Standard trip contacts in the normally closed position shall be used and shall have trip free operation, visible trip indication and test function. The overload relay shall have electronics that are self-protected and harmonic and ambient insensitive. The overload relays shall be field adjustable.
- E. Selector Switches: HAND/OFF/AUTO or as indicated on Drawings, standard operator, in front cover.
- F. Pushbutton units: Heavy-duty, oil-tight, momentary contact, spring return, NO or NC, as shown, with nameplate.
- G. Auxiliary Relays: Minimum 6 or as indicated on the Drawings. Auxiliary relays shall be field convertible to perform normally open (NO) or normally closed (NC) operation.
- H. Indicating Lights: Pilot light assemblies shall be heavy-duty, oil-tight, transformer-type, push-to-test LED type indicating lights, with red for RUN and green for STOP.
- I. Two-Speed Starting: Two-speed, two-winding, variable torque type. Specific type shall be as indicated on the Drawings. Include integral adjustable time delay transition (compelling) relay when going from FAST to SLOW speeds or slow to fast speeds. Provide fast red and slow amber LED push-to-test indicating lights. Two-speed starters shall meet all the other requirements for full voltage non-reversing starters specified in 2.4 A throughout 2.4 H.

2.5 CONTROL TRANSFORMERS

- A. Voltage: Provide 24V, 60 Hz control transformers for starters smaller than size 4. Size 4 and larger starters shall operate at 120V, 60Hz.
- B. Fuses: Provide fuse protection on both primary and secondary.

- C. Size: Control transformer shall be 200 VA minimum, in each motor starter or sized per drawings to accommodate control loads including heaters, as applicable.

2.6 FEEDER DEVICES

- A. Fusible switches shall be quick-make, quick-break with externally operable handle designed to accommodate Class RK1 fuses.

- B. Molded Case Circuit Breakers:

1. Breakers 400 ampere frame and less shall be manufacturer's standard industrial construction, bolt-on type, integral inverse time delay thermal and instantaneous magnetic trip. Breakers 225 ampere through 400 ampere shall have continuously adjustable magnetic pick-ups of approximately five to ten times trip rating.
2. Breakers 600-ampere frame and above shall be equipped with solid-state trip complete with built-in current transformers, solid-state trip unit and flux transfer shunt trip.
3. Interrupting capacity shall be as noted on drawings.

- C. Current Limiting Molded Case Circuit Breakers:

1. Breakers 100-ampere frame shall be inverse time delay thermal and instantaneous magnetic trip.
2. Breakers 250 ampere and 400 ampere frame shall be solid-state trip with built-in current transformers, sold-state trip unit and flux transfer shunt trip.
3. Current limiting breakers shall protect downstream molded case breakers. Submit manufacturer's test proving the protection, from both peak currents and I²T energy of downstream devices.
4. Breakers shall have integral automatically resetting current limiting element in each pole equal to Westinghouse Limit-R.

2.7 INSTRUMENT

Provide the following devices for each motor control center if shown on the Drawings:

- A. Power Monitor: Square D Model CM-2350 or as specified on the Drawings. Power monitor shall have an accessible optical port and network port for communications capability. Power monitor to be factory installed and door mounted in main lug section.
- B. Function: Refer to Section 26 09 13 Electrical Power Monitoring and Control for requirement.
- C. Current Transformers: As specified in Section 26 05 00 - Basic Electrical Material and Methods. ANSI C57.13, 5 ampere secondary, primary to match main bus continuous amperage rating, window type, with single secondary winding and secondary shorting device, with 0.3 accuracy at burden with connected metering devices, 60 Hz. Furnish shorting type terminal boards for all current transformers.

Provide a selector switch as specified in Section 26 05 00 - Basic Electrical Materials.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install motor control centers in accordance with manufacturer's written instructions and the applicable requirements of the latest editions of NEC, NEMA, and ANSI. Retighten current carrying, bolted connections, and enclosure support framing and panels to manufacturer's recommendations.
- B. Provide 4-inch-high concrete housekeeping pad for mounting of motor control center with anchor bolt pattern to match MCC. Pads to be a minimum of 4 inches larger than equipment footprint. The Contractor shall set the MCC in place, level and align each section, and secure with anchors in accordance with manufacturer's instructions.
- C. Set overload relay elements in electronic overload relays or install heater elements in thermal overload relays in motor starters based on actual motor nameplate ratings such as full load current, service factor, temperature rise, and ambient motor temperature. If overload sizes are incorrectly sized for the motor, they shall be changed out at no additional cost.
- D. Adjust operating mechanisms for free mechanical movement.
- E. Touch-up scratched or marred surfaces to match original finish.
- F. Subsequent to wire and cable connections, energize motor control centers and demonstrate functioning in accordance with requirements.
- G. The Contractor shall provide all conduit connections and wiring to and within the MCC to provide a complete and operable system. The Contractor shall be part of the motor acceptance test, do a field survey of all the motors and include manufacturer, model and serial number, operation voltage, horsepower, full load amps, no load amps and the remaining test results.
- H. Motor circuit breaker trip setting shown on Drawings is code maximum. Field set motor circuit protectors to the minimum trip setting which will permit motor starting under normal conditions using the procedures outlined in the manufacturer's instruction booklet.

3.2 CALIBRATION

- A. Completely test and calibrate all devices in the MCC and instruct the Owner on proper operation of all devices.
- B. Metering shall be calibrated after final placement, alignment and energizing.
- C. Test the ground fault trip system for proper operation (electronic overloads only).
- D. Provide quality control per Section 26 08 00 – Commissioning of Electrical Systems.

3.3 CLEANING

- A. Completely clean the inside and outside of the MCC prior to final completion.
- B. Protect the MCC during construction from dust and debris.
- C. Any scratches and dents in the cabinets shall be repaired to the Owner's satisfaction.

3.4 SPARE PARTS

- A. Turn over all spare parts to the Owner in labeled boxes, which reference the intended use.
- B. Provide one can of gray spray paint from the manufacturer, which matches the MCC color.
- C. Provide two full sets of each fuse size used in MCC.
- D. Provide two fuse pullers per MCC if applicable.

END OF SECTION

SECTION 26 27 26
WIRING DEVICES AND FLOOR BOXES

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Wiring Devices:

1. Wall switches.
2. Receptacles.
3. Device plates and box covers.
4. Wall dimmers.
5. Occupant sensors.

B. Floor boxes.

C. Wiring for HVAC in Division 23 shall meet the requirement of this specification.

1.2 REFERENCES

NOTE TO SPEC WRITER: INCLUDE ONLY REFERENCE STANDARDS THAT ARE TO BE INDICATED WITHIN THE TEXT OF THIS SECTION. EDIT THE FOLLOWING, ADDING AND DELETING AS REQUIRED FOR PROJECT AND PRODUCT SELECTION.

- A. Americans with Disabilities Act (ADA)
- B. ANSI/NEMA OS 1- Sheet-Steel Outlet Boxes, Device Boxes, Covers, and Box Supports.
- C. ANSI/UL 20 – General Use Snap Switches.
- D. ANSI/UL 498 – Attachment Plugs and Receptacles.
- E. ANSI/UL 943 – Ground Fault Circuit Interrupters.
- F. NEMA 250 – Enclosures for Electrical Equipment (1000 Volts maximum).
- G. NEMA WD 1 – General-Purpose Wiring Devices.
- H. NEMA WD 2 - Semiconductor Dimmers for Incandescent Lamps.
- I. NEMA WD 5 - Specific-Purpose Wiring Devices.
- J. Texas Accessibility Standards. (TAS)

1.3 SUBMITTALS

A. Provide submittals in accordance with and in addition to Section 26 00 00, Basic Electrical Requirements, and Division 01 for submittal requirement.

1.4 DELIVERY, STORAGE AND HANDLING

- A. Deliver wiring devices individually wrapped in factory-fabricated containers.
- B. Handle wiring devices carefully to avoid damage, breaking and scoring.
- C. Store in a clean dry space and protected from the weather.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Provide factory fabricated wiring devices in the type and electrical rating for the service indicated. Where type and grade are not indicated, provide proper selection to correspond with branch circuit wiring and overcurrent protection. Attachment of wires to devices shall be by screw pressure under the head of binding screws. Arrangements depending on spring pressure or tension are not acceptable. All binding screws shall be brass or bronze.
- B. Device color:
 - 1. Switches, receptacles, and dimmers on normal power shall be white.
 - 2. Switches, receptacles, and dimmers on emergency power shall be red.
 - 3. Isolated ground receptacles shall be orange.
 - 4. Key operated switches shall be gray.
 - 5. Provide receptacles in surface mounted raceways in colors as shown on drawings. Coordinate color of devices and device plates in other areas with the architectural finish. Refer to architectural drawings and specifications.
 - 6. For renovation or expansion of existing facilities, provide devices and plates to match existing.

2.2 WALL SWITCHES

- A. Acceptable manufacturers
 - 1. Arrow-Hart
 - 2. Hubbell
 - 3. General Electric
 - 4. Leviton
 - 5. Other manufacturers equal in design and function will be considered upon A/E approval following substitution procedure in 26 00 00 and Division 01 for substitution requirement.
- B. Material
 - 1. Wall switches for lighting circuits and motor loads under 1/3 hp shall be AC general use snap switch with toggle handle, 20 amperes and 120/277 volt AC with number of poles as required.
 - 2. Pilot light type shall be equipped with red toggle handle (glow when on), 20 amperes and 120/277 volt AC with number of poles as required.
 - 3. Key operated switches shall be Gray, 20 amperes and 120/277 volt AC with number of poles as required key all locks alike. Furnish keys compatible with key switch, quantity as directed by Owner, minimum of ten copies.

4. Illuminated Emergency-Power-Off switch shall be provided with button guard equal to Allen-Bradley #800T-QA10R or approved substitutions.
5. A listed manual switch having a horsepower rating not less than the rating of the motor and marked "Suitable as Motor Disconnect" shall be permitted to serve as disconnect means for stationary motor of 2 horsepower or less.
6. Switch terminal screws or connectors shall be designed to accommodate No. 10 solid conductor.

2.3 RECEPTACLES

A. Acceptable manufacturers

1. Arrow-Hart
2. Hubbell
3. General Electric
4. Leviton
5. Other manufacturers equal in design and function will be considered upon A/E approval following substitution procedure in Section 26 00 00 and Division 01 for substitution requirement.

B. Material

1. Hospital grade receptacles shall be installed in clinic, patient care and other areas required by NFPA. Tamper proof in areas serving children.
2. Dedicated circuit and convenience duplex receptacles shall be rated 20 amperes, 125 volt AC.
3. GFCI receptacles shall be rated 20 amperes, 125 volt with integral ground fault current interrupter
4. Isolated ground duplex receptacles shall be Orange, rated 20 amperes, 125 volt.
5. Heat trace receptacles shall be Arrow-Hart #5262CRGRY with Crouse Hinds #WLRD-1 cover. Install round plug on cord supplied with heat trace to match weatherproof bushing on receptacle cover for watertight installation.
6. Specific-use receptacles shall have volts, amps, poles and NEMA configuration as noted on drawings.
7. Heavy-duty lock-blade receptacles shall be NEMA WD5 heavy-duty specification grade.
8. Emergency receptacles shall be red plastic face or with pre-wired neon glow lamp behind each pair of slots as per drawings.
9. Weatherproof receptacles as specified shall be mounted in a cast steel box with gasketed, weatherproof device plate as specified.

2.4 WALL PLATES

A. Acceptable manufacturers

1. Arrow-Hart
2. Hubbell
3. General Electric
4. Leviton
5. Other manufacturers equal in design and function will be considered upon A/E approval following substitution procedure in Section 26 00 00 and Division 01 for substitution requirement.

B. Material

1. Wall plates in IT, mechanical and electrical rooms, loading dock, and other industrial areas shall be 316 or 302 stainless steel with cutouts as required for devices indicated on drawings, unless otherwise noted. Other wall plates shall be smooth plastic, 0.1-inch thick. Where switches or outlets are shown adjacent to each other, they shall be ganged with partitions between different type services and covered by a single custom wall plate.
2. Exposed boxes:
 - a. Dry interior spaces: Use cast metal plates with cast metal box. Use heavy cadmium-plated sheet steel plates with steel boxes and copper-free aluminum with aluminum boxes. All screws shall be stainless steel. Edges of plates must be flush with edges of boxes.
 - b. Other locations: Use weatherproof devices plates. Provide cast metal plates with gasketed spring door
3. Jumbo plates are not permitted.
4. Weatherproof cover plate shall be gasketed cast aluminum or ferrous alloy (by Crouse-Hinds) with hinged gasketed device covers.
5. Wall plate for isolated ground receptacles shall be silk-screened "ISOLATED GROUND".

2.5 WALL DIMMERS

A. Acceptable manufacturers

1. Lutron
2. Leviton
3. Other manufacturers equal in design and function will be considered upon A/E approval following substitution procedure in Section 26 00 00 and Division 01 for substitution requirement.

B. Material

1. Provide NEMA WD 2 solid-state wall-box dimmers, where indicated on drawings. Dimmers shall be complete, with linear slide-type solid-state dimming controls, and LED light level ON/OFF indicators. Dimmer shall produce IES square-law

response from blackout to full brightness. Dimmer rise time shall be restricted to prevent interference with professional quality audio or video equipment. Dimmer shall be compatible with ballast per manufacturer's specification.

2. Device: White finish plastic with linear slide.

3. Voltage: As noted on drawings.

4. Power rating: Match load shown; 1000 watts minimum, larger size is required to accommodate connected loads greater than 1000watts. Load to 80% of the dimmer capacity, maximum.

2.6 FLOOR MOUNTED SERVICE FITTINGS AND BOXES

A. Acceptable manufacturers

1. Steel City

2. Walker

3. Other manufacturers equal in design and function will be considered upon A/E approval following substitution procedure in Section 26 00 00 and Division 01 for substitution requirement.

B. Material

1. Floor mounted service boxes shall be flush mounted brushed aluminum housing with poke-through assembly. Provide brass cover plate with two hinged lift lids where carpeting is installed.

2. Quantity of outlets for A/V and power per drawings.

2.7 OCCUPANT SENSORS

A. Acceptable manufacturers

1. Pass & Seymour

2. Other manufacturers equal in design and function will be considered upon A/E approval following substitution procedure in Section 26 00 00 and Division 01 for substitution requirement.

B. Material

1. Self-mounting, ceiling bracket.

2. Quad element, infrared detector behind a fresnel lens.

3. Detection range

a. 8 to 14 micrometer frequency spectrum of bodily emitted infrared radiation.

b. 110 degree sensing field over 400 gross square feet.

c. Adjustable time-out delay: 5 second – 15 minutes.

d. Supplied with plenum rated low voltage wire leads for termination.

e. Manual shutoff per sensor is required.

4. Control unit

- a. Enclosure: Galvanized, heavy duty for mounting to a 4 inch or 4-11/16 inch square box.
- b. Control up to (7) sensors.
- c. Power rating
 - (1) 600 watts for incandescent at 120 volts.
 - (2) 2500 watts for fluorescent at 277 volts.
- d. Supplied with plenum rated low voltage wire leads for termination.

2.8 TAPE LABELS

- A. Provide tape labels in accordance with Section 26 05 53, Electrical Identification, on all receptacles and switches indicating panelboard and circuit number. White tape with 3/16 inch black letters/numbers.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Installer must examine the areas and conditions under which wiring devices and floor boxes are to be installed and notify the Contractor in writing of conditions detrimental to the proper and timely completion of the work. Inspect devices for physical damage. Do not proceed with the work until unsatisfactory conditions have been corrected.

3.2 DEVICE COORDINATION

- A. Where items of equipment are provided under other sections of this specification or by the Owner, provide a compatible receptacle and/or device plate for the cap or plug, and cord of the equipment.

3.3 INSTALLATION

A. General:

- 1. Install wiring devices and floor boxes as indicated, in accordance with the applicable requirements of the latest release of NEC, NEMA, and ANSI.
- 2. The approximate location of switches, power outlets, floor boxes, etc., is indicated on the drawings. These drawings, however, may not give complete and accurate information in regard to locations of such items. Determine exact locations by reference to the general building drawings and by actual measurements during construction of the building before rough-in, subject to the approval of the Constructor Inspector.
- 3. Where more than one device occurs in one outlet box, causing 300 volts or more voltage difference between them, a barrier must be provided for isolation to meet NEC Article 380.

B. Wall Switches and Dimmers:

1. Location:

- a. Install wall switches and dimmers in suitable outlet box centered at the height of 48 inches above finished floor, OFF position down.
- b. Where wainscot occurs at the 48" level, install device in the wall below the wainscot and as near the 48" level as possible to provide the most pleasing appearance, but in no case partially in the wainscot and partially in the wall.
- c. Where shown near doors, install switches and dimmers not less than 2" and not more than 12" from door trim.
- d. Verify all door swings before rough-in and locate switches and dimmers on strike side of door as finally installed.

2. Position:

- a. Wall switches: Install wall switches in a uniform position so the same direction of operation will open and close the circuits throughout the project, generally up or to the left for the ON position.
- b. Wall dimmers: Install dimmers in a uniform position so the same direction of operation will brighten and dim the lights throughout the project, generally up for brightest position.

3. Wall Box Dimmers:

- a. De-rate ganged dimmers as instructed by manufacturer. Do not use common neutral.
- b. Compatibility: Where dimmers are connected to fluorescent lights, verify with ballast manufacturer and dimmer manufacturer the suitability of the ballast for dimming applications.
- c. Test: Test dimmers per manufacturer's instructions. Demonstrate that unit's function as specified. Where remote dimmers are provided, demonstrate that unit's function properly as master and remote.
- d. Burn-in: Where dimmers are connected to fluorescent fixtures, operate at full brightness for the full burn-in duration as specified or recommended by the lamp manufacturer.

C. Receptacles:

1. Location:

- a. Install convenience outlets, telephone, data and TV outlets in suitable steel outlet boxes centered at the height of 18 inches above the finished floor, 6 inches above countertop or at the backsplash level, or as indicated on the drawings. Coordinate with equipment and architectural drawings.

- b. Install receptacles generally where indicated on drawings. The Owner's representative reserves the right to make any reasonable changes in receptacle locations without change in the contract sum.
- c. Install specific-use receptacles at heights shown on Drawings.

2. Position:

- a. Install receptacles vertically with ground pole on bottom. Install receptacles horizontally, where field condition does not allow vertical installation, with ground pole on left.
3. All receptacles with 6 feet of a water source such as sinks shall be GFCI type. Arrange circuit wiring for last receptacle on circuit to be GFCI. Feed through to non-GFCI receptacles is not permitted.

D. Plates:

1. Where cover plates do not completely conceal the rough openings for the devices, it shall be the responsibility of the General Contractor to patch, paint, etc. around the opening to the satisfaction of the Owner's representative.
2. All devices and cover plates shall be plumb and parallel to adjacent surfaces or trim. Devices must be flush with the finished trim cover plates and plates must be tight to surfaces over which they are installed.
3. Where switches controlling devices that are out of sight, or where three or more switches are gang mounted, plates shall be labeled to identify items being controlled, or areas being lighted. Labeling shall be 3/16-inch Condensed Gothic and shall be filled with black enamel.

E. Floor Boxes:

1. Verify locations of all floor boxes with the Owner's representative before installation. Increase slab thickness at boxes if required to obtain a minimum of 1 inch of concrete below bottom of box.
2. Install floor boxes level and flush with finish flooring material. Completely envelope floor boxes in concrete except at the top.
3. Adjust covers flush with finished floor.

F. Occupant Sensors:

1. Flush mount occupant sensors through round hole cut in ceiling tile, positioning and placement per sensor manufacturer's recommendation.
2. It is the installer's responsibility to replace damaged ceiling tiles during his installation of sensor.
3. The low voltage control wiring installed above ceiling tiles shall be plenum rated or general building wiring installed in raceway system.

END OF SECTION

SECTION 26 28 13
FUSES, 600 VOLT

PART 1 - GENERAL

1.1 WORK INCLUDED

- A. Dual-element, current limiting Class R fuses for loads up to 600 volts, 0-600 Amps.
- B. Time delay, current limiting Class L fuses for loads up to 600 volts, 601-6000 Amps.

1.2 REFERENCES

NOTE TO SPEC WRITER: INCLUDE ONLY REFERENCE STANDARDS THAT ARE TO BE INDICATED WITH THE TEXT OF THIS SECTION. EDIT THE FOLLOWING, ADDING AND DELETING AS REQUIRED FOR PROJECT AND PRODUCT SELECTION.

- A. UL 248-12 - Standard For Safety For Low-Voltage Fuses-Part 12: Class R Fuses
- B. UL 248-10 - Standard For Safety For Low-Voltage Fuses-Part 10: Class L Fuses
- C. Where application of local codes, trade association standard or publications appears to be in conflict with the requirements of this Section, the Architect/Engineer shall be asked for an interpretation.

1.3 SUBMITTALS

- A. Provide submittals in accordance with and in additional to Section 26 00 00, Basic Electrical Requirements, and Division 01 for submittal requirement.

1.4 PRODUCT DELIVERY, STORAGE AND HANDLING

- A. Store fuses in a clean and dry space and protected from weather. When necessary to store outdoors, elevate materials well above grade and enclose with durable, waterproof wrapping.

PART 2 - PRODUCTS

2.1 MATERIAL AND EQUIPMENT

- A. Furnish fuses manufactured by Buss, or equal, in accordance with the following:
 - 1. Motors and Transformers, 0 to 600 Amp:
 - a. 250 volt - Buss LPN-RK, UL Class RK1.
 - b. 600 volt - Buss LPS-RK, UL Class RK1.
 - 2. Lighting Loads, 0 to 600 Amp:
 - a. 250 volt - Buss KTN-R, UL Class RK1.
 - b. 600 volt - Buss KTS-R, UL Class RK1.

3. All Applications, 601 to 6000 Amp:
 - a. 600 volt - Buss KRP-C, UL Class L.
- B. Size fuses serving motor loads as specifically recommended by motor or equipment manufacturer or in the range of 150% to 175% of motor nameplate rating per NEC in accordance to the type of motor.
- C. Interrupting Rating: 300,000 RMS Amps.
- D. Maintenance Stock, Fuses:
 1. Furnish the following:
 - a. Three spare fuses of each size and type for a spare set.
 - b. Furnish spare fuse cabinet sized to contain required spare fuse stock.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install fuses where indicated, in accordance with the manufacturer's written instructions, the applicable requirements of NEC, national and local codes, regulations, and requirements.
- B. Provide quantity of spare fuses and fuse cabinet per the requirement of this Section at the location per drawing or the direction of Owner's Representative, in addition to replace blown or defective fuses during installation, startup, system commissioning and acceptance.

END OF SECTION

SECTION 26 28 16
DISCONNECT SWITCHES

PART 1 GENERAL

1.1 WORK INCLUDED

- A. Disconnect switches, fusible and non-fusible.
- B. Enclosures.

1.2 REFERENCES

NOTE TO SPEC WRITER: INCLUDE ONLY REFERENCE STANDARDS THAT ARE TO BE INDICATED WITHIN THE TEXT OF THIS SECTION. EDIT THE FOLLOWING, ADDING AND DELETING AS REQUIRED FOR PROJECT AND PRODUCT SELECTION.

- A. Federal Spec. W-S-865 - Switch, Box (Enclosed), Surface-Mounted.
- B. NEMA KS 1 - Enclosed Switches.
- C. NFPA 70 - National Electrical Code
- D. NFPA 70E - Electrical Safety Requirement for Employee Workplaces
- E. UL 98 - Enclosed Switches1.

1.3 SUBMITTALS

- A. Provide submittals in accordance with and in additional to Section 26 00 00, Basic Electrical Requirements, and Division 01 for submittal requirement.
- B. Submit manufacturer's product data. Submit dimensioned drawings and equipment ratings for voltage, capacity, horsepower, and short circuit.

1.4 DELIVERY, STORAGE AND HANDLING

- A. Deliver switches individually wrapped in factory-fabricated water-resistant type containers.
- B. Handle switches carefully to avoid damage to material components, enclosure and finish. Damaged switches shall not be installed on project.
- C. Store switches in a clean and dry space and protected from weather.

PART 2 PRODUCTS

2.1 FABRICATED SWITCHES

- A. NEMA KS 1; Type HD quick-make, quick-break, load interrupter enclosed knife switch with externally operable handle interlocked to prevent opening front cover with switch in ON position. Handle lockable in OFF position. Handle lockable in ON position for service entrance disconnect. Provide defeater so that qualified personnel can open door while switch is in the closed position.

- B. Use switches that have number of poles required as per drawings.
- C. Switches shall be Underwriters' approved for duty shown and enclosure type per drawings. NEMA 3R switches shall be provided where exposed to weather. NEMA 3R switches shall have weatherproof threaded hubs for all conduit entries into switch.
- D. Use fuse clips that are rejecting type to accept Class RK or L fuses only.
- E. Identify switches, as to equipment served, with engraved laminated plastic plates. Refer to 26 05 53 Electrical Identification Section of this specification.
- F. Voltage rating: 240VAC or 600VAC as per drawings.

PART 3 EXECUTION

3.1 INSPECTION

- A. Installer shall examine the areas and conditions under which safety and disconnect switches are to be installed and notify the Contractor in writing of conditions detrimental to the proper and timely completion of the work. Do not proceed with the work until unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF SAFETY AND DISCONNECT SWITCHES

- A. Install safety or disconnect switches, where required by NEC, where indicated on drawings, and where required by equipment manufacturer, in a location convenient for maintenance on switch and adjacent equipment.
- B. For equipment with motors larger than 1/8 hp, install disconnect switches within sight of the motor.
- C. Provide fused disconnect switches, whether or not indicated on drawings, when required to maintain equipment manufacturer's warranty. Coordinate with Division 23 for warranty requirements of equipment approved by submittal.
- D. Install fuses in fusible disconnect switches. Provide permanent marking inside switch enclosure for fuse type.
- E. Wall mount switches, where possible, or mount on unistrut supports.

END OF SECTION

SECTION 26 36 23
AUTOMATIC TRANSFER AND BYPASS/ISOLATION SWITCHES

PART 1 GENERAL

1.1 WORK INCLUDED

- A. The Section specifies furnishing and installation of automatic transfer switches to automatically transfer between the normal and emergency power sources with integral bypass/isolation.

1.2 RELATED WORK

- A. This Section shall be used in conjunction with the following other specifications and related Contract Documents to establish the total requirements for automatic transfer.
 - 1. Section 26 00 00 - Basic Electrical Requirements
 - 2. Section 26 05 33 – Raceways, Conduit, and Boxes
 - 3. Section 26 05 19 – Cable Wire and Connectors 600V
 - 4. Section 26 05 53 – Electrical Identification
 - 5. Section 26 05 26 - Grounding

1.3 REFERENCE STANDARDS

- A. The materials and installation shall conform to the minimum requirements and latest revisions of the following codes, standards and regulations wherein they apply:
 - 1. IEEE C37.2 – Electrical Power System Device Function Numbers and Contact Designations
 - 2. NEMA ICS 1 – General Requirements for Industrial Control and Systems
 - 3. NEMA ICS 6 – Industrial Control and System Enclosure
 - 4. NEMA ICS 10, Part 1 – Electromagnetic AC Transfer Switch Equipment
 - 5. NFPA 70 – National electrical Code
 - 6. UL 1008 – Transfer Switch Equipment
 - 7. NFPA 110 – Standard for Emergency and Standby Power Systems
 - 8. IEEE 446 – Recommended Practice for Emergency and Standby Power Systems

1.4 SUBMITTALS

- A. Provide submittals in accordance with and in addition to Section 26 00 00, Basic Electrical Requirements, and Division 01 for submittal requirement.

1. Descriptive product literature, to include, but not limited to:
 - a. Rated current, voltage and frequency
 - b. Number of poles
 - c. Symmetrical rms amperes withstand current at rated voltage
 - d. Physical dimensions, to include drawout clearances and working clearances
 - e. NEMA enclosure type
 - f. Itemized list of accessories
 - g. UL 1008 3-cycle close and withstand rating
2. Plan, elevation, side, and front view arrangement drawings, including overall dimension, weights, clearances for installation, drawout of removable components, and working clearances, as well as mounting or anchoring requirements and conduit entrance locations.
3. Schematic diagram (show wiring and only those components which are part of switch).
4. Provide wire diagram prior to shipping. Show all factory wiring on wiring diagram and clearly indicate all wiring and connections to remote devices which are to be made in the field.

1.5 PRODUCT DELIVERY AND STORAGE

- A. Deliver unit to the project site, protected from the weather and damage due to shipping and handling. Cover all piping connections.
- B. Store unit in a clean and dry space and protected from weather.

PART 2 PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

- A. ASCO
- B. Russelectric
- C. Cummins
- D. Cutler-Hammer
- E. Other manufacturers equal in design and function will be considered upon A/E approval following substitution procedure in Section 26 00 00 and Division 01 for substitution requirement.

2.2 RATINGS

- A. The transfer switches shall have voltage rating, current rating and interrupting ratings as shown on Drawings.
- B. The transfer switches shall be 100 percent equipment rated for continuous duty as shown on the Drawings and shall conform to the applicable requirements of UL 1008 for emergency system total load. The automatic transfer switches shall be

fully rated to protect all types of loads, inductive and resistive, from loss of continuity of power without de-rating.

- C. All pilot devices and relays shall be of the industrial type with self-cleaning contacts and rated 10 amperes.

2.3 CONSTRUCTION

- A. The transfer switches shall consist of completely enclosed contact assemblies and a separate control logic panel. The transfer switch shall be open-transition. The contact assemblies shall be operated by a non-fused motor operator or stored energy mechanism and be energized only momentarily during transfer, providing inherently double throw switching action. Control power for all transfer operations shall be derived from the line side of the source to which the load is being transferred.
- B. Transfer switches shall be capable of being operated manually under full load conditions. Manual operation shall be accomplished via a permanently affixed manual operator or integrally mounted pushbutton operators located on the face of the transfer switch assemblies. Removable manual operating handles and handles which move in the event that electrical operations should suddenly become energized while performing a manual transfer operation are not acceptable. The manual operator shall provided the same contact-to-contact transfer time as provided under normal automatic operation to prevent possible flashovers from switching the main contacts slowly. In addition, provisions shall be made to allow disengagement of the electrical operator during manual operation.
- C. Each transfer switch shall be positively interlocked both mechanically and electrically to prevent simultaneous closing of both sources under either automatic or manual operation. Main contacts shall be mechanically locked in position in both normal and emergency positions. A neutral position shall not be possible under normal electrical operation unless a delayed transition accessory is required for switching highly inductive loads. Each transfer switch shall have a manual neutral position for load circuit maintenance. A transfer switch position indicator shall be visible from the front of the switch to show which source the transfer switch is connected.
- D. All three-phase four-wire transfer switches used on system with ground fault equipment shall be true four-pole switched neutral type with fully rated and connected to a common shaft. The fourth (neutral) pole contacts shall be identical construction as, and operate simultaneously with, the main power contacts. Add-on or overlapping neutral contacts are not acceptable.
- E. Where shown on the Drawings, transfer switches applied as service entrance switches shall be provided with overcurrent trip units and a service entrance label. An external key-operated selector switch shall be provided to disconnect the power supplies. Indicators shall be provided to show the availability of each source as well as breakers in a tripped or disconnected position. Provide a neutral disconnect link for three-pole solid neutral switches, and a neutral-to-ground main bonding jumper for all switches to meet UL service entrance requirements. Ground fault

protection shall be provided for all switches rated 1000 amperes or more in accordance with NEC Article 230.95.

2.4 MICROPROCESSOR-BASED CONTROLLER

- A. A microprocessor-based controller shall be separately mounted from the power switching portion of the transfer switch. The two sections shall be connected by control cables with plug-in connectors. The control section shall be capable of being disconnected from the power section for maintenance purposes.
- B. The controller shall be rated for an operation temperature range of -20 degree C to +70 degree C, and a storage temperature range of -30 degree C to +85 degree C. The microprocessor-based controller shall be capable of operating with control input power available within the range of 55 percent to 133 percent of nominal voltage indefinitely. Connection to any external battery or to the engine battery is not permissible. The controller shall not in any way be adversely affected by line voltage or frequency fluctuation during the course of transferring heavy electrical loads from one source to another. Adverse effects may include, but are not limited to, an unintended retransfer to the original source.
- C. The controller shall be equipped with self diagnostics, which performs periodic checks of the memory, input/output (I/O), and communication circuits, with a watchdog/power fail circuit.
- D. The controller shall be accurate to within 1 percent of full-scale value for measured parameter. Voltage and current for all phases shall be sampled simultaneously to assure high accuracy in conditions of low power factor or large waveform distortions.
- E. A digital readout shall display each option as it is functioning. Readouts shall display:
 - 1. Three phase voltage with 1 percent accuracy to display all three separate phase-to-phase voltage simultaneously, for both the normal and emergency source.
 - 2. Frequency with 1 percent accuracy to display frequency for both normal and emergency source.
 - 3. Availability of normal source and emergency source.
- F. The following metered readings shall also be communicated by the Controller, via local display and serial communication.
 - 1. Current, per phase RMS and neutral
 - 2. Current unbalance %
 - 3. Voltage, phase-to-phase and phase-to-neutral
 - 4. Voltage unbalance %
 - 5. Real power (KW), per phase and 3-phase total
 - 6. Apparent power (KVA), per phase and 3-phase total
 - 7. Reactive power (KVAR), per phase and 3-phase total

8. Power factor, per phase and 3-phase total
 9. Frequency
 10. Accumulated energy (KWH, KVAH, and KVARH)
- G. When timers are functioning, the microprocessor shall display the timer counting down. All set points can be reprogrammed from the front of the switch when the switch is in the program mode. A test push button shall be included as part of the microprocessor.
- H. The controller shall be capable of storing records in memory for access either locally or remotely for up to 100 events. The reports shall include date, time and a description of the event, and shall be maintained in a non-volatile memory. The controller shall be capable to

2.5 ACCESSORIES

- A. The following logic and options shall be supplied:
1. The logic of the transfer switch shall function via a microprocessor-based controller. The set points shall be field adjustable without use of the special tools. The switch shall have a multi-tap voltage selection plug for ease of voltage adjustment in the field. LED lights shall be included on the exterior of the switch to show:
 - a. Normal source available
 - b. Emergency source available
 - c. Normal source connected
 - d. Emergency source connected
 - e. Load energizedPosition indicators shall be visible from the front of the switch.
 2. The switch shall include the following:
 - a. Provide a time delay transfer from the normal power source to the emergency power source (0 seconds to 30 minutes). This option does not affect the engine start circuit.
 - b. Provide a timer to override a momentary power outage or voltage fluctuation (0 seconds to 120 seconds).
 - c. Provide a time delay transfer from the emergency power source to the normal power source (0 seconds to 30 minutes).
 - d. Provided a timer to allow the generator to run unloaded after retransfer to the normal power source (0 seconds to 30 minutes).
 - e. Provided single-phase under-voltage and under-frequency sensing on the emergency power source. Voltage shall be factory set at 90 percent pickup and 80 percent dropout. Frequency sensing shall be set at 58-hertz pickup and 56-hertz dropout.

- f. Provide a pilot light to indicate that the switch is in the normal position as an integral part of the microprocessor.
 - g. Provide a pilot light to indicate that the switch is in emergency position as an integral part of the microprocessor.
 - h. Provide a pilot light to indicate that the normal power is available as an integral part of the microprocessor.
 - i. Provide a pilot light to indicate that the emergency power is available as an integral part of the microprocessor.
 - j. Provide auxiliary relay contacts that are energized when the power is available on the normal source.
 - k. Provide auxiliary relay contacts that are energized when the power is available on the emergency source.
- B. The following features shall be provided:
- 1. Time delay normal to emergency, adjustable.
 - 2. Time delay emergency to emergency, adjustable
 - 3. Green pilot light to indicate switch in normal position and red pilot light to indicate switch in emergency position.
 - 4. White pilot lights marked “Normal Source” and “Emergency Source” to indicate that respective source voltages are available.
 - 5. Tripped position indicating lights for both sources.
 - 6. Relay auxiliary contacts (2 NO and 2 NC) to indicate transfer switch position and the availability of each sources.
- C. When the alternate source is an engine generator, the following features shall also be provided:
- 1. Time delay engine start, adjustable.
 - 2. Time delay engine cool off, adjustable.
 - 3. Engine start contact.
 - 4. Frequency/voltage relay for emergency source, frequency adjustable from 45 to 50 Hz and voltage fixed at 90 percent pickup, 70 percent dropout.
 - 5. Four-position selector switch permitting four (4) modes of transfer switch operation: TEST (simulates normal power outage), AUTO (standard automatic operation), OFF (de-energizes control relays and opens the engine start circuit for maintenance purpose), ENGINE START (retains transfer switch in normal position and initiates a testing of the engine start circuit). Furnish white pilot light for OFF indication.
- D. Provide engine generator exerciser (selectable load no-load transfer).

2.6 COMMUNICATIONS

- A. Where shown on the Drawings, provided in the transfer switch a microprocessor-based unit capable of communicating phase and ground current, peak demand, present demand, energy consumption, contact status, and mode of trip. The transfer switch shall respond to open and close commands from a master control unit via a non-proprietary communication network.
- B. Provide communications capability to monitor the normal and emergency switch position and normal and emergency source availability. Where shown on the Drawings, provided additional communications capability to bypass time delays during transfer or retransfer, and to initiate engine start for no-load or load testing of the transfer switch from a remote master computer.

2.7 DRAWOUT OPTION

- A. Where shown on the Drawings, provide transfer switches with drawout mechanism to allow easy access for preventative maintenance, testing or inspection. The drawout mechanism shall provide visual indicators as to position the switch/breaker during the drawout operation.

2.8 BYPASS/ISOLATION SWITCH OPTION

- A. Where shown on the Drawings, provided bypass/isolation switch to electrically bypass and isolate, without load interruption, each automatic transfer switch. Furnish an integral bypass/isolation switch to provide a safe and convenient means for manually bypassing and isolating the automatic transfer switch, regardless of the condition or position of the ATS. The integral bypass/isolation switch shall also serve as an emergency back-up system in the event the automatic transfer switch should fail. In addition, the bypass/isolation switch shall be utilized to facilitate maintenance and repair of the automatic transfer switch.
- B. Completely isolate the automatic transfer switch from the bypass/isolation switch by means of insulating barriers and separate access doors to positively prevent hazard to operating personnel while servicing the automatic transfer switch. The isolation portion of the bypass/isolation shall allow the automatic transfer switch to be disconnected from all sources of power and control without opening the enclosure door. Provide transfer switch with a true drawout configuration which does not require disconnection of any electrical or mechanical devices by personnel performing maintenance upon and/or operation of the switch. Provide the automatic transfer switch with rollers or casters to allow removal from enclosure by simply rolling out the unit.
- C. The main contacts of the bypass/isolation switch shall be mechanically locked in both the normal bypass/isolation and emergency bypass/isolation positions without the use of hooks, latches, magnets, or springs and shall be silver-tungsten alloy, protected by arcing contacts with magnetic blowouts on each pole. The switching mechanism shall provide “quick-break”, “quick-make” operation of the contacts.
- D. Positive sequencing of all contacts, with no possible intermediate position, shall be accomplished through the manual operations from a dead front location. Electrical testing during maintenance of the automatic transfer switch shall be possible in the bypass/isolation position.

- E. The switch shall be fully manually operated and shall not be dependent upon electrical operators, relays, or interlocks for operation. The bypass/isolation switch shall be listed by Underwriters' Laboratories Inc., Standard UL-1008 and meet the identical withstand ratings of its associated transfer switch.
- F. Provide the bypass/isolation switch with mechanical interlocks to accomplish this separation of normal and emergency circuits, to prevent accidental connection of unsynchronized sources. Electrical interlocking, alone, will not be considered acceptable.

2.9 WIRING TERMINATIONS

- A. Terminal blocks shall conform to NEMA ICS 4. Terminal facilities shall be arranged for entrance of external conductors from the top or bottom of the enclosure. The main transfer switch terminals shall be suitable for the termination of conductors shown on the plans.

2.10 SEQUENCE OF OPERATION

- A. The transfer switch shall automatically transfer its load circuits to an emergency or alternate power supply upon failure of its normal or preferred source.
- B. Upon loss of phase-to-phase voltage of the normal source to 80 percent of nominal, and after a time delay, adjustable from 0.5 to 15 seconds, to override momentary dips and/or outages, a 10-ampere, 30-Vdc contact shall close to initiate starting of the emergency or standby source power plant. Transfer to the alternate source shall take place immediately upon attainment of 90 percent of rated voltage and frequency of that source. For switches not involving engine generator sets as power plants, transfer shall occur after an adjustable time delay of 1 to 60 seconds to override momentary dips and outages.
- C. When the normal source has been restored to 90 percent of rated voltage, and after a time delay, adjustable from 0 seconds to 30 minutes, the load shall be retransferred to the normal source.
- D. A time delay, adjustable from 0 seconds to 30 minutes, shall delay shutdown of the emergency or standard power source after retransfer to allow the generator to run unloaded for cool-down, after which the generator shall be automatically shut down.
- E. If the emergency or standby power should fail while carrying the load, transfer to the normal power supply shall be made instantaneously upon restoration of the normal source to satisfactory conditions.

2.11 ENCLOSURE AND FINISH

- A. Each transfer switch shall be provided in enclosure suitable for locations as indicated on the drawings and as indicated on Drawings.
- B. NEMA 1, 12 or 3R enclosure shall be painted with the manufacturer's standard painting procedures to ensure suitability for environmental conditions as referenced in the plans. Color shall be light gray ANSI 61. NEMA 4 or 4X shall be stainless steel, non-painted.

PART 3 EXECUTION

3.1 PRODUCT HANDLING AND VISUAL INSPECTION

- A. Handle unit carefully to avoid damage to material components, enclosure and finish. Use only lifting and brackets provided for that purpose. Unit shall be inspected prior to installation for damage. Damaged units shall be rejected and not be installed on project.

3.2 FOUNDATION PAD

- A. Install automatic transfer and bypass/isolation switch on a concrete house keeping pad with manufacturer's instruction and/or per Drawings.
- B. Coordinate conduit stub-up locations with Structural Engineer prior to placing conduit and farms for foundation pad.

3.3 INSTALLATION

- A. Install the automatic transfer and bypass/isolation switch as shown on the drawings. Installation shall follow manufacturer's installation procedures and be in accordance with NEC.
- B. Coordinate controller functions with packaged engine generator controls. Coordinate with metal clad medium voltage switchgear or low voltage metal-enclosed switchgear, which are designed for emergency power distribution. The entire system shall be demonstrated functional as a whole.
- C. Coordinate interfaces with other life safety and/or building control systems as shown on Drawings.

3.4 TOUCHUP PAINTING

- A. Restore any marred surfaces to factory finish.

3.5 FIELD TESTING

- A. Test the switches with the packaged engine generator set in operating condition. Demonstrate to the Owner that the automatic transfer switches and bypass/isolation switches perform all required functions.
- B. The manufacturer's representative(s) shall be on site for testing and start-up the systems.

3.6 TRAINING

- A. Provide on-site training for Owner's designated personnel in the construction, operation, maintenance, troubleshooting and repair of the automatic transfer and bypass/isolation switch.
- B. Formal training for the operation and maintenance shall be provided by factory trained and certified personnel.
- C. The training shall consist of a minimum of 8-hour training sessions or per Owner's direction.

- D. The timing of the training shall coincide with the schedule for the manufacturer's representative(s) to be on site for testing and start-up.
- E. The specific training shall be provided at a location designated and provided by the Owner for a minimum of 10 personnel selected by the Owner.
- F. A training program shall be submitted with material, instructor's qualification, and proposed schedule, a minimum 60 days prior to the proposed training. The Owner reserves the right of approval of any training course, material, instructor and schedule.
- G. The training program shall consist of, but not limited, instruction in the following subjects:
 - 1. Review of the applicable one-line drawings, wiring diagrams, and schematic for the automatic transfer and bypass/isolation switch.
 - 2. Review of the factory record shop drawings and placement of the various components.
 - 3. Review of Operation and Maintenance manuals.
 - 4. Instruction in manufacturer's published procedures for operation, maintenance, troubleshooting, and safety. Instruction shall include all modes of equipment operation and alignment.
 - 5. Review of maintenance procedures for removal and placement of major components, and removal and replacement of renewable parts, as applicable.
 - 6. Discuss the maintenance timetable and procedures to be followed in an ongoing maintenance program.
 - 7. Provide binders to participants complete with copies of drawings and other course material covered.
- H. A minimum of 12 bound copies of training material shall be provided at the time of training, with four additional copies submitted at the time of substantial completion included in the Owners manuals.

END OF SECTION

SECTION 26 41 00
LIGHTNING PROTECTION SYSTEMS

PART 1 GENERAL

1.1 WORK INCLUDED

- A. System design.
- B. Air terminals, interconnecting conductors, and other system components and accessories.
- C. Grounding and bonding for lightning protection.
- D. System inspection and certification.

1.2 RELATED WORK

- A. This Section shall be used in conjunction with the following other specifications and related Contract Documents to establish the total requirements for lightning protection systems.
 - 1. Section 26 00 00 - Basic Electrical Requirements
 - 2. Section 26 05 33 – Raceways, Conduit, and Boxes
 - 3. Section 26 05 26 - Grounding
- B. In the event of conflict involving requirements of lightning protection systems between this Section and any other Sections, the provisions of this Section shall govern.

1.3 APPLICABLE CODES AND STANDARDS

- A. The materials and installation shall conform to the minimum requirements and latest revisions of the following codes, standards and regulations wherein they apply:
 - 1. NFPA 70 - National Electrical Code
 - 2. UL 96 - Lightning Protection Components
 - 3. UL 96A – Installation Requirements for Lightning Protection Systems
 - 4. NFPA 780 - Lightning Protection Systems
 - 5. LPI 175 - Standard of Practice for the Design - Installation - Inspection of Lightning Protection Systems

1.4 SYSTEM DESCRIPTION

- A. Lightning Protection System: UL 96A Master Labeled system consisting of air terminals on roofs, roof mounted mechanical equipment, stacks, bonding of structure and other metal objects; grounding electrodes; and interconnecting conductors. Lightning protection systems shall be incorporated into the building

system by the lightning protection contractor as required for a complete master labeled system.

1.5 QUALIFICATIONS

- A. Manufacturer: Company specializing in lightning protection equipment with minimum three years documented experience and member of the Lightning Protection Institute.
- B. Installer: The Contractor for the work covered by this specification shall be recognized as being regularly engaged in the design and installation of lightning protection systems. The Contractor must have minimum three years documented experience and member of the Lightning Protection Institute (LPI). Installer shall be a certified LPI master installer of lightning protection systems.

1.6 COORDINATION

- A. Coordinate the work of this Section with concrete, roofing and exterior and interior finish installations.
- B. Coordinate all provisions for down conductors and system connections with all trades.

1.7 SUBMITTALS

- A. Provide submittals for the following information in addition to and in accordance with Section 26 00 00, Basic Electrical Requirements, and Division 01 for submittal requirement.
 - 1. Shop drawings showing layout of air terminals, grounding electrodes, and bonding connections to structure and other metal objects. Include terminal, electrode, and conductor sizes, and connection and termination details.
 - 2. Shop drawings shall include locations of conductors, roof penetrations, floor penetrations, etc., and their compatibility with provisions made during the construction. Once the contract has been established the Contractor shall make a review of provisions being made for the system installation and comment, in writing, with changes or compliance within two weeks of finalizing the contract. Contractor shall coordinate locations of conductors in walls and all penetrations with the appropriate trades: Failure to coordinate these requirements shall not relieve lightning protection Contractor from properly completing its work. This Contractor shall employ the proper trades to provide the chases in walls and roof and floor penetrations required to install the conductors if not coordinated before the floors, walls and roof are installed.
 - 3. Product data showing dimensions and materials of each component, and include indication of listing in accordance with UL 96.
 - 4. As Built Record Drawings: The Contractor shall maintain a master set of As Built Record Drawings that shows changes and any other deviations from the Base Drawings in accordance with Section 26 00 00.

1.8 MASTER LABEL

- A. The system design shall equal to or exceed the requirement of UL 96A for a Master “C” Label. Upon completion, the lightning protection systems shall be inspected by a representative of Underwriters Laboratories, Inc. The lightning protection systems must pass UL inspection and wear UL label.

1.9 WARRANTY

- A. Provide a warranty for material and installation per Section 26 00 00, Basic Electrical Requirements, unless a longer warranty period is required in specific product specifications.

PART 2 PRODUCTS

2.1 GENERAL

- A. The system provided under this specification shall be the standard product of a manufacturer regularly engaged in the production of lightning protection systems and shall be the manufacturer’s latest approved design.
- B. Materials used in connection of the installation of the lightning protection system shall be proved for lightning protection systems by UL. No combination of materials shall be used that form an electrolytic couple of such nature that corrosion is accelerated in the presence of moisture. Where unusual conditions exist which would cause corrosion of conductors, conductors with protective coatings or oversized conductors shall be used.
- C. Where a mechanical hazard is involved, conductor size shall be increased to compensate therefore, or suitable protection shall be provided. The conductors may be protected by covering them with molding or tubing made of nonmetallic material.
- D. Aluminum materials may not be used except on roofs that utilize aluminum roofing components. When aluminum materials are used, provide all materials of aluminum composition to ensure compatibility, except down conductors and grounding. Provide copper down conductors with bimetal transition at the roof assembly rated for the application.

2.2 CONDUCTORS

- A. All conductors shall be stranded copper and of the grade ordinarily required for commercial electrical work generally designated as being 98 percent conductive when annealed. Aluminum conductors may only be used on roofs that are built of aluminum roofing components. Conductor minimum size shall be in compliance with NFPA 780.

2.3 AIR TERMINALS

- A. Air terminals shall be [copper or copper alloy] or [aluminum] per UL 96. A copper or copper alloy air terminal intended for use on a chimney shall have a hot-dipped lead coating or equivalent. Class II air terminal shall be of solid construction. Air terminal minimum diameter shall be in compliance with NFPA 780.

2.4 GROUND ROD

- A. Ground rod shall be copper-clad steel, $\frac{3}{4}$ -inch diameter by 10 feet in length.

2.5 CONNECTIONS

- A. Connector fittings shall be [copper or copper alloy] or [aluminum] per UL 96 and compatible with material type used for air terminals and conductors.
- B. All belowground and concealed connections shall be made with exothermic welded connections.

2.6 ROOF PENETRATIONS

- A. Roof penetrations shall be accomplished with through-roof fittings specially designed for this purpose. Through-roof fittings shall utilize solid rods with appropriate hardware. Fittings shall incorporate a positive means for sealing around the rod.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that surfaces are ready to receive work.
- B. Verify that field measurements are as shown on the shop drawings.
- C. Beginning of installation means installer accepts existing conditions.

3.2 PROTECTION OF SURROUNDING ELEMENTS

- A. Protect elements surrounding work of this Section from damage or disfiguration.

3.3 CONDUCTORS

- A. Install in accordance with manufacturer's instructions. Conceal down conductors. Concealed down conductors shall be installed in continuous insulating PVC raceways. Metallic raceways shall not be used.
- B. PVC conduit shall not be installed in plenums. If PVC conduit has to be installed in plenum space, the PVC conduit shall have fire rated walls installed creating a chase space for the conduit.
- C. The Contractor shall bond each down conductor to the ground rod (Cad-Weld or equivalent) which is bonded to the counterpoise conductors creating a common ground.
- D. No bend of a conductor shall form an angle beyond 90 degrees nor shall have a bend radius less than 8 inches per NFPA 780.

3.4 AIR TERMINALS

- A. Air terminal height and support shall be in compliance with the requirement of NFPA 780.
- B. Air terminals shall not be mounted such they have to be moved to perform maintenance on the equipment they protect.

3.5 GROUND RING ELECTRODE

- A. A ground ring electrode encircling the building or structure shall be installed. Lightning protection systems down conductors shall be connected to the ground ring electrode.
- B. Interconnect lightning protection ground ring electrode with building ground electrode system.

3.6 ROOF CONNECTIONS

- A. Make direct connections to lightning protection system with copper conductor for all roof mounted equipment, enclosures, mast, fan stacks and all metallic objects alike. Provide bonding jumpers across all equipment mounting isolators and ductwork isolators to provide a complete ground path.
- B. All antennas shall be grounded.

3.7 ROOF ATTACHMENT AND PENETRATIONS

- A. Roof penetration. Contractor shall inform Owner's representative, in advance, of any required roof penetrations and shall obtain approval. Wherever the system penetrates the roof, approved through-roof fittings or sleeves shall be furnished by the lightning protection contractor and installed by the roofing contractor. All patching masonry and structural work shall be furnished and installed by the general contractor.
- B. All attachments to roofs must be in strict accordance with the roof manufacturer's recommendations. The lightning protection contractor shall submit details of all roof attachment to the appropriate roof manufacturer for approval prior to installation. Once the lightning protection system installation is complete, the lightning protection contractor shall engage the appropriate roof manufacturer to inspect all roof attachments on that manufacturer's roof. Subsequent to the inspection, the roof manufacturer shall furnish the Owner with a letter indicating that all lightning protection systems component roof attachment and penetration are satisfactory and such attachments and penetrations will not in any way to void or reduce the warranty on roof. Any fees for services or inspections provided by the roof manufacturer to accomplish the above related requirements shall be at the expense of the lightning protection contractor.

3.8 COVER-UP INSPECTION

- A. Prior to cover-up of concealed components and connections, notify the Owner so that a cover-up inspection can be performed. Correct any deficiencies prior to concealment of components and connections.

3.9 INSPECTION AND MASTER LABEL

- A. Upon completion, the lightning protection systems shall be inspected by the representative of the Owner.
- B. Obtain the services of Underwriters Laboratories, Inc. to provide inspection and certification of the lightning protection systems. If the system does not pass UL inspection, the Contractor must make corrections to the system in order to pass

inspection. Contractor shall furnish the Owner with appropriate approval certificate.

C. Obtain UL Master Label and attach to building at a location as directed by Owner.

3.10 CONFLICTS

A. In the event a conflict exists between this specification and any of the referenced standards, the requirements of referenced standards govern. Necessary variances or corrections shall be made at the expense of the lightning protection contractor in order to obtain UL Master Label.

END OF SECTION

SECTION 26 51 00
INTERIOR AND EXTERIOR LIGHTING

PART 1 GENERAL

1.1 WORK INCLUDED

- A. Interior lighting fixtures and accessories
- B. Exterior lighting fixtures and accessories
- C. Emergency lighting units
- D. Emergency exit signs
- E. Emergency fluorescent lamp power supplies
- F. Lamps
- G. Ballasts
- H. Site lighting poles
- I. Lighting controls

1.2 REFERENCES

NOTE TO SPEC WRITER: INCLUDE ONLY REFERENCE STANDARDS THAT ARE TO BE INDICATED WITHIN THE TEXT OF THIS SECTION. EDIT THE FOLLOWING, ADDING AND DELETING AS REQUIRED FOR PROJECT AND PRODUCT SELECTION.

- A. NEPA 101 - Code for Safety to Life from Fire in Buildings and Structures
- B. NEMA WD1 - General-Purpose Wiring Devices
- C. ANSI C82.1 - Specification for Fluorescent Lamp Ballasts
- D. ANSI C82.4 - Specifications for High-Intensity-Discharge Lamp Ballasts (Multiple Supply Type)
- E. NEMA LE - H-I-D Lighting System Noise Criterion (LS-NC) Ratings
- F. UL 844 - Electric Lighting Fixtures for Use in hazardous (classified) Locations
- G. UL 924 - Emergency Lighting and Power Equipment
- H. UL 935 - Fluorescent-Lamp Ballasts
- I. UL 1029 - High-Intensity-Discharge Lamp Ballasts
- J. UL 1572 - High Intensity Discharge Lighting Fixtures
- K. UL 1574 – Track Lighting Systems
- L. IESNA – Lighting Handbook
- M. NEMA WD 1 - General Color Requirements for Wiring devices

- N. NEMA LE 5B – Procedure for Determine Luminaire Efficacy Ratings for High-Intensity Discharge Industrial Luminaires
- O. NFPA 70 – National Electrical Code
- P. ASHRAE/IES 90.1 – Energy Standard for Buildings Except Low-Rise Residential Buildings
- Q. Standards For State-Funded Outdoor Lighting Fixture – Texas House Bill 916 (1999)
- R. UT System OFPC – Security Planning and Design Guidelines (2002 release)

1.3 DESIGN CRITERIA

- A. Lighting level design shall be per IESNA (Illuminating Engineering Society of North America) recommendation.
- B. The power consumption for interior and exterior lighting shall not exceed power allowance as per ASHRAE 90.1 latest revision.
- C. Outdoor lighting for state-funded project shall meet “cutoff luminaire” criteria set forth by Texas House Bill 916 (1999).
- D. Design for exterior lighting shall meet security criteria required by UT System OFPC – Security Planning and Design Guidelines (2002 release).

1.4 SUBMITTALS

- A. Provide submittals in accordance with and in addition to Section 26 00 00, Basic Electrical Requirements, and Division 1 for submittal requirement.
- B. Submit manufacturer's data on interior and exterior lighting fixtures in booklet form, with separate sheet for each fixture, assembled by luminaire "type" in alphabetical order, with the proposed fixture and accessories clearly labeled.
- C. Submit dimensioned drawings and performance data including complete photometric test data for each luminaire, candlepower distribution curves in two or more planes, candlepower chart zero to 90 degrees, lumen output zonal summary chart, average and maximum brightness data, and coefficients of utilization for zonal cavity calculations, , spacing to mounting height ration, efficiency and visual comfort probability. Also provide luminaire weights, mounting data, and accessory information for each luminaries type.
- D. Lamps: Catalog cuts showing voltages, colors, approximate hours life, approximate initial lumens, lumen maintenance curve, lamp type and base.
- E. Ballasts: Catalog cuts showing type, wiring diagram, nominal watts, input voltage, starting current, input watts, sound rating, power factor and low temperature characteristics.
- F. Site lighting pole data and catalog cuts, including wind loading, complete dimensions and finish.
- G. Shop drawings for site lighting luminaries showing pertinent physical characteristics, including fastening details, ballast type and location.

- H. Controls: Catalog cuts and/or shop drawings showing dimensions, voltage capacity, contact ratings, wiring diagrams, operating levels, and temperature ratings.
- I. Lighting design shall be in compliance with power allowance for lighting, which is stipulated by ASHRAE 90.1. Compliance forms along with engineering data associated with it shall be submitted for Owner's review during design phase.

1.5 PRODUCT DELIVERY, STORAGE AND HANDLING

- A. Deliver lighting fixtures individually wrapped in factory-fabricated fiberboard type containers. Parabolic louvers shall be shipped in thermally sealed polyethylene wrapper.
- B. Handle lighting fixtures carefully to prevent breakage, denting and scoring the fixture finish. Do not install damaged lighting fixtures.
- C. Store lighting fixtures in a clean, dry space and protected from the weather.

PART 2 – PRODUCTS

2.1 GENERAL

- A. Lighting fixtures and accessories shall comply with the design and function requirements of the project. Design characteristics shall be as noted in manufacturer's submittal data.
- B. Provide lighting fixtures of the size, type and rating as scheduled, complete with, but not limited to, lamps, lamp holders, reflectors, ballasts, poles and wiring.

2.2 INTERIOR LIGHTING FIXTURES

A. Fluorescent Fixtures

1. Lenses shall be UV stabilized, injection-molded, clear, 0.150- inch minimum thickness virgin acrylic. Provide a minimum of 8 hold-down lens retaining clips for troffers utilizing framed diffuser lenses.
2. Parabolic aluminum louvers shall be semi-specular, low-iridescence finish silver anodized aluminum, 2 or 3 inches deep as per drawings. Louvers shall be roll formed with roll grain horizontal to view plane. Louver intersections shall be of a close-fitting, tab-and-slot construction permitting no light leaks.
3. Parabolic plastic louvers shall be vacuum-metalized polystyrene with specular finish and antistatic properties.
4. Lighting fixture door frames shall be flush steel hinged and equipped with rotary-action cam latches.
5. Lighting fixture housing shall be minimum 22-gauge, cold-rolled steel with pre-punched knockouts and access plate for electrical connections. End plates shall be minimum 20-gauge with pre-punched hanger holes. Ballast mounts shall be separated for heat dissipation.

6. Three lamp luminaires for dual level switching shall have outer two lamps on one ballast, inner lamp on second ballast, shared with adjacent luminaire's inner lamp if practical.
- B. Incandescent fixtures shall be pre-wired equipped with integral thermal protection. Use incandescent only where aesthetics outweighs economic considerations.
 - C. Lighting track shall be surface mount or pendant mount per the requirement on drawings, by manufacturer of track mounted light fixtures.
 - D. High Bay, Low Bay HID Fixtures
 1. Provide rugged, lightweight, cast aluminum ballast housing with a baked electro-coat paint finish.
 2. Optic reflector shall be fully fluted, anodized aluminum providing high efficiency. Where enclosed and gasketed type fixtures are specified, provide luminaires designed for continuous operation in an ambient temperature of 55° C.
 - E. Lamp Holders or Sockets
 1. Incandescent lamp holders shall be screw base and have porcelain insulating shells and be rated for heavy duty, 660W.
 2. Fluorescent Sockets: Fluorescent lamp holders shall be heat-resistant porcelain or plastic, designed and rated for the lamp type specified. Lamp holders shall be designed to maintain solid electrical contact at all times. The detent position for bi-pin lamp holders shall be a positive lock so that mechanical effort shall be required to rotate the lamps. Lamp holder shall be specifically compatible with lamping.
 3. HID Medium and Mogul Base Sockets: Provide glazed porcelain pulse-rated heavy duty sockets with silicone leads hard soldered to nickel plated brass screw shell. Lamp holders shall also employ a positive spring locking means to maintain good electrical contact at the center terminal of the lamp.
 4. Lamp holders and sockets shall be provided with minimum 18 AWG wiring leads.
 - F. Reflector Finishes
 1. Painted Finishes: Provide electro-statically applied dry polyester white powder coat finish with minimum reflectance of 88 percent on all light reflecting surfaces.
 2. Specular/Semispecular Finishes: Provide Alzak-type anodized finish on aluminum louvers and reflectors as specified in Luminaire Schedule as shown on the drawings. Minimum reflectivity shall be:
 - a. Specular: 80 percent
 - b. Semi-specular: 75 percent
 - G. UL Listing

1. All Luminaries and components shall be UL tested, listed, and labeled.
2. Luminaries installed under canopies, roofs, or similar damp or wet locations shall be UL listed and labeled as suitable for damp or wet locations.
3. Recessed luminaries installed in fire rated ceilings and using a fire rated protective cover shall be thermally protected for this application and shall be approved for the installation in a fire-rated ceiling.

2.3 EXTERIOR LIGHTING FIXTURES

- A. Enclosures shall be complete with gaskets to form weatherproof seal and UL approved for wet locations.
- B. Provide low temperature ballasts with reliable starting to 0 degrees F.

2.4 BATTERY BACKED EMERGENCY LIGHTING UNITS

A. Acceptable Manufacturers

1. Dual Lite
2. Lithonia
3. Other manufacturers equal in design and function will be considered upon A/E approval following substitution procedure in 16010, and Division 1 for substitution requirement.

B General Requirements

1. Provide emergency lighting units self-contained complete with batteries, charger, and lamps to provide automatic emergency lighting upon failure of normal power.
2. Battery shall be 6 or 12 volts, sealed maintenance free, nickel cadmium type, 24-watt rated capacity, with 1.5 hours minimum capacity to supply the connected lamp load.
3. Charger shall be solid state capable of maintaining the battery fully charged during normal conditions, and capable of recharging discharged battery to full charged within 24 hours.
4. Lamps shall be 12 watt minimum, sealed beam Tungsten Halogen type.
5. Unit housing shall be thermoplastic or steel with beige finish.
6. Indicators: Provide lamps to indicate AC ON and RECHARGING.
7. Provide test switch to manually transfer unit from normal supply to battery supply.
8. Unit shall be 120 or 277 volt.

2.5 EXIT SIGNS

A. Acceptable Manufacturers

1. Dual Lite

2. Lithonia
3. Other manufacturers equal in design and function will be considered upon A/E approval following substitution procedure in 16010, and Division 1 for substitution requirement.

B. General Requirements

1. Provide red LED with red diffuser exit signs at the locations per drawings. Exit signs shall have stencil face, 6-inch high red letters on white background, or as specified otherwise, with red Chevron type directional arrows as indicated on drawings.
2. Battery backed exit signs shall be provided with integral battery-operated emergency power supply, including power failure relay, test switch, AC ON pilot light, battery, and fully-automatic charger. Provide test switch to manually transfer unit from normal supply to battery supply.
3. Battery shall be sealed maintenance free, nickel cadmium type, 6 or 12 volts, 24-watt rated capacity, with 1.5 hour minimum capacity to supply connected lamp load.
4. Unit shall be 120 or 277 volt.

2.6 LAMPS

A. Acceptable Manufacturers

1. General Electric Company
2. Philip Lighting Company
3. Sylvania
4. Other manufacturers equal in design and function will be considered upon A/E approval following substitution procedure in 16010, and Division 1 for substitution requirement.

B. General Requirements

1. Lamps including linear fluorescent, compact fluorescent, and HID shall be low mercury type and shall pass all federal TCLP (Toxicity Characteristic Leaching Procedure) test requirements in effect at the time of manufacture. All lamps shall be energy saving and rapid start type.
2. General use incandescent lamps shall be inside frosted type, 120 volts, 750 hour minimum.
3. Linear fluorescent lamps shall be T8 lamps. Compact lamps shall be twin or double twin tubes. All lamps for one project shall be provided by the same manufacturer with color temperature as indicated on drawings. Operation voltage and wattage shall be as indicated on drawings..
4. Mercury vapor HID lamps shall not be used.
5. Metal halide HID lamps shall be phosphor coated, suitable for the burning position required.

6. High-pressure sodium HID lamps shall be clear or diffuse coated.
7. Maintenance Stock: Furnish a stock of replacement lamps in the original cartons or packing sleeves, amounting to 10% (but not less than two lamps in each case) of each type and size lamp used in each fixture type. Deliver replacement stock as directed to Owner's storage space.

2.7 BALLASTS

A. Acceptable Manufacturers

1. Valmont
2. Advance
3. Magnetek
4. Other manufacturers equal in design and function will be considered upon A/E approval following substitution procedure in 16010, and Division 1 for substitution requirement.

B. General Requirements

All ballasts shall be UL listed and have the UL symbol on the label.

1. Ballasts for fluorescent lamps
 - a. Provide 277V ballasts for all operations except for under-counter fixtures that shall be rated for 120V operation. Ballasts shall be electronic type, rapid start, and power factor of 95 percent or greater, suitable to operate at 60 Hz input frequency.
 - b. Electronic ballasts shall comply with all FCC and NEMA limits governing EMI and RFI, and shall have Total Harmonic Distortion (THD) of less than 20 percent.
 - c. Ballasts shall be Class P thermally protected.
 - d. Sound level criteria
 - 1) Nominal 430 mA Lamps: Class A sound rated.
 - 2) Nominal 800 mA Lamps: Class B sound rated.
 - 3) Nominal 1500 mA Lamps: Class D sound rated. Provide isolation mounting and insulation to reduce sound transmission and radiation.
 - e. Electronic Dimming Ballasts: Compatible with lamp and dimming system, labeled for use and listed as compatible by dimmer manufacturer with a minimum full-to-20 percent dimming range.
 - f. Exterior Fluorescent Ballasts: Provide zero degree starting rating.
2. Ballasts for HID lamps
 - a. HID ballast shall be multi-tap encased and potted thermally protected high power factor of 90 percent or greater, constant wattage regulating, and

autotransformer type. Ballast ambient operating temperature range shall be -20 to +130 degrees F. Ballasts shall be compatible to the lamps chosen for specific burning position, and compensate for the loss in efficiency.

- b. Provide isolation mounting and insulation of HID ballasts to reduce sound transmission or radiation.
- c. Each HID ballast shall have a fast acting primary inline fuse built into the fixture assembly by the manufacturer.

2.8 LIGHTING POLES

- A. Lighting poles shall be metal, type and finish as specified in Luminaire Schedule as shown on the drawings.
- B. Site lighting poles shall meet wind load rating requirements per local building code.
- C. Pole foundation shall be design by A/E. Refer to pole base details as shown on the drawings for specific pole base requirements.
- D. The entire pole assembly shall be designed to withstand a steady wind load rating requirements per local building code and a gust factor of 1.3 without permanent deflection.
- E. Anchor bolts shall be fabricated from commercial quality hot rolled carbon steel bar with guaranteed minimum yield strength of 55,000 psi. Bolts shall have an "L" bend on one end and be galvanized a minimum of 12" on the tread end. Furnish four bolts and bolt setting template with each set of anchor bolts. Furnish one hex nut, 2 hardened steel washers, and one hex nut with a stainless steel locking pin with each bolt. Furnish two leveling shims with each anchor bolt set.
- F. Standard finish for pole and accessories shall be a factory applied polyester thermosetting powder coating electro-statically applied to the surface of the substrate to a minimum thickness of 3 mil. Color as specified.
- G. Provide and install pole base covers on all poles. Each pole to have internal grounding lug and ground rod.

2.9 LIGHTING CONTROL

- A. Refer to Section 26 27 26.UT Wiring Devices and Floor Boxes for lighting switch, dimming control, and occupancy sensor.
- B. Photocell shall be automatic dawn on, dusk off switching; moisture, temperature, and vibration-resistant die-cast aluminum housing; time delay feature to prevent false switching; field adjustable to control operating levels.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Prior to order lighting fixture, check the building electrical system requirements, architectural finishes, and the type of ceilings that lighting fixture will be installed. Any discrepancies of compatibility pertaining trim, frames, color, mounting, ballast, voltage and etc. shall be brought to the attention of A/E by written notice.

Do not proceed with procurement until discrepancies are resolved in a satisfactory manner.

- B. Installer shall examine the areas and conditions that light fixtures are to be installed and notify the Contractor in writing of conditions detrimental to the proper and timely completion of the work. Do not proceed with the work until unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF LIGHTING FIXTURES

- A. Install light fixtures in accordance with the manufacturer's written instructions, the applicable requirements of NEC and national and local code, standard, and regulations. Install lamps in accordance with manufacturer's instructions.
- B. Install luminaries at locations as shown on the Drawings; install aligned, aimed, and leveled. Install fixtures in accordance with manufacturer's installation instructions complete with mounting accessories, trim and support materials. Fasten fixtures securely to structural support members of the building; solid pendant fixtures shall be plumb.
- C. Coordinate with other crafts to avoid conflicts between luminaires, supports, fittings and mechanical equipment.
- D. Incandescent Fixtures
 - 1. Surface Mounted Incandescent Fixtures: Mount directly to outlet box equipped with fixture stud or mounting bar.
 - 2. Recessed Incandescent Fixtures: Mount with support rails attached to ceiling suspension support system.
- E. Surface Mounted Fluorescent Fixture:
 - 1. Mount with support rails attached to ceiling suspension support system, provided ceiling system has been certified to be suitable to support weight of fixtures.
 - 2. Where ceiling system has not been certified to support weight of fixtures, fixtures shall be supported at four points near each corner of fixtures.
 - 3. Provide a minimum 5/8" air space between the fixture and the ceiling.
- F. Recessed Fluorescent Fixtures:
 - 1. Handle specular/semi-specular louvers and down light cones using only new clean white cotton or silk gloves. Do not touch louvers or cones with bare hands. Leave luminaries clean and free of any visible dust, debris, or fingerprints with all lamps operational at time of acceptance of work.
 - 2. All recessed fluorescent fixtures shall be supported from building structure above ceiling with galvanized steel wire at not less than 4 points near corners of fixture. Size of wire shall be capable of supporting weight of fixtures.
 - 3. Recessed luminaries trims shall fit snugly to the mounting surface and shall not exhibit light leaks or gaps. Provide feed-through junction boxes or provide

separate junction boxes. All components shall be accessible through the ceiling opening.

4. Connect recessed luminaries to junction box with flexible steel conduit and fixture wire.

G. HID Fixtures

1. Mount with support rails attached to ceiling suspension support system, provided ceiling system has been certified to be suitable to support weight of fixtures.

H. Pole Mount Lighting

1. Provide in-line fusing at handhole for all pole-mounted luminaries.
2. Provide removable unitized ballast/component tray with separable connector in all pole-mounted luminaries.
3. Construct base of concrete with dimension and depth as noted on the drawings.
4. Install anchor bolts with minimum projection above top of bases, as specified by pole manufacturer. Ground as indicated on drawings.
5. Mount standards on bases plumb and true utilizing shims as necessary. Grout thoroughly between base-plate and foundation.
6. Touch up chips and scratches on poles (to match new finish) upon completion.

I. Lighting Fixtures Adjustment

1. Adjust to illuminate intended areas as directed.
2. Adjust exterior fixtures during hours of darkness.

- J. Immediately before final observation, clean all fixtures, inside and out, including plastics and glassware, and adjust all trim to properly fit adjacent surface, replace broken or damaged parts, and lamp and test all fixtures for electrical as well as mechanical operation.

- K. Protect installed fixtures from damage during the remainder of the construction period.

- L. Upon completion of installation of interior lighting fixtures, and after circuitry has been energized, apply electrical energy to demonstrate capability and compliance with requirements. When possible, correct malfunctioning units at the site, then retest to demonstrate compliance; otherwise, remove and replace with new units, and proceed with retesting.

- M. Incandescent lamps shall be new at time of final acceptance. Fluorescent lamps may be used in the final finishing of the building. Those that have exceeded more than 1/3 of their rated life (as established by Construction Inspector records), or that have blackened ends or inoperable shall be replaced with new lamps before final acceptance.

N. Lamp Disposal

1. The procedure of disposal of lamps that are mercury containing shall follow the guideline set by EPA (definitions in Title 40 Code of Federal Regulations 261 Subpart C, January 2000).

END OF SECTION

SECTION 28 31 00
FIRE ALARM AND SMOKE DETECTION SYSTEM

PART 1 GENERAL

1.1 WORK INCLUDED

- A. This Section specifies the requirements for furnishing and commissioning a fully functional addressable fire alarm and voice evacuation system with full interface with other related systems. Work shall include, but not limited to, the following.
1. Fire alarm control and annunciator panels
 2. Manual fire alarm stations
 3. Automatic fire, smoke, and heat detection devices
 4. Audible and visual alarm notification devices
 5. Required batteries, battery panels, and associated accessories
 6. Fire door control, security door control
 7. Air handler duct smoke detection, and shutdown
 8. Sprinkler system PIVs, OS&Y valves, and tamper switch monitoring
 9. Sprinkler systems water flow and/or pressure switch monitoring
 10. Monitoring of fire pump controls
 11. Fire/smoke damper control
 12. Smoke purge controls
 13. Activation of deluge and pre-action sprinkler systems
 14. Elevator recall and power shutdown
 15. System acceptance testing and commissioning
 16. Firefighters' two-way voice communication system

1.2 REFERENCES

- A. NFPA 101 - Safety to Life from Fire in Buildings and Structures
- B. NFPA 13 - Installation of Sprinkler Systems
- C. NFPA 20 – Installation of Stationary Pumps
- D. NFPA 70 - National Electric Code
- E. NFPA 72 - National Fire Alarm Code
- F. NFPA 90A – Installation of Air-Conditioning and Ventilating Systems
- G. NFPA 92A – Smoke- Control Systems
- H. UL 864 - Control Units for Fire Protective Signaling Systems
- I. ADA Accessibility Guidelines (ADAAG)

- J. Texas State Insurance Code
- K. Texas Accessibility Standards (TAS)
- L. Local-city Ordinances
- M. International Building Code
- N. All electronic equipment shall comply with all FCC limits governing radio frequency electromagnetic interference and be so labeled.
- O. None of the terms or provisions of this specification shall be constructed as waiving any of the rules, regulations or requirements of Codes.

1.3 SYSTEM DESCRIPTION

- A. The automatic fire detection and alarm system shall consist of a main fire alarm control panel, local control panel nodes, operator workstation, graphics terminal, audio control panel, printer, remote annunciator, detection devices, audible and visual notification devices, remote devices, and manual stations wired in accordance with the schedule on the Drawings and shall function as specified herein. The system shall use supervised multiplex data communications circuits, close loop initiation circuits, individual zone supervision, and individual audible and visual alarm circuit supervision.
- B. The system shall have sufficient capacity to incorporate all equipment and perform all functions as per intent of the specifications and Drawings. The system shall have an overall 20 percent spare capacity that includes but not limited to communication network, terminal strips, amplifier, batteries, etc., reserved for future expansion.
- C. The system shall be capable of being programmed on site for downloading, uploading or editing operating sequence or programming to accommodate and facilitate building parameter changes or changes as required by codes.
- D. A data communications network transmitting multiplexed input and output signals, which shall be electronically supervised, shall connect all control panel nodes. The communication network shall consist of a communication cable transmitting all system operations in a digitally encoded format, an audible signaling bus serving all remote amplifiers, and a two-way phone communications bus serving all individually controlled fire phone circuits.
- E. The fire alarm control panels shall provide power, annunciation, supervision, and control for the fire detection and alarm system. Fire alarm control panels shall be distributed per floor or per zone as practical, such that each fire alarm control panel shall operate as a local stand-alone system with communication network connection to peers and main fire alarm control panel that normally resides in Fire Command Center. The Main Fire Control Panel in Fire Command Center shall monitor and annunciate all alarms and troubles of each Fire Alarm Control Panel in the fire alarm network system scattered throughout the building. All data communication wiring between the controls panels shall be supervised for open circuit, short circuit and ground fault.

- F. Data communication transmission shall use a peer-to-peer network communication channel with token-ring communication protocol as follows.
1. Each node shall communicate to the next node in a peer-to-peer token-ring configuration.
 2. In the event that the path to the next node on the ring has experienced a communication failure, the node with possession of the token shall transmit it back in the direction from which it came to attempt to reach the next node by going around the ring in the opposite direction. At the same time the status of non-communication node shall be added into the content of transmission.
 3. In the event of communication break down and a group of nodes become isolated from the network, that group shall form a sub-network with all common interaction of monitoring and control remaining intact. The network shall be notified with the exact details of the lost communications.
 4. In the event that a single node becomes unable to handle the network token, the network interface card shall continue communications to the rest of the network. The off-line node is reported as such to the network and is periodically interrogated to determine if it is ready to be brought back online with the rest of the network.
- G. Fire detection initiation devices and audible visual alarm devices shall be wired to the fire alarm control panel on the same floor or with the same zone as practical. Smoke or heat alarm initiation devices shall be individually configurable on site to function desirable selective alarm, general alarm, evacuation, alert, test, fire/smoke damper operation, fire door/security door release, smoke control operation, HVAC interface or trouble warning.
- H. The system shall be designed such that alarm indications override trouble conditions. There shall be no limit, other than maximum system capacity, as to the number of addressable devices and/or zones, which may be in alarm simultaneously. The panel shall be capable of measuring the sensitivity of the addressable ionization and photoelectric detectors connected to it.
- I. The system shall initiate the following system outputs when any area or duct detector, manual station, or water flow switch operates in accordance with the fire alarm functional matrix:
1. Audible devices - speakers.
 2. Visual devices – strobes and/or beacons.
 3. Automatically notify fire department, central station, and/or command center.
 4. Display individual detector and/or zone number on alphanumeric display with optional user-defined message.
 5. Light an indicating lamp on the device initiating the alarm.
 6. Shut down the associated HVAC system and operate dampers per drawing.
 7. Activate the elevator recall.

- 8. Release all magnetic fire door holders.
- 9. Activate deluge or pre-action sprinklers.
- J. The fire alarm and smoke detection system shall be used to monitor tamper switches and water flow switches on sprinkler and fire suppression systems.
- K. Fire alarm and smoke detection system shall release fire doors that are held open and security access controlled doors that are held close if desired.
- L. Fire pumps shall be monitored by the fire alarm and smoke detection system.
- M. Fire alarm and smoke detection system shall include the installation of duct-mounted smoke detectors, interface with HVAC damper control, and air-handler shutdown.
- N. Type and quantity of signals, which are expected to be transferred and monitored by existing campus command/dispatch center, shall be verified during design phase. Compatibility issue also needs to be addressed.

1.4 QUALITY ASSURANCE

- A. The system shall be installed by competent mechanics, regularly employed by a Fire Alarm contractor with full responsibility for proper operation of the system including debugging and proper calibration of each component in the entire system. The Contractor shall be with 3 years or more experience with installation of this type. The fire alarm technician shall be licensed by State Fire Marshal in order to install, certify and service the fire alarm system. Supplier shall be licensed by State Fire Marshal in order to sell fire alarm product, and shall have an in-place support facility within 50 miles of the site with technical staff, spare parts inventory and all necessary test and diagnostic equipment.
- B. The complete Fire Alarm and Smoke Detection System installation shall be in strict accordance to the national and local electrical codes and the electrical Section of these specifications. The equipment shall be manufactured by a manufacturer who has been engaged in this type of production (both hardware and software) for at least ten years. The product shall be UL listed under standards 864 (Control Units for Fire Protective Signaling Systems).

1.5 SUBMITTALS

- A. Provide submittals for the following information in addition to and in accordance with 26 00 00, Basic Electrical Requirements, and Division 01 for submittal requirement.
- B. Complete plan drawings showing all devices, panels, and conduit runs.
- C. Project specific system interconnection (riser) diagrams. (System architecture.)
- D. Dimensional drawings/manufacturer's specification data for each component.
- E. Complete elementary and/or schematic drawings for all Fire Alarm System electrical and electronic circuits.
- F. Typical component connection and interconnection diagrams.

- G. Complete system wiring diagrams for all components and interfaces to equipment supplied by others.
 - H. Technical program for execution of interface between Fire Alarm System and facility Building Automation System (BAS) pertaining HVAC shutdown, smoke fan control, stairway pressurization control, fire/smoke damper control, etc. The proposal shall include estimated data input/output points interfacing with BAS.
 - I. Complete sequence of operations of all functions of the system. A fire alarm typical input/output functional matrix clearly defining fire alarm event and action, which is recommended by NFPA 72 A.10.6.2.3 (9), shall be submitted to the Owner for review and approval.
 - J. Graphic penetration tree showing all graphics and all points.
 - K. Detailed color conventions proposed for all graphics and graphic elements and states.
 - L. Data entry forms for initial parameters. Contractor shall provide a listing of all analog points with columnar blanks for high and low warning limits and high and low alarm limits, and samples of proposed text for points and messages (for at least two systems of at least 30 points total). All text and graphics shall be approved prior to data entry.
 - M. Recommended Spare Parts. The Contractor shall include a listing of their recommended spare parts.
 - N. Manufacturer's Representatives. The Contractor shall submit a listing of the manufacturer's representatives responsible for installation coordination and service.
- 1.6 DELIVERY, STORAGE AND HANDLING
- A. Deliver fire alarm system components in factory-fabricated containers.
 - B. Store in a clean, dry space and protected from the weather.
 - C. Handle control and annunciator panels carefully to avoid damage to material components, enclosure and finish.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

- A. Simplex
- B. Edwards
- C. Other manufacturers equal in design and function will be considered upon A/E approval following substitution procedure in Section 26 00 00 and Division 01 for substitution requirement.

2.2 FIRE COMMAND CENTER OPERATOR WORKSTATION

- A. Operator Workstation Hardware
 - 1. The operator workstation personal computer shall be a central network processing unit providing alarm signals, annunciation, status display, software

programming and controls for network functions using a Windows based graphic interface with a high resolution, touch-screen or mouse operated color monitor. The PC workstation shall provide control up to 50,000 points allowing future expansion without hardware additions.

2. The operator workstation shall provide color graphic-based display of alarms, troubles, and system activity. Terminal shall provide complete operator control over fire alarm system, including acknowledging events, silencing audible alarms, reset control panels, disarming points, and generating alarm reports and diagnostic reports. Terminal shall be UL listed for fire alarm use.
 - a. Computer: minimum Pentium III, 800MHz, 128 Mb RAM, 20 Gb hard disk.
 - b. Interface: touch-screen or mouse operated.
 - c. Monitor: 15 inch SVGA monitor.
 - d. Operating system: Microsoft Windows NT.
 - e. Password protection: 10 levels of password protection.
 - f. Drawing input: AutoCAD drawing imported.
 - g. Screen library: 5,000 custom screen capacities.
 - h. Zoom levels: 32 zoom levels per drawing.
 - i. Historical logging: 20,000 events minimum.
 - j. Fire alarm interface: RS-232 or RS-485
 - k. Network interface: Ethernet network card included.
 - l. Printer connection: two RS-232 ports, minimum.
 - m. System power: 120 Vac, 60 Hz, and single phase with integral UPS capable for 4-hour operation.
 - n. Clock: Real time clock.
 - o. Calendar: Electronic appointment calendar, with auto alarm.
 - p. Calculator: Basic arithmetic calculation functions (add, subtract, multiply, divide, percent, square root)
 - q. Control panel: Basic PC operating characteristic control; cursor blink rate, mouse sensitivity, screen color control, etc.
 - r. Note pad: Archive for miscellaneous notes.
3. The system provided must be capable of running standard off-the-shelf MS DOS compatible software packages concurrently with the real time system. Fully tested and qualified integrated third party software packages including spreadsheet, data base manager, and word processing shall be provided capable

of running under MS DOS is to be identified as system compatible and listed in the submittal.

- a. The base system software shall include a CRT "windowing" feature to allow the operator to monitor the real time system and use third party software simultaneously.
- b. All third party software packages identified shall have access to the system historical database previously specified.

B. Operator Workstation Software

1. Operator workstation software shall include as a minimum the Operating System (OS), Database Manager, Communications Control, Operator Interface (OI), Trend and History Files, Report Generator, Support Utilities, Scheduler, Time and Event Programs.
2. Real time operating system shall provide true multitasking providing concurrent execution of multiple real time programs and custom program development.
3. Database manager is to manage all data on an integrated and non-redundant basis. It shall allow additions and deletions to the database without any detriment to the existing data. Cross linkages are to be provided such that no data required by a software program may be deleted by the operator until that data has been deleted from its respective program.
4. Communications control, scheduler, trend files, reports, operator interface, and utilities shall be as specified hereinafter.
5. Provide a hierarchical linked dynamic graphic operator interface for accessing and displaying system data and commanding and modifying equipment operation. The interface shall utilize the mouse to provide "heads up operation" with pull-down menus, dialog boxes, zoom, coloration and animation to facilitate operator understanding of the system. A minimum of twenty (20) levels of graphic penetration shall be provided with the hierarchy operator assignable (for example, area, building, wing, floor, and sequence of operation pages, dynamic program display, and I/O point group). Dynamic system data points shall be assignable to each penetration level. Descriptors for graphics, points, alarms, etc. shall be modified through the operator's station under password control.
6. Operator access to the system is to be under personal ID and password control for up to 100 unique operators. Up to 12 alphanumeric characters for personal ID and up to 12 alphanumeric characters for password shall be assignable to each operator via the operator station. The operator shall be able to access the system from any operator station in the system by entry of the proper ID and password. The operators shall be permitted to change their own password without permitting access to any other password. Sign-off from a station shall be a manual operation via pull-down menu or, if no mouse or keyboard activity takes place within an assignable time period, shall be automatic. Automatic sign-off period shall be selectable from ten minutes to 120 minutes for each

operator or may be disabled on a per operator basis. All sign-on/sign-off activity shall be automatically archived on the operator station disk for subsequent display or printout as desired.

7. Operator access to system points shall be controlled by individual operator-assigned graphic hierarchy and by privileges. The hierarchy shall permit access to an operator-assigned initial graphic and to all graphics linked to and below the initial graphic. The operator shall not have access to graphics in another hierarchical graphic "tree".
8. Data to be displayed within a unique graphic shall be assignable regardless of physical hardware address, communication channel or point type. Graphics are to be on-line programmable and under ID and password control. Points may be assignable to multiple graphics where necessary to facilitate operator understanding of system operation and where specified. Graphics shall also contain calculated or pseudo points. Each physical point and each point assigned to a graphic shall be assigned a descriptor for use in reports.
9. Penetration within a graphic hierarchy shall display each graphic name as graphics are selected to facilitate operator understanding. The "back trace" shall permit the operator to move upward in the hierarchy by mouse click on the back trace. The back trace shall show at least the previous four penetration levels. The operator shall be provided the option of showing each graphic full screen size with the back trace as the horizontal header or by showing a "stack" of graphics, each with a back trace.
10. All operator accessible data shall be displayed on the color monitor. The operator shall select further penetration via mouse click on an area, building, floor, etc. The defined linked graphic below that selection shall then be displayed. Dynamic data shall be assignable to any and all graphics.
11. The operator shall be provided with a means to directly access any graphic or any point without going through the penetration path.
12. Direct access to graphics shall be menu selectable wherein the operator may optionally enter the name of the graphic system desired or select the desired graphic via cursor positioning on a scroll bar listing of all graphics, or may be selected via keyboard entry.
13. Points (physical and pseudo) shall be displayed with dynamic data provided by the system with appropriate text descriptors, status or value, and engineering unit. Coloration shall be used to denote status and alarm states. Coloration conventions shall be variable for each class of points, as chosen by the owner. In addition, animation shall be used to confirm latest status. All points shall be dynamic with update rates user adjustable on a per point basis from 20 seconds to 120 seconds, depending upon the process dynamics.
14. An operator shall be permitted to split or resize the viewing screen to show one graphic on the left half of the screen and another graphic, spreadsheet, bar chart, word processing, curve plot, etc., on the right half screen. This will allow real

time monitoring of one part of the system while displaying other parts of the system or data from the system to facilitate system operation.

15. An on-line context-sensitive "help" utility shall be provided to facilitate operator training and understanding. The help feature shall be a hypertext document with the ability to bridge to further explanation of selected keywords. The document shall contain text and graphics to clarify system operation. At a minimum, help shall be available for every menu item and dialog box. If the help utility does not have this ability to bridge on keywords for more information, four complete sets of user manuals shall be provided with quarterly updates and additional training as hereinafter described.

C. Site Specific Fire Alarm Software

1. Provide software that will allow the user to modify and tailor the Fire Alarm System to the specific and unique requirements of the equipment installed, the programs implemented, and to staffing and operational practices. On-line modification of system configuration, program parameters, and database shall be provided via menu selection and keyboard entry of data into preformatted self-prompting templates. As a minimum, the following modification capability shall be provided.
 - a. Operator assignment capability shall include designation of operator ID, passwords, privilege(s), starting graphic and auto sign off duration.
 - b. Peripheral assignment capability shall include assignment of segregation groups to consoles and printers, and designation of backup printers.
 - c. System configuration/diagnostic capability shall include communications and peripheral port assignments, assignment of command trace to points and initiation of diagnostics.
 - d. System text add/change capability shall include action messages for alarms, supervisory, and trouble condition messages.
 - e. Time/Schedule change capability shall include time/date set, time/occupancy schedules, holiday schedules, and daylight savings time schedules. All time and calendar scheduling and schedule modification shall be accomplished graphically via color bars and calendars in a hardware independent manner.
 - f. Points shall be uniquely definable as to coloration, animation, audible rate and duration, point descriptors, operator messages (480 characters minimum), printer options, alarm archival option, alarm and warning limits, and engineering units. All messages specified and all physical and pseudo point descriptors shall be entered by the vendor.
 - g. Point related change capability shall include system/point enable/disable; assignment of points to point classes, analog value offset, and setting a fixed input value or output status.

2. Graphic creation. An on-line graphic development facility shall be provided to allow the user to develop or modify graphic displays and assign and position any array of points within each graphic.
 - a. All graphic displays shall be on-line created via operator station graphics package. It shall not require taking the operator station off-line or interfere with point archiving and alarms. Graphics shall be created via mouse and keyboard selection of graphic library stored symbols and system profiles. Provide, in addition, the capability to create custom symbols, system profiles, floor plans, buildings, etc., and to store them in the graphic library.
- D. Alarm handler software shall be provided to respond to alarm conditions sensed and transmitted from fire alarm control panels. First in, first out handling of alarms in accordance with alarm priority ranking is required in case of simultaneous multiple alarms. There shall be no limitation of handling the amount of alarms, which may be activated simultaneously. Alarm handler shall be active in both the Signed On and Signed Off modes to assure that alarms will be processed even though an operator is not currently signed on.
 1. Alarms shall be displayed in a dialog box of the color monitor. Display shall include as a minimum:
 - a. Indication of alarm condition; i.e., ABNORMAL OFF, HI ALARM/LO ALARM, analog value or status, point identification.
 2. Alarms are to be directed to appropriate operators, operator stations, and printers for segregation assignments as specified in previous Sections of this specification.
 3. Alarm silence shall be by selecting the "silence" button or by authorized operator's acknowledgment. In all cases, alarm acknowledgment shall only be allowed by operators authorized to acknowledge a point in alarm.
 4. Each point shall be assigned to an alarm class, with no limit to the quantity of alarm classes. Each alarm class shall be uniquely assignable to any combination of the following alarm processing attributes:
 - a. Audible beep duration (none, 10 seconds, 20 seconds, continuous)
 - b. Audible beep rate (slow-medium-fast)
 - c. Alarm historically archived (yes or no)
 - d. Alarm printed, with printer ID
 - e. Associated coloration with any of 256 colors, with separate brightness control, assignable to each alarm state (high alarm, high warning, normal, low warning, low alarm). Digital points shall similarly be distinguished with different colors for each possible state.
 5. Alarms shall be displayed and/or printed at each peripheral to which its segregation allows, but only those operators having proper privilege level will be allowed to acknowledge alarms.

6. An unacknowledged alarm indicator shall be provided on the color monitor display to alert the operator that there are unacknowledged alarms in the system.
 7. Symbols for points in a graphic display that are in an unacknowledged alarm state shall flash red; when in an acknowledged state, the symbol shall be non-flashing-red.
 8. Run time limit messages shall be presented and processed as alarm messages except the action message shall be of a maintenance directive nature.
- E. Standard reports shall be provided, which shall be operator selectable to appear on the operator station, any selected printer or both. A "terminate report" command shall be available to allow the operator to stop any report in the process of being printed. In the event of failure of any printer, subsequent reports directed to that printer shall be automatically redirected to an operator pre-assigned backup printer located at the operator station. The following standard pre-formatted reports to be provided shall include:
1. Point summary reports may be requested at any penetration level (facility, building, area, system) and shall include only points at and below that level. Point summary reports shall include the current value/status and condition, system and point descriptors for all points. Point summary reports shall be selectable for all points, only those points in alarm, fixed points, disabled points locked out points, locked out and in alarm points, analog input or output points, digital input or output points. All reports shall be capable of being scheduled to run at a specific time and/or interval via an operator function supported by necessary data entry templates and interactive prompts.
 2. Dynamic trends shall provide up to six points and show real time activity of the associated points. This information shall be printed and/or displayed in numeric, bar chart, curve plot, pie chart, etc., as selected by the operator. Graphic plots shall allow a unique color for each point. As new point values are sampled, they shall be processed, scaled, and dynamically appended to any plot being displayed. Sample interval of points selected for dynamic trend shall be user selectable from five seconds to sixty minutes.
 3. Alarm and run time reports shall be automatically issued to assigned printers immediately upon occurrence, and shall consist of the point descriptor, the status or value of the point with engineering unit, the time and date, and an action taking alarm message.
 4. The user shall be provided with a command trace feature selectable on a per point basis allowing the archiving of all commands issued to each point. The archived trace shall include the command, the command source, the point ID, and the time and date. Command trace reports shall be output upon operator demand.
 5. A custom report capability shall be provided to allow the user to format reports of any mix of text, points with status/value and descriptors, and points with status/value only. Custom reports may be scheduled or requested manually. A

spreadsheet program similar to Microsoft Excel shall be provided fully integrated with the Fire Alarm System data base, and available to the user. Spreadsheet packages that require off-line execution or manual translation of data files from one program format to another are not acceptable.

- F. Digital System Management. The operator workstation shall provide complete utilities necessary for management of the network of digital controllers and devices.
 - 1. Provide a multi-page set of dynamic graphic architectural displays showing each digital module including each remote panel, PC, peripheral, and communication links. Clicking on any device shall start an interactive dialog allowing the user to observe the device status and to select device management options. Each device shall also be provided with a descriptor. Digital devices in a failed or non-responsive mode shall show up distinctly red in digital system graphics.
- G. The software shall be designed specifically for fire alarm applications and shall provide for polling and demand requests to monitor status; processing alarms according to priorities; executing event-initiating programs; controlling/processing communications with operator peripherals; and synchronizing all systems activity. For reasons of reliability and preventing inadvertent changes, system software (operating system and data file) shall be maintained in non-volatile memory. System shall permit reprogramming by authorized personnel.

2.3 FIRE ALARM CONTROL PANELS

- A. Control panel enclosure shall consist of a floor-standing or surface-mounted back-box, hinged door, keyed lock, and tamper switch. Tamper switch shall put control panel into a trouble mode when door is opened. Back-box shall be sized to accommodate batteries, battery charger, power supply, control panel, indicating, initiating, communications, relays, and switch modules.
- B. The control panel power connections (whether ac or dc) shall be separately fused within the control panel. The system power supply shall be provided with an integral uninterruptible power source (UPS). This UPS shall provide continuous power to the system in the event of a commercial power failure. Transfer from commercial power shall be instantaneous to ensure proper processor operation and indicated by flashing the system power long-life light-emitting diode (LED).
 - 1. Loss of commercial power shall be annunciated as a system trouble. System trouble shall be indicated for over-voltage or under-voltage conditions, blown fuses, or disconnected batteries.
 - 2. The system shall visually and audibly indicate operation from standby power. The system shall automatically restart upon the return of power. No operator intervention shall be required.
 - 3. A dual-rate battery charger shall be provided, which is capable of recharging the batteries to 80 percent capacity in 12 hours.

4. Batteries shall be sized to provide 24 hours of standby operation followed by 5 minutes of operation of alarm notification appliances and 15 minutes of voice/alarm communication systems.
- C. The control panel shall be modular with solid-state electronics and microprocessor. The control panel shall provide power, annunciation, supervision, and control for the detection and alarm system. The system shall be capable of reading and displaying at the control panel the sensitivity of remote addressable ionization and photoelectric detection devices. The detection system shall remain 100 percent operational and capable of responding to an alarm condition while in the routine maintenance mode. Addressable detection devices shall be individually identified by the system, and any quantity of addressable detection devices shall be in alarm at any time up to the total number connected to the system.
1. The control panel shall be capable of supporting addressable detection devices.
 2. The panel annunciator shall be an alphanumeric display, which shall provide an optional user-definable message associated with each detection device or zone.
 3. Dynamic supervision of system electronics, wiring, detection devices, and software shall be provided by the control system. Failure of system hardware or wiring shall be indicated by type and location on the alphanumeric annunciator. The system shall provide fail-safe operation, i.e., incoming alarms shall automatically override all other modes of operation, and the panel shall automatically return to normal operating mode from any operator-initiated mode.
 4. Ground fault detection shall be provided for all initiating and audible circuits. Lamp test capability shall be provided to test all visual panel indicators and associated software.
 5. The system alarm lamp shall flash and an integral trouble buzzer shall sound upon receipt of any alarm condition. Acknowledgment of the alarm by operation of the silence switch shall silence the audible alarm and cause the alarm lamp to light steadily. Receipt of subsequent alarms shall cause the alarm buzzer to resound and the alarm lamp to flash.
 6. The system trouble lamp shall flash and an integral trouble buzzer shall sound upon the occurrence of any trouble condition. Acknowledgment of the trouble condition by operation of the silence switch shall silence the audible alarm and cause the trouble lamp to light steadily. Receipt of subsequent troubles shall cause the trouble buzzer to resound and the trouble lamp to flash.
 7. The service mode shall permit the arming and disarming of individual detection or output devices, as well as manually operating output devices. Status of these devices shall be displayed upon command from the control panel. The panel shall automatically return to normal mode in the event the panel remains unattended in the service mode. The panel shall be capable of receiving and processing alarms even when in the service mode.

8. The control panel shall report, by specific device number, any device removed from an addressable initiating circuit, and all other devices shall continue to function.
9. The control panel shall have the ability to support an optional printer terminal.
10. No alarm or trouble indication shall be resettable until it has been acknowledged. It shall not be possible to reset the system until all alarms have been acknowledged and devices cleared.
11. Each panel shall have the following capacity:
 - a. Sensor Points: 275 addressable analog sensor points.
 - b. Module Points: 275 addressable monitoring and control module points, including 50 points as follows:
 - 1) Onboard Strobe Circuits: 10 circuits rated for 2 amps each at 24 Vdc.
 - 2) Onboard Speaker Circuits: 10 circuits rated for 25 watts each at 70.7 VRMS.
 - 3) Onboard Telephone Circuits: 10 fireman's telephone circuits.
 - 4) Onboard Auxiliary Relay Circuits: 10 general input circuits, 10 general output circuits.
 - c. Amplification: 500 watts, 70.7 VRMS, distributed, with one 500-watt backup amplifier every three panels.
 - d. Audio Channels: two.
 - e. Power Supply: 20 amps, 24 Vdc.
 - f. Battery Backup: 140 ampere-hour backups at 24 Vdc.
 - g. Mounting: NEMA 12 wall- or floor-mounted enclosure.
 - h. System Power: 120 Vac, 60 Hz, and single phase.
12. The following primary controls shall be visible through a front control panel.
 - a. 80-character liquid crystal display.
 - b. Individual red fire alarm LED.
 - c. Individual red priority 2 alarms LED.
 - d. Individual yellow supervisory service LED.
 - e. Individual yellow trouble LED.
 - f. Green "power on" LED.
 - g. Yellow signals silenced LED.
 - h. Fire alarm acknowledge key.

- i. Priority 2 alarm acknowledge key.
 - j. Supervisory service acknowledge key.
 - k. Trouble acknowledge key.
 - l. Alarm silence key.
 - m. System reset key.
 - n. Speaker circuit selection switches with LEDs.
 - o. Master audio control microphone.
 - p. Master fire fighters phone.
 - q. Phone circuit selection switches with LEDs.
13. The following functions shall be provided by operating the front control panel.
- a. LED testing.
 - b. Alarm, trouble, and abnormal condition listing.
 - c. Enabling and disabling of each monitor point separately.
 - d. Activation and deactivation of each control point separately.
 - e. One-person test enable.
 - f. Running self-diagnostic.
 - g. Display historic logs.
 - h. Point listing.
14. Scrolling through menu options or lists shall be accomplished in a self-directing manner in which prompting messages shall direct the user. These controls shall be located behind an access door.
15. Under normal conditions the front display panel shall display a “System Normal” message and the current time and date. Should an abnormal condition be detected the appropriate LED (Alarm, Supervisory or Trouble) shall flash. The unit audible signal shall pulse for alarm conditions and sound steady for supervisory and trouble conditions. The LCD shall display the following information relative to the abnormal condition of a point in the system.
- a. 40 character custom location label
 - b. Type of device (i.e., smoke, pull station, water flow)
 - c. Point status (i.e., alarm, trouble)
- D. Fire alarm audio control panel shall provide complete voice annunciation control of the fire alarm system. Panel shall include ability to select paging zone by area or all call. Panel shall include master fireman's telephone handset, and interface shall

be integral to panel. Panel shall support both live paging and prerecorded digital messages. Performance:

1. Audio Channels: two simultaneous 70.7 VRMS channels, minimum.
 2. Phone Risers: two fireman's telephone risers, minimum.
 3. Audio Levels: VU meter for audio level monitoring.
 4. Digital Message Length: 10 messages, 30 seconds each, minimum.
 5. Preamp Supervision and Automatic Changeover: yes.
 6. Amplification: supports 10 distributed- or central bank amplifiers.
 7. Backup Amplification: supports four backup amplifiers.
 8. Degrade Mode: degrade mode reverts to tone generation.
 9. Mounting: NEMA 12 wall- or floor-mounted enclosure.
 10. System Power: 120 Vac, 60 Hz, single phase.
- E. Line printer shall provide hard copy written record of alarms, troubles, and system activity. Printer shall be UL listed for fire alarm use. Performance:
1. Serial or parallel printer.
 2. 24 pin, dot matrix, wide-carriage type.
 3. Paper out, offline, paper jam, and power off alarm supervision.
 4. Power Supply: 120 Vac, 60 Hz, single phase. Note: System must have integral or plant uninterruptible power supply unit capable of 15-minute operation in conjunction with Secondary Power Supply defined by NPFA 72.
- F. Initiating circuit modules shall maintain complete reporting of device status while in trouble due to any addressable device having its active transmitting component fail, open, or shorted. The initiating circuit modules shall detect a line break and provide information to the control panel, allowing the user to determine between which two devices the break has occurred.
- G. Detection line circuit monitoring shall be provided by a zone input module. Each circuit shall be capable of Class A or B wiring. With Class B wiring, a capacitive end-of-line device shall be required. Each zone shall accommodate up to 96 ionization or photoelectric detectors, or 96 flame detectors, as well as any quantity of shorting-type contact devices. Upon actuation of any detector or device installed on a zone circuit, that particular zone shall lock into alarm and the zone identification and location shall be annunciated at the control unit. Zone troubles, such as opens, shall be annunciated at the control unit giving zone identification and trouble description. Alarm information and transmission shall have priority over trouble.
- H. An output circuit indicating operation of dc audible devices, leased line or city tie shall be provided by an indicating module. Upon command by the control unit the output circuits will respond as configured. Leased line or city circuits shall be limited energy outputs. All signal circuits shall require and be fitted with an

appropriate end-of-line resistor (EOLR). Each circuit shall be fused separately. The module shall be supervised by the control unit for open and shorted circuits. Open circuits shall report trouble only and respond with circuit identification. A shorted circuit shall respond in a similar manner. Each output circuit shall be individually fused with replaceable fuses.

- I. For control of air-handling units, elevators, and beacon lights, relay modules shall be provided. The module shall be system interconnected and shall be operable by the control unit or manually. It shall contain eight independent relays, fitted with Form C contacts, rated at 120 Vac, 10 amps, minimum, inductive.

2.4 PERIPHERAL DEVICES

- A. All detection devices shall contain an integral alarm LED. All addressable detectors shall be individually identifiable by zone. Mounting bases shall be provided by life safety contractor, included with detector as a complete assembly.
- B. The addressable ionization detector shall be a plug-in, twist/lock unit, which shall be capable of removal from or installation into its base with one hand.
 1. The detector shall contain two ionization chambers and solid-state indicator lamp. The reference chamber shall compensate against sensitivity changes due to changes in environmental temperature, humidity, and barometric pressure. The sensing chamber shall be open to the outside elements through a protective cover, which will permit product of combustion to enter while preventing foreign matter from entering and causing unwanted alarms.
 2. The detector shall be dynamically supervised, indicating a trouble condition at the control panel when the detector is unable to sense a fire condition due to either internal and external operation conditions or malfunctions.
- C. The addressable photoelectric smoke detector shall contain an LED as its light source and photodiode as a light receiver. An automatic gain control circuit shall be provided to maintain correct sensitivity by compensating for detector aging and dirt accumulation. The detector shall be a plug-in twist/lock unit, which allows for easy connection to its mounting base. The detector shall provide complete supervision of the detector optics. The detector shall be supervised for complete failure of the LED light source or a critical reduction in the light output of the LED caused by excessive dirt, which could not normally be compensated for by the automatic-gain control circuit.
- D. The addressable thermal detector shall be of the rate-compensated, fixed-temperature type. The detector shall be individually annunciated on the control panel. The detectors shall contain an integral alarm lamp.
- E. The addressable programmable interface module is designed to provide an interface for direct-shorting contact devices. The unit is used with water flow switches, pressure switches, tamper switches on OS&Y valves, and other contact closure devices. The unit shall electrically supervise wiring to contacts via EOLR provided by life safety contractor.

- F. The addressable manual pull station shall operate on any addressable detection circuit. The addressable manual pull station shall be individually annunciated on the control panel. The unit shall be double-action initiated, having latching relays.
- G. The air duct smoke detector shall operate on a cross-sectional air-sampling principle to overcome stratification and skin effect. The air duct detector shall consist of a standard addressable photoelectric detector mounted in an air duct sampling assembly and sampling tube that protrudes across the duct of the ventilating system. The air duct detector shall retain the features of the addressable photoelectric detector, and be installed in the ventilating duct as indicated in the manufacturer's instructions. The air duct smoke detector shall come with appropriate addressable detector and base, remote test station, and inlet sampling tubes.
- H. The detector mounting base shall be of the twist/lock type with screw terminals. Pigtailed or in-line connectors shall not be permitted. It shall be possible to secure the detector in the base. The detector mounting base shall be universal for addressable photoelectric detectors.
- I. Alarm bells shall be of the polarized 24-Vdc type. The mechanisms shall be fully enclosed and dust-proof. They shall be designed to be mounted on a wall, ceiling, or other suitable rigid surface that is free from vibration.
- J. Alarm horns shall be of the polarized 24-Vdc type. The mechanisms shall contain an aerospace-grade aluminum diaphragm; blued, tempered, and polished armature, and tungsten contact points, all housed in a die-cast frame-and-grill assembly. They shall be designed to be mounted on a wall, ceiling, or other suitable rigid surface and capable of being surface, semi flush, or flush mounted.
- K. Alarm speakers (non-ceiling mounted) shall be of the polarized 24-Vdc type. The speaker shall have 70.7 VRMS inputs and have field-selectable power taps from 1/8 watt to 8 watts. Speaker shall have frequency response of 400 to 4,000 Hz and be UL listed for fire alarm voice evacuation use. Speaker shall have vandal-resistant red grill faceplate. Speakers shall be designed to be mounted on a wall or other suitable rigid surface and shall be capable of being surface, semi flush, or flush mounted.
- L. Alarm speakers (ceiling mounted) shall be of the polarized 24-Vdc type. The speaker shall have 70.7 VRMS inputs and have field selectable power taps from 1/8 watt to 8 watts. Speaker shall have frequency response of 400 to 4,000 Hz and be UL listed for fire alarm voice evacuation use. Speaker shall have 4-inch cone and shall have 7.25-inch-diameter circular metal faceplate with white enamel finish. Speakers shall be designed to be mounted on a wall, ceiling, or other suitable rigid surface and be capable of being flush mounted.
- M. Alarm speakers (extra loud) shall be of the polarized 24-Vdc type. The speaker shall have 70.7 VRMS inputs and have field-selectable power taps from 0.9 watt to 15 watts. Speakers shall have frequency response of 400 to 4,000 Hz and be UL listed for fire alarm voice evacuation use. Peak speaker output shall be 121 dB at 4 feet, 15 watt or 111 dB at 10 feet, 15 watt. Speaker shall have high-efficiency

compression driver with re-entrant horn, and shall have a baked gray epoxy finish. Speakers shall be designed to be mounted on a wall, ceiling, or other suitable rigid surface, and be capable of being surface mounted.

- N. Strobe lights shall produce a minimum of 75 candelas at approximately one flash per second with continuously applied voltage. The maximum pulse duration shall be 0.2 seconds with a maximum duty cycle of 40 percent. Rated voltage shall range from 18 to 31.2 volts for nominal 24-Vdc models. The xenon flash tube and associated circuitry shall be enclosed in a translucent white polycarbonate lens with "fire" inscribed on the lens. Plate color shall be red.
- O. Water flow switches: Flow switches shall be UL listed for its intended purpose; furnished under Division 23 and electrically connected under Division 26. Individual addressable modules shall be provided on each switch.
- P. Sprinkler Valve Tamper Switches: Switch shall be provided with either one or two sets of SPDT micro switches as required. Tamper switch shall be UL listed for its intended purpose, furnished under Division 23 and electrically connected by Division 26. Individual addressable modules shall be provided on each switch.
- Q. Firefighter's emergency telephone shall include handset, cradle with switch hook and heavy gauge steel enclosure. Handset shall be red, high-impact plastic with retractable coil cord. Telephone assembly shall permit two-way communication from fire alarm audio control panel and shall produce a distinct zone or call-in signal when the handset is removed from its cradle. Enclosure shall be finished in baked, red enamel and shall bear a silk-screened handset symbol and the words "emergency telephone". Enclosure shall be suitable for flush or surface mounting. Anticipated enclosure size shall be 5 1/8 inches wide by 8 1/8 inches high by 3 inches deep.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Contractor shall examine the areas and conditions under which the fire alarm system is to be installed and notify the Contractor in writing of conditions detrimental to the proper and timely completion of the work. Do not proceed until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install system and materials in accordance with the manufacturer's written instructions, drawing set, and details, the applicable requirements of the NEC and NFPA 72, and specifications in Division 26.
- B. Junction boxes used as back boxes for fire alarm system field devices shall be 4-inch square with 2 1/8-inch minimums in depth. Install adapter plates and extension rings where required. Junction boxes for concealed conduit system shall be flush mounted.
- C. Mount outlet box for electric door holder to withstand 80-pound-pulling force.

- D. Upon initial installation, all fire alarm detection devices shall have the original plastic dust covers installed. Dust covers shall not be removed until installation is completed and the system is ready for test.
- E. Each conductor shall be identified as shown on the shop drawings by attaching permanent alphanumeric wire markers within 2 inches of the wire termination at both ends. Marker legends shall be visible. Junction box and pull box covers shall be painted yellow or have embossed adhesive tape labeling that is minimum 1/4-inch white letters over a yellow background with text "Fire Alarm". Install end-of-line device in box with text "End-of-Line" or "EOL". Number-code or color-code conductors, appropriately and permanently for identification and servicing of system.
- F. Splices shall only be made on terminal strips. All fire alarm wiring shall be installed in raceways as per drawing. All external wiring shall be color-coded and shall not be installed in the same outlet box, junction box, or conduit with conductors of lighting or power systems.
- G. Locate and install the detector assembly for optimum response time and easy accessibility.

3.3 TESTING

- A. The entire fire alarm system shall be field tested in accordance with NFPA standards and other applicable standards in the presence of the Construction Inspector. Inspection and test method shall be in compliance with NFPA 72. Inspection and test record forms that are recommended by NFPA 72 shall be utilized. Results of such testing shall be recorded on forms approved for the purpose, certified and submitted to the Construction Inspector prior to final acceptance.
- B. All test equipment; instruments, tools, and labor that required conducting the system tests shall be provided by the Contractor. The following equipment, but not limited to, shall be a minimum for conducting such tests.
 - 1. Ladders and scaffolds as required for access all field devices.
 - 2. Multi-meter for reading voltage, current and resistance.
 - 3. Intelligent device programmer/tester.
 - 4. Laptop computer with programming software for any required program revisions.
 - 5. Two-way radios, flashlights, smoke generation devices and supplies.
 - 6. Spare printer paper.
 - 7. Decibel meter.
- C. Perform all electrical and mechanical tests required by the equipment manufacturer's certification form. In addition, measure and adjust each of the ionization detectors to the maximum stable sensitivity setting. This must be performed with the detector at its operational environmental conditions in the area.

Bench settings are not acceptable. All test and report costs shall be in the contract price. A checkout report shall be prepared by the installation technicians and submitted in triplicate, of which one copy will be registered with the equipment manufacturer. The report shall include, but not be limited to:

1. A complete list of equipment installed and wired.
2. Indication that all equipment is properly installed and functions and conforms to these Specifications.
3. Serial numbers, locations by zone and model number for each installed detector. All intelligent devices shall be tested and logged for correct address and sensitivity using test equipment specifically designed for that purpose. Sensitivity settings for each ionization and photoelectric detector as measured in place with the HVAC system operating.
4. Wiring runs shall be tested for continuity, short circuits and ground before system is energized. Resistance, current and voltage reading shall be made as work progresses.
 - a. A systematic record shall be maintained for all readings using schedules or charts of tests and measurements. Areas shall be provided on the logging form for readings, dates, and witnesses.
 - b. The Owner shall be notified before the start of the required tests. All items found at variance with the applicable drawings and/or specifications during testing and inspection by the Owner, shall be corrected by Contractor at no additional cost to the Owner.
 - c. Test reports shall be delivered to the Owner when completed.
5. Test of individual zones as applicable.
6. Duct detector cfm readings with HVAC system operating.
7. HVAC shutdown response upon smoke detection.
8. Water flow alarm response upon water flow or tamper switch activation.
9. Elevator recall, alternate floor recall, and power shutdown response.
10. Firefighter's emergency telephone response time.
11. Response time on thermostats and flame detectors (if used).
12. Technician's name, certificate number, and date.

D. Final Acceptance Test (FAT)

1. The FAT shall be conducted in the presence of the Owner and under the supervision of the Manufacturer. Prior to FAT, the Owner shall be provided drawings showing the correct address for all addressable alarm initiation devices. The address shall be shown in their respective locations for the device on drawings. Signals shall be sequentially numbered as the address of the controlling module.

2. System wiring shall be tested to demonstrate correct system response and correct subsequent system operation in the event of:
 - a. Open, short, and ground fault for intelligent analog signaling circuit.
 - b. Open, short, and ground fault for intelligent digital signaling circuit.
 - c. Open, short, and ground fault for network signaling circuit.
 - d. Intelligent device removal.
 - e. Primary power or battery disconnected.
 - f. Type of device miss-match the address ID.
 - g. Polarity check.
 - h. Printer trouble, off line or out of paper.
3. System indications shall be demonstrated as follows.
 - a. Correct message display for each alarm input at the remote control panel, central control panel and operator's workstation graphic display.
 - 1) Correct annunciator light for each alarm input at each annunciator and color graphic of operator's workstation.
 - 2) Correct printer logging for all system activity.
 - b. Secondary power capacities shall be demonstrated as follows.
 - 1) System primary power shall be disconnected for a period of 8 hours. At the end of that period, an alarm condition shall be created and the system shall perform as specified for a period of 5 minutes.
 - 2) System primary power shall be restored 48 hours and system charging current shall be normal trickle charge for a fully charges battery pack.
 - 3) System battery voltages and charging currents shall be checked at the fire alarm control panel using the test code and displayed on the LCD display.
 - c. Firefighter's HVAC override system functions shall be demonstrated as following.
 - 1) On/off control of each controlled element and test for interaction of others automatic and manual control functions while in the override mode.
 - 2) Correct status display of monitored elements.
 - 3) Correct logging of activity to printer and historical memory as programmed.
4. The entire system needs to be tested in compliance with the building emergency operation sequence specified by contract document. The tests are included,

but not limited to, fire door control, security door control interface, air handler duct smoke detection shutdown interface, sprinkler system PIVs, OS&Y valves, and tamper switch monitoring, sprinkler systems water flow and/or pressure switch monitoring, monitoring of fire pump controls, fire/smoke damper control, smoke purge control interface, activation of deluge or pre-action sprinkler systems, and elevator recall power shutdown.

5. In the event of system failure to perform as specified and programmed during the FAT, the test shall be terminated at the discretion of the Owner.
 - a. The Contractor shall retest the system correcting all deficiencies and providing test documentation to the Owner without additional cost to the Owner.
 - b. In the event that software changes are required during the FAT, a utility program shall be provided by the system manufacturer to compare the edited program with the original. The utility shall field a printed list of the changes and all system functions, inputs and outputs affected by the changes. The items listed by the program shall be the minimum acceptable to be retested before calling for resumption of the FAT. The printed list and the printer log of the retesting shall be submitted before scheduling of the FAT.
 - c. The Owner may elect to require the complete FAT to be performed again if, in their opinion, modifications to the system hardware or software warrant complete retesting.

3.4 MANUFACTURER'S FIELD SERVICES

- A. Include services of factory-certified technicians to supervise installation, adjustments, calibrations, final connections, and system testing. A representative of the manufacturer shall instruct the Owner and demonstrate the system after the Owner has occupied the building.
- B. Formal training for the operation and maintenance of fire alarm equipment and the systems specified herein shall be provided by manufacturer trained and certified personnel. The formal training shall consist of a minimum of five-day eight-hour training sessions or the number of hours as indicated per contract document. The timing of the training shall coincide with the schedule for the manufacturer's representatives to be on site for testing and start-up of each building fire alarm system. The formal training shall be provided at a location designated or provided by the Owner for number of personnel selected by the Owner, in addition to any informal on-site orientation and training.
- C. A formal training proposal shall be submitted with curriculum material, schedule, instructor's qualification for the Owner's approval at least 60 days prior to formal training. The trainer shall provide approved training material manus at the time of training with quantity of copies per Owner's instruction.
- D. As-built drawings shall be provided upon acceptance of the system with quantities per contract document.

END OF SECTION

SECTION 28 31 00
FIRE ALARM AND SMOKE DETECTION SYSTEM

SECTION 33 71 19
UNDERGROUND DUCTBANKS AND MANHOLES

PART 1 GENERAL

1.1 WORK INCLUDED

- A. This Section specifies the requirements necessary to provide underground ductbanks in reinforced concrete.

1.2 RELATED WORK

- A. This Section shall be used in conjunction with the following other specifications and related Contract Documents to establish the total requirements for underground electrical ductbanks. All earth and concrete work under this Section shall be under the supervision of the Civil Engineer.

- 1. Division 01 Sections included in the project specifications
- 2. Excavation Support Systems
- 3. Excavation and Backfilling
- 4. Concrete Formwork
- 5. Concrete Reinforcement and Embedded Materials
- 6 Section 26 00 00 - Basic Electrical Requirements
- 7. Section 26 05 00 - Basic Electrical Materials and Methods
- 8 Section 26 05 33 – Raceway, Conduit, and Boxes

- B. In the event of conflict involving underground electrical ductbank requirements between this Section and any other Sections, the provisions of this Section shall govern.

1.3 APPLICABLE CODES AND STANDARDS

- A. NEMA TC 6 & 8 – Polyvinyl Chloride (PVC) Plastic Utilities Duct for Underground Installations
- B. NEMA TC 9 – Fittings for Polyvinyl Chloride (PVC) Plastic Utilities Duct for Underground Installations
- C. ASTM C 31 – Standards Practice for Making and Curing Concrete Test Specimens in the Field
- D. ASTM C 39 – Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
- E. ASTM C 172 – Standards Practice for Sampling Freshly Mixed Concrete
- F. ACI 301 – Structural Concrete
- G. ASTM A 615 – Deformed and Plain Carbon Steel Bars for Concrete Reinforcement
- H. ASTM D 698 – Standard Test Methods for laboratory Compaction Characteristics of Soil Using Standard Effort

1.4 SUBMITTALS

- A. Submit the following in addition to, and in accordance with, Section 26 00 00, Basic Electrical Requirements, and Division 01 for submittal requirement.
 1. Complete list of equipment and materials including manufacturer's descriptive and technical literature, catalog cuts, and installation instructions for conduit and fittings, concrete (including admixture), and rebar.
 2. Ready-mix delivery tickets shall be submitted to the Owner for review prior to unloading at the site.
 3. Delivery ticket minimum information:
 - a. Name of ready-mix plant
 - b. Serial number of ticket
 - c. Date and truck number
 - d. Name of contractor
 - e. Job name and location
 - f. Mix design number
 - g. Amount concrete (cubic yards)
 - h. Type and amount of admixtures
 - i. Amount of water added at the batch plant
 - j. Times of loading, arriving at the site, and unloading
 - k. Volume of water added by receiver of concrete and his initials
 4. Provide concrete testing and inspection as required by Division 03 specifications.
 5. Submit trench safety plans, sealed and signed by a professional engineer registered in the State of Texas, as outlined by 3.1 A of this specification.
- B. Provide the following one week before pulling medium-voltage cable:
 1. Diagram of ductbank indicating lengths of straight conduit sections, bend locations with radius of bands, conduit sizes.
 2. Pulling calculation per cable manufacturer's recommended method with acceptable values for pulling tension and sidewall pressure indicated for each cable size/type.

1.5 WARRANTY

- A. Provide a warranty for material and installation per Section 26 00 00, Basic Electrical Requirements, unless a longer warranty period is required in specific product specifications.

PART 2 PRODUCTS

2.1 CONDUIT AND FITTINGS

- A. All products shall be new, first-quality materials.
- B. Nonmetallic Conduit: rigid PVC per NEMA TC-6 & 8. Conduit sizes and type shall be in accordance with Drawings. Conduit shall be of standard length, with tapered end and matching solvent weld couplings. Provide fitting of the same type material as ducts.
- C. Provide spacers with minimum separation between conduits as indicated on Drawings.
- D. Provide polypropylene pull full length.

2.2 CONCRETE

- A. Cast-in-place concrete and components: Conform to the following general requirements:
 - 1. Provide concrete work per ACI 301.
 - 2. Concrete shall be normal weight, air-entrained with 28 day strength of 2,500 psi or in the direction per Civil Engineer.
 - 3. Slump: Performed at the point of placement shall not exceed 6 inches. Make slump tests for each nine cubic yards of concrete placed.
 - 4. Color: All electrical ductbank concrete shall be color dyed by mixing red inorganic pigment (iron oxide) in cement; rate shall be 1 ½ pounds of iron oxide per cubic yard of cement. All communications duct bank shall be dyed orange in a manner acceptable to the Owner. The inner duct for telecom shall be UL listed for underground use with optical and copper communication cables.
 - 5. Cylinder Tests: Make four cylinder tests from each pouring operation and not less than four cylinders for each 18 cubic yards, or part thereof, over 10 cubic yards of concrete poured and not less than once a day nor less than once for each concreting operation. Take samples at point of placement; conform to ASTM C 172 and ASTM C 31.
 - a. Test two (2) cylinders at 7 days.
 - b. Test two (2) cylinders at 28 days.
 - c. Tests conform to ASTM C 39.
 - 6. Temperature limits for concrete work shall be in accordance with civil engineering standard.

2.3 REINFORCING STEEL

- A. All ductbanks shall be constructed with reinforcing bars in the ductbank. The quantities and sizes of the reinforcing bars shall be provided as directed by the project structural engineer.

2.4 MANHOLES

- A. The manholes shall be precast concrete quality and dimensions as per civil drawings. The manhole shall have grade 60 reinforcement of H20 loading and 4,500 psi concrete. Precast end bell type terminators shall be provided for each ductbank entry as noted on the Drawings. Pulling eyes shall be located opposite each set of duct openings. The manhole shall include a 30 inch type B frame and cover suitable for vehicular traffic appropriately marked “electric” or “telephone”. The frame shall be doweled into the manhole to prevent any movement away from the opening. A #4/0 bare copper ground wire shall penetrate the side wall in the bottom Section of the manhole and shall extend 48 inches inside and outside the manhole. The exterior end of this grounding lead shall be connected to a ¾ inch diameter 10-foot long grounding rod. The interior end of this grounding lead shall be connected to a copper grounding plate. The exposed metal surfaces such as cable rack, metal conduit shall be connected to the grounding plate. Use of a ground rod to penetrate the manhole wall is unacceptable. A sump shall be included in the bottom of each manhole.
- B. Mastic joint compound shall be provided and shall be placed in the grooves of the attached Sections.
- C. Provide cable support hardware and all supports for all cable, cable splices and cable terminations as required to support cable inside manhole.

PART 3 EXECUTION

3.1 TRENCH EXCAVATION

- A. Comply with the following OSHA Part 1926 – Safety and Health Regulations for Construction, Subpart P - Excavation
 - 1. 1926.650 - Requirements for Open Excavations
 - 2. 1926.651 - Requirements for Specific Excavations
 - 3. 1926.652 – Requirements for Protective Systems
 - 4. 1926.653 - Definitions
- B. Before beginning trenching operations, stake out the proposed ductbank routing including trench width and obtain approval from the Owner’s representative. After trenching has begun and before any ducts or conduits are placed, notify the Owner’s representative so that the trenching and installation may be inspected. Also notify the Owner’s representative prior to any placement of concrete for ductbanks, so that he may observe the placement.
- C. Excavate to permit installation of the duct bank along the grades shown on the Drawings. Deviations to ductbank depth must have prior approval from the Owner and Engineer.

- D. Excavate a trench of sufficient width to allow thorough compacting of the backfill under and around the duct bank. A level sand bed a minimum of 6 inches deep shall be placed in the trench before conduit is installed.
- E. Where excavation is in rock, remove all rock to a depth below the grade shown on the Drawings. Rock is defined as material that cannot be ripped or excavated by a backhoe with a one cubic yard bucket with rock teeth. Water shall be continuously pumped out from the trench.
- F. The Owner's approval is required for the extent of the trench excavation prior to the duct bank installation. Contractor shall schedule excavation in accordance with the Owner's requirements prior to beginning construction.
- G. Provide all necessary bracing and bridging to maintain traffic flow during construction through all areas interrupted by trenching. Provide construction signage, traffic barriers, and warning notices throughout the construction period.
- H. Provide all necessary repairs to erosion control measures and reseeded of grass in areas disturbed by trenching.
- I. Sheet and brace the excavation as required to prevent caving. The trench width may be increased accordingly. Maintain sheeting until the ductbank has been inspected and backfilled to either a depth of 30-inch minimum over the top of the ductbank or as indicated on Drawings. Leave sheeting and shoring in place where directed by the Owner's representative.

3.2 DUCTBANK INSTALLATION

- A. Provide conduit in one complete lot. Partial shipment is not approved.
- B. Carefully handle and place all conduits to prevent breakage or other damage. Brace and support all conduits as shown on the Drawings to prevent shifting when concrete is poured. All underground ductbanks under roads and parking lots shall be steel reinforced.
- C. Lay conduit in true straight line of a gradual or uniform sweep. Maintain uniform grade between buildings and/or manholes per profile Drawings. Conduits shall be sloped to drain into manholes or buildings where possible at a minimum grade 4 inches per 100 feet. Provide factory made long sweep bends for all bends 15 degrees or more, either horizontal or vertical, unless prior approval is given by Owner to bend conduit in field. Bend radius shall be 48" minimum unless noted otherwise on Drawings.
- D. Space ducts or conduits a minimum of 3 inches, or in accordance with Drawings, from adjacent ducts. Place spacers or separators on not greater than 5-foot centers.
- E. Stagger joints 6 inches vertically and horizontally in horizontal duct runs and make joints watertight in accordance with manufacturer's recommendations. Where necessary to cut a tapered end on a duct, make the cut with a tool or lathe designed to cut such a taper to match the taper of the particular duct used.
- F. Cleanout conduits as work progresses and securely plug all open ends to prevent water, mud or debris from entering the duct.

- G. Prior to acceptance of ductbank by the Owner, the Contractor shall pull an approved mandrel through each conduit witnessed by the Owner's representative. Mandrel must not be less than 12 inches long with a diameter approximately ¼ inch less than the inside diameter of the duct or conduit. Swab all conduits clean immediately before pulling cable.
- H. Form conduits into ductbanks as shown on the Drawings. Quantity of spacers shall be as required to insure conduit is supported to maintain a true straight line without sagging. Spacers shall be made of plastic, concrete or a suitable nonmetallic, non-decaying material. Conduits shall be secured to the spacers using plastic ties; use of wire is not acceptable.
- I. A minimum 10-foot Section of galvanized rigid steel conduit shall be used when ducts enter and terminate in manholes, buildings, concrete walls, or other rigid structures. Provide PVC/rigid steel conduit adapters and rigid steel end bells where the ducts enter and terminate in the manhole, building, concrete walls, or other rigid structures.
- J. Concrete forming and placement. Concrete shall be placed in forms within the excavated trench. Top of concrete shall be level. Trowel in additional red dye on top of concrete. Conduits shall be not less than 3 inches from the edge of concrete.
- K. Identify the ductbank location with metallic safety tape or vinyl tape with magnetic tracer marked "CAUTION! BURIED HIGH VOLTAGE ELECTRICAL LINE". Tape shall be located 12 inches above the ductbank. Identify each individual conduit as per the schedule in the Drawings. Conduits shall be identified in accordance with 26 05 53.UT Electrical Identification.
- L. Inner ducts shall be pre-lubricated to meet coefficient of friction requirements recommended by manufacturers.
- M. Inner duct assembly alignment shall be maintained by internal spacers.
- N. PVC inner ducts and PVC outer shell shall expand and contract at the same rate.

3.3 MANHOLE INSTALLATION

- A. The excavation for the manhole shall be to a suitable depth to allow for the manhole cover to be slightly elevated above the finished grade to prevent run-off from the entering. The finished grade material shall be sloped around the manhole collar of frame to prevent adequate cover and support.
- B. The site preparation for the manhole shall conform to the manufacturer's recommendations. Generally 3 to 6 inches of stabilize sand and base material shall be spread in the bottom of the excavation. The base material or sand shall be compacted and graded to the proper elevation.

3.4 TRENCH BACKFILLING

- A. Backfill using fine material up to 24 inches above the top of the ductbank placed in 6-inch lifts and thoroughly tamped.

- B. Consolidate the ductbank fill material under roads or similar traffic areas in such a manner as to provide an unyielding foundation of the paving. Remove all excess materials.
- C. Succeeding layers of backfill 18 inches and greater above the ductbank may contain courser materials. Backfill shall be free of all organic material or any other material that would cause subsequent settlement. Maximum size of backfill stone or aggregate shall not exceed 6 inches in its greatest dimension.
- D. Surface of backfill shall be safe for vehicular traffic as soon as possible. At the upper 12 inches of the backfill provide an approved moist material, thoroughly compacted by tamping thin lifts (approximately 4 inches per lift). Lay the top layer at the required grade surface.
- E. Compact backfill by tamping or other method as approved by the Owner's representative. Maintain compaction at a minimum of 95 percent of the maximum density at optimum moisture content as determined by ASTM D 698. The Owner's representative shall direct which method of consolidation is to be followed on each part of the work.
- F. Contractor shall assume full responsibility for any deficiency in quantity of material or filling of depressions caused by settlement of backfill material. Damage to other trade's work caused by settling shall be corrected at the Contractor's expense. Contractor shall assume full responsibility for damages to any underground utility lines or other structure.
- G. Dispose of all excess material from the construction site as directed by the Owner. Contractor should remove excess spoils and other material from the site.

3.5 RECORD DRAWINGS

- A. Provide all concrete test reports required per Division 03 specifications.
- B. All duct bank locations shall be located with respect to site horizontal controls. All ductbanks shall be located at ends and change of directions. Record accurately all ductbank bends (radius and center point) ± 1 -foot by 0-inch accuracy on the construction As-Build drawings.
- C. Record the installed length of each conduit in the ductbank to the nearest foot and transmit to the Owner's representative.

END OF SECTION

SECTION 11 53 23
ENVIRONMENTAL ROOMS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Pre-manufactured, Pre-engineered Environmental Rooms
- B. Pre-engineered, Field-assembled Environmental Rooms
- C. Wall Sleeves and Louvers
- D. Controls

1.02 RELATED SECTIONS

- A. Section 26 05 19 - Cable, Wire and Connectors, 600 Volt
- B. Section 26 05 00 - Equipment Wiring Systems: Electrical supply to units

1.03 REFERENCES

- A. ARI 210 - Unitary Air-Conditioning Equipment
- B. ARI 240 - Air Source Unitary Heat Pump Equipment
- C. ARI 270 - Sound Rating of Outdoor Unitary Equipment
- D. MIL-H-22547B - Heat Pump, Heating and Cooling (Unitary)

1.04 SCOPE OF WORK:

- A. The Mechanical Contractor shall furnish and install all materials and equipment required in conjunction with the fabrication and delivery of environmental rooms as specified herein.
- B. The Electrical Contractor shall provide electrical service to the Environmental Rooms as shown on the Electrical Drawings.
- C. Rooms shall be constructed of various quantities of panels, depending on the size of the room. Construction shall allow for future expansion and easy disassembly for relocation at a later date. Rooms shall be completely self-contained with necessary temperature controls, heating, refrigeration, ceiling conditioning plenum systems,

lighting systems and all necessary mechanical and electrical components to provide the environmental conditions herein described.

1.05 MANUFACTURER'S QUALIFICATIONS:

- A. The environmental walk-in rooms covered by this specification shall be a product of an established manufacturer of this type equipment.
- B. Catalog numbers referenced are those of the Sherer Division of Kysor Industrial Corporation, Marshall, Michigan 49068.
- C. The specified product of the above named manufacturer is the basis unit standard only. Bids of other manufacturers' units equal to those specified will be considered.
- D. It is not the intent of the specifications to preclude any bidders by reason of their requirements of patented items not available to all bidders. Bidders may stipulate in their proposal any exception to the requirements of this specification and shall set forth and include in writing in the bid proposal any proposed substitute for such patented items.
- E. Bidders must have in operation a factory adequate for and devoted to the manufacture of the equipment which it proposes to furnish, and has the necessary specialized design molds and tools, quality control, to provide the proper service and accessories.
- F. Bidder must have been engaged in the manufacture of similar equipment as that specified for a period of not less than four years and the manufacturer shall have satisfactorily completed installation of similar complexity, contemplated by this specification and proposal within four years which has proven satisfactory in similar operating conditions. The names of at least three such installations must be submitted when requesting approval of manufacturer.
- G. The bidder must have financial and personnel resources of sufficient scope to assure prompt and satisfactory performance in the production, delivery and warranty of all equipment specified, so as not to place any unnecessary risk on the purchaser.
- H. This Contractor shall furnish to other trades complete rough-in Drawings within 60 days after award of contract. Rough-in Drawings are to indicate accurately all service outlets. This Contractor shall cooperate with other trades during installation to insure adequate working area in and around service connections.

- 1.06 PERFORMANCE BOND:
- A. Mechanical Contractor shall provide a 100% performance bond that the Environmental Equipment will provide the desired performance after installation.

1.07 MOCKUP

- A. Provide mockup of installation of one unit under provisions of Section 23 00 00.

Note to specification writer: Engineer shall coordinate mockup requirements.

- B. Approved mockup shall not remain as part of the Work, but shall be removed only after the work of this section is inspected and accepted as complete, or as instructed by the Owner in writing.

1.08 SUBMITTALS

- A. Submit shop drawings and product data under provisions of Section 23 00 00.
- B. Submit shop drawings and product data for manufactured products and assemblies required for this project.
- C. Indicate water, drain, and electrical rough-in connections on shop drawings and product data.
- D. Submit samples under provisions of Section 23 00 00.
- E. Submit one sample of wall mounted control panel.
- F. Submit manufacturer's installation instructions under provisions of Section 23 00 00.UT and Uniform General Conditions.

1.09 OPERATION AND MAINTENANCE DATA

- A. Submit operation and maintenance data under provisions of Section 23 00 00.UT and Uniform General Conditions.
- B. Include manufacturer's descriptive literature, operating instructions, installation instructions, and maintenance and repair data.

1.10 DELIVERY, STORAGE, AND HANDLING

- A. Deliver products to site under provisions of Section 23 00 00.

- B. Store and protect products under provisions of Section 23 00 00.
- C. Protect finished cabinets from physical damage by leaving factory packing cases in place before installation and providing temporary covers after installation.

1.11 WARRANTY

- A. Provide five-year manufacturer's warranty under provisions of Section 23 00 00.
- B. Warranty: Include coverage of refrigeration compressors and [_____].]

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. [_____].]
- B. [_____].]
- C. [_____].]
- D. Substitutions: Under provisions of Section 23 00 00.UT, and as listed below. If a conflict in the described procedure occurs, then the description below shall govern, but only for the area of the specific conflict.

2.02 EQUIPMENT SUBSTITUTION REQUIREMENTS:

- A. Wherever a manufacturer's name, type or catalog number appears in equipment schedules, Drawings or Specifications, it indicates the manufacturer of this particular item of equipment upon which the design has been calculated and Design Drawings have been based. In all cases where a bidder intends to offer a substitution for the Architect's approval, it is to be understood and agreed upon by all concerned that the Bidder has taken into account in the original bid, any and all changes that may be required in the work on account of the substitution and shall include additional labor and material costs for changes in service connections and construction required as a result of such substitution. Bidder shall also be responsible for coordinating all work necessitated as a result of such substitutions.

2.03 SHOP DRAWINGS:

- A. The manufacturer shall prepare and submit Shop Drawings showing fabrication of components including kinds and thicknesses of materials, methods of assembly, dimensions and rough-in details, provisions for wiring for each room. Shop Drawings shall be in sufficient detail to serve as Working Drawings for erection. Refrigeration equipment complete with refrigerant lines and including all accessories, shall be sized and shown in detail on Schematic Drawings. Also, the method of fabrication and routing of refrigerant lines shall be described. Wiring diagrams must be complete in every detail and must include a tabulation of amperage, load on each phase leg at each point of connection. All piping, including drain piping, and all sleeves in walls of environmental rooms, foundations and hangers shall be detailed. Fabrication shall not proceed until Shop Drawings and Schematics have been approved by the Architect/Engineer and the Owner.

2.04 CONSTRUCTION:

- A. Material: Interior and exterior material shall be .040 inch thick patterned aluminum. All sections used in construction of the room shall be fabricated to prevent any metal-to-metal (thermo-bridge) contact from inner to outer surface. To reduce the amount of heat transfer through the walls, ceiling or floor, no wood, metal or fiberglass framing shall be used in construction except for framing at doors and windows. Panel sections shall lock together from the inside of the room using a cam lock system to provide for accurate, tight joining. (No special tools shall be required for joining sections).
- B. Floor: Insulated floor shall be reinforced for extra bearing strength with 14 gauge, galvanized steel with overall stationary loading capacity of up to 300 pounds per square foot of distributed loading. Entire interior floor surface shall be covered with grey vinyl sponge matting, 1/4" thick, to provide a non-skid resilient surface. Matting shall be sectional and easily removable for cleaning.

2.05 INSULATION:

- A. To be rigid urethane, foamed-in-place to integrate foam and skins into rigid panels. All joints to be tongue and groove for structural strength and to provide vapor barrier to prevent heat loss and moisture infiltration. Foam to be of a nonflammable, non-flame supporting grade per ASTM-D-1692-59-T with a "K" value of 0.118 BTU/hour/sq ft/degree Fahrenheit. All sections to be provided with a minimum of 3-1/2" foamed-in-place insulation to provide a compressive strength of at least 28 pounds per square inch.

- B. A nominal 10' x 3' integrated skin and insulation section shall show not greater than a 1/8" deflection when loaded with 500 pounds, concentrated on a one square foot area in the center of the section.

2.06 DOOR:

- A. To provide a minimum clean opening of 34" x 78". Doors to open outward with locations and swing as indicated on the Drawings.
- B. Gasket: To be extruded polyvinyl chloride, NSF approved and resistant to oil, fats and sunlight. Gasket to have smooth surface on all sides with no crevices to harbor dirt particles or bacteria. Gasket to be easily cleaned and replaced. Gasketing to be furnished for entire perimeter of door. (Floorless room: Gasket is omitted along bottom edge and replaced with an adjustable double wiper type seal.) Manufacturer has the option of providing magnetic gaskets.
- C. Hardware: To be chrome plated, positive latching safety type complete with keyed cylinder lock. Latch to allow opening from the interior even if locked from outside. Strike to be adjustable for proper seal. Hinges to be polished aluminum, strap type for maximum support and strength. Pins to be stainless steel with self-closing nylon cams.
- D. Anti-Sweat Heaters: To be provided on all doors of rooms having operating temperature range of 0 degrees C. or below to prevent frost accumulation. Also in these rooms install heat tape with insulation over heat tape on all water, drain and waste lines.
- E. Breaker Strips: A nonconductive vinyl extrusion is provided on interior framing of door section to prevent transfer of heat or cold.
- F. A 12" x 16" observation window, consisting of three panes with 1/4" air spaces and a light tight covering door can be provided.

2.07 FINISH:

- A. All metal skins shall be processed through an automated five-stage washer. This process shall include: (1) alkali bath for cleaning all surfaces, (2) hot water rinse, (3) Zinc phosphate coating, (4) cold water rinse, and, (5) chromic acidulated rinse. All of these operations are accomplished with automatic power spray processing equipment. Minimum comparable processing of metals is required to achieve maximum paint and foam adhesions.
- B. All ceilings and interior walls shall be finished in a white epoxy enamel. Enamel to be in two coats, individually oven baked at 350 degrees F. on exposed side and a primer coat on foamed side to insure and provide a tenacious bond of foam to metal.

Perimeter edges of top and bottom panels as well as the control console, and exterior of the entrance door shall have a charcoal finish.

- C. The exterior walls shall be one of the manufacturer's standard colors which shall be selected by the Architect.

2.08 INSTRUMENTS AND CONTROL SYSTEM:

- A. All instruments, control, and major electrical components shall be located in a control console next to strike side of entrance door. The bottom of the control console shall be a minimum of forty-two inches (42") above building finished floor when any cabinetry is in front of console. A clear Plexiglass cover shall protect controls from damage and shall be furnished with lock and two keys to prevent accidental or unauthorized adjustment of controls from set positions. Interior room lighting shall be controlled by an exterior switch located on the outside of the control panel with an operational pilot light. Both light and switch shall be clearly identified.
- B. Main Temperature Controller: Shall be fully calibrated, solid state, electronic control, utilizing bridge type circuit with thermistor sensor. Sensor shall be protected against damage. Controller shall provide direct settings of desired operating temperature and be calibrated both in degrees Centigrade and Fahrenheit.
- C. Temperature Safety Limit Controls: Individually adjustable settings on temperature limit controls for high and low temperatures shall be furnished. Limit controls shall cut off refrigeration and/or heat producing systems in the event of malfunction of these systems.
- D. Visible and Audible Alarm System: To be circuited with limit controls to indicate a temperature condition which has exceeded the high and low limit control setting has occurred. Separate indicator lights for high and low temperature alarm shall be provided in control panel.
- E. Variable Heater Control: Shall provide for variation of heat input and provide for more precise sensitive balancing of conditioning systems to achieve room performance.
- F. Dial Thermometer: Control Console to include a 2-1/2", remote reading, dial thermometer calibrated in degrees Centigrade and Fahrenheit over full scale. Delete dial thermometer from control console where recording instrumentation is specified.

2.09 LIGHTING:

- A. Lighting systems shall utilize cool white, 40 w rapid start type fluorescent lamps. Lamps and ballasts to be enclosed in vapor proof fixtures. The fixtures will be Underwriters Laboratories approved and rated to operate at temperatures as low as -20 degrees F. Light fixtures to be mounted above ceiling in plenum area and be provided in sufficient quantity for minimum intensities of 75 foot candles, 40" above floor.
- B. Incandescent vapor proof lights in room operating at constant temperatures of 0 degrees C. or below. Lights shall be installed to provide uniform distribution of light.

2.10 ENVIRONMENTAL CONDITIONING SYSTEM:

- A. Central conditioning equipment to be separated from the environmental compartment by a positive pressure plenum system. Plenum shall contain heaters, cooling coils and air movers. A heavy gauge aluminum condensate pan to be built into the plenum and to be provided with a drain fitting to allow connection of waste line, for removal of condensate.
- B. Plenum system shall allow correct percentage of total opening for uniform air distribution throughout the room to achieve and maintain specified performance. Ceiling shall be thin cell louvers of 1/2" x 1/2" x 1/2" aluminum with baked white enamel finish mounted in exposed T-bar grid system.

2.11 REFRIGERATION SYSTEM:

- A. The refrigeration system shall be an integral part of the control and conditioning system. Each system shall be designed and furnished to operate continuously. System to incorporate a proportional bypass to maintain specified temperature ranges. Refrigerant lines shall be properly sized for distances required between the evaporator and condensing units.
- B. Compressor shall be furnished for self contained air cooled operation with automatic switch over standby system to switch from air cooled operation to water cooled in the event the ambient temperature in the mechanical chase should exceed 90 degrees F. Air cooled condenser to be of special construction for connection for water cooling when the system calls for this operation.
- C. Compressor/Condensing Unit: Shall be specifically designed, engineered, manufactured and of adequate capacities to achieve and maintain the individual room operating temperature requirements and performance and shall be balanced in operation with conditioning systems. Compressor/Condensing Unit shall be complete in all respects, and shall include high/low pressure control, receiver, sight glass, drier, expansion valves, and all necessary equipment to achieve the performance specified.

- D. Defrost system required only on those rooms with operating temperature ranges which extend to 4 degrees C. or lower. Condensate pan to be furnished with electric heaters to minimize ice formation and accumulation on rooms operating at ± 3 degrees C. or lower. Defrost system shall be electric with time clock, manually programmable, to control the time and cycle of the system. Automatic bypass of the defrost cycle shall be provided for use when room is operated above 5 degrees C. There will be a nominal temperature rise on defrost.

- E. Fabrication and Installation: All fabrication work on the refrigerant systems shall be done by qualified refrigeration mechanics approved by the Owner. Refrigerant lines shall be dehydrated refrigerant copper tubing assembled by silver soldering, using wrought copper fittings. Silver soldering shall be done in presence of nitrogen (oil pumped) in tubing to prevent oxidation and scale formation. Grade all refrigerant lines to compressor or install approved suction line traps. Refrigerant lines shall be adequately supported with approved pipe hanger assemblies consisting of rods and hangers outside of insulation. After fabrication, each system shall be evacuated three times and flushed between each evacuation with R-12 refrigerant. Each system shall be evacuated to pressure of 100 microns maximum. After the refrigerant lines are proven tight the suction lines shall be insulated with Armaflex Foamed Plastic Insulation which shall be slipped over tubing wherever possible. Use Armaflex 529 Adhesive. Use rigid Armaflex where hangers occur (on bottom of tubing only, if desired). Paint Armaflex White Finish where insulation is visible. Use 1/2" thick material on temperature down to 0 degrees C., 3/4" thick Armaflex on applications below 0 degrees C.

- F. Heaters: Low watt density, Ni-chrome, tubular finned heaters shall be used. Open wire heaters shall not be acceptable.

2.12 DIMENSIONS:

- A. Refer to Schedule of Equipment and to the Mechanical Drawings for sizes.

2.13 CONTROL AND PERFORMANCE PARAMETERS:

- A. For temperature range, refer to Schedule of Equipment. Temperature control of ± 0.2 degrees C., is the variation at the sensing bulb. Temperature uniformity of ± 0.5 degrees C., is the variation in temperature between any points in the working area of the room as measured by a multipoint strip chart recorder.

2.14 ELECTRICAL:

- A. All electric components utilized within each room shall be Underwriters Laboratories approved with interior wiring practices in accordance with Underwriters Laboratories and the National Electrical Code. Conductors to conform to Article 310 of the National Electrical Code and all motors, motor circuits and controllers to conform to Article 430 of the National Electrical Code.
 - 1. Required electric power is shown on Schedule of Equipment.
 - 2. Electrical Contractor under Division 26 work shall make service connection to condensing unit and to control cabinet and shall provide interconnecting wire and conduit between these two points only.
 - 3. Circuit Breakers: Complete breaker protection for lights, receptacles, controls, condensing units, etc., shall be provided. All circuits at rooms shall be protected by circuit breakers of proper amperage rating (common fuses will not be acceptable). An individual circuit breaker type disconnect shall be provided at each condensing unit in addition to other breakers. Each room and controls shall operate from a separate 120/208 volt, 3-phase, 4-wire feeders and each condensing unit shall operate from a separate 208 volt, 3-phase, 3-wire feeder.

2.15 CONTROLLED HUMIDIFICATION SYSTEM:

- A. Rooms having humidity up to 98% will be furnished with steam type humidifiers with steam to environmental rooms provided by Mechanical Contractor. Rooms with humidity up to 90% will be furnished with centrifugal atomizer type humidifiers. Both types of humidity systems are to be controlled by an electronic controller with a humidity range of 10% to 100%. Control of humidity for the humidified rooms will be as limited by a 40 degrees F. minimum dew point $\pm 5\%$ RH.

2.16 ACCESSORIES:

- A. Receptacles: See Schedule of Equipment and Drawings for the type of outlets to be provided as well as the number of outlets.
- B. Filler Panels: Furnish, where required, necessary vertical and horizontal panels or closure strips to enclose openings between environmental rooms and adjacent corridors, building walls and ceilings.
- C. Recorders: See Schedule of Equipment for those rooms requiring temperature and/or humidity recorders. Recorders to be Honeywell or equal 7-day type with 10" minimum circular charts.

2.17 FACTORY DEMONSTRATION:

- A. After a manufacturer has been approved on the basis of Manufacturer's Qualifications and the approved Shop Drawings have been returned to the manufacturer, the Owner will set a date for the manufacturer to make a complete Environmental Room (specific one to be selected by the Owner) according to Project Specification requirements to demonstrate capacity and specific compliance with the Specifications.
- B. The Environmental Room shall be complete and working in every respect and shall be assembled for demonstration at the factory's main plant where instrumentation and Factory Engineers are available to answer technical questions and make tests.
- C. This Environmental Room shall be checked by the Factory Engineers to meet all specified performance and shall be specifically run through all tests that are specified under article of these Specifications entitled "Certification and Tests" prior to the demonstration referred to in Paragraph ____.
- D. After above checking has been successfully completed, the manufacturer will demonstrate the Environmental Room and run the performance tests listed in article "Certification and Tests" in the presence of the Owner's representative on the date set by the Owner. The Contractor shall provide for all costs for this first factory demonstration in the bid proposal including commercial air transportation costs, food and lodging for the Owner's official representatives:
 - 1. One UT _____ user from _____, Texas. Two UT System, Office of Facilities Planning and Construction representatives from Austin, Texas. One Architect from _____, Texas. One Engineer from _____, Texas.
 - 2. Representatives of the General Contractor and the Mechanical Contractor shall attend the demonstration at their own expense.
- E. If the Manufacturer is unable to demonstrate satisfactory performance in compliance with Specifications, in this first demonstration, modifications shall be made as required, a demonstration shall be rescheduled and the Contractor shall again provide for all transportation, food and lodging costs to reassemble the above listed Owner's Official Representatives and the Contractor's Representative(s) for the second and each additional demonstration until the equipment is demonstrated to the satisfaction of the Owner.
- F. If more than the first and second demonstrations are required as a result of noncompliance, the Contractor shall be required to reimburse each Owner's Official Representative at the rate of \$50.00 per hour (portal to portal) for the third and all additional demonstrations to compensate for wasted man-hour charges.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install in accordance with manufacturers' instructions.
- B. Coordinate installation of units with architectural, [mechanical,] and electrical work.
- C. Supply units fully charged with refrigerant and filled with oil.
- D. Scheduled performance is based on [ARI 210] [ARI 240] test conditions. [Scheduled sound rating is based on ARI 270.]

3.02 INSTALLATION:

- A. Installing Contractor shall deliver to the job site, uncrate, place in proper location, and assemble all equipment covered by this specification. All external mechanical and electrical work shall be done by other Contractors under the supervision of the room manufacturer or an assigned representative of the manufacturer. After connection by others, the room manufacturer shall completely field check the equipment prior to final acceptance.
- B. The Installing Contractor assigned to accomplish the installation shall be specialized in the installation of this type of equipment and the installation shall be accomplished under the direct supervision of the original room manufacturer. The room manufacturer shall be responsible for the work of any Contractor utilized in the installation of their equipment and it will be the original room manufacturer's responsibility to accomplish the start up, check out, testing, calibration and instruction of using personnel and maintain all warranties.

3.03 CERTIFICATION AND TESTS:

- A. Rooms shall be completely tested after installation to insure compliance to the specified operating requirements of the room.
- B. Upon acceptance of the equipment, provide full instruction and demonstrate to the Owner's designated Representatives the proper method of care, operation and maintenance of the environmental rooms.
- C. Provide the Owner with a complete set of typed operating and maintenance instructions required to insure the continuous satisfactory operation of the room. Manual shall be enclosed in folders complete with detailed electrical and refrigeration schematics of respective systems for each room.

- D. The environmental rooms shall be furnished and installed complete under this section including all interior room electrical work; all electrical controls; all refrigerant, refrigerant piping and insulation; all condensate drain piping and all components assembly and installation.
- E. Defrost systems shall utilize the hot-gas phase of the refrigerant to remove frost from the evaporator coils. A time clock, manually programmable, shall control the beginning and duration of the defrost time. Automatic bypass of the defrost cycle shall be provided for the use when rooms are operated above 5 degrees C. Rooms operating from 0 degrees C. to 5 degrees C. shall defrost in a maximum time of 2 minutes of each 12 hours. Room air temperature shall not rise more than 1 degree C.
- F. Rooms operating from 0 degrees to -20 degrees C. shall defrost in a maximum of 3 minutes of each 3 hours. Room air temperature shall not rise more than 5 degrees C.
- G. Defrost systems shall be required only on those rooms with operating temperatures which extend below 3 degrees C. All condensate and drain lines to be furnished with electric heaters to prevent ice formation and accumulation.
- H. Rooms operating at 4 degrees C. and above shall recover preset operating temperature within 3 minutes after door has been opened to 75 degrees F. ambient for a period of one full minute. Rooms operating at 3 degrees C. and below shall recover preset operating temperature within 5 minutes after door has been opened to highest operating temperature of the adjoining room.
- I. Acceptance Test: These tests shall be made on the demonstration unit at the factory and on each individual room installed at the building project. These tests shall be conducted by a Factory Engineer in the presence of the A/E and Owner. The procedure shall be as follows:
 - 1. At the appointed time of the test, the room shall have had the temperature and humidity (as applicable) set and stabilized at the lowest values at which the room is to operate.
 - 2. Rooms with a low operating limit of from +5 degrees C. to 0 degrees C. shall have been operating at its low value for 12 hours prior to this test. Rooms with a low operating limit of from 0 degrees C. to -20 degrees C. shall have been operating at its low value for 3 hours prior to this test.
 - 3. The reviewing personnel shall have the opportunity to visually inspect the physical features of the room and its attendant equipment. All controls and recorders are to be in operation. The recorder chart shall be a 12 hour chart for this test, regardless of what is specified.

4. The defrost cycle will be activated and timed with rise in room temperature as prescribed in paragraph _____ and _____ noted.
 5. After temperature stabilization, perform the open door test of paragraph _____.
 6. Set temperature and humidity at intermediate values and verify this condition can be held for two hours.
 7. Set temperature and humidity at upper operating limits and verify this condition can be held for two hours.
 8. Set temperature and humidity at values which are 25% above the lower operating values. In this case and in all of the above cases, the recorder chart will provide the temperature/humidity vs. time record of these tests.
 9. During the above test the following shall be demonstrated:
 - (1) Safety limit controls
 - (2) Alarm signals
 - (3) Indicator lights
 10. A Rosemont Series 78 Platinum Resistance Temperature Sensor, or equivalent will be used to verify the accuracy of the temperature indicator on the room control panel. This will be done in the presence of the A/E and Owner's representative.
- J. A multiple point potentiometric strip chart recorder shall provide six temperature readings at six different locations within the control zone throughout the test. Recorder thermocouples shall be calibrated at the beginning and end of test. Test results shall be summarized and witnessed by Factory Engineer and Owner's Representative with a copy provided for each. The test equipment recorder, and Rosemont Platinum RTD shall be furnished by the Environmental Room Manufacturer.
- K. Acceptance: Shall be provided upon completion of satisfactory acceptance tests as witnessed by Owner's Representative and factory personnel of both the factory test and the as-installed test at the site. At the site, the room operation will become the Owner's responsibility, and the warranty period initiation will coincide with site acceptance.

NOTE TO DESIGN ENGINEER: ENGINEER SHALL INVESTIGATE AND ALLOW AMPLY FOR SPECIAL LOADS SUCH AS:

1. LARGE PRODUCT LOAD IN SOME FREEZERS.
2. LARGER MOTOR LOADS SUCH AS CENTRIFUGE AND OTHER SPECIAL EQUIPMENT IN ROOM.
3. ABNORMAL USE OF DOORS BY USER PERSONNEL.

3.04 GUARANTEE:

- A. The Contractor guarantees all work to be in accordance with contract requirements and free from defective or inferior materials, equipment, and workmanship for one year after the date the equipment is accepted for use by the Owner.
- B. If, within the guarantee period, the Owner finds that guaranteed work needs to be repaired or changed because of the use of materials, equipment or workmanship which, in the opinion of the Owner are inferior, defective, or not in accordance with the terms of the contract, he shall so inform the Contractor in writing and the Contractor shall promptly and without additional expense to the Owner: Place in a satisfactory condition all of such guaranteed work; make good all damage to equipment, the site, the building, or contents thereof, which is the result of unsatisfactory guaranteed work; and make good any work, materials, and equipment that are disturbed in fulfilling the guarantee, including any disturbed work, materials, and equipment that may have been guaranteed under another contract.

Should the Contractor fail to proceed promptly in accordance with the guarantee, the Owner may have such work performed at the expense of the Contractor.

- C. Any special guarantees that may be required under the contract shall be subject to the stipulations set forth above, insofar as they do not conflict with the provisions of such special guarantees.
- D. During the period of guarantee the Contractor shall have maintenance service available in the City of _____, Texas, 24 hours a day, 7 days per week. Should the Owner require service out of normal working hours he shall pay any additional charges that may be incurred. The Contractor shall include the name of the person or firm responsible for the maintenance of the equipment during the guarantee period, who shall be acceptable to the Owner.

3.05 SCHEDULE

Drawing Code

ENVR-1

ENVR-2

Location
Manufacturer
Model Number
Total Cooling Capacity
Cooling SEER
Electric Resistance Heating Capacity
Reverse Cycle Heating Capacity
Reverse Cycle COP
Condenser Water Flow
Condenser Water Temperature
Electrical Requirements:
Amps
Volts

3.06 SCHEDULES ON DRAWINGS:

- A. In general, all capacities of equipment, and motor and starter characteristics are shown in schedules on the Drawings. Reference shall be made to the schedules for such information. The capacities shown are minimum capacities. Variations in the capacities of the scheduled equipment supplied under this contract will be permitted only with the written direction of the owner. All equipment shall be shipped to the job with not less than a prime coat of paint or an acceptable protective coating such as galvanizing. Insofar as is possible, all items of the same type (i.e., pumps, fans, etc.) shall be by the same manufacturer. Where installation instructions are not included in these Specifications or on the Drawings, the manufacturer's instructions shall be followed. All equipment affected by altitude shall be rated to operate at the altitude where it is installed.

END OF SECTION

**SECTION 11 53 53
BIOLOGICAL SAFETY CABINETS**

PART 1 GENERAL

1.00 The following sections are to be included as if written herein:

- A. Section 23 00 00 – Basic Mechanical Requirements
- B. Section 23 05 29 – Sleeves, Flashings, Supports and Anchors
- C. Section 23 05 53 – Mechanical Identification

1.01 RELATED DOCUMENTS

- A. Provisions established within the General and Supplementary General Conditions of the Contract, Division 01 - General Requirements, and the Drawings are collectively applicable to this Section.

1.02 SECTION INCLUDES

- A. Furnish all supporting, cabinets, hoods, and miscellaneous items of equipment as listed in these specifications, equipment schedules, or as shown on drawings.
- B. Furnish and deliver all utility service outlet accessory fittings, electrical receptacles, and switches specified to be mounted on the biological safety cabinets.

1.03 RELATED SECTIONS

- A. Special Conditions: Equipment categories
- B. Section 12 35 53 - Laboratory Casework
- C. Division 23 - HVAC: Connections to utility services
- D. Division 26 - Electrical Requirement: Connections to utility services

1.04 REFERENCES

- A. American Society for Testing of Materials: E84, Surface Burning Characteristics of Building Materials
- B. ANSI/ASTM A167 - Stainless and Heat Resisting Chromium-Nickel Steel Plate, Sheet and strip

- C. ANSI/ASTM A446 - Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process, Structural (Physical) Quality
- D. ANSI/ASTM A526 - Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process, Commercial Quality
- E. ASTM C1 048 - Heat-Treated Flat Glass - Kind HS, Kind FT Coated and Uncoated Glass

1.05 DEFINITIONS

- A. SERVICE FIXTURES: Gas cocks and/or needle point cocks or valves; remote control valves, electrical receptacles with necessary conduits and plates, fluorescent light fixtures, light switches, warning lights, and other items, provided they are a functional part of the equipment to be furnished under this contract
- B. SERVICE LINES: Compressed air and vacuum piping, fittings, and shutoff valves necessary to carry the respective services from the building roughing-in outlets in the floors or walls through the equipment to the "Service Fixtures".
- C. SERVICE LINES include all conduit, junction boxes, conduits, fittings, wire, disconnect switches, and fuse or circuit breakers necessary to carry the electrical services from the building roughing-in outlets in the floors or walls through the equipment to the "Service Fixtures."

1.06 SUBMITTALS

- A. Submit under provisions of Section 01 33 26 and 23 00 00.
- B. Shop Drawings: Indicate locations, large scale plans, elevations, cross sections, rough-in and anchor placement dimensions and tolerances, and clearances required.
- C. Product Data: Provide component dimensions, configurations, construction details, joint details, and attachments, utility and service requirements and locations and all accessories required for complete installation.
- D. Manufacturer's Installation Instructions: Indicate special installation requirements.

1.07 QUALIFICATIONS

- A. Manufacturer Company specializing in manufacturing the Products specified in this section with minimum ten years documented experience.

1.08 EXAMINATION OF SITE

- A. Visit site and thoroughly check all conditions affecting the installation.
- B. Confirm field dimensions required for the proper fitting of equipment. If any discrepancies exist between the drawings and the field dimensions, report this condition to the Architect in writing, and shall not proceed with that portion of the work in question until all discrepancies are clarified.

1.09 DELIVERY, STORAGE AND HANDLING

- A. Deliver, store, handle, and protect products in accordance with Division 01 and Section 23 20 00.A.
- B. Protect materials from damage, soiling and deterioration.
- C. Do not deliver finish carpentry materials until job site conditions and operations which could damage, soil or deteriorate work are complete.
- D. Coordinate size of access and route to place of installation.

1.10 FIELD MEASUREMENTS

- A. Verify that field measurements are as instructed by the manufacturer and as described in Part 3 - TESTING.

1.11 COORDINATION

- A. Coordinate work under provisions of Division 01.
- B. Coordinate installation with size, location and installation of service utilities with other Division 23 sections and Division 26 sections.

1.12 WARRANTY

- A. Furnish the Owner a written warranty for the hoods and shall cover defects in materials or workmanship for a period of one year from the date of acceptance by the Owner.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Baker.

- B. Substitutions: Under provisions of Section 01 33 26 and 23 20 00.A. Substitutions must have Owner approval prior to bidding.

2.02 MATERIALS

- A. Comply with quality and grading standards contained herein for each material.
- B. Sheet Steel: ANSI/ASTM A446 Grade B galvanized G90 coating, stretcher leveled.
- C. Stainless Steel: ASTM A1 67, Type 304.
- D. Safety Glass: ASTM C1 048, Kind FT fully tempered 1/4 inch thick minimum; exposed edges ground, cut or drilled to receive hardware.

2.03 BIOLOGICAL SAFETY CABINETS

- A. Class II, Type A/B3 Laminar Flow Biological Safety Cabinets
 1. Acceptable Product: The Baker Company, Sterilgard SG-600 (6' unit).
 2. Cabinet shall provide airflows and biological safety performance as specified in NSF Standard 49 and as tested per Part 3 - TESTING.
 - a. Maintain a minimum average inflow velocity of 100 LFPM through the work access opening.
 - b. Has HEPA filtered down flow air composed largely of uncontaminated recirculated inflow air.
 - c. Exhausts 30% of the down flow air through a common plenum passing through a HEPA filter before being exhausted.
 - d. Have all biologically contaminated ducts and plenums under negative pressure.
 3. Cabinet shell shall be pressure tight consisting of an all welded 16 gauge, type 304 stainless steel one piece wrap, with all exhaust-supply air passages constructed of stainless steel.
 4. Cabinet shall have eye-level electronic Service Control Center that is easily serviced with quick disconnects. A Magnehelic gauge shall display pressure drops across the supply HEPA filter.
 5. The cabinet shall employ an electronic exhaust flow sensing system that continually measures and displays total exhaust mass flow with audible alarm.

6. The cabinet shall provide a set of contacts for a remove alarm system or building automation system in the event of loss of exhaust flow.
7. The cabinet sliding window shall be fully closing, constructed of 1/4" tempered glass, and contain visual-audible alarm when window is raised beyond its 8 inch working height.
8. The single motor driven forward curve fan system shall be controlled by a solid state motor speed control for the internal supply air.
9. All cabinet seals and access panels shall be held a vacuum under all operating conditions to absolutely preclude leaks to the environment.
10. All pressure plenums are surrounded by a vacuum with the cabinet shell precluding any contamination of the work zone.
11. The cabinet shall include a support stand with adjustable levelers which provides a work surface height of 30 inches.
12. The blower/motor shall automatically compensate for as the filters load with particulate to achieve a 80% increase in pressure drop across the filters with no more than 10% decrease in airflow. With the use of the speed control a greater than 180% increase in pressure drop across the filters shall be achievable.
13. The cabinet work zone shall be all stainless steel with the work tray removable with coved corners for easy cleaning.
14. Both the supply and exhaust HEPA filters shall be removable from the front of the cabinet without disassembly of the window assembly or service control center.
15. The drain trough beneath the work surface shall empty to a 3/8" stainless steel ball valve to effect 99% drainage.
16. The unit shall meet the performance requirements of NIH Specification NIHO3-112 and shall be listed by NSF as meeting Standard No.49. Before shipping, each unit shall have a complete test to assure that cabinet meets Class II requirements. A copy of the test report shall be provided with the unit.
17. The cabinet shall be UL listed.
18. The cabinet shall contain an ultraviolet light

19. All utility connections to be plumbed out top of hood and black steel pipe must be used for gas connections with copper for all other services.
 20. An average uniform light intensity of 90-120 foot candles shall be provided at the work surface.
 21. Overall noise level measured to 12 inches in front of the work area opening and 15 inches above the work tray shall not exceed 65 dbA.
- B. Class II, Type B2 Total Exhaust Laminar Flow Biological Safety Cabinets (100% exhaust).
1. Acceptable Product: The Baker Company, Sterilchemgard 6TX (6' unit).
 2. Cabinet shall provide airflows and biological safety performance as specified in NSF Standard 49.
 - a. Cabinet shall be a single pass flow through design in which all HEPA filtered work zone and work access inflow air, is drawn through the cabinet's internal exhaust HEPA filter and exhaust ductwork to a remotely located roof exhaust blower.
 - b. Cabinet shall not only reduce the potential for exposure of both product and personnel to airborne biological agents in low to moderate risk research, but shall extend the use of the cabinet to work with chemicals and radioactive materials.
 - c. Work zone air down flow is laminar and held to an average velocity of 55 + 10% LFPM measured in the plane of the bottom edge of the viewing window. Individual velocity readings shall be no less than 45 or greater than 65 at the average velocity of 55 LFPM.
 - d. The supply air through the front work access opening at the 8 inch opening shall be a minimum of 100 LFPM (not to exceed 110 LFPM).
 - e. An average uniform light intensity of 90-120 foot candles shall be provided at the work surface.
 - f. Overall noise level measured to 12 inches in front of the work area opening and 15 inches above the work tray shall not exceed 65 dbA
 3. Cabinet shell shall be pressure tight consisting of an all welded, 16 gauge, type 304 stainless steel one piece wrap, with all exhaust-supply air passage constructed of stainless steel.

4. Cabinet shall be eye-level electronic service control center has is easily serviced with quick disconnects. A Magnehelic gauge shall display pressure drop across the supply HEPA filter.
5. The cabinet shall employ an electronic exhaust flow sensing system that continually measures and displays total exhaust mass flow.
6. The cabinet shall contain an exhaust interlock system that prevents operation of the internal supply blower unless the exhaust flow is sufficient to provide a minimum 100 FPM air barrier inflow velocity at start up.
7. The cabinet full closure sliding window shall be 1/4" tempered glass with visual-audible alarm above when window is raised beyond its 8 inch working height.
8. The single motor driven forward curve fan system shall be controlled by a solid state motor speed control for the internal supply air.
9. The blower motor shall automatically compensate for air low as the filters load with particulate to achieve a 50% increase in pressure drop across the filters with no more than a 10% decrease in air flow. With the use of the speed control a greater than 150% increase in pressure drop across the filters shall be achievable.
10. All cabinet seals and access panels shall be held at a vacuum under all operating conditions to absolutely preclude leaks to the environment.
11. All pressure plenums (supply air) are surrounded by a vacuum down to the HEPA filter scale with the cabinet shell precluding any contamination of the work zone.
12. The cabinet work zone shall be all stainless steel with the work tray removable with coved comers for easy cleaning.
13. Both the supply and exhaust HEPA filters shall be removable from the front of the cabinet without disassembly of the window assembly or Service Control Center.
14. The drain trough beneath the work tray shall empty to a 3/8" stainless steel ball valve to effect 99% drainage.
15. The cabinet shall contain an ultraviolet light.

2.04 MECHANICAL SERVICE FIXTURES

- A. Service Fixtures: Provide units complete with washers, locknuts, unions, nipples and other accessories for positive mounting to supporting laboratory units. Include wall and deck

flanges, escutcheons, handle extension rods, remove valves, and similar items required. Fabricate units to withstand test pressure of 100 psig.

- B. **Material and Finish:** Fabricate service fixtures from cast or forged red brass containing a minimum of 85 percent copper. Exposed surfaces including fittings and escutcheons. Finish shall be sepia bronze with clear epoxy finish.
- C. **Service Outlets Identification:** Provide colored plastic index discs with embossed identification letters at each service fixture handle or knob. Secure discs to fixture handles to be virtually tamperproof. Color-code discs as follows for services indicated:

<u>Service</u>	<u>Color</u>	<u>Code</u>	<u>Letter</u>	<u>Color</u>
Air	Orange	Air		Black
Vacuum	Yellow	VAC		Black

- D. **Ground Key Type Hose Cocks:** Tapered core and handle of one piece forged brass, ground and lapped, held in place under constant spring pressure.
- E. **Handles:** Provide 4-arm forged brass handles for valve, stops, faucets, remote controls, and cocks, except for ground key cocks, steam valves, and micro-adjustable needle cocks.
- F. **Hand of Fixtures:** Furnish fixtures on side of cabinet indicated on the Drawings.
- G. Refer to drawings for service required for each hood.

2.05 ELECTRICAL SERVICE FIXTURES

- A. **Service Fixtures:** Provide units complete with complete with metal housing or box; necessary receptacles, terminals, switches, device plates; and fittings and gaskets required for mounting on casework. All fixtures UL labeled.
- B. **Recessed Type Fixtures:** Galvanized steel outlet box, size as required complete with cover plate and receptacles or other devices indicated.
- C. **Cover Plates:** Provide stainless steel cover plates for AC outlets and devices.
 - 1. Stainless steel, Type 302, satin finish, with formed beveled edges.
- D. **Receptacles:** Furnish a duplex 120 volt GFI receptacle, prewired, on each side of the cabinet

2.06 FINISHES

- A. **Metal-Exposed**

1. Metal shall be cleaned of all grease and oils. All welds, punched holes, and machine marks shall be sanded or filed smooth. Surface shall be primer coated. Finish coat shall be applied and surface shall be baked. Color Pure white.
 2. Stainless Steel: No.4 brushed finish.
- B. Metal - Unexposed
1. Metal shall receive a baked-on coat of white acid-resistant finish.
 2. Stainless Steel: No.4 brushed finish.
- C. Items not having shop finish will be finished in field, in accordance with Section 09 91 00.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify existing conditions under provisions of Section 01 31 00.
- B. Verify adequacy of support framing and anchors.
- C. Visit the site and thoroughly check all conditions affecting the installation.

3.02 INSTALLATION

- A. Set and secure materials and components, rigid, plumb, and square.
- B. Sequence installation to ensure utility connections are achieved in an orderly and expeditious manner.
- C. Contractor shall supply, install and connect cabinets, accessories and utility connections as required to provide complete, homogenous functioning unit

3.03 ADJUSTING

- A. Adjust work under provisions of Section 01705.
- B. Adjust hardware, fixtures, and other moving or operating parts to function smoothly.

3.04 CLEANING

- A. Clean work under provisions of 01705.

- B. Clean cabinet, shelves, glass, legs, hardware, fittings and fixtures.

3.05 PROTECTION OF FINISHED WORK

- A. Protect finished Work under provisions of Section 01500 and 23 00 00.
- B. Do not permit finished casework to be exposed to continued construction activity.

3.5 TESTING

- A. Each biosafety cabinet shall be tested for flow utilizing a thermoanemometer attached to a ring stand, or other stationary device to eliminate hand held fluctuations. The thermoanemometer shall be directly linked to a computer to automatically take readings every second for at least 30 seconds and then average those readings to one value. This process shall be repeated at each measuring point in a grid fashion six inches on center, no closer than four inches to a wall or opening edge.
- B. This procedure shall be done both at the factory and after the cabinet is installed at the site for an as used test and shall use the following instrumentation.
- C. Instrumentation - A fully integrated flow analysis system which includes:
 - 1. A direct digital link from the thermoanemometer (accurate to 3% of indicated reading, or $\pm 1-2$ fpm) to the electronic test file to prevent transcription error.
 - 2. A software application that:
 - a. Accepts the linked data.
 - b. Creates a dated/time coded profile documenting the unit identification/location and other test results and documentation.
 - c. Archives the data collected in a relational and historical database.
 - d. Generates professionally formatted reports and certification label for each test.
 - 3. The reports include a graphical depiction of the air flow data gathered in a grid format. At least 30 readings, no more than 1 second apart, must be taken at each point of the grid. The average flow and statistical representation of variation is provided for each location.

3.06 CERTIFICATION

- A. Certify field installed cabinets in accordance with NSF Standard 49 and the above testing procedure.
- B. Provide certification documentation under provisions of Division 01.

END OF SECTION

SECTION 13 48 00
SOUND ATTENUATORS

PART 1 GENERAL

1.00 The following sections are to be included as if written herein:

- A. Section 23 00 00 – Basic Mechanical Requirements
- B. Section 23 05 29 – Sleeves, Flashings, Supports and Anchors
- C. Section 23 05 53 – Mechanical Identification

1.1 SECTION INCLUDES

- A. Duct Silencers
- B. Cross-Talk Silencers
- C. Acoustic Housings
- D. Ductwork Lagging
- E. Acoustical Louvers

1.2 RELATED SECTIONS

- A. Section 07 90 00- Joint Sealers
- B. Section 23 31 00 - Ductwork: Connections to Silencers
- C. Section 23 33 00 - Ductwork Accessories: Flexible Duct Connections
- D. Section 23 05 93.A - Testing Adjusting and Balancing

1.3 REFERENCES

- A. AMCA 300 - Test Code for Sound Rating
- B. AMCA 301 - Methods for Calculating Fan Sound Ratings from Laboratory Test Data
- C. AMCA 302 - Application of Sound Loudness Ratings for Non-Ducted Air Moving Devices

SECTION 13 48 00
SOUND ATTENUATORS

- D. AMCA 303 - Application of Sound Power Level Ratings for Ducted Air Moving Devices Recommended Typical dBa Calculation
- E. ANSI S1.1 - Acoustical Terminology (Including Mechanical Shock and Vibration)
- F. ANSI S1.8 - Preferred Reference Quantities for Acoustical Levels
- G. ANSI S1.13 - Methods for Measurement of Sound Pressure Levels
- H. ARI 270 - Sound Rating of Outdoor Unitary Equipment
- I. ARI 575 - Measuring Machinery Sound within Equipment Rooms
- J. ASA 16 (ANSI S1.36) - Survey Methods for Determination of Sound Power Levels of Noise Sources
- K. ASA 29 (ANSI S1.29) - Measurement and Designation of Noise Emitted by Computer and Business Equipment
- L. ASA 47 (ANSI S1.4) - Specification for Sound Level Meters
- M. ASA 49 (ANSI S12.1) - Preparation of Standard Procedures to Determine the Noise Emission from Sources
- N. ASA 61 (ANSI S12.10) - Computer and Business Equipment
- O. ASHRAE 68 - Method of Testing In-Duct Sound Power Measurement Procedure for Fans
- P. ASHRAE Handbook - Systems Volume, Chapter "Sound and Vibration Control"
- Q. ASTM E90 - Method for Laboratory Measurement of Airborne Sound Transmission of Building Partitions
- R. ASTM E477 - Method of Testing Duct Liner Materials and Prefabricated Silencers for Acoustical and Airflow Performance
- S. ASTM E596 - Method for Laboratory Measurement of the Noise Reduction of Sound Isolating Enclosures
- T. NEBB - Procedural Standards for Measuring Sound and Vibration
- U. SMACNA - HVAC Duct Construction Standards - Metal and Flexible

1.4 DEFINITIONS

- A. Submittals and Report: Conform to ANSI S1.1.

1.5 PERFORMANCE REQUIREMENTS

- A. Maintain sound level of spaces at levels not to exceed those listed below by utilizing acoustical devices as required to achieve specified sound levels.

- B. Maintain rooms at following maximum sound levels, in Noise Criteria (NC) as defined by ASHRAE Handbook and ANSI S1.8.

- 1. Private Residences [25] [30]
- 2. Apartments [30] [35]
- 3. Hotels/Motels:
 - a. Individual rooms/suites [30] [35]
 - b. Meeting/banquet rooms [30] [35]
 - c. Halls, corridors, lobbies [35] [40]
 - d. Service/support areas [40] [45]
- 4. Offices:
 - a. Executive [25] [30]
 - b. Conference rooms [25] [30]
 - c. Private [30] [35]
 - d. Open-plan areas [35] [40]
 - e. Computer/business machine areas [40] [45]
 - f. Public circulation [40] [45]
- 5. Hospitals and Clinics:

- a. Private rooms [25] [30]
 - b. Wards [30] [35]
 - c. Operating rooms [25] [30]
 - d. Laboratories [30] [35]
 - e. Corridors [30] [35]
 - f. Public areas [35] [40]
6. Schools:
- a. Lecture and classrooms [25] [30]
 - b. Open-plan classrooms [30] [35]
7. Libraries [30] [35]
8. Concert Halls and Legitimate Theaters:
- a. Theater[20] [25]
 - b. Stagehouse [20] [25]
 - c. Trap room [20] [25]
 - d. Orchestra pit [20] [25]
 - e. Rehearsal rooms [20] [25]
 - f. Teaching studios [25] [30]
 - g. Practice rooms [25] [30]
 - h. Ensemble rooms [25] [30]
 - i. Shop [40] [45]
9. Recording Studios:
- a. Recording room [15] [20]

- b. Sound Control room [20] [25]
 - c. Other Control rooms [20] [25]
10. Lecture Theaters [25] [30]

1.6 SUBMITTALS

- A. Submit under provisions of Section 23 00 00.
- B. Shop Drawings: Indicate assembly, materials, thicknesses, dimensional data, pressure losses, acoustical performance, layout, and connection details.
- C. Product Data: Provide catalog information indicating, materials, dimensional data, pressure losses, and acoustical performance.
- D. Samples: Submit two cross-talk silencers, constructed as detailed in the Construction Drawings.
- E. Design Data: Provide engineering calculations, referenced to specifications and [AMCA 301] [AMCA 302] [AMCA 303] [ARI 270] [ASA 49 (ANSI S12.1)] standards indicating that maximum room sound levels are not exceeded.
- F. Test Reports: Indicate acoustic housings meet or exceed specified sound transmission loss values.
- G. Manufacturer's Installation Instructions: Indicate installation requirements which maintain integrity of sound isolation.
- H. Manufacturer's Field Reports: Submit under provisions of Section 23 00 00.
- I. Manufacturer's Field Reports: Indicate installation is complete and in accordance with instructions.

1.7 PROJECT RECORD DOCUMENTS

- A. Submit under provisions of Section 23 00 00.
- B. Accurately record actual locations of cross-talk silencers, acoustic housings, and ductwork lagging.

1.8 QUALITY ASSURANCE

- A. Perform Work in accordance with [AMCA 300] [ANSI S1.13] [ARI 575] [ASA 16 (ANSI S1.36)] [ASA 29 (ANSI S1.20)] [ASA 61 (ANSI S12.10)] standards and recommendations of [ASHRAE 68.] [NEBB.]
- B. Maintain one copy of each document on site.

1.9 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing the products specified in this Section with minimum three years documented experience.
- B. Design application of duct silencers or acoustic housings under direct supervision of a Professional Engineer experienced in design of this work and licensed in the State of Texas.

1.10 REGULATORY REQUIREMENTS

- A. Conform to applicable code for sound levels at property line.

PART 2 PRODUCTS

2.01 DUCT SOUND ABSORBERS:

- A. General:
 - 1. The Contractor shall furnish and install prefabricated silencers in the air handling system of the size and performance shown on the duct silencer schedule. The Silencer manufacturer shall furnish to the Contractor complete submittal data which shall indicate the size, type, performance and certified test reports from a nationally known qualified independent laboratory corroborating his catalogue performance. Test reports shall be based on 24" x 24" cross sectional area of each type and model required for this project. Further, the submittal data shall indicate clearly outlined procedures for installing the duct silencers.
 - 2. The duct silencers supplier or his qualified representative shall be responsible for providing such supervision as may be required to assure correct and complete installation of the duct silencers.
 - 3. The duct silencers shall be as supplied by Industrial Acoustics, Koppers, Rink Corporation or approved equal.
- B. General Design Features:

1. The outer casings of all rectangular silencers shall be of not less than 22 gauge galvanized steel construction and external seams shall be locked form and filled with mastic or continuously welded and shall be air tight up to 8" pressure differential.
2. Interior partitions shall be of not less than 24 gauge galvanized perforated steel.
3. The acoustical filler materials shall consist of inorganic mineral or glass fiber of a density required to obtain the specified acoustic performance and packed under not less than 5% compression to eliminate voids due to vibration and settling. Materials shall be inert, vermin and moisture proof, and impart no odor into the air. The incombustible acoustical filler material shall exhibit not more than the following fire hazard classification values when tested in accordance with the Standard ASTM E-84, or UL 723 test methods:

Flame Spread Smoke Developed

25 50

C. Acoustic and Aerodynamic Performance:

1. Acoustical testing shall be determined by the "duct to a reverberation room", as recommended by SIW 42 Subcommittee of the American National Standards Institute. Tests shall be run with air flowing through the silencer at not less than three (3) different flow rates and also at zero (0) flow. All ratings shall be based on test data from a nationally known qualified independent laboratory. Test methods shall eliminate effects due to end reflection vibration flaring transmission and standing waves in the reverberant room. Air flow and pressure loss data taken in accordance with the AMCA procedures shall be obtained from the same silencer used for acoustical performance test.
2. Static pressure loss of silencers shall not exceed those listed in the silencer schedule at the indicated air flow.

NOTE TO REVIEWER: THE BALANCE OF PART 2 OF THIS SPECIFICATION IS THE SPECIFICATION SUGGESTED BY CSI. IT IS INCLUDED TO GIVE GUIDANCE TO IMPROVE THIS SPECIFICATION IN THE FUTURE. IT IS THE FEELING OF THE WRITER THAT THIS SECTION OF THE SPECIFICATIONS IS IN SORE NEED OF IMPROVEMENT, BUT WITH TIME CONSTRAINTS, IMPROVEMENT PRIOR TO THIS RELEASE WAS NOT POSSIBLE.

2.02 MANUFACTURERS

- A. [] Model [.]
- B. [] Model [.]
- C. [] Model [.]
- D. Substitutions: Under provisions of Section [00 26 00.] [01 25 00.]

2.03 DUCT SILENCERS

- A. Description: Duct section with sheet metal outer casing, sound absorbing fill material, and inner casing of perforated sheet metal; incorporating interior baffles of similar construction. Fabricate in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible.
- B. Configuration: Tubular [with] [without] inner casing and liner, [without center body] [with absorptive] [aerodynamically shaped center body with nose cone and truncated tail cone] [splitters with radiused nose and contoured tails], [] diameter [as indicated], length [1.5] [2] [3] [4] times diameter.
- C. ***** [OR] ***** Configuration: Rectangular with lined splitters with radiused nose and contoured tails, modular [] high, [] wide, [] long.
- D. Materials:
 - 1. Outer Casing: Minimum [22 gauge (0.8 mm)] [20 gauge (0.9 mm)] thick galvanized steel stiffened as required, with [mastic filled lock formed] [welded] seams, 2 inch (50 mm) long, 11 gauge (2.9 mm) slip joints on both ends.
 - 2. Inner Casing and Splitters: Minimum 24 gauge (0.6 mm) thick perforated galvanized steel.
 - 3. Fill: Glass fiber or mineral wool of minimum [4 lb/cu ft (64 kg/cu m)] [3 lb/cu ft (48 kg/cu m)] density.
 - 4. Fill Liner: [Bonded glass fiber matting.] [1 mil (0.0254 mm) mylar film.]
- E. Rating:

1. ASTM E477 Insertion Loss and Maximum Generated Noise at [1000 fpm (7 m/sec)] [2000 fpm (10 m/sec)] [4000 fpm (20 m/sec)] Face Velocity:

Octave Band Center Frequency (Hz)

63 125 250 500 1000 2000 4000

Insertion

Loss (dB) [] [] [] [] [] [] []

Generated

Noise (dB) [] [] [] [] [] [] []

2. Static Pressure Drop at [1000 fpm (5 m/sec)] [2000 fpm (10 m/sec)] Face Velocity: [] inches wg ([] kPa).

3. Air Tight Static Pressure: [10 inches wg (2.5 kPa)].

- F. Performance: Achieve noise reduction of:

Octave Band Center Frequency (Hz)

63 125 250 500 1000 2000 4000

Insertion

Loss (dB) [] [] [] [] [] [] []

- G. Model: [] manufactured by [].

2.04 CROSS-TALK SILENCERS

- A. Description: Duct sections with sheet metal outer casing, sound absorbing fill material [], and inner casing of perforated sheet metal]; incorporating interior baffles of similar construction. Fabricate in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible.
- B. Configuration: Rectangular, lined [with inner casing] with splitters with radiused nosed and contoured tails, [] high, [] wide, [] long.
- C. Materials:
 1. Outer Casing: Minimum [22 gauge (0.8 mm)] thick galvanized steel with [mastic filled lock formed] [welded] seams, 3 inch (75 mm)] long, 11 gauge (2.9 mm) slip joint on both ends.
 2. Inner Casing and Splitters: Minimum 24 gauge (0.6 mm) thick perforated galvanized steel.

3. Fill: Glass fiber or mineral wool of minimum [4 lb/cu ft (64 kg/cu m)] [3 lb/cu ft (48 kg/cu m)] density.

4. Fill Liner: [Bonded glass fiber matting.] [1 mil (0.0254 mm) mylar film.]

D. Rating:

1. Equivalent STC: [_____].

2. Static Pressure Drop at [500 fpm (2.5 m/sec)] [1000 fpm (5 m/sec)] Face Velocity: [_____] inches wg ([_____] kPa).

E. Model: [_____] manufactured by [_____].

2.05 ACOUSTIC HOUSINGS

A. Description: Modular panels, including access doors and windows, nominal 4 inches (100 mm) thick, with filled outer and inner casing. Fabricate and support in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible.

B. Materials:

1. Outer Casing: Minimum [18 gauge (1.2mm)] [22 gauge (0.9 mm)] thick galvanized steel stiffened as required, with [mastic filled lock formed] [welded] seams for [internal flange butt] [covering strip butt] [overlapping lip] [tongue and groove] joining.

2. Inner Casing and Splitters: Minimum 22 gauge (0.8 mm) thick perforated galvanized steel.

3. Fill: Glass fiber or mineral wool of minimum [4 lb/cu ft (64 kg/cu m)] [4-3/4 lb/cu ft (76 kg/cu m)] density.

4. Fill Liner: [Bonded glass fiber matting.] [1 mil (0.0254 mm) mylar film.]

5. Window: [_____] x [_____] inch ([_____] x [_____] mm) double glazed with 1/4 inch (6 mm) safety glass.

C. Rating: ASTM E90 sound transmission loss minimum:

Octave Band Center Frequency (Hz)

63 125 250 500 1000 2000 4000

Transmission

Loss (dB)

D. Performance: ASTM E596, achieve A-Scale noise reduction of:

Octave Band Center Frequency (Hz)

63 125 250 500 1000 2000 4000

Insertion

Loss (dB)

E. Model: manufactured by .

2.06 DUCTWORK LAGGING

A. Acoustic Insulation: [2 inch (50 mm)] thick, 3 to 5 lb/cu ft (50 to 80 kg/cu m) density glass fiber or mineral wool insulation.

B. Covering: [Sheet lead] [plaster] [or] [gypsum board] with surface weight minimum 4 lb/sq ft (20 kg/sq m).

2.07 ACOUSTICAL LOUVERS

A. Configuration: [8] [12] inch ([200] [300] mm deep louvers with blades on 45 degree slope; sound absorbing fill material, and inner surface of perforated sheet metal, heavy channel frame, birdscreen.

B. Materials:

1. Louvers: [16 gauge (1.50 mm) galvanized steel] [or] [12 gauge (2.50 mm) extruded aluminum], welded assembly, with factory [prime coat] [baked enamel] [color anodized] finish.

2. Inner Surface: Minimum 24 gauge (0.6 mm) thick perforated galvanized steel.

3. Fill: Glass fiber or mineral wool of minimum [4 lb/cu ft (64 kg/cu m)] [3 lb/cu ft (48 kg/cu m)] density.

4. Fill Liner: [Bonded glass fiber matting.] [1 mil (0.0254 mm) mylar film.]

5. Birdscreen: [1] [1/2] [3/4] inch ([25] [13] [20] mm) square wire mesh.

6. Mounting: [Interior] [Exterior] [flat flange.] [angle flange.] [Screw holes in jambs.] [Masonry strap anchors.]

C. Rating:

1. Insertion loss:

Octave Band Center Frequency (Hz)

63 125 250 500 1000 2000 4000

Insertion

Loss (dB) [] [] [] [] [] [] []

2. Static Pressure Drop at [200 fpm (1 m/sec)] [300 fpm (1.5 m/sec)] [400 fpm (2 m/sec)] Face Velocity: [] inches wg ([] kPa).

D. Model: [] manufactured by [].

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Support duct silencers with ductwork. Refer to Section 23 31 00 and 23 33 00.
- C. Install cross-talk silencers in wall with wall penetrations caulked.
- D. Lag ductwork, where indicated by wrapping with insulation and covering. Apply covering to be air tight. Do not attach covering rigidly to ductwork.
- E. Attach ductwork to acoustic louvers with flexible duct connections. Refer to Section 23 33 00.

3.02 MANUFACTURER'S FIELD SERVICES

- A. Inspect installation periodically under provisions of Section [01 45 33.] [].
- B. Provide services of NEBB testing agency to take noise measurement. Use meters meeting requirements of ASA 47 (ANSI S1.4).
- C. After start-up, final corrections and balancing of systems take octave band sound measurements over full audio frequency range in areas adjacent to mechanical equipment rooms, duct and pipe shafts, and other critical locations, as directed.
- D. Provide one-third octave band measurements of artificial sound sources in areas indicated as having critical requirements.

E. Submit complete report of test results including sound curves.

3.03 SCHEDULE

Drawing Code SA-1 SA-2 SA-3 SA-4

Manufacturer
Model Number
Location
Service
Duct Location
Width or inside dia.
Depth or outside dia.
Length
Total air flow
Face Velocity
Air pressure drop
Dynamic insertion loss (dB)
 2nd Octave
 3rd Octave
 4th Octave
 5th Octave
 6th Octave
 7th Octave
 8th Octave

END OF SECTION



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UTHealth FPE Standard Specification

SECTION 21-00-00

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BASIC FIRE PROTECTION REQUIREMENTS

~~This Standard Specification Section is controlled by the Office of Facilities Planning and Engineering, UTHealth. It is to be used as guideline on all UTHealth projects, unless deviations are approved in writing by the Project Manager. It is not to be used for bidding, permitting, construction or any other purpose. This document is the property of UTHealth, and use of this document, in part or in whole, for any purpose other than for a UTHealth project may not be done without written permission of UTHealth.~~

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The issuance and revision history of this Section is tabulated below. Please destroy any previous copy in your possession.

Rev.No.	Date	Pages	Remarks
1	June 2017	21	New Specification section

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BASIC FIRE PROTECTION REQUIREMENTS
SECTION 21 00 00

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4 OF 21

SECTION 21 00 00

BASIC FIRE—~~basic fire~~ PROTECTION REQUIREMENTS
~~requirements~~

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PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Basic Fire Protection Requirements specifically applicable to Division 21 sections, in addition to Division 01 - General Requirements.

1.2 RELATED DOCUMENTS

- A. Basic and supplemental requirements common to Fire Protection.
- B. THE UNIFORM GENERAL CONDITIONS, SUPPLEMENTARY GENERAL CONDITIONS, and Division 01 of the specifications apply to the work specified in this section.
- C. All work covered by this section of these specifications shall be accomplished in accordance with all applicable provisions of the Contract Documents and any addenda or directives which may be issued herewith, or otherwise.

1.3 GENERAL

- A. The Contractor shall execute all work herein after specified or indicated on accompanying drawings. Contractor shall provide all equipment necessary and usually furnished in connection with such work and systems whether or not mentioned specifically herein or on the drawings
- B. The Contractor shall be responsible for fitting his material and apparatus into the building and shall carefully lay out his work at the site to conform to the structural conditions, to avoid all obstructions, to conform to the details of the installation and thereby to provide an integrated satisfactory operating installation
- C. The Fire Protection drawings are necessarily diagrammatic by their nature, and are not intended to show every connection in detail or every pipe in its exact location. These details are subject to the requirements of standards referenced elsewhere in these specifications, and structural and architectural conditions. The Contractor shall carefully investigate structural and finish conditions and shall coordinate the separate trades in order to avoid interference between the various phases of work. Work shall be organized and laid out so that it will be concealed in furred chases, above suspended ceilings, etc., in finished portions of the building, unless specifically noted to be exposed. Or where no ceilings exist. All exposed work shall be installed parallel or perpendicular to the lines of the building unless otherwise noted. All work shall be NFPA compliant and compliant with Insurance Underwriter requirements and guidelines.

- D. When the Fire Protection drawings do not give exact details as to the elevation of pipe the Contractor shall physically arrange the systems to fit in the space available at the elevations intended with proper grades for the functioning of the system involved. Piping is generally intended to be installed true and square to the building construction, the drawings do not show all required offsets, control lines, pilot lines and other location details. Work shall be concealed in all finished areas, unless there is no ceiling.
- E. All fire alarm conduit shall be clearly labeled.
- F. All fire sprinkler pipe shall be painted or uniquely identified with either solid color or hashed colored piping.

1.4 DEFINITIONS

- A. These definitions are included to clarify the direction and intention of these Specifications. The list given here is not by any means complete. For further clarification as required, contractor shall contact the designated Owner's representative.
 - 1. Concealed / Exposed: Concealed areas are those that cannot be seen by the building occupants. Exposed areas are all areas that are exposed to view by the building occupants, including under counters, inside cabinets and closets, plus all mechanical rooms.
 - 2. General Requirements: The provisions of requirements of other Division 01 sections apply to entire work of contract and, where so indicated, to other elements that are included in project. Basic contract definitions are included in the General Conditions.
 - 3. Indicated: The term "indicated" is a cross reference to graphic representations, notes or schedules on drawings, to other paragraphs or schedules in the specifications, and to similar means of recording requirements on contract documents. Where terms such as "shown," "noted," "scheduled," and "specified" are used in lieu of "indicated," it is for the purpose of helping reader locate the cross reference, and no limitation of location is intended except as specifically noted.
 - 4. Directed, requested, etc.: Where not otherwise explained, terms such as "directed," "requested," "authorized," "selected," "approved," "required," "accepted," and "permitted" mean "directed by Architect/Engineer," "requested by Architect/Engineer" and similar phrases. However, no such implied meaning will be interpreted to extend Architect's/Engineer's responsibility into Contractor's area of construction supervision and job safety.
 - 5. Approve: Where used in conjunction with Architect's/Engineer's response to submittals, requests, applications, inquiries, reports and claims by Contractor, the meaning of term "approved" will be held to limitations to Architect's/Engineer's responsibilities and duties as specified in General and Supplementary Conditions. In no case will "approval" by Architect/Engineer be interpreted as a release of Contractor from responsibilities to fulfill requirements of contract documents or to extend Architect's/Engineer's responsibility into Contractor's area of construction supervision and job safety.

6. As required: Where "as required" is used in these specifications or on the drawings, it shall mean "that situations exist that are not necessarily described in detail or indicated that may cause the contractor certain complications in performing the work described or indicated. These complications entail the normal coordination activities expected of the Contractor where multiple trades are involved and new or existing construction causes deviations to otherwise simplistic approaches to the work to be performed. The term shall not be interpreted to permit an option on the part of the Contractor to achieve the end result."
7. Furnish: The term "furnish" is used to mean "supply and deliver to project site, ready for unloading, unpacking, assemble, installation, and similar operations. Where "furnish" applies to work for which the installation is not otherwise specified, "furnish" in such case shall mean "furnish and install."
8. Install: The term "install" is used to describe operations at Project Site including the actual "unloading, unpacking, assembly, erection, placing, anchoring, applying, working to dimension, finishing, curing, protecting, cleaning, and similar operations.
9. Provide: The term "provide" means "to furnish and install, complete and ready for the intended use.

1.05 PERMITS, UTILITY CONNECTIONS AND INSPECTIONS

- A. General: Refer to Division 01 for construction phasing and time increments.
- B. Fees and Costs: If, during the course of the construction, a need arises to buy utilities, the Contractor shall pay all fees attendant thereto. If city or privately owned utility piping or electrical cable needs to be extended, relocated, or terminated, the Contractor will pay all permits and construction/inspection fees associated with that particular work.
- C. All work performed on this project is under the authority of the State of Texas, therefore no local construction fees or construction permits will be required except as may be required for new service taps, or new or modified connections to city controlled services. If inspections by city personnel are specifically required by this document, then the Contractor is responsible for any fees or permits in connection to those requirements.
- D. Compliance: The Contractor shall comply in every respect with all requirements of National Fire Protection Association, local Fire Department regulations and utility company requirements. In no case does this relieve the Contractor of the responsibility of complying with these specifications and drawings where specified conditions are of higher quality than the requirements of the above-specified authorities. Where requirements of the specifications and drawings are more lenient than the requirements of the above authorities having jurisdiction, the Contractor shall make installations in compliance with the requirements of the above authorities with no extra compensation.

1.6 CONTRACT DRAWINGS

- A. All dimensional information related to new structures shall be taken from the appropriate drawings. All dimensional information related to existing facilities shall be taken from actual measurements made by the Contractor on the site.
- B. The interrelation of the specifications, the drawings, and the schedules are as follows: The specifications determine the nature and setting of the several materials, the drawings establish the quantities, dimensions and details, and the schedules give the performance characteristics. If the Contractor requires additional clarification, he shall request it in writing, following the contractually prescribed information flow requirements.
- C. Should the drawings or specifications conflict within themselves, or with each other, the better quality, or greater size or quantity of work or materials shall be performed or furnished.

1.7 FUTURE WORK

- A. Provide for future work under requirements of Section 01 11 00.
- B. Project is designed for future expansion of [_____] system [as specified] [and] [as indicated].

1.8 ALLOWANCES

- A. Cash Allowance: Refer to Division 01 of the Construction Documents for information and requirements.

1.9 ALTERNATES

- A. Alternates quoted on Bid Forms will be reviewed and accepted or rejected at the Owner's option. Accepted Alternates will be identified in Owner Contractor Agreement.
- B. Coordinate related work and modify surrounding work as required.
- C. Schedule of Alternates: See "Special Conditions" and Bid Form.
- D. Any Alternate Proposals are summarized in Division 01 of the specifications. The Contractor is directed to refer to all sections of the specifications and drawings for this project to determine the exact extent and scope of the various Alternate Proposals as each pertains to the work of all trades.

1.10 SUBMITTALS

- A. Refer to Division 1, UGC, and supplemental UGCs for specification requirements pertaining to timeliness of submission and review, quantity, and format. Each specification section describes the content of the submittals and any submittals which must be approved prior to submission of others.
- B. Proposed Products List: Include Products specified in the following sections:
 - 1. Section 21 05 29 – Fire Protection Supports and Sleeves

2. Section 21 05 53 – Fire Protection Piping and Equipment Identification
 3. Section 21 13 13 – Fire Protection Systems
 4. Section 21 30 00 -- Fire Pumps
- C. Submit shop drawings and product data grouped to include complete submittals of related systems, products, and accessories clearly marked and/or highlighted, with non-applicable information or data clearly noted in a single submittal.
- D. Mark dimensions and values in units to match those specified.
- E. Submit fabrication drawings whenever (1) equipment proposed varies in physical size and arrangement from that indicated on the drawings, thus causing rearrangement of equipment space, (2) where tight spaces require extreme coordination between ductwork, piping, conduit, and other equipment, (3) where called for elsewhere in these specifications; and (4) where specifically requested by the Architect/Engineer. Fabrication drawings shall be made at no additional charge to the Owner or the Architect/Engineer.

1.11 SUBSTITUTION OF MATERIALS AND EQUIPMENT

- A. Refer to General Conditions for substitution of materials and equipment.
- B. General: Within thirty days after the date of contract award or work order, whichever is later, and before purchasing or starting installation of materials or equipment, the Contractor shall submit for review, a complete list of suppliers, contractors and manufacturers for all materials and equipment that will be submitted for incorporation into the project. The list shall be arranged in accordance with the organization of the specifications. This initial list shall include the manufacturer's name and type or catalog number as required to identify the quality of material or equipment proposed. This list will be reviewed by the Engineer and the Owner and will be returned to the Contractor with comments as to which items are acceptable without further submittal data and which items will require detailed submittal data for further review and subsequent approval. The initial list shall be submitted as herein specified. Materials and equipment requiring detailed submittal data shall be submitted with sufficient data to indicate that all requirements of these specifications have been met and samples shall be furnished when requested. All manufacturers' data used as part of the submittal shall have all inapplicable features crossed out or deleted in a manner that will clearly indicate exactly what is to be furnished.

- C. It is not the intent of the drawings and/or specifications to limit products to any particular manufacturer nor to discriminate against an "APPROVED EQUAL" product as produced by another manufacturer. Some proprietary products are mentioned to set a definite standard for acceptance and to serve as a reference in comparison with other products. When a manufacturer's name appears in these specifications, it is not to be construed that the manufacturer is unconditionally acceptable as a provider of equipment for this project. The successful manufacturer or supplier shall meet all of the provisions of the appropriate specification(s).
- D. The specified products have been used in preparing the drawings and specifications and thus establish minimum qualities with which substitutes must at least equal to be considered acceptable. The burden of proof of equality rests with the Contractor. The decision of the Architect/Engineer is final.
- E. When requested by the Architect/Engineer, the Contractor shall provide a sample of the proposed substitute item. In some cases, samples of both the specified item and the proposed item shall be provided for comparison purposes.
- F. Timeliness: The burden of timeliness in the complete cycle of submittal data, shop drawings, and sample processing is on the Contractor. The Contractor shall allow a minimum of six (6) weeks' time frame for review of each submission by the office of the design discipline involved after receipt of such submissions by that design discipline. The Contractor is responsible for allowing sufficient time in the construction schedule to cover the aforementioned cycles of data processing, including time for all resubmittal cycles on unacceptable materials, equipment, etc. covered by the data submitted. Construction delays and/or lack of timeliness in the above regard are the responsibility of the Contractor and will not be considered in any request for scheduled construction time extensions and/or additional costs to the Owner.
- G. All equipment installed on this project shall have local representation, local factory authorized service, and a local stock of repair parts.
- H. Acceptance of materials and equipment will be based on manufacturer's published data and will be tentative subject to the submission of complete shop drawings indicating compliance with the contract documents and that adequate and acceptable clearances for entry, servicing, and maintenance will exist. Acceptance of materials and equipment under this provision shall not be construed as authorizing any deviations from the specifications, unless the attention of the Architect/Engineer has been directed in writing to the specific deviations. Data submitted shall not contain unrelated information unless all pertinent information is properly identified.
- I. Certification: The Contractor shall carefully examine all data forwarded for approval and shall sign a certificate to the effect that the data has been carefully checked and found to be correct with respect to dimensions and available space and that the equipment complies with all requirements of the specifications.
- J. Physical Size of Equipment: Space is critical; therefore, equipment of larger sizes than shown, even though of specified manufacturer, will not be acceptable unless it can be demonstrated that ample space exists for proper installation, operation, and maintenance.

- K. Materials and Equipment Lists: Eight (8) copies of the list of materials and equipment, the name of manufacturer, trade name, type, and catalog number shall be submitted to the Architect/Engineer. The lists shall be accompanied by eight (8) sets of pictorial and descriptive data derived from the manufacturers' catalogs, sales literature, or incorporated in the shop drawings.
- L. Should a substitution be accepted, and should the substitute material prove defective, or otherwise unsatisfactory for the service intended within the guarantee period, this material or equipment shall be replaced with the material or equipment specified at no additional cost to the Owner.

1.12 MATERIALS AND WORKMANSHIP

- A. All materials, unless otherwise specified, shall be new, free from all defects, suitable for the intended use, and of the best quality of their respective kinds. Materials and equipment shall be installed in accordance with the manufacturer's recommendations and the best standard practice for the type of work involved. All work shall be executed by mechanics skilled in their respective trades, and the installations shall provide a neat, precise appearance. Materials and/or equipment damaged in shipment or otherwise damaged prior to installation shall not be repaired at the job site but shall be replaced with new materials and/or equipment.
- B. The responsibility for the furnishing of the proper equipment and/or material and seeing that it is installed as intended by the manufacturer, rests entirely upon the Contractor who shall request advice and supervisory assistance from the representative of specific manufacturers during the installation.

1.13 FLAME SPREAD PROPERTIES OF MATERIALS

- A. Materials and adhesives incorporated in this project shall conform to NFPA Standard 255, "Method of Test of Surface Burning Characteristics of Building Materials" and NFPA 90. The classification shall not exceed a flame spread rating of 25 for all materials, adhesives, finishes, etc., specified for each system, and shall not exceed a smoke developed rating of 50.

1.14 REGULATORY REQUIREMENTS

- A. The "Authority Having Jurisdiction" over the project described by these documents is the Owner, as an Agency of the State of Texas. As such, it is required that the installation shall meet the minimum standards prescribed in the latest editions of the following listed codes and standards, which are made a part of these specifications. All referenced codes and standards shall be those current at the date of issue of the design documents.
- B. National Fire Protection Association Standards (NFPA)
 - 1. NFPA No. 13, Sprinkler System, Installation
 - 2. NFPA No. 14, Standpipes and Hose Systems

BASIC FIRE PROTECTION REQUIREMENTS

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3. NFPA No. 20, Centrifugal Fire Pumps
 4. NFPA No. 37, Stationary Combustion Engines & Gas Turbines
 5. NFPA No. 45, Fire Protection for Laboratories Using Chemicals
 6. NFPA No. 70, National Electrical Code
 7. NFPA No. 72D, Proprietary Signaling Systems
 8. NFPA No. 88A, Standard for Parking Structures
 9. NFPA No. 99, Health Care Facilities
 10. NFPA No. 101, Life Safety Code
- C. American National Standards Institute (ANSI)
- D. American Society of Testing Materials (ASTM): All current editions of applicable manuals and standards
- E. American Water Works Association (AWWA): All current editions of applicable manuals and standards.
- F. National Electrical Manufacturers' Association (NEMA): All current editions of applicable manuals and standards.
- G. City of [*], Fire Department as may be applicable to construction on this site.
- H. Texas Occupational Safety Act: All applicable safety standards.
- I. Occupational Safety and Health Act (OSHA).
- J. ADA and ANSI Standards: All work shall be in accord with all regulations and requirements of the Standards and Specifications for Handicapped and Disabled for the Construction of Public Buildings and Facilities in the State of Texas Usable by Physically Handicapped and Disabled persons, ANSI Standards and the requirements of the American Disabilities Act.
- K. Refer to specification sections hereinafter bound for additional Codes and Standards.
- L. All materials and workmanship shall comply with all applicable state and national codes, specifications, and industry standards. In all cases where Underwriters Laboratories, Inc. has established standards for a particular type material, such material shall comply with these standards. Evidence of compliance shall be the UL "label" or "listing" under Re-Examination Service.

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- M. The Contract Documents are intended to comply with the aforementioned rules and regulations; however, some discrepancies may occur. Where such discrepancies occur, the Contractor shall immediately notify the Architect/Engineer in writing of said discrepancies and apply for an interpretation. Should the discovery and notification occur after the execution of a contract, any additional work required for compliance with said regulations shall be paid for as covered by Division 01 of these Contract Documents, providing no work of fabrication of materials has been accomplished in a manner of noncompliance. Should the Contractor fabricate and/or install materials and/or workmanship in such a manner that does not comply with the applicable codes, rules and regulations, the Contractor who performed such work shall bear all costs arising in correcting these deficiencies to comply with said rules and regulations

1.15 GENERAL MATERIAL AND EQUIPMENT REQUIREMENTS

- A. Storage at Site: The Contractor shall not receive material or equipment at the job site until there is suitable space provided to properly protect equipment from rust, drip, humidity, and dust damage.
- B. Capacities shall be not less than those indicated but shall be such that no component or system becomes inoperative or is damaged because of startup or other overload conditions.
- C. Conformance with Agency Requirements: Where materials or equipment are specified to be approved, listed, tested, or labeled by the Underwriters Laboratories, Inc., or constructed and/or tested in accordance with the standards of the American Society of Mechanical Engineers or the Air Moving and Conditioning Association, the Contractor shall submit proof that the items furnished under this section of the specifications conform to such requirements. The label of the Underwriters Laboratories, Inc., applied to the item will be acceptable as sufficient evidence that the items conform to such requirements. The ASME stamp or the AMCA label will be acceptable as sufficient evidence that the items conform to the respective requirements.
- D. Nameplates: Each major component of equipment shall have the manufacturer's name, address, and catalog number on a plate securely attached to the item of equipment. All data on nameplates shall be legible at the time of Final Inspection.
- E. Prevention of Rust: Standard factory finish will be acceptable on equipment specified by model number; otherwise, surfaces of ferrous metal shall be given a rust inhibiting coating. The treatment shall withstand 200 hours in salt spray fog test, in accordance with Method 6061 of Federal Standard No. 141. Immediately after completion of the test, the specimen shall show no signs of wrinkling or cracking and no signs of rust creepage beyond 1/8" on either side of the scratch mark. Where rust inhibitor coating is specified hereinafter, any treatment that will pass the above test is acceptable unless a specific coating is specified except that coal tar or asphalt type coating will not be acceptable unless so stated for a specific item. Where steel is specified to be hot dip galvanized, mill galvanized sheet steel may be used provided all raw edges are painted with a zinc-pigmented paint conforming to Military Specification MIL-P-26915.

BASIC FIRE PROTECTION REQUIREMENTS

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- F. Protection from Moving Parts: Belts, pulleys, chains, gears, couplings, projecting set screws, keys, and other rotating parts shall be fully enclosed or properly guarded for personnel protection.
- G. Verification of Dimensions: The Contractor shall be responsible for the coordination and proper relation of his work to the building structure and to the work of all trades. The Contractor shall visit the premises and become thoroughly familiar with all details of the work and working conditions, to verify all dimensions in the field, and to advise the Architect/Engineer of any discrepancy before performing any work. Adjustments to the work required in order to facilitate a coordinated installation shall be made at no additional cost to the Owner or the Architect/Engineer.

1.16 PROJECT/SITE CONDITIONS

- A. Install Work in locations shown on drawings, unless prevented by Project conditions.
- B. Prepare drawings showing proposed rearrangement of Work to meet Project conditions, including changes to Work specified in other sections. Obtain permission of [Owner] [Architect/Engineer] before proceeding.

1.17 MANUFACTURER'S RECOMMENDATIONS

- A. The manufacturer's published directions shall be followed in the delivery, storage, protection, installation, testing and piping of all equipment and material. The Contractor shall promptly notify the Architect/Engineer, in writing, of any conflict between the requirements of the Contract Documents and the manufacturer's directions, and shall obtain the Architect/Engineer's instructions before proceeding with the work. Should the Contractor perform any such work that does not comply with the manufacturer's directions or such instructions from the Architect/Engineer, he shall bear all costs arising in connection with the deficiencies.

1.18 SPACE AND EQUIPMENT ARRANGEMENT

- A. The size of Fire Protection equipment indicated on the drawings is based on the dimensions of a particular manufacturer. While other manufacturers may be acceptable, it is the responsibility of the Contractor to determine if the equipment he proposes to furnish will fit in the space. Fabrication drawings shall be prepared when required by the Architect/Engineer or Owner to indicate a suitable arrangement.
- B. All equipment shall be installed in a manner to permit access to all surfaces. All valves, motors, drives, and other accessory items shall be installed in a position to allow removal for service without disassembly of another part.

1.19 LARGE APPARATUS

- A. Any large piece of apparatus that is to be installed in any space in the building, and that is too large to permit access through stairways, doorways, or shafts shall be brought to the job and placed in the space before the enclosing structure is completed. Following placement in the space, such apparatus shall be thoroughly, completely protected from damage as hereinafter specified.

1.20 PROTECTION

- A. The Contractor shall at all times take such precautions as may be necessary to properly protect all materials and equipment from damage from the time of delivery until the completion of the work. This shall include the erection of all required temporary shelters and supports to adequately protect any items stored in the open on the site from the weather, the ground and surrounding work; the cribbing of any items above the floor of the construction; and the covering of items in the incomplete building with tarpaulins or other protective covering; the installation of electric heaters in electrical switchgear and similar equipment to prevent moisture damage. Failure on the part of the Contractor to comply with the above will be sufficient cause for the rejection of the items in question.
- B. Take particular care not to damage the building structure in performing work. All finished floors, step treads, and finished surfaces shall be covered to prevent any damage by workers or their tools and equipment during the construction of the building.
- C. Equipment and materials shall be protected from rust both before and after installation. Any equipment or materials found in a rusty condition at the time of final inspection must be cleaned of rust and repainted as specified elsewhere in these specifications.

1.21 COOPERATION BETWEEN TRADES AND WITH OTHER CONTRACTORS

- A. Each trade, subcontractor, and/or Contractor must work in harmony with the various other trades, subcontractors and/or Contractors on the job as may be required to facilitate the progress to the best advantage of the job as a whole. Each trade, subcontractor, and/or Contractor must pursue its work promptly and carefully so as not to delay the general progress of the job. This Contractor shall work in harmony with Contractors working under other contracts on the premises.

1.22 ELECTRICAL WIRING OF MOTORS AND EQUIPMENT

- A. The Contractor shall note that the electrical design and drawings are based on the equipment scheduled and indicated on the drawings, and should any mechanical equipment be provided requiring changes to the electrical design, the required electrical changes shall be made at no cost to the Owner.
- B. The electrical trades shall provide all interconnecting wiring for the installation of all power. The electrical trades shall provide all disconnect switches as required for proper operation, as indicated on the drawings or required by applicable code. All combination starters, individual starters, and other motor starting apparatus not specifically scheduled or specified as provided by the equipment manufacturer under the scope of Division 23, shall be provided under the scope of Division 21.

- C. Provide complete wiring diagrams indicating power wiring and interlock wiring. Diagrams shall be submitted to the Architect/Engineer for review within thirty (30) days after the submittals for equipment have been reviewed. Diagrams shall be based on accepted equipment and shall be complete full phase and interlock control drawings, not a series of manufacturer's individual diagrams. After these diagrams have been reviewed by the Architect/Engineer, copies shall be transmitted to the electrical trades by the Contractor.

1.23 SUPERVISION

- A. Each Contractor and subcontractor shall keep a competent superintendent or foreman on the job at all times. (Refer to the Uniform General Conditions for additional information concerning supervision.)
- B. It shall be the responsibility of each superintendent to study all drawings and familiarize himself with the work to be done by other trades. He shall coordinate his work with other trades and before material is fabricated or installed, make sure that his work will not cause an interference with another trade. Where interferences are encountered, they shall be resolved at the job site by the superintendents involved. Where interferences cannot be resolved without major changes to the drawings, the matter shall be referred to the A/E for ruling.

1.24 SITE OBSERVATION

- A. Site observation by the Architect/Engineer is for the express purpose of verifying compliance by the Contractor with the Contract Documents, and shall not be construed as construction supervision nor indication of approval of the manner or location in which the work is being performed as being a safe practice or place.

1.25 INSTALLATION METHODS

- A. Where to Conceal: All pipes shall be concealed in pipe chases, walls, furred spaces, or above the ceilings of the building unless otherwise indicated.
- B. Where to Expose: In mechanical rooms, janitor's closets tight against pan soffits in exposed "Tee" structures, or storage spaces, but only where necessary, piping may be run exposed. All exposed piping shall be run in the most aesthetic, inconspicuous manner, and parallel or perpendicular to the building lines.
- C. Support: All piping shall be adequately and properly supported from the building structure by means of hanger rods or clamps to walls as herein specified.
- D. Maintaining Clearance: Where limited space is available above the ceilings below concrete beams or other deep projections, pipe shall be sleeved through the projection where it crosses, rather than hung below them in a manner to provide maximum above floor clearance. Sleeves shall be as herein specified. Approval shall be obtained from the Architect/Engineer for each penetration.

- E. All pipe shall be cut accurately to measurements established at the building and shall be worked into place without springing or forcing. All pipes run exposed in machinery and equipment rooms shall be installed parallel to the building lines, except that piping shall be sloped to obtain the proper pitch. Piping run in furred ceilings, etc., shall be similarly installed, except as otherwise shown. All pipe openings shall be kept closed until the systems are closed with final connections.
1. All piping not directly buried in the ground shall be considered as "interior piping."
 2. Prior to the installation of any ceiling material, gypsum, plaster, or acoustical board, the Contractor shall notify the construction inspector so that arrangement can be made for an inspection of the above ceiling area about to be "sealed" off. The Contractor shall give as much advance notice as possible no less than 5 working days or as agreed by the Project Manager.
 3. All above ceiling areas will be subject to a formal inspection before ceiling panels are installed, or installation is otherwise concealed from view. All mechanical and electrical work at and above the ceiling, including items supported by the ceiling grid shall be complete and installed in accordance with contract requirements, including power to other powered items. Adequate lighting shall be provided to permit thorough inspection of all above ceiling items. The inspection will include representatives of the following: General Contractor and each Subcontractor having work above the ceiling, Architect/Engineer, Physical Plant, Resident Construction Manager's Construction Inspector(s), the Resident Construction Manager, and Office of Facilities Planning and Engineering (UTH FPE). Areas to be included and time of inspection shall be coordinated with the Construction Inspector.
 4. The purpose of this inspection is to verify the completeness and quality of the installation of the air conditioning systems, the electrical systems, the plumbing systems, and any other special above ceiling systems such as pneumatic tube, vacuum systems, fire sprinkler piping and cable tray systems. The ceiling supports (tee bar or lath) shall be in place so that access panel and light fixture locations are identifiable and so that clearances and access provisions may be evaluated.
 5. No ceiling materials may be installed until the resulting deficiency list from this inspection is worked off and the Construction Inspector has given approval.

1.26 RECORDS FOR OWNER

NOTE TO THE ENGINEER: COORDINATE THIS SECTION WITH DIVISION 01 REQUIREMENTS FOR RECORDS AND "AS BUILTS."

- A. The Contractor shall maintain a set of "blueprint" prints in the Field Office for the sole purpose of recording "installed" conditions. Daily note all changes made in these drawings in connection with the final installation including exact dimensioned locations of all new underground utilities, services and systems and all uncovered existing active and inactive piping outside the building.

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- B. At contract completion, the Contractor shall provide an electronic file of the revised drawings. The contractor shall transfer the information from the "blue-line" prints maintained as described above, and turn over this neatly marked set of reproducible drawings representing the "as installed" work to the Architect/Engineers for verification and subsequent transmittal to the Owner. The Contractor shall refer to Division 01 of these specifications, and to the Uniform General Conditions, for additional information. These drawings shall include as a minimum:
1. Addendum written drawing changes.
 2. Addendum supplementary drawings.
 3. Accurate, dimensioned locations of all underground utilities, services and systems.
 4. Identification of equipment work shown on Alternates as to whether alternates were accepted and work actually installed.
 5. Change Order written drawing changes.
 6. Change Order supplementary drawings.
- C. Electronic Media
1. The contractor shall submit three compact discs containing all the drawings in AUTOCAD 19 format.
- D. "As installed" plans shall bear a stamp, "stick-on decal" or lettered title block generally located in lower right hand corner of drawing entitled "AS INSTALLED DRAWING" with Company name of the installing trade Subcontractor and with a place for the date and the name of the responsible company representative.
- E. In addition to the above, the Contractor shall accumulate during the progress of the job the following data, in duplicate, prepared in a neat brochure or packet folder and turn over to the Architect/Engineer for review, and subsequent delivery to the Owner.
1. All warranties and guarantees and manufacturers' directions on equipment and material covered by the Contract.
 2. Two sets of operating instructions for heating and cooling and other mechanical and electrical systems. Operating instructions shall also include recommended preventative maintenance and seasonal changeover procedures.
 3. Valve tag charts and diagrams specified herein.
 4. Approved wiring diagrams and control diagrams representing "as installed" conditions.
 5. Copies of approved shop drawings.
 6. Any and all other data and/or drawings required as submittals during construction.

7. Repair parts list of all major items and equipment including name, address and telephone number of local supplier or agent.

F. All of the above data shall be submitted to the Architect/Engineer for approval, and shall be corrected as instructed by the Architect/Engineer prior to submission of the final request for payment.

1.27 CUTTING AND PATCHING

A. General: Cut and patch walls, floors, etc., resulting from work in existing construction or by failure to provide proper openings or recesses in new construction.

B. Methods of cutting: Openings cut through concrete and masonry shall be made with masonry saws and/or core drills and at such locations acceptable to the Architect/Engineer. Impact type equipment shall not be used except where specifically acceptable to the Architect/Engineer. Openings in precast concrete slabs for pipes shall be core drilled to exact size.

C. Restoration: All openings shall be restored to "as new" condition under the appropriate specification section for the materials involved, and shall match remaining surrounding materials and/or finishes.

D. Masonry: Where openings are cut through masonry walls, provide and install lintels or other structural supports to protect the remaining masonry. Adequate supports shall be provided during the cutting operation to prevent any damage to the masonry occasioned by the operation. All structural members, supports, etc., shall be of the proper size and shape, and shall be installed in a manner acceptable to the Architect/Engineer.

E. Plaster: All mechanical work in areas containing plaster shall be completed prior to the application of the finish plaster coat. Cutting of finish plaster coat will not be permitted.

F. Special Note: No cutting, boring, or excavating that will weaken the structure shall be undertaken.

1.28 ROOF PENETRATIONS AND FLASHING

A. Pipe, sleeves, pitch pockets, and flashings compatible with the roofing installation shall be provided and installed by a qualified contractor for all roof penetrations. This shall be the responsibility of the General Contractor.

1.29 EXCAVATION, TRENCHING AND BACKFILL

A. Excavation (See Divisions 00 and 01 for special requirements related to excavation and trenching.):

1. The subcontractors shall perform all excavations of every description, for their particular installations and of whatever substances encountered, to the depths indicated on the drawings and/or required for the installation of piping. All exterior lines shall be installed with a minimum cover of 24," unless otherwise indicated. Generally, more cover shall be provided if grade will permit. All excavation materials not required for backfill or fill shall be removed and wasted as acceptable to the Construction Inspector. All excavations shall be made only by open cut. The banks of trenches shall be kept as nearly vertical as possible and where required, shall be properly sheeted and braced. Trenches shall be not less than 12" wider nor more than 16" wider than the outside edges of the pipe to be laid therein, and shall be excavated true to line so that a clear space not less than 6" nor more than 8" in width is provided on each side of the pipe.
2. The bottom of trenches shall be accurately graded to provide proper fall and uniform bearing and support for each section of the pipe on undisturbed soil or 2" of sand fill at every point along its entire length, except for portions of the pipe sections where it is necessary to excavate for bell holes and for the proper sealing of pipe joints. Bell holes shall be dug after the trench bottom has been graded. Where inverts are not shown, grading shall be determined by the National Plumbing Code for the service intended and the size used. Bell holes for pipe joints shall be 12" in depth below the trench bottom and shall extend from a point 6" back of the face of the bell. Such bell holes shall be of sufficient width to provide ample room to complete the pipe joint. Bell holes for sewer tile and water pipe shall be excavated only to an extent sufficient to permit accurate work in the making of the joints and to insure that the pipe, for a maximum of its length, will rest upon the prepared bottom of the trench. Depressions for joints other than bell-and-spigot shall be made in accordance with the recommendations of the joint manufacturer for the particular type of joint used. Special pipe beds shall be provided as specified hereinafter.
3. The lower 4" of the pipe trenches measuring from an overhead line set parallel to the grade line of the sewer shall be excavated only a few feet in advance to the pipe laying, by workers especially skilled in this type of work. Where damage is likely to result from withdrawing sheeting, the sheeting shall be left in place. Except at locations where excavation of rock from the bottom of trenches is required, care shall be taken not to excavate below the depths required. Where rock excavation is required, the rock shall be excavated to a minimum over depth of 6" below the trench depths specified. The over depth rock excavation and all excess trench excavation shall be backfilled with sand. Whenever wet or otherwise unstable soil is incapable of properly supporting the pipe is encountered in the trench bottom, such soil shall be removed to a depth and for the trench lengths required, and then backfilled to trench bottom grade, as hereinafter specified, with sand.

4. All grading in the vicinity of excavation shall be controlled to prevent surface ground water from flowing into the excavations. Any water accumulated in the excavations shall be removed by pumping or other acceptable method. During excavation, material suitable for backfilling shall be stacked in an orderly manner a sufficient distance back from edges of trenches to avoid overloading and prevent slides or cave-ins. Material unsuitable for backfilling shall be wasted and removed from the job site as directed by the Construction Inspector.
5. All shoring and sheeting required to perform and protect the excavations and to safeguard employees and/or adjacent structures shall be provided.
6. Excavate as required under the building in order that all piping etc., shall clear the ground a minimum of 12" for a distance of 24" on either side. Edges of such excavations shall slope at an angle of not over 45 degrees with the horizontal unless otherwise approved by the Construction Inspector. The bottom of such excavation shall be graded to drain in a manner acceptable to the Construction Inspector.
7. Trenches for water lines inside the building shall be properly excavated, following, in general, the procedures set out for exterior lines. Where floors are to be poured over these lines, they shall be backfilled, tamped and settled with water. Where no flooring is to cover the lines, they shall be backfilled to form a level grade.
8. All surplus materials removed in these trenching operations becomes the property of the contractor, and shall be disposed of at the expense of the contractor, at a legal disposal site, off of the campus.

B. Backfilling

1. Trenches shall not be backfilled until all required tests are performed and until the piping, utilities systems, etc., as installed are certified by the Owner's inspector to conform to the requirements specified hereinafter. The trenches shall be carefully backfilled with sand to a depth of 12 inches above the top of the pipe. The next layer and subsequent layers of backfill may be excavated materials approved for backfilling, consisting of earth, loam, sandy clay, sand and gravel, soft shale, or other approved materials free from large clods of earth or stones larger than 1 1/2" in diameter, flooded until the pipe has cover of not less than one foot. The remainder of the backfill material shall then be thrown into the trenches, moistened, and tamped or flooded in one-foot layers. Blasted rock, broken concrete or pavement, and large boulders shall not be used as backfill material. Any trenches improperly backfilled, or where settlement occurs, shall be reopened to the depth required for proper compaction, then refilled and mounded over, and smoothed off.
2. Backfill under concrete slabs-on-fill shall be as specified above, shall be gravel, or shall be other such materials more suitable for the application. Installation and compaction shall be as required for compatibility with adjacent materials.

- C. Opening and Re-closing Pavement and Lawns: Where excavation requires the opening of existing walks, streets, drives, other existing pavement, or lawns, such surfaces shall be cut as required to install new lines and to make new connections to existing lines. The sizes of the cut shall be held to a minimum, consistent with the work to be accomplished. After the installation of the new work is completed and the excavation has been backfilled and flooded, the area shall be patched, using materials to match those cut out. The patches shall thoroughly bond with the original surfaces and shall be level with them, and shall meet all the requirements established by the authorities having jurisdiction over such areas.
- D. Excavation in Vicinity of Trees: All trees including low hanging limbs within the immediate area of construction shall be adequately protected to a height of at least 5 ft. to prevent damage from the construction operations and/or equipment. All excavation within the outermost limb radius of all trees shall be accomplished with extreme care. All roots located within this outermost limb radius shall be brought to the attention of the Construction Inspector before they are cut or damaged in any way. The Construction Inspector will give immediate instructions for the disposition of it. All stumps and roots encountered in the excavation, which are not within the outermost limb radius of existing trees, shall be cut back to a distance of not less than 18" from the outside of any concrete structure or pipeline. No chips, parts of stumps, or loose rock shall be left in the excavation. Where stumps and roots have been cut out of the excavation, clean compacted dry bank sand shall be backfilled and tamped.

1.30 OPERATION PRIOR TO COMPLETION

- A. When any piece of Fire Protection equipment is operable and it is to the advantage of the Contractor to operate the equipment, he may do so, providing that he properly supervises the operation, and has the Project Manager's written permission to do so. The warranty period shall, however, not commence until the equipment is operated for the beneficial use of the Owner, or date of substantial completion, whichever occurs first.
- B. Regardless of whether or not the equipment has or has not been operated, the Contractor shall properly clean the equipment, properly adjust and complete all deficiency list items prior to being started, commissioned and before final acceptance by the Owner. The date of acceptance and performance certification will be the same date.

NOTE TO SPECIFICATION WRITER: PARAGRAPHS 1.32 AND 1.33 SHALL BE EDITED TO SUIT PROJECT. COORDINATE OUTAGES WITH DIVISION 11 REQUIREMENTS.

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1.31 EXISTING FACILITIES

- A. The Contractor shall be responsible for loss or damage to the existing facilities caused by him and his workers, and shall be responsible for repairing or replacing such loss or damage. The Contractor shall send proper notices, make necessary arrangements, and perform other services required for the care, protection and in service maintenance of the fire protection system for the new and existing facilities. The Contractor shall erect temporary barricades, with necessary safety devices, as required to protect personnel from injury, removing all such temporary protection upon completion of the work.

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- B. The Contractor shall provide temporary or new services to all existing facilities as required to maintain their proper operation when normal services are disrupted as a result of the work being accomplished under this project.
- C. Where existing construction is removed to provide working and extension access to existing utilities, Contractor shall remove doors, piping, conduit, outlet boxes, wiring, light fixtures, air conditioning ductwork and equipment, etc., to provide this access and shall reinstall them upon completion of work in the areas affected.
- D. Where partitions, walls, floors, or ceilings of existing construction are indicated to be removed, all Contractors shall remove and reinstall in locations approved by the Architect/Engineer all devices required for the operation of the various systems installed in the existing construction. This is to include but is not limited to temperature controls system devices, electrical switches, relays, fixtures, and piping.
- E. Outages of services as required by the new installation will be permitted but only at a time approved by the Owner. The Contractor shall allow the Owner two weeks in order to schedule required outages. The time allowed for outages will not be during normal working hours unless otherwise approved by the Owner. All costs of outages, including overtime charges, coordination meetings shall be included in the contract amount.

1.32 DEMOLITION AND RELOCATION

- A. The Contractor shall modify, remove, and/or relocate all materials and items so indicated on the drawings or required by the installation of new facilities. All removals and/or dismantling shall be conducted in a manner as to produce maximum salvage. Salvage materials shall remain the property of the Owner, and shall be delivered to such destination or otherwise disposed of as directed by the Owner. Materials and/or items scheduled for relocation and which are damaged during dismantling or reassembly operations shall be repaired and restored to good operative condition. The Contractor may, at his discretion, and upon the approval of the Owner, substitute new materials and/or items of like design and quality in lieu of materials and/or items to be relocated.
- B. All items that are to be relocated shall be carefully removed in reverse to original assembly or placement and protected until relocated. The Contractor shall clean and repair and provide all new materials, fittings, and appurtenances required to complete the relocations and to restore to good operative order. All relocations shall be performed by workers skilled in the work and in accordance with standard practice of the trades involved.
- C. When items scheduled for relocation and/or reuse are found to be in damaged condition before work has been started on dismantling, the Contractor shall call the attention of the Owner to such items and receive further instructions before removal. Items damaged in repositioning operations are the Contractor's responsibility and shall be repaired or replaced by the Contractor as approved by the Owner, at no additional cost to the Owner.

- D. Service lines and wiring to items to be removed, salvaged, or relocated shall be removed to points indicated on the drawings, specified, or acceptable to the Owner. Service lines and wiring not scheduled for reuse shall be removed to the points at which reuse is to be continued or service is to remain. Such services shall be sealed, capped, or otherwise tied off or disconnected in a safe manner acceptable to the Owner. All disconnections or connections into the existing facilities shall be done in such a manner as to result in minimum interruption of services to adjacent occupied areas. Services to existing areas or facilities that must remain in operation during the construction period shall not be interrupted without prior specific approval of the Owner as hereinbefore specified.

1.33 CHECKING AND TESTING MATERIALS AND/OR EQUIPMENT

- A. Check inspections shall include fire sprinkler piping, equipment, overall fire protection system controls, and such other items hereinafter specified or specifically designated by the Architect/Engineer.

1.34 COOPERATION AND CLEANUP

- A. It shall be the responsibility of each trade to cooperate fully with the other trades on the job to help keep the job site in a clean and safe condition. At the end of each day's work, each trade shall properly store all of his tools, equipment and materials and shall clean his debris from the job. Upon the completion of the job, each trade shall immediately remove all of his tools, equipment, any surplus materials and all debris caused by that portion of the work.

1.35 CLEANING AND PAINTING

- A. All equipment and piping, etc., furnished and installed in exposed areas under Division 21 of these specifications and as hereinafter specified shall be cleaned, prepared, and painted according to the following specification. In the event of a conflict between the specifications referenced, the provisions of this specification shall prevail only for Division 21 work.
- B. All purchased equipment shall be delivered to the job with a suitable factory protective finish with the colors hereinafter specified. The following materials shall not be painted: copper, galvanized metal, stainless steel, fiberglass, PVC, and PVDF.
- C. Before painting, materials and equipment surfaces shall be thoroughly cleaned of cement, plaster, and other foreign materials, and all oil and grease spots shall be removed. Such surfaces shall be carefully wiped and all cracks and corners scraped out. Exposed metalwork shall be carefully brushed down with the steel brushes to remove rust and other spots and left smooth and clean.
- D. Color of finish painting shall be painted in accordance with The University of Texas Standard Color Schedule for machinery spaces using Pratt and Lambert, Inc.'s "Effector" enamel, or approved equal. Two coats shall be applied with a light tint first coat and deep color for final coat. Colors shall be as follows:

NOTE TO ENGINEER: MODIFY THE MATERIAL OF THIS SECTION TO ACRYLIC LATEX IF PAINTING IS TO BE DONE IN A HAZARDOUS ENVIRONMENT.

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ITEM	COLOR	"P and L" PAINT NUMBER
Fire Protection Equipment and Piping	Safety Red	R131R (Vibrant Red)

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NOTE THAT THE PAINT SPECIFIED ABOVE IS INCLUDED FOR PURPOSES OF ESTABLISHING A QUALITY THAT SHALL BE USED ON THIS PROJECT. THE PROPOSED PAINT SHALL BE SUBMITTED, AND ALTERNATIVES WILL BE CONSIDERED USING THE SUBMITTAL PROCEDURES SPECIFIED IN THIS DOCUMENT.

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- E. Jacketing on insulation shall not be painted.
- F. No nameplates on equipment shall be painted, and suitable protection shall be afforded to the plates to prevent their being rendered illegible due to the painting operation.
- G. Scope of painting for Division 21--work in areas other than those defined as "exposed" is as follows:
 1. All uncovered steel pipe, supports, exposed pipe and hanger rod threads, and hangers in underfloor spaces shall be cleaned and painted with two coats of Tropical Paint Co. No. 77-black asphaltic emulsion. Galvanized steel and copper lines in these spaces shall not be painted.
 2. All canvas finishes including those underfloor and in concealed spaces shall be painted with one sizing coat if not already sized, containing mildew resistant additive and Arabol adhesive prior to any other specified finish paint.
 3. All fire protection piping shall be painted whether concealed or exposed, in all areas of the project without exception. Fire protection piping shall be painted safety red. These "safety" colors shall be as defined by OSHA.
 4. If insulated, the piping shall be primed, only, prior to insulation, and the insulation jacketing shall be painted as specified for piping. The requirements of this paragraph are "primary" and have priority over any conflicting specification or instruction, should a conflict in the Construction Documents exist.

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PART 2 - PRODUCTS

2.1 GENERAL

- A. All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.
- B. All equipment installed shall have local representation, local factory authorized service, and a local stock of repair parts.

BASIC FIRE PROTECTION REQUIREMENTS

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- C. Responsibility for furnishing proper equipment and/or material and ensuring that equipment and/or material is installed as intended by the manufacturer, rests entirely upon the Contractor. Contractor shall request advice and supervisory assistance from the representative of specific manufacturers during the installation.
- D. All materials, unless otherwise specified, shall be new, free from all defects, suitable for the intended use and of the best quality of their respective kinds. Materials and equipment shall be installed in accordance with the manufacturer's recommendations and the best standard practice for the type of Work involved. All Work shall be executed by mechanics skilled in their respective trades, and the installations shall provide a neat, precise appearance. Materials and/or equipment damaged in shipment or otherwise damaged prior to installation shall not be repaired at the job Site but shall be replaced with new materials and/or equipment.
- E. Materials and equipment manufactured domestically are preferred when possible. Materials and equipment that are not available from a domestic manufacturer may be by a non-domestic manufacturer provided they fully comply with Contract Documents.
- F. Prevention of Rust: Standard factory finish will be acceptable on equipment specified by model number; otherwise, surfaces of ferrous metal shall be given a rust inhibiting coating.

2.2 NAMEPLATES

- A. Each major component of equipment shall have the manufacturer's name, address, and catalog number on a plate securely attached to the item of equipment. All data on nameplates shall be legible at the time of Final Inspection.
- B. Nameplates shall be black laminated rigid phenolic with white core. Nameplate minimum size shall be 1 inch high by 3 inches long with 3/16-inch-high engraved white letters.
- C. Nameplate Fasteners: Fasten nameplates to the front of equipment only by means of stainless steel self-tapping screws. Stick-ons or adhesives will not be allowed unless the NEMA enclosure rating is compromised, then only epoxy adhesive shall be used to attach nameplates.
- D. Nameplate Information: In general, the following information is to be provided for the types of electrical components or enclosures supplied with equipment.
 - 1. Individual Starters, Contactors, Disconnect Switches, and Similar Equipment: Identify the device, and voltage characteristics source and load served.

2.3 WALL, FLOOR AND CEILING PLATES (ESCUTCHEONS)

- A. Except as otherwise noted, provide stainless steel or chrome plated brass floor and ceiling plates around all pipes passing exposed through walls, floors or ceilings, in any spaces except underfloor and plenum spaces.
- B. Plates shall be sized to fit snugly against the outside of the pipe or against the insulation on lines that are insulated and positively secured to such pipe or insulation.

- C. For finished ceiling installation, secure escutcheons to ceiling with escutcheon fasteners.
- D. Plates will not be required for piping where pipe sleeves extend $\frac{3}{4}$ -inch or more above finished floor.

2.4 ROOF PENETRATIONS AND FLASHING

- A. Pipe sleeves, pitch pockets and flashings compatible with the roofing installation shall be provided and installed for all roof penetrations by a contractor qualified in such Work. Installation shall comply with the Contract Documents and with FM General Data Sheets 1-28, 1-29, 1-31 & 1-49 along with the FM approval guide.
- B. All other penetrations through fire rated walls shall be filled with an approved fire caulk that meets NFPA requirements.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Cooperate with trades of adjacent, related or affected materials or operations, and with trades performing continuations of this Work in order to effect timely and accurate placing of Work and to coordinate, in proper and correct sequence, the Work of such trades.
- B. The size of equipment indicated on the Drawings is based on the dimensions of a particular manufacturer. While other manufacturers may be acceptable, it is the responsibility of the Contractor to determine that the equipment proposed will fit in the space. Fabrication Drawings shall be prepared when required by the Architect/Engineer or Owner to indicate a suitable arrangement.
- C. All equipment shall be installed in a manner to permit access to all surfaces. All valves, motors, drives, filters, and other accessory items shall be installed in a position to allow removal for service without disassembly of another part.
- D. Space Requirements:
 - 1. Consider space limitations imposed by contiguous Work in location of equipment and material. Do not provide equipment or material which is not suitable in this respect.
 - 2. Make changes in material and equipment locations of up to five (5) feet, to allow for field conditions prior to actual installation, and as directed by the Architect/Engineer at no additional cost to the Owner.
- E. Contractor shall note that the electrical design and Drawings are based on the equipment scheduled and indicated on the Drawings. Should any equipment be provided requiring changes to the electrical design, the required electrical changes shall be made at no cost to the Owner.

3.2 INSTALLATION

- A. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.
- B. All installation shall be in accordance with manufacturer's published recommendations, as shown on the drawings and stated in the specifications.
- C. Piping may be run exposed in rooms typically without ceilings such as mechanical rooms, janitor's closets, tight against pan soffits in exposed "tee" structures, or storage spaces, but only where necessary. Shutoff and isolation valves shall be easily accessible.
- D. All pipe, conduits, etc., shall be cut accurately to measurements established at the building and shall be worked into place without springing or forcing. All ducts, pipes and conduits run exposed in machinery and equipment rooms shall be installed parallel to the building lines, except that piping shall be sloped to obtain the proper pitch. Piping and ducts run in furred ceilings, etc., shall be similarly installed, except as otherwise shown. All pipe openings shall be kept closed until the systems are closed with final connections.
- E. Prior to the installation of any ceiling material, gypsum, plaster or acoustical board, the Contractor shall notify Project Manager so that arrangement can be made for an inspection of the above-ceiling area about to be "sealed" off. The Contractor shall provide written notification to the Owner at least five (5) calendar days prior to the inspection.
- F. Precedence of Materials:
 - 1. The Specifications determine the nature and setting of materials and equipment. The Drawings establish quantities, dimensions and details.
 - 2. If interference is encountered, the following installation precedence of materials shall guide the Contractor to determine which trade shall be given the "Right of Way":
 - a. Building lines
 - b. Structural members
 - c. Structural support frames supporting ceiling equipment
 - d. Electric tracked vehicle system
 - e. Pneumatic trash and linen system
 - f. Pneumatic tube system
 - g. Soil and drain piping
 - h. Vent piping
 - i. Supply, return and outside air ductwork
 - j. Exhaust ductwork

- k. HVAC water and steam piping
 - l. Condensate piping
 - m. Fire protection piping
 - n. Natural gas piping
 - o. Medical/Laboratory gases
 - p. Domestic water (cold and hot, softened, treated)
 - q. Refrigerant piping
 - r. Electrical conduit
3. Coordinate fire protection system with other trade systems as required to maintain system right-of-ways.

3.3 TESTING

- A. When any piece of equipment is operable and it is to the advantage of the Contractor to operate the equipment, Contractor may do so, provided that Contractor properly supervises the operation, and has the Project Manager's written permission to do so. The warranty period shall, however, not commence until such time as the equipment is operated for the beneficial use of the Owner, or date of Substantial Completion, whichever occurs first.
- B. Regardless of whether or not the equipment has or has not been operated, the Contractor shall properly clean the equipment, install clean and properly adjust, and complete all deficiency list items before final acceptance by the Owner. The date of acceptance and performance certification will be the same date.
- C. The Contractor shall execute, at no additional cost to the Owner, any tests required by the Owner or the National Fire Protection Association, ASTM, etc. Standards listed. The Contractor shall provide all equipment, materials and labor for making such tests. The Owner will pay reasonable amounts of fuel and electrical energy costs for system tests. Fuel and electrical energy costs for system adjustment and tests, which follow Substantial Completion by the Owner, will be borne by the Owner.
- D. Notify the Project Manager and the Architect/Engineer in writing at least five (5) calendar days or as agreed by the Project Manager prior to each test and prior to other Specification requirements requiring Owner and Architect/Engineer to observe and/or approve tests.
- E. All tests shall have pertinent data logged by the Contractor at the time of testing. Data shall include date, time, personnel performing, observing and inspecting, description of the test and extent of system tested, test conditions, test results, specified results and other pertinent data. Data shall be delivered to the Architect/Engineer as specified under "Requirements for Final Acceptance." The Contractor or Contractor's authorized job superintendent shall legibly sign all Test Log entries.

- F. Maintain Log of Tests as hereinafter specified.
- G. See specifications hereinafter for additional tests and requirements.
- H. Refer to Commissioning Specification Sections for additional Start-up, pre-functional and operational checkout, and for functional performance test procedures.

3.4 TRAINING

- A. Operating and Maintenance Manuals and instruction shall be provided as specified under the Division 01 Section entitled "Project Closeout Procedures."
- B. Specific training and operating instructions for individual equipment components shall be as specified in the individual Specification Sections.

END OF SECTION ~~21-00-00~~

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UTHealth FPE Standard Specification

SECTION 21 05 13

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FIRE PROTECTION MOTORS

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The issuance and revision history of this Section is tabulated below. Please destroy any previous copy in your possession

Rev No.	Date	Pages	Remarks
1	June 2017	6	Specification update

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~~The University of Texas Health Science Center at Houston~~

SECTION 21 05 13

– FIRE PROTECTION ~~motors~~ MOTORS

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PART 1 - GENERAL

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1.1 THE FOLLOWING SECTIONS ARE TO BE INCLUDED AS IF WRITTEN HEREIN:

- A. Section 21 00 00 – Basic Fire Protection Requirements.
- B. Section 21 05 29 – Fire Protection Supports and Sleeves.
- C. Section 21 05 53 – Fire Protection Piping and Equipment Identification.

1.2 SECTION INCLUDES

- A. Single phase electric motors.
- B. Three phase electric motors.
- C. The Contractor shall provide all motors required for equipment supplied under this Division of the work.

1.3 RELATED WORK

- A. Section 21 13 13 – Fire Protection Systems.
- B. Section 21 30 00 – Fire Pumps.

1.4 REFERENCES

- A. AFBMA 9 – Load Ratings and Fatigue Life for Ball Bearings.
- B. AFBMA 11 – Load Ratings and Fatigue Life for Roller Bearings.
- C. ANSI/IEEE 112 – Test Procedure for Polyphase Induction Motors and Generators.
- D. ANSI/NEMA MG 1 – Motors and Generators.
- E. ANSI/NFPA 70 – National Electrical Code.

1.5 SUBMITTALS

- A. Submit product data under provisions of Section 21 00 00.

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FIRE PROTECTION MOTORS

FIRE PROTECTION MOTORS
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B. Submit test results verifying nominal efficiency and power factor for motors 1 horsepower and larger.

C. Submit manufacturer's installation instructions under provisions of Section 21 00 00.

1.6 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data under provisions of Section 21 00 00.

B. Include assembly drawings, bearing data including replacement sizes, and lubrication instructions.

1.7 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacture of electric motors for commercial use, and their accessories, with minimum three-years documented product development, testing, and manufacturing experience.

1.8 REGULATORY REQUIREMENTS

A. Conform to the National Electrical Code.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to site under provisions of Section 21 00 00.

B. Store and protect products under provisions of Section 21 00 00.

C. Protect motors stored on site from weather and moisture by maintaining factory covers and suitable weather-proof coverings. For extended outdoor storage, remove motors from equipment and store separately.

1.10 WARRANTY

A. Provide five-year manufacturer's warranty under provisions of Section 21 00 00.

B. Warranty: Include coverage for motors 1 horsepower and larger.

PART 2 - PRODUCTS

2.1 GENERAL

A. All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.

B. Electrical Service: Refer to Drawing schedules for required electrical characteristics.

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- C. Design for continuous operation in 40 degrees C environment and for temperature rise in accordance with ANSI/NEMA MG 1 limits for insulation class, Service Factor and motor enclosure type.
 - 1. Totally Enclosed Motors: Design for a service factor of 1.00 and an 80 degrees C maximum temperature rise in the same conditions.
 - 2. Explosion-Proof Motors: UL approved and labeled for hazard classification, with over temperature protection.
- D. Visible Stainless Steel Nameplate: Indicating motor horsepower, voltage, phase, cycles, RPM, full load amps, locked rotor amps, frame size, manufacturer's name and model number, Service Factor, Power Factor, efficiency.
- E. Electrical Connection: Provide adequately sized metal electrical connection box for conduit connection. For fractional horsepower motors where connection is made directly, provide metal electrical box for conduit connection.
- F. Motors shall be built in accordance with the latest ANSI, IEEE and NEMA Standards and shall be fully coordinated with the equipment served, shall be of sizes and electrical characteristics scheduled and of approved manufacturer as listed below or of the same manufacturer as the equipment which they serve. Nameplate rating of motors shall match the characteristics scheduled.
- G. All motors shall be designed for normal starting torque unless the driven machine requires high starting torque and shall be selected for quiet operation, free from magnetic hum.
- H. All motors shall be provided with adequately sized electrical connection box for attachment of flexible conduit. Paragraph 1.03 of this specification refers to the NEMA standards and publications relevant to applications and use of both metal and liquid tight flexible conduit. When motors are connected to driven equipment by the use of a V-belt drive, they shall be furnished with adjustable rails.
- I. Motors shall be open drip-proof type, except where specified or noted otherwise on the construction drawing.
- J. Motors ¼ to ¾ hp shall be Subtype II and meet the minimum requirements of EPA Act 92 for minimum NEMA nominal efficiency motors.
- K. Motors 1 to 200 hp shall be Subtype I and meet the minimum requirements of NEMA Table 12-12 for NEMA premium efficiency motors.

2.2 MANUFACTURERS

- A. Manufacturer: Company specializing in the manufacture of electric motors for HVAC and plumbing equipment use, and their accessories, with minimum three (3) years documented product development, testing and manufacturing experience.
 - 1. Baldor - Super E – NEMA Premium Efficiency.

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FIRE PROTECTION MOTORS

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2. Marathon - NEMA Premium Efficiency.
3. Siemens – NEMA Premium Efficiency
4. U.S. Electrical – NEMA Premium Efficiency.

2.3 THREE PHASE POWER - SQUIRREL CAGE MOTORS

- A. Enclosures shall be of the open drip proof type with a service factor as specified herein and Class B insulation rated at 90 degrees C temperature rise measured above 40 degrees C room ambient condition at full load, unless otherwise noted.
- B. All motors 3/4 horsepower and larger, unless smaller motors are indicated to be supplied as 3-phase, shall be 3-phase and shall be squirrel cage high efficiency induction type with standard NEMA frame sizes.
- C. Three phase motors not connected to variable frequency drives are to be protected for phase loss and phase unbalance protection.
- D. Motors 1 HP and larger shall have integral frames.
- E. Starting Torque: Between one and one and one-half times full load torque.
- F. Starting Current: Six times full load current.
- G. Power Output, Locked Rotor Torque, Breakdown or Pullout Torque: NEMA Design B characteristics.
- H. Design, Construction, Testing and Performance: Conform to ANSI/NEMA MG 1 for Design B motors.
- I. Insulation System: NEMA Class B or better.
- J. Testing Procedure: In accordance with ANSI/IEEE 112, Test Method B. Load test motors to determine freedom from electrical or mechanical defects and compliance with performance data.
- K. Motor Frames: NEMA standard T-frames of steel, aluminum, or cast iron with end brackets of cast iron or aluminum with steel inserts.
- L. Bearings:
 1. Ball or roller type, double shielded with continuous grease relief to accommodate excessive pressure caused by thermal expansion or over lubrication.
 2. All motor bearings shall be factory prepacked with a nondetergent lubricant and shall be provided with lubrication fitting arranged to provide easy access when installed on the driven apparatus except as noted hereinafter.

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3. Permanently lubricated factory-sealed motors may be provided in fractional horsepower sizes only where they are an integral part of a piece of approved apparatus.
 4. All bearings shall be designed for L-10, 40,000 hour minimum life hours of continuous service. Direct driven equipment may require specific bearings other than ball type, verify equipment specification where motor may be used where bearing life requirement may exceed L-10 rating. Stamp bearing sizes on nameplate.
- M. Sound Power Levels: Refer to ANSI/NEMA MG 1.
- N. Part Winding Start (Where Indicated): Epoxy seal windings using vacuum and pressure with rotor and starter surfaces protected with epoxy enamel. Bearings shall be double shielded with waterproof non-washing grease.
- O. Nominal Efficiency and Power Factor: Meet or exceed values as scheduled at load and rated voltage when tested in accordance with ANSI/IEEE 112.
- P. Motors one horsepower and larger shall be provided with a copper frame grounding lug of hydraulic compression design, for installation by the electrical subcontractor.

2.4 STARTING EQUIPMENT

- A. Each motor shall be provided with proper starting equipment. Starting equipment shall be furnished by this Division.
- B. Relays and equipment supplied by this Contractor shall be integral with electrical equipment supplied.

2.5 RATING

- A. Speed and Size: Speed and approximate horsepower ratings are specified in equipment Specification Sections or are indicated on the Drawings. Furnish motors sufficiently sized for the particular application and with full-load rating not less than required by the driven equipment at specified capacity. Size motors so as not to overload at any point throughout the normal operating range.
- B. Voltage:
 1. Three phase: 230 volts for 240-volt nominal system voltage.
 2. Three phase: 230/460 volts for 240/480-volt nominal system voltage.
 3. Three phase: 460 volts for 480-volt nominal system voltage.
- C. Frequency: 60 Hertz.

- D. Efficiency: Provide energy-efficient motors meeting the requirements of NEMA MG1-12.55A, Table 12Y and MG 1.41.3. Efficiency to be determined by testing in accordance with NEMA MG 112.53 using IEEE 112A – Method B.
- E. Service Factor: According to NEMA MG 1-12.47 but not less than those indicated per the Table below.

PART 3 - EXECUTION

3.1 APPLICATION

- A. Motors located in exterior locations shall be totally enclosed weatherproof epoxy-sealed type.

3.2 NEMA OPEN MOTOR SERVICE FACTORS

<u>Horsepower</u>	<u>3600 RPM</u>	<u>1800 RPM</u>	<u>1200 RPM</u>	<u>900 RPM</u>
<u>1/6 – 1/3</u>	1.35	1.35	1.35	1.35
<u>1/2</u>	1.25	1.25	1.25	1.15
<u>3/4</u>	1.25	1.25	1.15	1.15
<u>1</u>	1.25	1.15	1.15	1.15
<u>1.5-150 and above</u> 150	1.15	1.15	1.15	1.15

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3.3 MANUFACTURER INSTALLED

- A. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.
- B. All installation shall be in accordance with manufacturer’s published recommendations.
- C. Properly install and align motors after installation on the driven equipment.
- D. Motor feeders shall be free of splices. In special cases when splice-free feeders are impractical, splices may be allowed given prior written approval from the Owner.
- E. Use crimp-on, solderless copper terminals on the branch circuit conductors. For motors 20 horsepower and larger, use 5300 Series 3M motor lead splicing kit or approved equal.
- F. When the motor and equipment are installed, the motor’s nameplate must be in full view.

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G. MOTOR EFFICIENCY TABLE

Minimum Nominal Full Load Efficiency (5) for Motors Manufactured on or after December 19, 2010								
Open Drip-Proof Motors					Totally Enclosed Fan Cooled Motors			
Number of Poles	2	4	6	8	2	4	6	8
Synchronous Speed (RPM)	3600	1800	1200	900	3600	1800	1200	900
Motor Horsepower								
1	NR	82.5	80.0	74.0	75.5	82.5	80.0	74.0
1.5	82.5	84.0	84.0	75.5	82.5	84.0	85.5	77.0
2	84.0	84.0	85.5	85.5	84.0	84.0	86.5	82.5
3	84.0	86.5	86.5	86.5	85.5	87.5	87.5	84.0
5	85.5	87.5	87.5	87.5	87.5	87.5	87.5	85.5
7.5	87.5	88.5	88.5	88.5	88.5	89.5	89.5	85.5
10	88.5	89.5	90.2	89.5	89.5	89.5	89.5	88.5
15	89.5	91.0	90.2	89.5	90.2	91.0	90.2	88.5
20	90.2	91.0	91.0	90.2	90.2	91.0	90.2	89.5
25	91.0	91.7	91.7	90.2	91.0	92.4	91.7	89.5
30	91.0	92.4	92.4	91.0	91.0	92.4	91.7	91.0
40	91.7	93.0	93.0	91.0	91.7	93.0	93.0	93.0
50	92.4	93.0	93.0	91.7	92.4	93.0	93.0	91.7
60	93.0	93.6	93.6	92.4	93.0	93.6	93.6	91.7
75	93.0	94.1	93.6	93.6	93.0	94.1	93.6	93.0
100	93.0	94.1	94.1	93.6	93.6	94.5	94.1	93.0
125	93.6	94.5	94.1	93.6	94.5	94.5	94.1	93.6
150	93.6	95.0	94.5	93.6	94.5	95.0	95.0	93.6
200	94.5	95.0	94.5	93.6	95.0	95.0	95.0	94.1
250	94.5	95.4	95.4	94.5	95.4	95.0	95.0	94.5
300	95.0	95.4	95.4	NR	95.4	95.4	95.0	NR
350	95.0	95.4	95.4	NR	95.4	95.4	95.0	NR
400	95.4	95.4	NR	NR	95.4	95.4	NR	NR
450	95.8	95.8	NR	NR	95.4	95.4	NR	NR
500	95.8	95.8	NR	NR	95.4	95.8	NR	NR

RE: ANSI/ASHRAE/IES Standard 90.1-ZD10, Table 10.8c minimum nominal full-load efficiency of general purpose electric motors (subtype 11 and design 13)

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FIRE PROTECTION MOTORS

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UTHealth FPE Standard Specification

SECTION 21 05 29

FIRE PROTECTION SUPORTS AND SLEEVES

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Rev No.	Date	Pages	Remarks
1	June 2017	9	New Specification Section

SECTION 21 05 29

—FIRE PROTECTION SUPPORTS AND SLEEVES

PART 1 - GENERAL

1.1 The following sections are to be included as if written herein:

- A. Section 21 00 00 – Basic Fire Protection Requirements
- B. Section 21 05 53 – Fire Protection Piping and Equipment Identification

1.2 SECTION INCLUDES

- A. Pipe and equipment hanger and supports
- B. Equipment bases and supports
- C. Sleeves and seals
- D. Flashing and sealing equipment and pipe stacks

1.3 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION

- A. Section [____ - _____]: Placement of [inserts] [sleeves] in concrete formwork.
- B. Section [____ - _____]: Placement of roofing [pipe] [duct] supports.
- C. Section [____ - _____]: Placement of equipment roof supports.
- D. Section [____ - _____]: Placement of roof sleeves, vents, and curbs.

1.4 PRODUCTS INSTALLED BUT NOT FURNISHED UNDER THIS SECTION

- A. Section [____ - _____]: Supply of roofing [pipe] [duct] [equipment] supports for placement by this Section.

1.5 RELATED SECTIONS

- A. Section 03300 – Cast-In-Place Concrete: Equipment bases
- B. Section 07 84 00 – Firestopping: Joint seals for piping penetration of fire rated assemblies

- C. Section 09 91 00 – Painting
- D. Section 21 13 13 – Fire Protection Systems
- E. Section 21 30 00 – Fire Pumps

1.6 REFERENCES

- A. ASME B31.1 – Power Piping
- B. ASME B31.9 – Building Services Piping
- C. ASTM F708 – Design and Installation of Rigid Pipe Hangers
- D. MSS SP58 – Pipe Hangers and Supports – Materials, Design and Manufacturer
- E. MSS SP69 – Pipe Hangers and Supports – Selection and Application
- F. MSS SP89 – Pipe Hangers and Supports – Fabrication and Installation Practices
- G. NFPA 13 – Installation of Sprinkler Systems
- H. NFPA 14 – Installation of Standpipe and Hose Systems
- I. UL 203 – Pipe Hanger Equipment for Fire Protection Service

1.7 SUBMITTALS

- A. Submit under provisions of Section 21 00 00.
- B. Shop Drawings: Indicate system layout with location and detail of trapeze hangers.
- C. Product Data: Provide manufacturers catalog data including load capacity.
- D. Design Data: Indicate load carrying capacity of trapeze, multiple pipe, and riser support hangers.
- E. Manufacturer’s Installation Instructions: Indicate special procedures and assembly of components.

1.8 REGULATORY REQUIREMENTS

- A. Supports for Sprinkler Piping: Shall be in conformance with NFPA 13.
- B. Supports for Standpipes: Shall be in conformance with NFPA 14.

PART 2 - PRODUCTS

2.1 HANGERS AND SUPPORTS

- A. Hangers and Supports:
 - 1. Anvil International.
 - 2. Kinder.
 - 3. Cooper B-Line.
 - 4. Power Strut.
 - 5. Unistrut
- B. Supports, hangers, anchors and guides shall be provided for all horizontal and vertical piping. Shop Drawings shall be provided, indicating locations and details of anchors, supports, joints, hangers, etc. The hanger design shall conform to the ASME Code for Pressure Piping.
- C. All auxiliary steel required for supports, anchors, guides, etc. shall be provided unless specifically indicated to be provided by others.
- D. Contractor shall review all Drawings, including Structural Drawings, for details regarding pipe supports, anchors, hangers, and guides.
- E. All Supports shall be of type and arrangement to prevent excessive deflection, to avoid excessive bending stresses between supports, and to eliminate transmission of vibration.
- F. All rod sizes indicated in this Specification are minimum sizes only. This trade shall be responsible for structural integrity of all supports, anchors, guides, etc. All structural hanging materials shall have a minimum safety factor of 5 built in.
- G. Anchor points as indicated on Drawings or as required shall be located and constructed to permit the piping system to take up its expansion and contraction freely in opposite directions away from the anchored points.
- H. Supports, hangers, anchors, and guides shall be fastened to the structure only at such points where the structure is capable of restraining the forces in the piping system.

- I. Hangers supporting and contacting brass or copper lines 3" in size and smaller shall be Anvil Fig. CT-99c, adjustable, copper plated, tubing ring. Hangers supporting and contacting brass or copper lines 4" and larger shall be Anvil Fig. 260, adjustable clevis, with a nut above and below the hanger, and approved neoprene isolating material between pipe (or tubing) and hanger on the support rod. For insulated copper or brass domestic water lines, hangers for all sizes of pipe shall be Anvil Fig. 300, adjustable clevis, with a nut above and below the hanger, and approved neoprene isolating material between pipe (or tubing) and hanger on the support rod. Isolate all copper or brass lines from all ferrous materials with approved dielectric materials. Hangers supporting and contacting ferrous lines larger than 6" in size and outside of insulation on lines with the outside diameter equivalent to 10" diameter pipe shall be Anvil Fig. 260, adjustable clevis, with a nut above and below the hanger on the support rod.
- J. Other special type of hangers may be employed where so specified or indicated on the Drawings, or where required by the particular conditions. In any case, all hangers must be acceptable to the owner.
- K. Supports for vertical piping in concealed areas shall be double bolt riser clamps, Anvil Fig. 261, or other approved equal, with each end having equal bearing on the building structure, and located at each floor. Two-hole rigid pipe clamps at 4 ft. o.c. or steel framing channels and Anvil Fig. 261 riser clamps may be used to support pipe directly from vertical surfaces or members where lines are not subject to expansion and contraction. Where brass or copper lines are supported on trapeze hangers or steel framing channels, the pipes shall be isolated from these supports with plastic tape with insulating qualities, or strut clamps. Supports for vertical piping in exposed areas (such as fire protection standpipe in stairwells) shall be attached to the underside of the building structure above the top of the riser, and the underside of the penetrated structure. The Contractor shall use a drilled anchor as specified above, and use a Anvil No. 595 Socket Clamp with Anvil No. 594 Socket Clamp Washers, as a riser clamp. The top riser hanger shall consist of two (2) hanger rods (sized as specified) anchored to the underside of the building structure, supporting the pipe by means of the material specified. Risers penetrating floors shall be supported from the underside of the penetrated floor as specified for the top of the riser.
- L. Pipe Supports in Chases and Partitions: Horizontal and vertical piping in chases and partitions shall be supported by hangers or other suitable support. Pipes serving equipment shall be securely supported near the point where pipes penetrate the finish wall. Supports shall be steel plate, angles, or special channels such as Unistrut mounted in vertical or horizontal position. Pipe clamps such as Unistrut P2426, P2008, P1109 or other approved clamps shall be attached to supports. Supports shall be attached to wall or floor construction with clip angles, brackets, or other approved method. Supports may be attached to cast iron pipe with pipe clamp, or other approved method. All copper or brass lines shall be isolated from ferrous metals with dielectric materials to prevent electrolytic action.

- M. All electrical conduits shall be run parallel or perpendicular to adjacent building lines. Single conduits running horizontally shall be supported by "Caddy" or "Minerallac" type hangers from adequately sized rods (minimum 1/4") from the building structure. Where multiple conduits are run horizontally, they shall be supported on trapeze of "Unistrut" type channel suspended on rods or bolted to vertical building members. Conduit shall be secured to channel with galvanized "Unistrut" type conduit clamps or stainless steel "Unistrut" type "Uni-Clips." All hangers shall be fastened to the building structure in the same manner as specified above for pipe hangers. Spacing of hangers shall be adequate for the weight and rigidity of the conduits involved; in any case, no greater than 8' centers. Where feasible, conduits may be fastened to the concrete by one-hole straps thoroughly anchored to the concrete in an approved manner. Flexible conduit shall also be supported in an acceptable manner so as not to interfere with the maintenance of above-ceiling equipment, and to support it from touching the ceiling system. Conduit shall be located so as not to inhibit removal of ceiling tiles.

IMPORTANT EXCEPTION: IF SUSPENSION SYSTEM FOR THE LAY-IN CEILING IS OF ADEQUATE STRENGTH, IN THE OPINION OF THE STRUCTURAL ENGINEER, ONE ONLY, 3/4" MAXIMUM SIZE FLEXIBLE METALLIC CONDUIT MAY BE SUPPORTED FROM A HANGER WIRE BY "CADDY" TYPE CLIPS. CONDUIT SHALL BE SO LOCATED SO AS NOT TO INHIBIT REMOVAL OF CEILING TILES.

NOTE TO SPECIFICATION WRITER: ADEQUACY OF CEILING SUSPENSION SYSTEM SHALL BE DETERMINED IN DESIGN PHASE. DO NOT INCLUDE ABOVE EXCEPTION IF INAPPROPRIATE.

- N. Vertical conduits shall be supported as often as necessary for rigidity by clamps resting on adjacent beams or floor slabs, using a minimum of one support per floor.
- O. Perforated strap iron or wire will not, under any circumstances, be acceptable as hanger material.
- P. Vibration Isolation: Resilient hangers shall be provided on all piping connected to rotating equipment (pumps, etc.). Piping that may vibrate and create an audible noise shall also be isolated.
- Q. Attachment:
1. The load and spacing on each hanger and/or insert shall not exceed the safe allowable load for any component of the support system, including the concrete which holds the inserts. Reinforcement at inserts shall be provided as required to develop the strength required.

2. Inserts shall be of a type which will not interfere with reinforcing as shown on the structural Drawings and which will not displace excessive amounts of structural concrete.
3. All supports shall be designed and installed to avoid interference with other piping, hangers, ducts, electrical conduit, supports, building structures, equipment, etc. All piping shall be installed with due regard to expansion and contraction and the type of hanger method of support, location of support, etc. shall be governed in part by this Specification.
4. Hangers shall be attached to the structure as follows:
 - a. **Poured In Place Concrete:** Where pipes and equipment are supported under poured in place concrete construction, each hanger rod shall be fitted with a nut at its upper end, which nut shall be set into an Underwriters Laboratories, Inc. listed universal concrete insert placed in the form work before concrete is poured. Where inserts are placed in the bottom faces of concrete joists which are too narrow to provide adequate strength of concrete to hold the insert properly or where a larger insert would require displacement of the bottom joist steel, the hanger rod shall be suspended from the center of a horizontal angle iron, channel iron, I-beam, etc. spanning across two adjacent joists. The horizontal support shall be bolted to nonadjustable concrete inserts of the "spot" type, of physical size small enough to avoid the bottom joist steel.
 - b. **Steel Bar Joists:** Where pipes and loads are supported under bar joists, hanger rods may be run through the space between the bottom angles and secured with a washer and two nuts. Where larger lines are supported beneath bar joists, hanger rods shall be secured to angle irons of adequate size; each angle shall span across two or more joists as required to distribute the weight properly and shall be welded to the joists or otherwise permanently fixed thereto.
 - c. **Steel Beams:** Where pipes and loads are supported under steel beams, approved type beam clamps shall be used.
 - d. **Wood Framing:** Where pipes and loads are supported from wood framing, hanger rods shall be attached to framing with side beam brackets or angle clips.

- e. Pre-Cast Tee Structural Concrete: Hanger supports, anchors, etc. required for mechanical systems attached to the precast, double tee, structural concrete system are to be installed in accord with approved shop Drawings only. Holes required for hanger rods shall be core drilled in the "flange" of the double tee only; impact type tools are not allowed under any circumstances. Core drilling in the "stem" portions of the double tee is not allowed. Holes core drilled through the "flange" for hanger rods shall be no greater than 1/4" larger than the diameter of the hanger rod. Hanger rods shall be supported by means of bearing plates of size and shape acceptable to the Architect/Engineer, with welded double nuts on the hanger rod above the bearing plate. Cinch anchors, lead shields, expansion bolts, and studs driven by explosion charges are not allowed under any circumstances in the lower 15" of each stem and in the "shadow" of the stem on the top side of the "double tees."
- f. If it is necessary to install a method of fastening a hanger after the structure has been installed, then only clamps or drilled anchors shall be used.
- g. Power-actuated fasteners (shooting) will not be acceptable under any circumstances.

NOTE: UNDER NO CIRCUMSTANCES WILL THE USE OF PLASTIC ANCHORS OR PLASTIC EXPANSION SHIELDS BE PERMITTED FOR ANY PURPOSE WHATSOEVER.

- R. Trapezes: Where multiple lines are run horizontally at the same elevation and grade, they may be supported on trapezes of Cooper BLine, Uni-Strut, Power Strut, or approved equal, channel-suspended on rods or pipes. Trapeze members including suspension rods shall each be properly sized for the number, size, and loaded weight of the lines they are to support.
- S. Finishes: All hangers on piping including clevis hangers, rods, inserts, clamps, stanchions, and brackets, shall be dipped in Zinc Chromate Primer before installation. Rods may be galvanized or cadmium plated after threading, in lieu of dipping zinc chromate. Universal concrete inserts shall be cadmium plated.
- T. Miscellaneous: Provide any other special foundations, hangers and supports indicated on the Drawings, specified elsewhere herein; or required by conditions at the site. Hangers and supporting structures for suspended equipment shall be provided as required to support the load from the building structure in a manner acceptable to the Architect/Engineer.
- U. All hangers and supports for fire standpipe systems and fire sprinkler systems shall be Factory Mutual and Underwriters Laboratories, Inc. listed and labeled. Construction of hangers shall be as described above for common piping, except for the above-mentioned requirements.

2.2 ACCESSORIES

- A. Hanger Rods: Galvanized mild steel threaded both ends, galvanized threaded one end, or galvanized continuous threaded.
- B. Inserts: Malleable iron case of galvanized steel shell and expander plug for threaded connection with lateral adjustment, top slot for reinforcing rods, lugs for attaching to forms; size inserts to suit threaded hanger rods. Suitable concrete inserts for pipe and equipment hangers shall be set and properly located for all pipe and equipment to be suspended from concrete construction. If the inserts are later found not to be in the proper location for the placement of hangers, then drilled anchors shall be installed. Drilled anchors in concrete or masonry shall be submitted for the approval by the Owner.

2.3 FLASHING AND EQUIPMENT CURBS

- A. Metal Flashing: 26 gauge galvanized (stainless steel) steel.
- B. Metal Counterflashing: 22 gauge galvanized (stainless steel) steel.
- C. Roofing Flashing: See specifications for Roofing, elsewhere in these Specifications.
- D. Caps: Steel, 22 gauge minimum; 16 gauge at fire resistant elements.

2.4 CONCRETE FOUNDATIONS ("HOUSEKEEPING PADS"):

- A. Concrete foundations for the support of equipment such as floor mounted panels, pumps, etc., shall extend 4" on all sides beyond the limits of the mounted equipment unless otherwise noted and shall be poured in forms built of new dressed 6" nominal lumber. All corners of the foundations shall be neatly chamfered by means of sheet metal or triangular wood strips nailed to the form. Foundation bolts shall be placed in the forms when the concrete is poured, the bolts being correctly located by means of templates. Each bolt shall be set in a sleeve of size to provide 1/2" clearance around bolt. Allow 1" below the equipment bases for alignment and grouting. After grouting, the forms shall be removed and the surface of the foundations shall be hand rubbed with Carborundum. Foundations for equipment located on the exterior of the building shall be provided as indicated. Foundations shall be constructed in accordance with Shop Drawings submitted by the Contractor for review by the Architect/Engineer.

2.5 WALL, FLOOR AND CEILING PLATES:

- A. Except as otherwise noted, provide C.P. (Chrome plated) brass floor and ceiling plates around all pipes, conduits, etc., passing exposed through walls, floors, or ceilings, in any spaces except underfloor and attic spaces. Plates shall be sized to fit snugly against the outside of the pipe or against the insulation on lines which are insulated and positively secured to such pipe or insulation. Plates will not be required for piping where pipe sleeves extend 3/4" above finished floor. All equipment rooms are classified as finished areas. Floor penetrations in exposed (except in stair wells) areas shall be finished using 'bell' fitting to fit pipe or insulation and sleeve and shall be painted to match the pipe. Penetrations in stairwells shall have flat floor plate painted to match pipe.

2.6 SLEEVES

- A. General: All openings through all floors, walls, and roofs, etc., regardless of material for the passage of piping, etc., shall be sleeved. All penetrations must pass through sleeves. Sleeves shall be set in new construction before concrete is poured, as cutting holes through any part of the concrete will not be permitted unless acceptable to the Architect/Engineer. If a penetration is cored into an existing vertical solid concrete, masonry or stone structure, then the installation of a sleeve will not be necessary.
1. Sleeve material for floors and exterior walls shall be Schedule 40 galvanized steel with welded water stop rings.
 2. Sleeves through interior walls to be galvanized sheet metal with gauge as required by wall fire rating, 20 gauge minimum.
- B. The minimum clearance between horizontal penetrations including insulation where applicable, and sleeve shall be 1/4", except that the minimum clearance shall accommodate a Thunderline Link-seal closure where piping exits the building, or penetrates a wall below ground level. Contractor shall be responsible for the accurate location of penetrations in the slab for his pipe, duct, etc. All penetrations shall be of ample size to accommodate the pipe, duct, etc., plus any specified insulation. Void between sleeve and pipe in interior penetrations shall be filled with Nelson Flameseal Firestop or approved equal caulk or putty.
- C. Floor sleeves shall extend above the finished floor as detailed on the drawings, except that floor sleeves in stairwells shall be flush with the finished floor. Sleeves in walls shall be trimmed flush with wall surface. Refer to the details on the project drawings. Where the details differ from these specifications, the drawings take precedence.
- D. Sleeves for penetrations passing through walls or floors on or below grade shall be removed, if practical, and after the pipes have been installed, the void space around the pipe shall be caulked with a suitable material to effect a waterproof penetration. Note that the practicality of the removal of the sleeve shall be the decision of the Construction Inspector. The decision of the Inspector shall be final.

- E. Vermin proofing: The open space around all piping, etc., passing through the ground floor and/or exterior walls shall be vermin proofed in a manner acceptable to the Architect/Engineer.
- F. Waterproofing: The annular space between a pipe and its sleeve in interior floors shall be filled with polyurethane foam rods 50 percent greater in diameter than the space as backing and fill material and made watertight with a permanent elastic polysulfide compound. Seal both surfaces of floor.
- G. Air Plenums: The space around piping, etc., passing through air plenums shall be made airtight in a manner acceptable to the Architect/Engineer.
- H. Fireproofing: Seal all pipe, etc., penetrations through roof, fire rated walls and floors with a foam or sealant as described below, that will form a watertight, vermin tight barrier that is capable of containing smoke and fire up to 2000° F for two hours. Sealing of cable trays and conduits that extend through rated walls from ends of cable tray shall be done after conductors have been installed. For wet locations, the foam material shall be a silicone RTV foam or an approved equal. For dry locations, a premixed putty equal to Nelson Flameseal Firestop putty may be used

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install in accordance with manufacturer's instructions.

3.2 INSERTS

- A. Provide inserts for placement in concrete formwork.
- B. Provide inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.
- C. Provide hooked rod to concrete reinforcement section for inserts carrying pipe over 4 inches.
- D. Where concrete slabs form finished ceiling, locate inserts flush with slab surface.
- E. Where inserts are omitted, drill through concrete slab from below and provide through-bolt with recessed square steel plate and nut recessed into and grouted flush with slab.

3.3 PIPE HANGERS AND SUPPORTS

- A. Support horizontal piping as scheduled.
- B. Install hangers to provide minimum 1/2-inch space between finished covering and adjacent work.

- C. Place hangers within 12 inches of each horizontal elbow.
- D. Use hangers with 1-1/2-inch minimum vertical adjustment.
- E. Support horizontal cast iron pipe adjacent to each hub, with 5 feet maximum spacing between hangers.
- F. Support vertical piping at every floor. Support vertical cast iron pipe at each floor at hub.
- G. Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.
- H. Support riser piping independently of connected horizontal piping.
- I. Provide copper plated hangers and supports for copper piping.
- J. Design hangers for pipe movement without disengagement of supported pipe.
- K. Prime coat exposed steel hangers and supports. Hangers and supports located in crawl spaces, pipe shafts, and suspended ceiling spaces are not considered exposed, but shall be corrosion protected with galvanized plating. Repair any damaged galvanized plating with a coating of 'Galvalum'.
- L. Hanger Rods: (NOTE: All hanger rods shall be trimmed neatly so that no more than 1 inch of excess hanger rod protrudes beyond the hanger nut. In the event a rod is intentionally but temporarily left excessively long (for sloped or insulated lines for example), the contractor shall take appropriate measures to protect the pipe or other materials from damage.)

3.4 FLASHING

- A. Provide flexible flashing and metal counterflashing where piping and ductwork penetrate weather or waterproofed walls, floors, and roofs.
- B. Provide acoustical lead flashing around pipes penetrating equipment rooms, installed in accordance with manufacturer's instructions for sound control.
- C. Adjust storm collars tight to pipe with bolts; caulk around top edge. Use storm collars above roof jacks. Screw vertical flange section to face of curb.

3.5 SLEEVES

- A. Set sleeves in position in formwork. Provide reinforcing around sleeves.
- B. Size sleeves large enough to allow for movement due to expansion and contraction. Provide for continuous insulation wrapping.

- C. Extend sleeves through floors (except in stairwells) two inches above finished floor level. Sleeves through floors shall have welded waterstop rings. Sleeves shall be sealed watertight to floors and pipe.
- D. Where piping penetrates floor, ceiling, or wall, close space between pipe and adjacent work with fire stopping insulation and caulk airtight. Provide close fitting metal collar or escutcheon covers, as appropriate, at both sides of penetration.
- E. Install chrome plated steel or stainless steel escutcheons at finished surfaces.

3.6 PIPE SUPPORT SCHEDULE

STEEL PIPE SIZE <u>Inches</u>	MAX. HANGER SPACING <u>Feet</u>	HANGER ROD DIAMETER <u>Inches</u>
1/2 to 1-1/4	6.5	3/8
1-1/2 to 2	10	3/8
2-1/2 to 3	10	1/2
4 to 6	10	5/8
8 to 12	14	7/8

END OF SECTION ~~21-05-29~~

SECTION 21 05 53
FIRE PROTECTION PIPING AND EQUIPMENT IDENTIFICATION

PART 1 - GENERAL

1.1 The following sections are to be included as if written herein:

- A. Section 21 00 00 – Basic Fire Protection Requirements.
- B. Section 21 05 29 – Fire Protection Supports and Sleeves.

1.2 SECTION INCLUDES

- A. Nameplates
- B. Tags
- C. Stencils
- D. Pipe Markers

1.3 RELATED SECTIONS

- A. Section 09 91 00 – Painting: Identification painting.

1.4 REFERENCES

- A. ASME A13.1 – Scheme for the Identification of Piping Systems.

1.5 SUBMITTALS

- A. Submit under provisions of Section 21 00 00.
- B. Submit list of wording, symbols, letter size, and color coding for mechanical identification.
- C. Submit valve chart and schedule, including valve tag number, location, function, and valve manufacturer's name and model number.
- D. Product Data: Provide manufacturers catalog literature for each product required.
- E. Samples: Submit two of each type of label, tag, etc., of the approximate size specified of implied in the specification.
- F. Manufacturer's Installation Instructions: Indicate special procedures, and installation.

1.6 PROJECT RECORD DOCUMENTS

- A. Submit under provisions of Section 21 00 00.
- B. Record actual locations of tagged valves.

PART 2 - PRODUCTS

2.1 GENERAL

- A. All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.

2.2 MANUFACTURERS

- A. Equipment Tags, Valve Tags, and Markers:
 - 1. Marking Systems, Inc.
 - 2. Seton Name Plate Company.
 - 3. W.H. Brady Company.
 - 4. Graphic Products, Inc.

2.3 EQUIPMENT

- A. Description: 3” x 4” vinyl label, 3.0 Mil self-adhesive vinyl similar to DuraLabel Pro. Label color shall be black text on a white background. The label shall contain the following information per the template, described in Attachment “B”:
 - 1. Asset Short Description As listed in Equipment Matrix.
 - 2. Asset Number: As listed in Equipment Matrix.
 - 3. Asset Location: As listed in Equipment Matrix.
 - 4. Asset Bar Code Number.
- B. All scheduled equipment shall be identified with an Equipment Tag.

2.4 VALVE TAGS

- A. Valve tags shall conform to ANSI A13.1-1981 "Scheme for the Identification of Piping Systems", refer to Attachment “A” for abbreviation, and label color designations.
- B. Valve tags shall be black ABS plastic tags: Injected molded ABS plastic, 3.375” X 4.75” with self-adhesive vinyl label, similar to DuraLabel Pro, affixed to valve tag. Each tag shall be attached to its valve with one tie strap.
- C. Vinyl Label: 3.0 Mil self-adhesive vinyl similar to DuraLabel Pro. Label color shall be as per the standard designated colors listed in the attachment to this specification. The label shall contain the following information as per template, refer to Attachment “B”:
 - 1. Asset Short Description: As listed in Equipment Matrix.
 - 2. Asset Number: As listed in Equipment Matrix.

3. Asset Location: As listed in Equipment Matrix. .
 4. Asset Bar Code Number.
- D. Each valve shall be named as per attached valve tag naming convention, refer to Attachment “C”.
- E. In addition to valve tags, valves at PRV stations, and other valves as specified shall be tagged with standardized color coded plastic tags. Each tag shall be attached to its valve with one tie strap. These tags shall be 2-½ inches wide by 1-½ inches high with these color codings:
1. Red = normally closed.
 2. Green = normally open.
 3. Blue = open in winter, closed in summer.
 4. Yellow = closed in winter, open in summer.
- F. Valve Tag Fasteners: Single ABS plastic tie strap.

2.5 PIPE MARKERS

- A. Pipe Markers shall conform to ANSI A13.1-2007 "Scheme for the Identification of Piping Systems" as indicated below.

Pipe Contents	Label Abbreviation	Label Colors (Background/Text)
Fire Suppression Water	FIRE	Red/White
Dry Pipe Sprinklers	DRY FIRE	Red/White
Pre-action Sprinklers	PREACTION	Red/White
Wet Sprinklers	WET FIRE	Red/White

- B. Arrow markers must have same ANSI background colors as their companion pipe markers, or be incorporated into the pipe identification marker.
- C. Plastic Pipe Markers: Factory fabricated, flexible, semi-rigid plastic, preformed to fit around pipe or pipe covering; minimum information indicating flow direction arrow and identification of fluid being conveyed.
- D. Plastic Tape Pipe Markers: Heat sealed or heat shrink, spring fasteners, clips or snap-on are acceptable.
- E. Underground Plastic Pipe markers: Bright colored continuously printed plastic ribbon tape, minimum 6 inches wide by 4 mil thick, manufactured for direct burial service.
- F. Pipe markers and arrow markers also shall be provided for all piping systems.

- G. Use Seton Setmark Type SNA or Brady snap-on type identification for all piping systems, up through 6 inch. For piping systems larger than 6 inches, use Seton or Brady strap-on markers or similar by Marking Services, Inc.

2.6 CEILING GRID TAG FOR EQUIPMENT LOCATED ABOVE LAY-IN CEILING

- A. Description: 3/4" x variable length" vinyl label, 3.0 Mil self-adhesive vinyl similar to Dura Label Pro. Label color shall be black text on a white background. The label shall contain the following information per the template, described in Attachment "C":
 - 1. Asset Short Description: As listed in Equipment Matrix.
 - 2. Asset Bar Code Number.
- B. All scheduled equipment above finish lay-in ceiling shall be identified with an Equipment Tag.
- C. All ceiling grid tags shall be installed prior to the ceiling cover inspection.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.
- B. All installation shall be in accordance with manufacturer's published recommendations.
- C. Install plastic tape, and pipe markers completely around pipe in accordance with manufacturer's instructions.
- D. Locate markers on the two (2) lower quarters of the pipe where view is unobstructed.

3.2 VALVE TAGS

- A. Contractor(s) shall provide and install valve tags on all valves installed within this Project, except check valves; Existing valve tags shall not be attached to new valves. When removing and/or replacing existing tagged valves, give the Owner all existing tags that are attached to the valves that are removed. New tags with new asset numbers shall be provided for new valves.

3.3 APPLICATION OF MARKERS AND STENCILS

- A. Piping runs throughout the Project including those above lift-out ceilings, under floor and those exposed to view when access doors or access panels are opened shall be identified by means of pipe markers and/or stencils. Concealed areas, for purposes of this identification section, are those areas that cannot be seen except by demolition of the building elements. In addition to pipe markers and/or stencils, arrow markers shall be used to indicate direction of flow.

- B. As a minimum, locate pipe markers and/or stencils as follows:
1. Provide a pipe marker at each valve to indicate proper identification of pipe contents. Where several valves exist on one (1) header, it is necessary to mark only the header.
 2. Every 20 feet in exposed and concealed areas on all piping systems. Provide at least one (1) pipe marker in each room on all piping systems.
 3. At each branch or riser take off on piping systems, excluding short takeoffs for fixtures.
 4. Provide a pipe marker or stencil and an arrow marker at every point of pipe entry or exit where the pipe penetrates a wall, floor, service column or enclosure.
 - a) At access doors, manholes and similar access points that permit view of concealed piping.
 - b) Near major equipment items and other points of origination and termination.
- C. Provide an arrow marker with each pipe marker pointing away from the pipe marker to indicate direction of flow.
- D. Provide a double-ended arrow marker when flow can be in either or both directions.
- E. Install underground plastic pipe markers 6 to 8 inches below finished grade, directly above buried pipe.
- F. Identify control panels and major control components outside panels with plastic nameplates.
- G. Identify valves in main and branch piping with tags.
- H. Tag automatic controls, instruments and relays. Key to control schematic.
- I. Provide ceiling grid tags to locate valves or other concealed equipment above T-bar type panel ceilings. Locate in corner of grid closest to equipment.
- J. Identify right and left nipple and coupling union assemblies with the statement "Right/Left Nipple/Coupling".

END OF SECTION

SECTION 21 08 00
COMMISSIONING OF FIRE PROTECTION SYSTEMS

PART 1 – GENERAL

1.1 SUMMARY

- A. This Section includes commissioning process requirements for Fire Protection systems, assemblies, controls, and equipment.
- B. This project will have selected building systems commissioned. The equipment and systems to be commissioned are specified “SECTION 01 91 00 - GENERAL COMMISSIONING REQUIREMENTS”.

1.2 RELATED SECTIONS

- A. SECTION 01 91 00 - COMMISSIONING GENERAL REQUIREMENTS
- B. SECTION 22 08 00 – COMMISSIONING OF PLUMBING SYSTEMS
- C. SECTION 23 08 00 – COMMISSIONING OF HVAC SYSTEMS
- D. SECTION 26 08 00 – COMMISSIONING OF ELECTRICAL SYSTEMS
- E. SECTION 28 08 00 – COMMISSIONING OF FIRE ALARM SYSTEMS

1.3 DEFINITIONS

- A. Refer to section 01 91 00 - GENERAL COMMISSIONING REQUIREMENTS

1.4 SUBMITTALS

- A. Certificate Of Readiness, signed by the Contractor, certifying that systems, assemblies, equipment, components, and associated controls are ready for testing.
- B. Manufacturer’s completed start-up reports for equipment and systems.

1.5 CONTRACTOR'S RESPONSIBILITIES

- A. Reference Project Specification Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS for details of contractor’s responsibilities related to commissioning.
- B. Perform commissioning tests at the direction of the CxA.
- C. Attend commissioning meetings.
- D. Provide information requested by the CxA for functional testing and for final commissioning documentation.

- E. Provide measuring instruments and logging devices to record test data, and provide data acquisition equipment to record data for the complete range of testing for the required test period.
- F. Functional testing of systems will be carried out solely by contractor's personnel, under the direction of CxA. Provide experienced personnel, familiar with the systems being installed under this project.

1.6 CxA'S RESPONSIBILITIES

- A. Reference Project Specification Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS.
- B. CxA will direct commissioning testing.

PART 2 – PRODUCTS (Not Used)

PART 3 – EXECUTION

3.1 GENERAL TESTING REQUIREMENTS

- A. Equipment Testing and Acceptance Procedures: Testing requirements are specified in Division 21 Sections. Provide submittals, test data, inspector record, and certification to the CxA.
- B. Reference Project Specification Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS for detailed requirements of commissioning of Mechanical systems.
- C. Provide technicians, instrumentation, and tools to perform commissioning test at the direction of the CxA.
- D. Test all operating modes, interlocks, control responses, and responses to abnormal or emergency conditions, and verify proper response of building automation system controllers and sensors.
- E. Tests will be performed using design conditions whenever possible.

3.2 SYSTEM START-UP

- A. Contractor is solely responsible for system start-up. CxA may, at his discretion, witness start up procedures, but will not perform any Functional Testing of systems until Contractor has completed start-up and resolved all operating deficiencies, and has so certified.

3.3 TESTING PREPARATION

- A. Certify that Fire Protection systems, subsystems, and equipment have been installed, calibrated, and started and are operating according to the Contract Documents.

- B. Certify that testing, adjusting, and balancing procedures for Fire Protection systems have been completed and submitted, discrepancies corrected, and corrective work approved.
- C. Set systems, subsystems, and equipment into operating mode to be tested (e.g., normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).
- D. Inspect and verify the position of each device and interlock identified on checklists.
- E. Check safety cutouts, alarms, and interlocks with life-safety systems during each mode of operation.

3.4 FUNCTIONAL TESTING / GENERAL

- A. Reference Project Specification Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS for detailed requirements of commissioning of Plumbing systems.
- B. Provide measuring instruments to record test data as directed by the CxA.

3.5 PIPING SYSTEMS

- A. Pipe system cleaning, flushing, hydrostatic tests, and chemical treatment requirements are specified in Division 22 piping Sections. Plumbing Contractor shall prepare a pipe system cleaning, flushing, and hydrostatic testing plan. Provide cleaning, flushing, testing, and treating plan and final reports to the CxA. Include sequence of testing and testing procedures, description of equipment for flushing operations, drawings for each pipe sector, showing the physical location of each designated pipe test section, minimum flushing water velocity, and chemical treatment plan.

3.6 DEFERRED TESTING

- A. Initial commissioning will be done as soon as contract work is completed, though building may not be at full occupancy and equipment may not be at full loading.
- B. If adequate load may be artificially placed upon heating or cooling equipment, CxA, at his discretion, may perform functional testing during non-peak load periods. If testing cannot be carried out under these conditions to adequately verify system performance, testing will be deferred until such time as conditions are more satisfactory.
 - 1. Contractor is to provide services of personnel and participate in deferred or seasonal testing process in the same manner as he would in non-seasonal testing.
 - 2. If tests cannot be completed because of a deficiency outside the scope of the Plumbing system, document the deficiency and report it to the Owner. After deficiencies are resolved, reschedule tests.

3.7 RE-TESTING

- A. Reference Project Specification Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS for detailed requirements of re-testing of Plumbing systems.

3.8 SYSTEMS TO BE COMMISSIONED

- A. Reference Project Specification Section 01 91 00 COMMISSIONING GENERAL REQUIREMENTS for list of Plumbing systems to be commissioned.

END OF SECTION

**SECTION 21 13 13
FIRE PROTECTION SYSTEMS**

PART 1 - GENERAL

1.1 THE FOLLOWING SECTIONS ARE TO BE INCLUDED AS IF WRITTEN HEREIN:

- A. Section 21 00 00 – Basic Fire Protection Requirements
- B. Section 21 05 29 – Fire Protection Supports and Sleeves
- C. Section 21 05 53 – Fire Protection Piping and Equipment Identification

1.2 SECTION INCLUDES

- A. Pipe, fittings, valves, and connections for sprinkler, standpipe and fire hose, and combination sprinkler and standpipe systems.

1.3 RELATED SECTIONS

- A. Section 31 23 16.13 – Trenching
- B. Section 09 91 00 - Painting
- C. Section 21 05 13 – Fire Protection Motors
- D. Section 21 30 00 - Fire Pumps
- E. Section 22 20 00 – Plumbing, Piping, Valves and Fittings

1.4 REFERENCES

- A. ANSI/ASME B16.1 - Cast Iron Pipe Flanges and Flanged Fittings, Class 25, 125, 250, and 800.
- B. ANSI/ASME B16.3 - Malleable Iron Threaded Fittings, Class 150 and 300.
- C. ANSI/ASME B16.4 - Cast Iron Threaded Fittings, Class 125 and 250.
- D. ANSI/ASME B16.5 - Pipe Flanges and Flanged Fittings.
- E. ANSI/ASME B16.9 - Factory-made Wrought Steel Buttwelding Fittings.
- F. ANSI/ASME B16.11 - Forged Steel Fittings, Socket-welding and Threaded.
- G. ANSI/ASME B16.18 - Cast Copper Alloy Solder-Joint Pressure Fittings.
- H. ANSI/ASME B16.22 - Wrought Copper and Copper Alloy Solder Joint Pressure Fittings.
- I. ANSI/ASME B16.25 - Buttwelding Ends.
- J. ANSI/ASME B36.10 - Welded and Seamless Wrought Steel Pipe.

- K. ANSI/ASME Sec 9 - Welding and Brazing Qualifications.
- L. ANSI/ASTM A135 - Electric-Resistance-Welded Steel Pipe.
- M. ANSI/ASTM A47 - Malleable Iron Castings.
- N. ANSI/ASTM B32 - Solder Metal.
- O. ANSI/AWS A5.8 - Brazing Filler Metal.
- P. ANSI/AWWA C110 - Ductile Iron and Gray Iron Fittings.
- Q. ANSI/AWWA C151 - Ductile Iron Pipe, Centrifugally Cast.
- R. ASTM A53 - Pipe, Steel, Black and Hot-Dipped, Zinc-coated Welded and Seamless.
- S. ASTM A120 - Pipe, Steel, Black and Hot-Dipped, Zinc-coated (Galvanized) Welded and Seamless, for Ordinary Uses.
- T. ASTM A234 - Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and Elevated Temperatures.
- U. ASTM A795 - Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless Steel Pipe for Fire Protection Use.
- V. ASTM B75 - Seamless Copper Tube.
- W. ASTM B88 - Seamless Copper Water Tube.
- X. ASTM B251 - General Requirements for Wrought Seamless Copper and Copper-Alloy Tube.
- Y. ASTM F442 - Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe (SDR-PR).
- Z. AWS D10.9 - Specifications for Qualification of Welding Procedures and Welders for Piping and Tubing.
- AA. NFPA 13 - Installation of Sprinkler Systems.
- BB. NFPA 14 - Standpipe and Hose Systems.
- CC. NFPA 24 - Installation of Private Fire Service Mains and Their Appurtenances
- DD. UL - Fire Protection Equipment Directory.
- EE. City of * , Texas, Fire Department Standards.
- FF. State of Texas, State Fire Marshal Rules.
- GG. All hose threads, coupling types, etc., utilized in the fire protection systems shall conform to the standards and requirements of the City of * , Texas Fire Department.

1.5 SUBMITTALS

SECTION 21 13 13 FIRE PROTECTION SYSTEMS

- A. Submit under provisions of Section 21 00 00.
- B. Shop Drawings: Indicate pipe materials used, jointing methods, supports, floor and wall penetration seals. Indicate installation, layout, weights, mounting and support details, and piping connections.
- C. Product Data: Provide data on sprinkler heads, valves, and specialties, including manufacturer's catalogue information. Submit performance ratings rough-in details, weights, support requirements, and piping connections.
- D. Manufacturer's Certificate: Certify that system has been tested and meets or exceeds requirements specified, and suggested by listed codes.
- E. Provide certificate of compliance from authority have jurisdiction indicating approval of field acceptance tests.

1.6 OPERATION AND MAINTENANCE DATA

- A. Submit under provisions of Section 21 00 00.
- B. Maintenance Instructions: Include installation instructions, spare parts lists, procedures, and treatment programs.

1.7 QUALITY ASSURANCE

- A. Sprinkler Systems: Perform work to NFPA 13.
- B. Standpipe and Hose Systems: Perform to NFPA 14.
- C. Welding Materials and Procedures: Perform to ASME Code.
- D. Equipment and Components: Bear FM label or marking. Provide manufacturer's name and pressure rating marked on valve body.
- E. Maintain one copy of each document on site.
- F. Design system under direct supervision of a Professional Engineer experienced in design of this work and licensed in the State of Texas. All design submittal documents and shop drawings shall bear the responsible engineers signed and dated seal.
- G. All parts of fire protection piping systems shall conform to all provisions of Underwriters' Laboratories requirements. All equipment shall bear the Underwriters' Laboratories label of approval.
- H. Determine volume and pressure of incoming water supply from residual pressure water flow test.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Deliver, store, protect, and handle products to site under provisions of Section 21 00 00.
- B. Deliver and store valves in shipping containers, with labeling in place.

SECTION 21 13 13 FIRE PROTECTION SYSTEMS

- C. Provide temporary protective coating on cast iron and steel valves.
- D. Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.

PART 2 - PRODUCTS

2.1 UNIONS:

- A. Provide and install unions at proper points to permit removal of pipe and various equipment and machinery items without injury to other parts of the system. No unions will be required in welded lines. Unions 2 inch and smaller shall be Class 300 AAR threaded malleable iron unions with iron to brass seats, and 2 ½ inch and larger shall be ground flange unions. Companion flanges on lines at various items for equipment machines and pieces of apparatus shall serve as unions to permit removal of the particular items.

2.2 FLANGES:

- A. All 150 lb. and 300 lb. ANSI flanges shall be weld neck and shall be domestically manufactured, forged carbon steel, conforming to ANSI B16.5 and ASTM A-181 Grade I or II or A-105-71 as made by Tube Turn, Hackney or Ladish Company. Slip on flanges shall not be used. Each fitting shall be stamped as specified by ANSI B16.9 and, in addition, shall have the laboratory control number stenciled on each fitting for ready reference as to physical properties and chemical composition of the material. Complete test reports may be required for any fitting selected at random. Flanges which have been machined, remarked, painted or otherwise produced domestically from imported forges will not be acceptable. Flanges shall have the manufacturer's trademark permanently identified in accordance with MSS SP-25. Contractor shall submit data for firm certifying compliance with these Specifications. Bolts used shall be carbon steel bolts with semi-finished hexagon nuts of American Standard Heavy dimensions. Allthread rods will not be an acceptable for flange bolts. Steam system flange bolts shall have a tensile strength of 105,000 psi and an elastic limit of 81,000 psi and rated at least ANSI Grade V. Other bolts shall have a tensile strength of 80,000 psi and an elastic limit of 36,000 psi and rated at least ANSI Grade I.
- B. Flat faced flanges shall be furnished to match 125 lb cast iron flanges on pumps, check valves, strainers, etc. with full flange gaskets. Bolting of raised face flanges to flat faced flanges is not allowed.

2.3 FLANGE GASKETS

- A. Gaskets shall be placed between the flanges of all flanged joints.
- B. Gaskets shall be ring form gaskets fitting within the bolt circle of their respective flanges. Gaskets shall be 1/16" thick asbestos free material recommended for service by Anchor, Garlock, or John Crane. The inside diameter of such gaskets shall conform to the nominal pipe size and the outside diameter shall be such that the gasket extends outward to the studs or bolts employed in the flanged joint.

- C. Spares - Contractor shall provide ten spares for every flange size and rating.

2.4 WALL, FLOOR AND CEILING PLATES:

- A. See Section 21 00 00.

2.5 SLEEVES, INSERTS, AND FASTENINGS:

- A. General: All openings through all floors, walls, and roofs, etc., regardless of material for the passage of piping, etc., shall be sleeved. Refer to Specification Section 21 05 29.

2.6 MATERIALS:

A. PIPING:

1. All pipe used for fire protection standpipe systems and fire sprinkler systems shall be Schedule 40 black steel seamless pipe conforming to ASTM A-795 or ASTM A-53. All piping 2 1/2" and larger shall be welded, unless otherwise indicated herein.
2. Use of piping, when approved by UT System, shall be "roll" grooved type; cut grooved pipe is not permitted.
3. No pipe smaller than 4" nominal pipe size shall be used for standpipe systems except for individual runouts to one hose cabinet. The 1-1/2" or 2-1/2" runout to cabinet shall have a maximum center line height of 60".
4. Scheduled 10 pipe is not permitted.

B. FITTINGS:

1. All welding type steel fittings employed in fabricating fire protection standpipe system and fire sprinkler systems shall conform to A.S.T.M. Specification A-234 and ANSI Standard B16.9-1964. All threaded fittings shall be Class 150 malleable iron fittings conforming to ASME B16.3. Grooved type fittings will not be accepted for use in standpipe systems unless specifically indicated. Pipe size changes shall be performed through the use of reducing tees or reducers designed for that purpose. The use of bushings is explicitly prohibited.
2. Unless otherwise shown or required, all fittings shall be welding type steel fittings. Refer to specification Section 22 20 00.
3. Threaded fittings shall be used when shown and shall be used from the point of connection of the pipe to the riser to each fire hose cabinet. Threaded fittings shall be Crane or Grinnell Company's Class 150 malleable iron fittings.
4. Grooved end couplings 2 1/2" and larger shall be Victaulic Style 07 "Zero-Flex" Rigid Coupling, with EPDM gasket (minimum 700 psi working pressure) for use with roll grooved piping. Products by Gustin-Bacon, Gruvlok are acceptable, or Engineer-approved equal. Reducing type couplings, outlet couplings, "T" outlet fittings, cut-in style fittings, snap joint couplings, and flange adapter type fittings

are not acceptable. Provide grooved fittings similar to standard weld fittings.

5. Extra heavy "Thread-o-lets" shall be used at each point of departure from the riser to the fire hose or valve cabinet. A "Thread-o-let" shall be installed below the level of the valve in the cabinet and a minimum of two (2) threaded ells shall be used to provide a swing joint connection from the riser to the valve in the cabinet.

2.7 VALVES:

- A. General – All shutoff valves shall be UL listed and FM approved for fire protection service.
- B. Shutoff valves for sizes 2 inch and smaller:
 1. Two piece bronze ball valve, bubble-tight shutoff, full port, blow-out proof stem, chrome plated brass ball and silicon bronze stem, threaded end connections, conforming to MSS SP-110.
 2. One piece, butterfly valve, full port, threaded ends, bronze housing and body, stainless steel disc. EPDM disc seal and slow closing.
 3. All valves shall be furnished with two factory mounted internal supervisory switches.
- C. Shut off valves for sizes over 2 inch:
 1. Butterfly valves lug type with EPDM molded in seat liner, ductile iron disc, stainless steel stem, manual gear operator, conforms to MSS SP-67 and MSS SP-25, with integral supervisory switch. Where a grooved piping system is allowed grooved end type butterfly valves may be used, consisting of ductile iron body and disc EPDM seats, stainless steel stem. Valves shall be equipped with internal supervisory switch.
 2. Gate valves – OS&Y (Outside Yoke and Stem) resilient wedge, epoxy coated interior and exterior, ASTM A 536 ductile iron valve body, bonnet and resilient wedge, ASTM B150 stem and flanged ends.
- D. Check valves for sizes 2 inch and smaller:
 1. Horizontal swing, bronze body, conforming to MSS Sp-80, threaded ends and rubber disc.
- E. Check valves for sizes over 2 inch:
 1. Iron body swing-check, bronze disc, seat ring and hinge pin, UL listed and FM approved, flanged ends, renewable seats and disc, tapped $\frac{3}{4}$ inch for ball drip assembly.
- F. Standard of Quality for Fire Protection Valves:

<u>Size</u>	<u>Type</u>	<u>Class</u>	<u>Manufacturer</u>
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2" and Smaller	Ball	300	Nibco No. KT-505-W-8, Stockham No. T-255-FB-P-UL
2" and Smaller	Butterfly	175	Milwaukee No. BB-SC02
2 ½" and Larger	Butterfly (lug)	250	Nibco No. LD3510-8
2 ½" and Larger	Butterfly (grooved)	300	Nibco No. GD-4765-8N
2" and Smaller	Check	200	Nibco No. KT-403-W
2 ½" and Larger	Check	175	Nibco No. F-908-W
2 ½" and Larger	Check (grooved)	250	Nibco No. G-917 W

2.8 BACKFLOW PREVENTERS:

- A. Provide double check valve assembly on fire water service entry inside building, unless local municipality requires a reduced pressure type backflow preventer. Double check valve assembly shall be UL listed, FM approved and ASSE 1015 listed, with flanged OS & Y resilient seated gate valves with type 304 schedule 40 stainless steel housing and sleeve with replaceable check disc rubber, manufactured by Watts No. 757OSY or approved equal by Wilkins or Apollo.

2.9 SPRINKLER SYSTEM

A. SYSTEM DESCRIPTION

1. System to provide coverage for entire building.
2. Provide system to NFPA 13 [light hazard] [ordinary hazard, Group 1] [ordinary hazard, Group 2] [ordinary hazard, Group 3] [extra hazard] occupancy requirements unless otherwise noted. Refer to "FP" drawings for locations of design densities of specific rooms and areas.
3. Interface system with building fire and smoke alarm system.

B. SUBMITTALS

1. Submit under provisions of Section 21 00 00.
2. Preliminary Shop Drawings: Prior to detailed submission, submit preliminary layout of finished ceiling areas indicating only head locations coordinated with ceiling installation.
3. Shop Drawings: Indicate hydraulic calculations, detailed pipe layout, hangers and supports, components and accessories. Indicate system controls.
4. Submit shop drawings, product data, and hydraulic calculations to Factory Mutual for review. Submit copies of all information, and review comments to Architect/Engineer and Owner.

5. Samples: Submit two of each style of sprinkler head specified.

C. PROJECT RECORD DOCUMENTS

1. Submit under provisions of Section 21 00 00.
2. Record actual locations of sprinkler heads and deviations of piping from drawings. Indicate drain and test locations.

D. OPERATION AND MAINTENANCE DATA

1. Submit under provisions of Section 21 00 00.
2. Maintenance Data: Include components of system, servicing requirements, Record Drawings, inspection data, replacement part numbers and availability, and location and numbers of service depot.

E. QUALITY ASSURANCE

1. Perform Work in accordance with NFPA 13.
2. Equipment and Components: Bear FM label or marking.
3. Maintain one copy of all documents on site.

F. EXTRA MATERIALS

1. Furnish under provisions of Section 21 00 00.
2. Provide extra sprinkler heads as suggested under provisions of NFPA 13.
3. Provide suitable wrenches for each head type.
4. Provide metal storage cabinet in location designated.

G. PRODUCTS

1. General: The Contractor shall provide all components required for the complete installation of automatic sprinkler systems as hereinafter specified and indicated on the Drawings.
2. Qualifications of the Installer: The system shall be installed by a firm regularly engaged in the design and installation of automatic sprinkler systems in accordance with requirements of the National Fire Protection Association and Fire Protection and Engineering Bureau of Texas, or by an authorized agent of such firm. Evidence to support the above requirements may be required and any proposed installer who cannot show suitable experience will be rejected.
3. System Layout: The fire sprinkler areas, piping, head locations, etc. as indicated is only for Contractor's reference as to areas to be protected and possible piping routes. If header or manifold sizes are given in the drawings, then the sizes given shall be the minimum sizes installed. Actual number, spacing and location of

heads, size and routes of piping shall be provided in accordance with the applicable Specifications and acceptable Shop Drawings. All layouts, head spacing, coverage, etc., as may be required by the referenced authorities and/or Architectural and Structural conditions shall be made without increase in cost to the Owner or the Architect/Engineer. Modifications to head spacing, pipe routes, etc. shall be closely coordinated with the work of all other trades. The Fire Sprinkler Subcontractor shall be responsible for the design and installation of the fire sprinkler system as described herein and on the project drawings. The piping of the system shall be sized using the "hydraulic" method, as included in NFPA Standard No. 13. Piping sized using the "schedule" method is unacceptable, except where expanding an existing "scheduled" system.

4. Shop Drawings: Shop Drawings shall be submitted prior to fabrication. The Shop Drawings shall include detail plans of sprinkler systems including piping sizes, sections and plot plan indicating the locations of underground supply connections, control valves, fire department connections, and other equipment to be used. The Shop Drawings shall become an integral part of these Specifications.
5. Materials and Equipment:
 - a. General: All materials and equipment used in the installation of the sprinkler system shall be listed as approved by the Underwriters' Laboratories, Inc., List of Inspected Fire Protection Equipment and Materials, or the Factory Mutual Testing Laboratories List of Approved Equipment, Fire Protection Devices and Devices Involving Fire Hazard, and shall be the latest design of the manufacturer. All piping, control valves, drain valves, fittings, etc. shall be as specified under this Section, Fire Protection System, & in Section 22 20 00 utilizing welded, flanged, and threaded fittings only. Where valves are not specified by Figure No. they shall be of specified manufacture, U.L. listed for service, and of same quality level as Figure Nos. specified. All pipe 2 1/2" and larger shall be welded, except as may be allowed herein. All pipe 2" and smaller shall be threaded using Class 150 pound malleable iron, A135 Schedule 40 black steel pipe and fittings. Note that if galvanized pipe or fittings are installed in other than dry systems, the contractor shall be responsible to remove the galvanized pipe or fittings and replace them with specified materials as soon as possible prior to further installation of the system. (EXCEPTION: Dry pipe systems shall be hot dipped galvanized pipe and fittings of same schedule as dry systems, per Factory Mutual recommendations.)
6. Sprinkler Heads:
 - a. Unless otherwise specified or indicated on the Drawings, sprinkler heads shall be quick response type spray heads of the upright or pendant ordinary degree temperature rating type except that sprinkler heads to be installed in the vicinity of heating equipment and lights shall be of the temperature rating required for such locations by National Fire Protection Association Standard No. 13. [Chrome plated bronze heads shall be installed in all locations.]

[Ceiling sprinklers shall be Tyco No. Ty-FRB semi-recessed with white finish and polished chrome plated brass sprinkler head. Uprights shall be Tyco No. Ty-FRB.

- b. Heads shall be located in a symmetrical pattern related to ceiling features such as grid, beams, light fixtures, diffusers, etc., and where applicable, heads shall be located symmetrically with the ceiling grid, centered in two directions.
 - c. The Contractor shall provide spare heads equal to one percent (1%) of the total number of heads installed under the Contract, but not less than ten (10). The heads shall be packed in a suitable wall mounted sprinkler cabinet and shall be representative of, and in proportion to, the number of each type and temperature rating heads installed. In addition to the spare heads, the Contractor shall provide not less than one special sprinkler head wrench for each type of head. The cabinet shall be located where directed by the Construction Inspector.
- 7. Piping: Installation of piping, fittings and valves shall be as specified in Chapter 3, System Components, NFPA Standard No. 13, except where noted otherwise. Piping shall be concealed in all areas with finished ceilings. Piping shall be sterilized as specified in Section 21 20 00. The O.S.& Y. valves shall be provided as specified herein.
 - 8. Note that the use of piping bushings for any purpose is explicitly prohibited.
 - 9. Water Alarm: A water motor alarm shall be connected to each alarm valve and shall discharge to a brass alarm gong located on the exterior of the building as directed by the Architect. Alarm gong finish to be selected by the Architect. The alarm valves shall be Underwriters' Laboratories approved, wet type, connected to water supply and indicated on the Shop Drawings. Each alarm valve shall be provided with a circuit closer. Valves shall conform to the equipment of NFPA Standard No. 13, complete with retarding chamber and pressure switch.
 - 10. Water Flow Alarm Switch: Provide, where indicated on the Drawings, McDonnell UL approved line size flow switches. Flow switch shall be provided with delay, adjustable up to 90 seconds (60 to 90 seconds in Austin). See Division 26 for electrical signal connection by others to these flow switches.

NOTE TO ENGINEER: CONFIRM CAMPUS STANDARD DELAY SETTING, IF ANY, AND SPECIFY INSTALLATION SETPOINT.

H. Add locations and hazards as required by project conditions.

Location	System Type/Hazard
Offices, Lobbies	Light Hazard
Warehouses	Ordinary Hazard, Group 2
Laboratories	Ordinary Hazard, Group 2
Mechanical Rooms	Ordinary Hazard, Group 2

2.10 STANDPIPE SYSTEMS:

- A. General: The Contractor shall provide all components required for the complete installation of standpipe systems as hereinafter specified and indicated on the Drawings.
- B. Qualifications of the Installer: The system shall be installed by a firm regularly engaged in the design and installation of automatic sprinkler systems in accordance with requirements of the National Fire Protection Association and Fire Protection and Engineering Bureau of Texas, or by an authorized agent of such firm. Evidence to support the above requirements may be required and any proposed installer who cannot show suitable experience will be rejected.
- C. System Layout: The fire zones, piping, etc. as indicated is only for Contractor's reference as to areas to be protected and for possible piping routes. If header or manifold sizes are given in the drawings, then the sizes given shall be the minimum sizes installed. Actual number, spacing and locations, size and routes of piping shall be provided in accordance with the applicable Specifications and acceptable Shop Drawings. All layouts, coverage, etc., as may be required by the referenced authorities and/or Architectural and Structural conditions shall be made without increase in cost to the Owner or the Architect/Engineer. Modifications to head spacing, pipe routes, etc. shall be closely coordinated with the work of all other trades. The Fire Sprinkler Subcontractor shall be responsible for the design and installation of the fire system as described herein and on the project drawings.
- D. Shop Drawings: Shop Drawings shall be submitted prior to fabrication. The Shop Drawings shall include detail plans of systems including piping sizes, sections and plot plan indicating the locations of underground supply connections, control valves, fire department connections, and other equipment to be used. The Shop Drawings shall become an integral part of these Specifications. Submit to Factory Mutual for review and comment.
- E. Materials and Equipment:
 - 1. General: All materials and equipment used in the installation of the sprinkler system shall be listed as approved by the Underwriters' Laboratories, Inc., List of Inspected Fire Protection Equipment and Materials, or the Factory Mutual Testing Laboratories List of Approved Equipment, Fire Protection Devices and Devices Involving Fire Hazard, and shall be the latest design of the manufacturer. All piping, control valves, drain valves, fittings, etc. shall be as specified under this Section, utilizing welded, flanged, and threaded fittings only. Where valves are not specified by Figure No. they shall be of specified manufacture, U.L. listed for service, and of same quality level as Figure Nos. specified. All pipe 2 1/2" and larger shall be welded, except as may be allowed herein. All pipe 2" and smaller shall be threaded using Class 150 malleable iron, A120 Schedule 40 black steel pipe and fittings. Note that if galvanized pipe or fittings are installed, the contractor shall be responsible to remove the galvanized pipe or fittings and replace them with specified materials as soon as possible prior to further installation of the system.

2.11 FIRE DEPARTMENT SIAMESE CONNECTIONS:

- A. At the points designated on the accompanying Drawings, install Siamese fittings required for fire protection purposes. From a point on the incoming water supply line, the Contractor shall extend water line for fire protection purposes to Siamese connections.
- B. Provide 2 way wall type Siamese connection equal to Potter Roemer No. ____ double clapper flush type Siamese connections with 2 ½ outlets having threads complying with the requirements of the Fire Department of the City of ____*. They shall have proper caps with pin type lugs attached to the body of the Siamese connections with substantial chains. The plate fitting against the building shall have raised letters reading "AUTOMATIC SPRINKLER" or "STANDPIPE". All external surfaces shall be chromium plated polished surfaces or as directed by Architect.
- C. Provide [2 way] [3way] [4 way] [6 way] free standing type Siamese shall be equal to Potter-Romer No. ____ cast brass body with 2 ½" outlets and escutcheon. They shall have proper caps with pin type lugs attached to the body of connection with substantial chains. "STANDPIPE" or "AUTOMATIC SPRINKLER" is to be cast on head of connection. All external surfaces shall be chromium plated polished surfaces or as directed by Architect.

2.12 ROOF MANIFOLDS:

- A. Roof manifolds shall be equal to Potter Roemer cast brass Underwriters' Laboratory listed horizontal roof manifold. Complete with listed brass manufactured by Potter Roemer No. ____ valve and 2-1/2" brass caps and chains, [2 way] [3 way] outlets shall be 7-1/2 threads per inch iron pipe size.
- B. Systems shall be flushed through a temporary hose until the system is clean. Any leaks found shall be remedied in each instance in a manner approved in advance by the Owner's duly authorized representative. The systems shall be alternately tested and repaired where necessary until they have demonstrated their capability to withstand the test pressure for a period of 24 hours without any appreciable drop in the test pressure initially applied.

PART 3 - EXECUTION

3.1 PREPARATION - ALL SYSTEMS:

- A. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.
- B. Remove scale and foreign material, from inside and outside, before assembly.
- C. Prepare piping connections to equipment with flanges or unions.
- D. Flush entire system of foreign matter prior to installation of sprinkler heads.

3.2 SYSTEM TESTS

- A. Hydrostatically test entire standpipe system in accordance with NFPA 14 and sprinkler system in accordance with NFPA 13, with a pressure of 200 psi maintaining that pressure

with loss for 24 hours. Where portions of the system exceeds 150 psi working per the system shall be tested at a pressure of 50 psi in excess of the system working pressure for a 24 hour period.

B. Test shall be witnessed by campus Fire Marshal.

3.3 INSTALLATION

A. SPRINKLERS

1. Install piping in accordance with NFPA 13 for sprinkler systems, NFPA 14 for standpipe and hose systems, and NFPA 24 for service mains. Note that the piping sizes indicated in the plans are the minimum acceptable. The Qualified Contractor shall provide proper sizes, materials and installation as required in the appropriate NFPA Standard.
2. Route piping in orderly manner, plumb and parallel to building structure. Maintain gradient. See Section 21 00 00 and 21 05 29.
3. Slope piping and arrange systems to drain at low points. Use eccentric reducers to maintain top of pipe level.
4. Provide drain valves at main shut-off valves, low points of piping and apparatus. Provide Fire Department test station, piped to drain.
5. Locate outside alarm gong on building wall as indicated.
6. Place pipe runs to minimize obstructions with other work.
7. Place piping in concealed spaces above finished ceilings.
8. Center heads in two directions in ceiling tile and provide piping offsets as required.
9. Apply paper cover to ensure concealed sprinkler head and cover plates do not receive field paint finish.
10. Install and connect fire pumps in accordance with Section 21 30 00 and NFPA 13.
11. Locate fire department connection with sufficient clearance from walls, obstructions, or adjacent Siamese connectors to allow full swing of fire department wrench handle.

B. STANDPIPES

1. Fire standpipe risers shall be located at the stairs as shown on the drawings. System shall be [empty (dry without air pressurization) and] shall be complete with fire valves for Fire Department hose connections.
2. Install in accordance with manufacturer's instructions.
3. Install in accordance with NFPA 14 for standpipe and hose systems.

4. Locate and secure hose cabinet plumb and level. Establish top of cabinet surface 66 inches above finished floor.
5. All polyester hoses must be new and unused at the time of acceptance of the project.
6. Locate angle valve in cabinet at 60 inches above floor.
7. Locate dry chemical fire extinguisher in cabinet.
8. Connect standpipe system to water source ahead of domestic water connection.
9. Where static pressure exceeds 100 psi at any hose station, provide pressure reducing valve to prevent pressure on hose exceeding 90 psi.
10. Provide [two-way] [three-way] fire department outlet connection on roof.

END OF SECTION

**SECTION 21 30 00
FIRE PUMPS**

PART 1 - GENERAL

1.1 THE FOLLOWING SECTIONS ARE TO BE INCLUDED AS IF WRITTEN HEREIN:

- A. Section 21 00 00 – Basic Fire Protection Requirements
- B. Section 21 05 29 – Fire Protection Supports and Sleeves
- C. Section 21 05 13 – Fire Protection Motors
- D. Section 21 05 53 – Fire protection Piping and Equipment Identification

1.2 SECTION INCLUDES

- A. Fire pump package
- B. Fire pump [motor] [engine]
- C. Electric jockey pump
- D. Controllers
- E. Fire Pump Test Header
- F. Flow metering device

1.3 RELATED SECTIONS

- A. Section 21 05 13 – Fire Protection Motors
- B. Section 21 13 13 - Fire Protection Systems
- C. Section 26 27 26 - Equipment Wiring Systems

1.4 REFERENCES

- A. Factory Mutual System (FM) - Approval Guide
- B. NEMA MG-1 - Motors and Generators
- C. NEMA 250 - Enclosures for Electrical Equipment (1000 Volt Maximum)
- D. NFPA 20 - Installation of Centrifugal Fire Pumps
- E. NFPA 24 - Private Fire Service Mains and their Appurtenances
- F. NFPA 37 - Installation and use of Stationary Combustion Engines and Gas Turbines
- G. UL - Fire Protection Equipment Directory
- H. UL 448 - Pumps for Fire Protection Service
- I. UL 778 - Motor Operated Water Pumps
- J. UL 1247 - Diesel Engines for Driving Centrifugal Fire Pumps
- K. UL 1478 - Fire Pump Relief Valves

1.5 SYSTEM DESCRIPTION

- A. [Electric motor] [Diesel engine] driven horizontal, double inlet, split case fire pump with jockey pump [electric controllers] [diesel engine controller].

1.6 SUBMITTALS

- A. Submit under provisions of Section 21 00 00.
- B. Shop Drawings: Indicate layout, general assembly, components, dimensions, weights, clearances, and methods of assembly.
- C. Product Data: Provide manufacturers literature including general assembly, pump curves showing performance characteristics with pump and system with operating point indicated, NPSH curve, controls, wiring diagrams, and service connections.
- D. Manufacturer's Installation Instruction: Indicate support details, connection requirements, and include start-up instructions for fire pump system.
- E. Manufacturer's Certificate: Certify that fire pump(s) meet or exceed specified requirements at specified operating conditions. Submit summary and results of shop tests performed in accordance with NFPA 20.
- F. Field Reports: Indicate summary of hydrostatic test and field acceptance tests performed in accordance with NFPA 20.

1.7 OPERATION AND MAINTENANCE DATA

- A. Submit under provisions of Section 21 00 00.
- B. Operation Data: Include manufacturer's instructions, start-up data, trouble-shooting checklists, for pumps, drivers, and controllers.
- C. Maintenance Data: Include manufacturer's literature, cleaning procedures, replacement parts lists, and repair data for pumps, drivers and controllers.

1.8 QUALITY ASSURANCE

- A. Perform work in accordance with NFPA 20.
- B. Equipment and Components: Bear UL and FM label or marking.
- C. Maintain one copy of each document onsite.

1.9 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing the products specified in this Section with minimum three years documented experience.
- B. Installer: Company specializing in performing the work of this Section with minimum three years documented experience.

1.10 REGULATORY REQUIREMENTS

- A. Conform to NFPA 20 for installation and testing of fire pumps, drivers, and controllers.
- B. Provide certificate of compliance from authority having jurisdiction indicating approval of field acceptance tests.

1.11 DELIVERY, STORAGE, AND HANDLING

- A. Delivery, store, protect and handle products to site under provisions of Section 21 00 00.
- B. Accept fire pumps and components on site in factory packing. Inspect for damage. Comply with manufacturers rigging and installation instructions.
- C. Protect fire pumps and components from physical damage including effects of weather, water, and construction debris.
- D. Provide temporary inlet and outlet caps, and maintain in place until installation.

1.12 MAINTENANCE SERVICE

- A. Furnish service and maintenance of fire pump, driver, and controller for one year from date of Substantial Completion.

1.13 EXTRA MATERIALS

- A. Furnish under provisions of Section 21 00 00.
- B. Provide one complete set of gaskets, screens, and seals for each pump type and model supplied.

PART 2 - PRODUCTS

2.1 HORIZONTAL BASE MOUNTED PUMPS

- A. Type: NFPA 20 compliant UL 448 and UL 778 listed, horizontal shaft, single stage, double suction, direct connected, horizontally split casing, pump suction flange shall be rated for 125 psi working pressure on inlet side and the discharge flanged shall be rated for 250 psi, manufactured by Aurora, Peerless, Patterson or AC.
- B. Casing: Cast iron, with suction and discharge gage ports, renewable bronze casing wearing rings, seal flush connection, drain plug, flanged suction and discharge.
- C. Impeller: Bronze double suction fully enclosed, balanced and keyed to shaft.
- D. Bearings: Grease lubricated ball bearings, replaceable without opening casing.
- E. Shaft: Alloy steel with replaceable bronze shaft.
- F. Seal: Packing gland with minimum four rings graphite impregnated packing and bronze lantern rings, 230 degrees F maximum continuous operating temperature.
- G. Drive: Flexible coupling with coupling guard.
- H. Baseplate: Cast iron with integral drain rim.
- I. Motor: Squirrel cage induction type in open drip proof NEMA MG-1 enclosure [1750] [3450] RPM

2.2 FIRE PUMP ACCESSORIES

- A. Eccentric suction reducer and OS&Y gate or butterfly valve on suction side of pump.
- B. Concentric increaser and check valve in pump discharge and OS&Y gate or butterfly valve on system side of check valve.
- C. Fire pump bypass fitted with OS&Y gate or butterfly valves and check valve.

- D. Main relief valve, UL 1478, and open type waste cone.
- E. Suction pressure gage, 4 1/2 inch diameter dial with snubber, valve cock and lever handle.
- F. Discharge pressure gage mounted on board attached to pump, with snubber, valve cock and lever handle.
- G. Casing 3/4 inch relief valve.
- H. Float operated 3/4 inch automatic air release valve.
- I. Provide a wall mounted fire pump test header, consisting of a ductile iron body,(3) 2-1/2" swivel inlet hose gate valves with male hose threaded outlet, angle style 6" inlet, fire pump test connection, complete with polished chrome plated exposed surfaces, with plate lettered "Pump Test Connection", manufactured by Potter Roemer No. 5863-7-13-D, or approved equal.
- J. Provide flow metering system for closed loop testing. The flow meter shall be FM approved for testing fire pumps, flanged venture type BV manufactured by Aeroequip, or approved equal.

2.3 ELECTRIC MOTOR DRIVE

- A. Combination Fire Pump Controller/Automatic Transfer Switch: The fire pump controller/automatic transfer switch shall be of the combined manual and automatic type, solid state reduced voltage, minimum, 100,000 amp withstand rating, full service, and UL listed and FM approved per NFPA 20 currently enforced. The fire pump controller/automatic transfer switch shall be housed in a NEMA 2 floor-mounted, non-vented enclosure, mounted on a 4" thick concrete pad, and include the following:
 - 1. Isolation switch with a separate NEMA operating handle interlocked with circuit breaker.
 - 2. Time delay circuit breaker set at 300 percent motor full load current with external LED supervised locked rotor protector, instant and time delay trip test switch, and external NEMA operator handle.
 - 3. Differential adjustable pressure switch with energize to start relay.
 - 4. Minimum run timer, 10 minutes non-adjustable, with timed out LED indicator.
 - 5. POWER AVAILABLE and PHASE REVERSAL pilot lights wired to the line side of the motor starter. Indicating lights shall be long life LEDs.
 - 6. Digital ammeter and voltmeter with three phase selector switch, calibrated traceable to NBS standards.
 - 7. Built in alarm panel and supervisory power pilot light powered from separate reliable 120 VAC power source with lights, bell, silence button, and lamp test switch for indication of PUMP RUNNING, POWER FAILURE, PHASE REVERSAL, TRANSFER SWITCH IN EMERGENCY, ISOLATION SWITCH OPEN. A status panel for start and run demands shall also be included. All indicating lights shall be long life LEDs with lamp test feature.
 - 8. START and STOP pushbuttons for manual control.
 - 9. Two sets each of dry form "C" contacts for remote indication at main fire alarm panel for PUMP RUNNING, POWER FAILURE, PHASE REVERSAL, TRANSFER SWITCH IN EMERGENCY, ISOLATION SWITCH OPEN, and SUPERVISORY POWER FAILURE.
 - 10. Digital paperless alarm recorder.

11. Three non-fused control power transformers, surge protector wired to the load side of the isolation switch with short circuit protection, magnetic contactors with externally operable mechanical start mechanism, and restart delay timer.
 12. Automatic transfer switch housed in a separate compartment of the fire pump controller. The transfer switch shall have normal power light and monitors, emergency power light and monitor, test switch, and time delays for generator start, transfer to emergency, and retransfer to normal. All control and monitoring components shall be individually serviceable. Unit shall have, as a minimum, a 5 year warranty on parts and a 2 year warranty on labor.
 13. The fire pump controller and transfer switch shall be for fire pump scheduled horsepower, UL 1008 listed, 460 volt, 3 phase motor. Manufactured by Firetrol No. FTA1900, or approved equal by Master or Metron.
- B. The fire pump controller/ATS shall also have the following control functions:
1. Provide an interlock between the fire pump controller and ATS that will when the fire pump is running, inhibit the automatic transfer switch from "TRANSFERRING-TO-NORMAL" power source as long as the fire pump is operating on the "EMERGENCY" source.
 2. Interlock control wiring from the Fire Pump Controller to the Fire Pump Automatic Transfer Switch shall be factory-installed.

2.4 DIESEL ENGINE DRIVE

- A. Diesel Engine: Conform to NFPA 1247, arranged for automatic operation and include overspeed/overcrank switch and drive, two contactor switches, low oil pressure and high water temperature warning switches, and fuel shut-off solenoid, with wiring terminating in junction box.
- B. Include following engine accessories:
 1. Stub shaft
 2. Oil bath air cleaner
 3. Water cooled exhaust manifold
 4. Heat exchanger
 5. Mechanical speed governor
 6. Fuel filter
 7. Lube oil filter and by-pass valve
 8. Lube oil cooler and relief valve
 9. Fuel pump
- C. Instrument panel with tachometer, hour meter, oil pressure gauge, water temperature gauge, ammeter, hand speed control and start switch.
- D. Starting system including generator/alternator, starting motor and voltage regulator.

NOTE TO SPECIFICATION WRITER: VERIFY RESIDENTIAL GRADE SILENCER MEETS PROJECT REQUIREMENTS.

- E. Exhaust silencer, residential type.

- F. Flexible exhaust tubing, minimum 24 inches long.
- G. Cooling water system: Closed system with cooling water supply to heat exchanger from fire pump discharge. Include four (4) manual shut-off valves (including by- pass line), two strainers, pressure regulating valve, automatic solenoid valve and pressure gauge.
- H. Storage batteries: Dual lead acid batteries with cables and battery racks.
- I. Fuel system: [250] [____] gallon above ground, integral base-enclosed storage tank, fill pipe and cap, manual shut-off valve, flame arrestor, oil level gauge, braided bronze flexible connectors, seamless type L copper tubing with flared joints.
- J. Automatic diesel engine controller: Enclosed in floor mounted 14 gage steel housing, UL listed and labeled.
 - 1. Controller: Function to automatically start fire pump from water pressure control switch or test switch.
 - 2. Stop push button: To manually stop engine.
 - 3. Automatic conditions: Controller shall alternate batteries automatically on each 15 second cranking cycle. Alarm if engine not started after six attempts.
 - 4. Battery charger: Dual, built-in, to recharge both batteries within 24-hour period, with automatic overload protection (current limiting), individual voltmeters and ammeters for each battery.
 - 5. Individual pilot lights and common alarm bell for:
 - a. Low Engine Oil Pressure
 - b. High Engine Jacket Water Temperature
 - c. Failure to Start Automatically
 - d. Charger Failure
 - e. Battery 1 Failure
 - f. Battery 2 Failure
 - g. Overspeed Shutdown
 - 6. Power: [____] volt, single phase, 60 Hz.
- K. Remote Alarm and Signal Panel: Provide wall mounted panel in NEMA 250 Type 1 enclosure with:
 - 1. Engine running light.
 - 2. Common engine failure light for:
 - a. Low Engine Oil Pressure
 - b. High Engine Jacket Water Temperature
 - c. Failure to Start Automatically
 - d. Charger Failure

- e. Battery 1 Failure
 - f. Battery 2 Failure
 - g. Overspeed Shutdown
 - h. Low Engine Oil Pressure
 - i. High Engine Jacket Water Temperature
 - j. Failure to Start Automatically
 - k. Charger Failure
 - l. Battery 1 Failure
 - m. Battery 2 Failure
 - n. Overspeed Shutdown
- 3. Power on light.
 - 4. Switch off light indicating position of main control switch (off or manual).
 - 5. Power: [] volt, single phase, 60 Hz.

2.5 PRESSURE BOOSTER (JOCKEY) PUMP

- A. Electrically operated, vertical multi-stage centrifugal type with standard open drip-proof motor manufactured by Grundfos, Aurora, Armstrong or Gould.
- B. Performance: As scheduled on drawings.
- C. Control by automatic jockey pump controller with full voltage starter and minimum run timer to start pump on pressure drop in system and stay in operation for minimum period of time. Fire pump shall start automatically on further pressure drop or on jockey pump failure.
- D. Relief Valve: Provide the fire jockey pump with a factory-mounted bypass relief valve complete with piping. Set relief valve to relieve at a pressure of 25 psig above design total dynamic head to prevent motor overload and system damage
- E. The electric jockey pump controller shall be UL listed and NEC compliant. Unit shall include a circuit breaker, magnetic starter with overloads, 0-300 psig pressure switch, H-O-A selector switch, minimum run timer, dual fused control transformer, two sets of remote form "C" contacts for pump running, and a NEMA 2 enclosure, Master control Model PMC series, or Firetrol Model FTA500, or Metron.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. All installation shall be in accordance with manufacturer's instructions.
- B. Install diesel engine drive to NFPA 37.
- C. Provide access space around pumps for service. Provide no less than minimum as recommended by manufacturer.

- D. Decrease from line size with long radius reducing elbows or reducers. Support piping adjacent to pump such that no weight is carried on pump casings. For base mounted pumps, provide supports under elbows on pump suction and discharge. Refer to Section 21 13 13.
- E. Provide drains for bases and seals, piped to and discharging into floor drains.
- F. Mount unit on vibration isolators. Refer to Section 21 05 48.
- G. Provide piping for fuel supply and return connected to motor. Provide piping to and from exhaust silencer with thimble at wall or roof penetrations. Refer to Section 22 13 16.
- H. Provide for connection to electrical service. Refer to Section 26 27 26.
- I. Lubricate pumps before start-up.
- J. Check, align, and certify base mounted pumps by qualified millwright prior to start-up.
- K. Installation shall meet or exceed all applicable, state requirements and referenced standards having jurisdiction.
- L. Provide piping to, and route discharge from all relief valves and drains to exterior of building and terminate at a location and in a manner to prevent any damage to surrounding areas.

3.2 FIELD QUALITY CONTROL

- A. Perform field inspection and hydrostatic field tests on entire system in accordance with NFPA 20.

END OF SECTION

**SECTION 22 11 23
PLUMBING EQUIPMENT**

PART 1 GENERAL

1.00 The following sections are to be included as if written herein:

- A. Section 23 00 00 – Basic Mechanical Requirements
- B. Section 23 05 29 – Sleeves, Flashings, Supports and Anchors
- C. Section 23 05 53 – Mechanical Identification

1.01 SECTION INCLUDES

- A. Water Heaters
- B. Packaged Water Heating Systems
- C. Domestic Water Heat Exchangers
- D. Water Storage Tanks
- E. Pumps
- F. Water Pressure Booster System

1.02 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION

- A. Section 01 11 00 - Summary of Work: Owner installed water storage tanks.
- B. Section [____ - _____]: Placement of water storage tanks.

1.03 PRODUCTS INSTALLED BUT NOT FURNISHED UNDER THIS SECTION

- A. Section 01 11 00 - Summary of Work: Owner furnished water storage tanks.
- B. Section [____ - _____]: Supply of water storage tanks for placement by this Section.

1.04 RELATED SECTIONS

- A. Section 23 05 48 - Vibration Isolation

- B. Section 26 05 19 - Cable, Wire and Connectors, 600 Volt: Electrical characteristics, cable, wire, materials
- C. Section 26 27 26 - Wiring Devices and Floor Boxes: Wiring connections

1.05 REFERENCES

- A. ANSI/ASHRAE 90A - Energy Conservation in New Building Design
- B. ASME Section VIII D - Pressure Vessels; Boiler and Pressure Vessel Codes
- C. ANSI/NFPA 30 - Flammable and Combustible Liquids Code
- D. ANSI/NFPA 54 - National Fuel Gas Code
- E. ANSI/NFPA 58 - Storage and Handling of Liquefied Petroleum Gases
- F. ANSI/NFPA 70 - National Electrical Code
- G. ANSI/UL 1453 - Electric Booster and Commercial Storage Tank Water Heaters
- H. ANSI/UL 174 - Household Electric Storage Tank Water Heaters
- I. ANSI/NEMA 250 - Enclosure for Electrical Equipment (1000 Volts Maximum)

1.06 SUBMITTALS

- A. Submit under provisions of Section 23 00 00.
- B. Shop Drawings:
 - 1. Include heat exchanger dimensions, size of tapings, and performance data.
 - 2. Include dimensions of tanks, tank lining methods, anchors, attachments, lifting points, tapings, and drains.
- C. Product Data:
 - 1. Include dimension drawings of water heaters indicating components and connections to other equipment and piping.
 - 2. Indicate pump type, capacity, power requirements, and affected adjacent construction.

3. Submit certified pump curves showing pump performance characteristics with pump and system operating point plotted. Include NPSH curve when applicable.
4. Provide electrical characteristics and connection requirements.

D. Manufacturer's Installation Instructions.

1.07 OPERATION AND MAINTENANCE DATA

- A. Submit under provisions of Section 23 00 00.
- B. Include operation, maintenance, and inspection data, replacement part numbers and availability, and service depot location and telephone number.

1.08 QUALITY ASSURANCE

- A. Perform Work in accordance with State of Texas Department of Health Standards.
- B. Provide pumps with manufacturer's name, model number, and rating/capacity identified.
- C. Ensure products and installation of specified products are in conformance with recommendations and requirements of the following organizations:
 1. American Gas Association (AGA).
 2. National Sanitation Foundation (NSF).
 3. American Society of Mechanical Engineers (ASME).
 4. National Board of Boiler and Pressure Vessel Inspectors (NBBPVI).
 5. National Electrical Manufacturers' Association (NEMA).
 6. Underwriters Laboratories (UL).
- D. Ensure pumps operate at specified system fluid temperatures without vapor binding and cavitation, are non-overloading in parallel or individual operation, operate within 10 percent of midpoint of published maximum efficiency curve.

1.09 REGULATORY REQUIREMENTS

- A. Conform to AGA, NSF, ANSI/NFPA 54, ANSI/NFPA 58, ANSI/NFPA 70, ANSI/UL 174, and ANSI/UL 1453, as appropriate, requirements for water heaters.

- B. Conform to ASME Section VIII D for manufacture of pressure vessels for heat exchangers.
- C. Conform to ASME Section VIII D, ANSI/NFPA 30, or ANSI/NFPA 31 for tanks.

1.10 DELIVERY, STORAGE, AND HANDLING

- A. Deliver, store, protect and handle products to site under provisions of Section 23 00 00.
- B. Provide temporary inlet and outlet caps. Maintain caps in place until installation.

1.11 WARRANTY

- A. Provide five-year warranty under provisions of Section 23 00 00.
- B. Warranty: Include coverage of domestic water heaters, water storage tanks, packaged water heating systems, in-line circulator, submersible sump pumps, sump pumps, sewage ejectors.

PART 2 PRODUCTS

2.01 DOMESTIC HOT WATER STORAGE GENERATOR (STEAM):

- A. Furnish and install where shown on Drawings (horizontal) (vertical) hot water storage generators with dimensions and capacities as scheduled on the Drawings, or outlined herein. Specifications are given for both copper and nickel lined tanks. Either construction will be acceptable for installation in this project, providing the generator conforms to the provisions of this specification. The manufacturers mentioned in this Specification or on the Drawings are entered for the purposes of indicating acceptable manufacturers, and establishing a standard of quality for the equipment to be provided for this project. The equipment as supplied by any of these acceptable manufacturers, or an approved equal, shall comply with all of the provisions of this specification.
- B. The shell and heads of the vessel shall be constructed of ASME Code quality steel with all seams welded. The vessel shall be designed and fabricated for a minimum of 125 pounds per square inch working pressure. All tanks shall be hydrostatically tested to 150 percent of the working pressure in accordance with ASME Code and so inspected and stamped.
- C. Controls: There shall be a minimum of two operating thermostats. These operating controls should be set at 120 degrees F. for the lower and 130 degrees F. for the upper

with a maximum circulating water temperature in the plumbing system not to exceed 130 degrees F. There shall be one temperature limiting device designed to prevent temperatures from exceeding a maximum of 200 degrees F. There shall also be an ASME temperature and pressure relief valve set at not more than 125 psi and 205 degrees F. A thermal expansion control valve shall be installed in the cold section of the tank, set to relieve pressures of no greater than 100 psi.

- D. Insulation: The tank shall be insulated with a heavy density fiberglass insulation and shall be jacketed with a minimum of 22 gauge aluminum sheet metal. Non-aluminum sheet jacketing shall be protected with a factory baked enamel finish. The heat loss of the insulated tank shall not exceed 14 Btu/hr. per square foot of tank surface area at an ambient temperature of 65 degrees F. The entire water heater shall rest on galvanized or baked enamel protected channel iron skids.
- E. Option A - Nickel Lined Tank: The Nickel lined (plated) tank shall be constructed in accordance with ASME Code Section IV, stamped with the appropriate symbol, and hydrostatically tested at a minimum of 190 psi. The tank shall have a removable manway entry into the vessel with a minimum diameter of 23 inches. The tank may be of modular design where more than one tank module will be required to meet the total gallon capacity, however the total space required shall not exceed the footprint shown in the Drawings, and the total tank capacity shall be as scheduled on the Drawings. The tank shall contain a baffle to divert the incoming cold water to allow 80 percent of the total tank storage to be effective at a useable temperature of within 5 degrees F. from the set point of the operating thermostats. All fittings shall be of Type K heavy copper, and shall be welded to the tank prior to the application of the nickel plating, and subsequent application of the polymer coating.
1. Lining: The tank shall be completely lined, inside and out, with 97 percent pure nickel. The method of applying the nickel shall be by non-electric, chemical deposition method, creating a holiday-free, nonferrous layer of nickel over the interior of the vessel. The nickel lined tank shall have an additional interior overcoat of an elastomeric, polymeric, hydrophobic cross-linked plastic to prevent any electrolysis that may develop within the plumbing system. Note: Sacrificial anodes will not be required.
 2. Steam Heat Exchanger: The heat exchanger element shall have the capacity as scheduled on the Drawings. The steam heat exchanger shall produce a minimum of the capacity listed for a water source temperature of 40 degrees F. and heat the water to a temperature of 120 degrees F. when supplied with 15 psi steam. This installation will be supplied with the quality of steam indicated on the Drawings. The steam heat exchanger shall produce a minimum of 1300 Btu/degree F /square foot of heating surface. All internal wetted parts shall be made of 9010 copper-nickel.

3. Manufacturer: Nickel lined generators shall be manufactured by PVI Industries, Fort Worth, Texas.
- F. Option B - Copper Lined Tank: Extra heavy copper silicon threaded or flanged openings shall be provided for inlet, outlet, drain, recirculation, relief valve, vacuum breaker, thermometer, pressure gauge and thermostat. One 11" x 15" manhole shall be provided, having copper lined ring and cover. Nozzles and couplings shall be ASTM SB466 alloy CDA710 annealed (80-20 copper nickel). The vessel shall be lined with 3 lb. per square foot deoxidized electrolytic sheet copper, attached to the steel shell and to all fittings by inert gas, shielded arc welding. Lining shall be installed so that stored water contacts only nonferrous metals, and is to be tested and proven free of leaks prior to shipment. The annulus between the tank shell and lining shall be pressurized to 1-1/2 psi and soap applied to all welded seams to test for leakage. The quantity of 1-1/2" vacuum breakers shall be as recommended and furnished by the tank manufacturer. All connections to the tank, whether just a fitting or pipe connection, shall be made with properly installed dielectric fittings.
1. Exterior Covering: Exterior of vessel shall be painted with two coats of red oxide primer. The vessel shall be insulated by the manufacturer as described above under "Insulation."
 2. Steam Heat Exchanger: The heat exchanger element shall have the capacity as scheduled on the Drawings. The heating element shall consist of (3/4" o.d. x 18 gauge, vertical tanks) (1-1/2" o.d. x 16 gauge, horizontal tanks), seamless copper U-tubes expanded into a solid bronze tube sheet. Element head shall be cast iron. If heating element exceeds two feet (2 feet) in length, a solid bronze spacer plate shall be provided. If heating element length is four feet (4 feet) or longer, a solid bronze element support shall be provided. The heating element length shall be at least two-thirds (2/3) of the (length horizontal) (diameter vertical) of the tank. The nozzle into which the element is inserted shall be constructed with neck portion of solid copper silicon to which the steel slip-on flange is welded.
 3. Manufacturer: Copper lined generators shall be manufactured by Adamson Company, Inc., East Palestine, Ohio, or Aerco International, Inc., Northvale, New Jersey.
- G. Tank Warranty: Generator tanks shall have a minimum of an eight (8) year warranty to protect the owner against defects in material and workmanship, discolored water or tank perforation due to erosion and corrosion. Should the tank or liner fail for any reason within the first eight full years after startup, the manufacturer shall, at the owners option, pay for all repairs or replacement, including material, labor, incidental costs, and freight. The tank warranty must be submitted with the total package submittals. The submission of any submittal with a warranty less than that described,

or the absence of a warranty with the submittal, will be sufficient cause for complete submittal rejection.

- H. Heat Exchanger Warranty: The heat exchanger shall have a minimum of a three (3) year warranty against material and workmanship, corrosion and erosion, thermal shock, and fouling. All material, labor, freight, and incidental expenses shall be the responsibility of the manufacturer, should the warranty be exercised. The heat exchanger warranty must be submitted with total package submittals. The submission of any warranty less than that described, or the absence of a warranty with the submittal, will be sufficient cause for complete submittal rejection.
- I. Startup: The hot water generators shall be started up by a factory supplied startup engineer. The factory engineer shall also provide a technical and practical operation and maintenance training seminar including a hands-on operation and maintenance demonstration, and classroom presentation with handouts and visual aids, for no less than three physical plant personnel.

2.02 DOMESTIC HOT WATER STORAGE GENERATOR (GAS FIRED):

- A. Furnish and install where shown on Drawings (horizontal) (vertical) controlled combustion, natural gas, fired tube water heaters, with dimensions and capacities as scheduled on the Drawings, or as outlined herein. Specifications are given for both copper and nickel lined tanks. Either construction will be acceptable for installation in this project, providing the water heater conforms to the provisions of this specification. The manufacturers mentioned in this Specification or on the Drawings are entered for the purposes of indicating acceptable manufacturers, and establishing a standard of quality for the equipment to be provided for this project. The equipment as supplied by any of these acceptable manufacturers, or an approved equal, shall comply with all of the provisions of this specification.
- B. The shell and heads of the vessel shall be constructed of ASME Code quality steel with all seams welded. The vessel shall be designed and fabricated for a minimum of 125 pounds per square inch working pressure. All tanks shall be hydrostatically tested to 150 percent of the working pressure in accordance with ASME Code and so inspected and stamped.
- C. Controls: There shall be a minimum of two operating thermostats. These operating controls should be set at 120 degrees F. for the lower and 130 degrees F. for the upper with a maximum circulating water temperature in the plumbing system not to exceed 130 degrees F. There shall be one temperature limiting device designed to prevent temperatures from exceeding a maximum of 200 degrees F. There shall also be an ASME temperature and pressure relief valve set at not more than 125 psi and 205

degrees F. A thermal expansion control valve shall be installed in the cold section of the tank, set to relieve pressures of no greater than 100 psi.

- D. Insulation: The tank shall be insulated with a heavy density fiberglass insulation and shall be jacketed with a minimum of 22 gauge aluminum sheet metal. Non-aluminum sheet jacketing shall be protected with a factory baked enamel finish. The heat loss of the insulated tank shall not exceed 14 Btu/hr. per square foot of tank surface area at an ambient temperature of 65 degrees F. The entire water heater shall rest on galvanized or baked enamel protected channel iron skids.
- E. Option A - Nickel Lined Tank: The Nickel lined (plated) tank shall be constructed in accordance with ASME Code Section IV, stamped with the appropriate symbol, and hydrostatically tested at a minimum of 190 psi. The tank shall have a removable manway entry into the vessel with a minimum diameter of 23 inches. The tank may be of modular design where more than one tank module will be required to meet the total gallon capacity, however the total space required shall not exceed the footprint shown in the Drawings, and the total tank capacity shall be as scheduled on the Drawings. The tank shall contain a baffle to divert the incoming cold water to allow 80 percent of the total tank storage to be effective at a useable temperature of within 5 degrees F. from the set point of the operating thermostats. All fittings shall be of Type K heavy copper, and shall be welded to the tank prior to the application of the nickel plating, and subsequent application of the polymer coating.
1. Lining: The tank shall be completely lined, inside and out, with 97 percent pure nickel. The method of applying the nickel shall be by non-electric, chemical deposition method, creating a holiday-free, nonferrous layer of nickel over the interior of the vessel. The nickel lined tank shall have an additional interior overcoat of an elastomeric, polymeric, hydrophobic cross-linked plastic to prevent any electrolysis that may develop within the plumbing system. Note: Sacrificial anodes will not be required.
 2. Manufacturer: Nickel lined water heaters shall be manufactured by PVI Industries, Fort Worth, Texas.
- F. Option B - Copper Lined Tank: Extra heavy copper silicon threaded or flanged openings shall be provided for inlet, outlet, drain, recirculation, relief valve, vacuum breaker, thermometer, pressure gauge and thermostat. One 11" x 15" manhole shall be provided, having copper lined ring and cover. Nozzles and couplings shall be ASTM SB466 alloy CDA710 annealed (80-20 copper nickel). The vessel shall be lined with 3 lb. per square foot deoxidized electrolytic sheet copper, attached to the steel shell and to all fittings by inert gas, shielded arc welding. Lining shall be installed so that stored

water contacts only nonferrous metals, and is to be tested and proven free of leaks prior to shipment. The annulus between the tank shell and lining shall be pressurized to 1-1/2 psi and soap applied to all welded seams to test for leakage. The quantity of 1-1/2" vacuum breakers shall be as recommended and furnished by the tank manufacturer. All connections to the tank, whether just a fitting or pipe connection, shall be made with properly installed dielectric fittings.

1. Exterior Covering: Exterior of vessel shall be painted with two coats of red oxide primer. The vessel shall be factory insulated by the manufacturer as described above under "Insulation."
2. Manufacturer: Copper lined water heaters shall be manufactured by Patterson-Kelly Co., East Stroudsburg, Pennsylvania, or Aerco International, Northvale, New Jersey.

G. Combustion Unit:

1. Unit Construction and Performance: The combustion unit for either water heater shall consist of a gas fired module guaranteed to produce a fuel-to-water operating efficiency of 80 percent minimum. Start up performance data, verifying the unit efficiency shall be supplied to the owner. With 140 degree F. stored water, a minimum nomograph reading of 9 1/2 percent CO₂ with a maximum net stack temperature of 300 degrees F. will be required. The complete combustion chamber shall be 100 percent submerged in water and shall be completely lined with copper. All fire tubes shall be of pure copper.
2. Burner and Controls: The burner shall be a forced draft power type with high fan curves that enable the burner to create an overfire pressure in the combustion chamber, and in the fire tubes. The burner shall be certified by Underwriter's Laboratories and shall include a Factory Mutual Approved gas train. The burner and controls shall have a one year unconditional warranty which shall include provisions for manufacturer responsibility for all materials, labor and freight necessary to correct the malfunction.
3. Warranty: The combustion unit shall have a three year warranty against defects in material, workmanship, and for corrosion and erosion. All material, labor and freight shall be the responsibility of the manufacturer should any warranty claim be necessary. The energy package warranty must be supplied with submittals. The heat exchanger warranty must be submitted with total package submittals. The submission of any warranty less than that described, or the absence of a warranty with the submittal, will be sufficient cause for complete submittal rejection.

- H. Tank Warranty: Water heater tanks shall have a minimum of an eight (8) year warranty to protect the owner against defects in material and workmanship, discolored water or either tank or liner perforation due to erosion and corrosion. Should the tank or liner fail for any reason within the first eight full years after startup, the manufacturer shall, at the owners option, pay for all repairs or replacement, including material, labor, incidental costs, and freight. The tank warranty must be submitted with the total package submittals. The submission of any submittal with a warranty less than that described, or the absence of a warranty with the submittal, will be sufficient cause for complete submittal rejection.
- I. Certification and Codes: The complete water heater shall be UL listed and shall meet the standards of ASHRAE 90A-87. The water heater shall fit properly in the floor space ("footprint") indicated in the Drawings. Installation must be completed in accordance with the codes and standards listed in Section 15A.
- J. Startup: The hot water generators shall be started up by a factory supplied startup engineer. The factory engineer shall also provide a technical and practical operation and maintenance training seminar including a hands-on operation and maintenance demonstration, and classroom presentation with handouts and visual aids, for no less than three physical plant personnel.

2.03 DOMESTIC HW CIRCULATING PUMPS:

- A. These pumps shall be Bell and Gossett, Grundigfos (magnetic coupled) or approved equal, having a circulating capacity as shown on the Drawings. Pumps shall be all bronze construction. Furnish for the control of each pump an Allen Bradley Bulletin 600 Toggle Switch with thermal overload protection and pilot light.

2.04 DOMESTIC WATER PUMPING SYSTEM:

- A. The domestic water pumping system shall consist of two variable speed pumps operated from one automatic control panel.
- B. The duplex variable speed house pump controller shall be of the solid state type. The controller panel shall be of the NEMA 1 design containing fused disconnect switches, running lights and shall be floor mounted. The control panel shall contain such elements as are necessary for variable speed control with all wiring brought to factory wired control strip. Said control panel shall be equipped with suction and discharge pressure gauges.
- C. A transducer shall be furnished to sense system pressure. It should be equal to Minneapolis Honeywell Modulating Pressuretrol. Said Pressuretrol shall be mounted a minimum of 10 diameters away from check valves or other obstructions in the discharge pipe.

- D. A time clock alternator shall be furnished, which will periodically and automatically interchange the lead and lag variable speed pumps. The time clock alternator shall be furnished inside of the control center.
- E. Limit switches for high pressure cut off, low pressure cut off, and low pressure cut off with alarm, silencing button and automatic reset shall be furnished. These components shall come completely assembled and wired.
- F. The pumps shall be double suction type as manufactured by Buffalo Forge, or approved equal. These pumps shall be a unit of standard manufacturer and shall be cast iron, bronze fitted. The pump glands shall be of the packed type. Pump capacities shall be as scheduled on the Drawings. Design suction pressure is to be 35 psi.
- G. The pump motors shall be designed to be compatible with the solid state controller and operating at an approximate maximum speed of 1550 RPM.
- H. The system shall be designed so that either pump shall operate singly during normal building operating hours. When the demand exceeds the capacity of one pump, the second pump shall automatically start and run as long as required to meet the demand. The maximum differential at the pump discharge shall be 10 psi.

NOTE TO SPECIFICATION WRITER: THE FOLLOWING SCHEDULES ARE INCLUDED MORE FOR INFORMATION. JOB SCHEDULES ARE TO APPEAR ON THE DRAWINGS RATHER THAN IN THE SPECIFICATIONS.

PART 3 EXECUTION

3.01 WATER HEATER SCHEDULE

<u>Drawing Code</u>	<u>DWH-1</u>	<u>DWH-2</u>	<u>DWH-3</u>	<u>DWH-4</u>
Manufacturer:				
Model:				
Input:				
Recovery:				
Recovery Temp. Rise:				
Storage Capacity:				
Volt/phase/cycle:				

3.02 DOMESTIC WATER HEAT EXCHANGER SCHEDULE

<u>Drawing Code</u>	<u>HE-1</u>	<u>HE-2</u>	<u>HE-3</u>	<u>HE-4</u>
Location:				

Service:
Heating Media
Type:
Entering:
Leaving:
Flow:
Max. Head Loss:
Fouling Factor:
Working Pressure:

Heated Media
Type:
Entering:
Leaving:
Flow:
Max. Head Loss:
Fouling Factor:
Working Pressure:

3.03 TANK SCHEDULE

<u>Drawing Code</u>	<u>TK-1</u>	<u>TK-2</u>	<u>TK-3</u>	<u>TK-4</u>
Location				
Service				
Capacity				
Diameter				
Length				

3.04 PUMP SCHEDULE

<u>Drawing Code</u>	<u>P-1</u>	<u>P-2</u>	<u>P-3</u>	<u>P-4</u>
Manufacturer:				
Model No.:				
Location:				
Service:				
Capacity:				
Head:				
Minimum Efficiency:				
Seal Type:				
Motor Size:				
Motor volt/phase/cycle:				

END OF SECTION

**SECTION 22 13 16
PLUMBING PIPING**

PART 1 GENERAL

1.00 The following sections are to be included as if written herein:

- A. Section 23 00 00 – Basic Mechanical Requirements
- B. Section 23 05 29 – Sleeves, Flashings, Supports and Anchors
- C. Section 23 05 53 – Mechanical Identification

1.01 SECTION INCLUDES

- A. Pipe and Pipe Fittings
- B. Valves

1.02 RELATED SECTIONS

- A. Section 31 23 16 - Excavating
- B. Section 31 23 23.13 - Backfilling
- C. Section 31 23 16.13 - Trenching
- D. Section 33 13 00 - Disinfection of Water Distribution System
- E. Section 08 31 13 - Access Doors
- F. Section 09 91 00 - Painting
- G. Section 23 20 00.A - Piping, Valves and Fittings
- H. Section 23 05 16 - Expansion Compensation
- I. Section 23 05 48 - Vibration Isolation
- J. Section 23 07 19 - Piping Insulation
- K. Section 22 13 16.A - Plumbing Specialties
- L. Section 22 40 00 - Plumbing Fixtures

- M. Section 22 11 23 - Plumbing Equipment
- 1.03 REFERENCES
 - A. See Section 23 20 00
- 1.04 SUBMITTALS
 - A. Submit under provisions of Section 23 00 00.
 - B. Product Data: Provide data on pipe materials, pipe fittings, valves, and accessories. Provide manufacturers catalog information. Indicate valve data and ratings.
- 1.05 PROJECT RECORD DOCUMENTS
 - A. Submit under provisions of Section 23 00 00.
 - B. Record actual locations of valves, etc., and prepare valve charts.
- 1.06 OPERATION AND MAINTENANCE DATA
 - A. Submit under provisions of Section 23 00 00.
 - B. Maintenance Data: Include installation instructions, spare parts lists, exploded assembly views.
- 1.07 QUALITY ASSURANCE
 - A. See Section 23 20 00.A
- 1.08 QUALIFICATIONS
 - A. Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience.
 - B. Installer: Company specializing in performing the work of this section with minimum of three years documented experience.
- 1.09 REGULATORY REQUIREMENTS
 - A. Perform Work in accordance with Uniform Plumbing Code.
 - B. Conform to applicable code for installation of backflow prevention devices.

1.10 DELIVERY, STORAGE, AND HANDLING

- A. Deliver, store, protect and handle products to site under provisions of Section 23 00 00.
- B. Accept valves on site in shipping containers with labeling in place. Inspect for damage.
- C. Provide temporary protective coating on cast iron and steel valves.
- D. Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.
- E. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed system.

1.11 ENVIRONMENTAL REQUIREMENTS

- A. Do not install underground piping when bedding is wet or frozen.

1.12 EXTRA MATERIALS

- A. Furnish under provisions of Section 23 00 00.
- B. Provide two repacking kits for each size valve.

PART 2 PRODUCTS

2.01 WALL, FLOOR AND CEILING PLATES:

See Section 23 05 29.

2.02 SLEEVES, INSERTS, AND FASTENINGS:

See Section 23 05 29.

2.03 VALVES:

A. See Section 23 20 00.A

2.04 UNIONS:

- A. See Section 23 20 00.A.

- B. Unions connecting ferrous pipe to copper or brass pipe shall be dielectric type equal to EpcO.
- C. In all domestic water lines where the material of the pipe is changed from ferrous to copper or brass, a dielectric coupling shall be used at the transition.

2.05 FLANGES:

- A. See Section 23 20 00.A.

2.06 STORM WATER SYSTEM:

- A. A complete system of storm water drainage piping shall be installed as indicated on the Drawings. Storm water systems shall be installed with the materials and methods as specified in Section 23 20 00.A.

B. PIPE & FITTINGS:

1. All interior downspouts and interior storm drainage piping, and all such piping up to a point five feet (5') outside the building walls, or to any other point indicated on the Drawings, shall be service weight cast iron soil pipe, hub and spigot for pipe ten inch (10") and larger and hubless for eight inch (8") and smaller. Each piece of pipe and each fitting shall be coated at the factory with asphaltum or coal tar pitch and with the manufacturer's mark or name cast on it. Piping shall be Type DWV copper pipe with wrought copper sweat joints where indicated on the Drawings. Where roof drains are 50 or more feet above the horizontal runout at grade level, all the downspout piping system 50' below the roof line shall be constructed of Schedule 40 black steel pipe with weld fittings.
2. Exterior storm water drainage piping from a point five feet (5') outside building walls or to point shown shall be precast concrete sewer pipe. Where piping passes under specific areas noted on Drawings, it shall be service weight cast iron up to fifteen inches (15") in size.

C. INSTALLATION OF PIPING:

1. All piping shall be run in the most direct manner. Horizontal pipes shall have a grade of one-quarter inch (1/4") per foot, wherever possible, and not less in any case than one-eighth inch (1/8") per foot, unless otherwise noted on Drawings.
2. Cleanouts shall be provided at the bottom of each downspout, at each change of direction and at intervals not exceeding 95 feet in horizontal runs. Interior cleanouts shall be brass caulked into the lines, and where they occur in walls or floors of finished areas, shall be provided with nickel-bronze tops or access

plates. All interior cleanouts shall be of the same size as the pipe served up to four inch (4") size and four inches (4") for all larger lines.

3. Exterior cleanouts shall consist of a concrete encased wye in the line with sewer pipe extending upward therefrom and terminating in a concrete slab below grade. A standard cast iron cleanout casting shall be set on this slab in such manner as to be flush with finished grade and to provide access through its cover to the cleanout. A removable concrete stopper shall be set in the open top of the cleanout pipe.
4. All storm drain bodies, the first 10' feet of pipe from the drain and all horizontal runs of storm drainage piping within the building, except in crawl space shall be insulated as described in the insulation specifications.
5. All sizes of all underground storm drain piping within the building shall be cast iron hub and spigot type, with Tyseal (or approved equal) neoprene gaskets, coated at the factory with asphaltum or coal tar pitch, and with the manufacturer's mark or name cast on it. Hubless piping systems shall not be used in a directly buried, underground application.

D. ROOF AND AREA DRAINS:

1. All roof and area drains will be furnished and installed with all accessories required for the particular construction in which they are to be mounted. Area drains shall be as indicated on the Drawings and as specified in other sections.

E. TREE WELL DRAINS AND CATCH BASINS:

1. All tree well drains and catch basins shall be furnished and installed by the Mechanical Contractor with all accessories as indicated on the Drawings and as specified in other sections.

F. SUB-SOIL DRAINAGE:

1. Excavation to bottom of grade beam is by General Contractor. Final fine grading for sub-soil pipe is by Mechanical Contractor.
2. Material for backfill, twelve inch (12") both sides of pipe and twenty-four (24") above pipe bottom of excavation, shall be furnished by General Contractor and installed by Mechanical Contractor. Additional backfill is furnished and installed by General Contractor.
3. Where shown on Drawings and as detailed, furnish and install Perforated PVC Drain Pipe of the size as indicated on the Drawings.

NOTE TO SPECIFICATION WRITER: SHOW DRAIN PIPING ON PLUMBING DRAWINGS IF SUB-SOIL DRAINAGE PIPE IS IN PLUMBING SUBCONTRACT.

G. TESTS:

1. All storm drains shall be tested in vertical sections of approximately 50 feet each by filling leader with water and allowing to stand twenty-four (24) hours. Any leaks discovered shall be repaired and the test repeated. All tests shall be observed by the Owner's representative and the Architect/Engineer before tests are removed.

2.08 SANITARY DRAINAGE SYSTEM:

A. The sanitary drainage system shall be installed as indicated on the Drawings complete with all fixtures, drains, traps and required connections. All fixtures and drains shall be properly vented and trapped. The Contractor shall complete the installation of the sanitary drainage system by making approved connections as indicated on the Drawings.

B. Materials and installation of the system shall be as specified in the following paragraphs and Section 23 20 00.A.

C. PIPE AND FITTINGS:

1. All pipe used for interior, above ground sewer and drainage purposes, unless specifically shown to the contrary, shall be service weight cast iron soil pipe.
2. All pipe and fittings from the sump pumps and sewage ejectors shall be Schedule 80 PVC with PVC bolted flange connections at pump discharge and at each valve. PVC piping shall be run from the pumps to the exterior piping connection point within 6" of 5'-0" outside of the building.
3. Galvanized or black steel pipe shall not be used in any waste connection to a fixture or in any section of the soil or waste piping system.
4. All underground sanitary waste piping, of all sizes, shall be cast iron hub and spigot type, with Tyseal (or approved equal) neoprene gaskets. Hubless piping systems shall not be used in a directly buried, underground application.

D. INSTALLATION OF PIPING:

1. All piping shall be run in the most direct manner. Horizontal pipes shall have a grade of one-quarter inch (1/4") per foot, wherever possible, and not less in any case than one-eighth inch (1/8") per foot, unless otherwise noted on Drawings.
2. Cleanouts shall be provided at the bottom of each riser, at each change of direction and at intervals not exceeding 95 feet in horizontal runs. Interior cleanouts shall be brass caulked into the lines, and where they occur in walls or floors of finished areas, shall be provided with nickel-bronze tops or access plates. All interior cleanouts shall be of the same size at the pipe served up to four inch (4") size and four inches (4") for all larger lines.
3. Exterior cleanouts shall consist of a concrete encased wye in the line with sewer pipe extending upward therefrom and terminating in a concrete slab below grade. A standard cast iron cleanout casting shall be set on this slab in such manner as to be flush with finished grade and to provide access through its cover to the cleanout. A removable concrete stopper shall be set in the open top of the cleanout pipe.

E. FLASHINGS:

1. All vent pipes passing through the roof shall be provided with roof flashings per Section 23 05 29.

F. TESTING:

1. After the vertical lines of soil pipe, waste, and other parts of the sanitary system have been set from the basement to the top of the building, all outlets shall be temporarily "plugged up", except as are required for testing as described herein. One floor level of the building shall be tested at a time. Each floor shall be tested from a level below the structure of the floor, or the outlet of the building in the case of the lowest level, to a level of 12 inches above the floor immediately above the floor being tested, or the top of the highest vent in the case of the highest building level. The pipes for the level being tested shall be filled with water to a verifiable and visible level as described above and be allowed to remain so for 24 hours. If after 24 hours the level of the water has been lowered by leakage, the leaks must be found and stopped, and the water level shall again be raised to the level described, and the test repeated until, after a 24 hour retention period, there shall be no perceptible lowering of the water level in the system being tested.

2. A final test shall be conducted after all vertical and horizontal pipes and "rough-ins" have been complete but before the sewer connection is made. The test procedure shall be identical with that described above except that the entire plumbing system, i.e., the vertical and horizontal pipe and "rough-in", shall be subjected to water under the head imposed by filling the system to the top of the building. After all testing operations have been completed, all waste lines shall be cleaned.
3. Should the completion of these tests leave any reasonable question of a doubt relative to the integrity of the installation, additional tests or measures shall be performed to demonstrate the reliability of these systems to the complete satisfaction of the Owner's duly authorized representative. Such tests shall be conducted and completed before any joints in plumbing are concealed or made inaccessible.

G. FABRICATION METHODS FOR SEWAGE AND DRAINAGE PIPE LINES:

1. Install promptly all sewers, drains and piping after excavating, chasing or cutting for them has been done to keep the openings for such piping open as short a time as possible. No piping shall, however, be permanently closed up, furred in or covered before the examination of same by the authorities having jurisdiction.
2. Waste pipes shall be sized to conform to the sizes indicated on the Drawings. Under no circumstances shall any drain line be smaller than two inches. The waste pipes from water closets shall not be smaller than four inches.
3. The drilling and tapping of soil or waste lines or the use of saddle joints or the welding or brazing of hubs or pipe to any soil, waste or vent lines is prohibited.
4. Wastes must be brought up directly in back of each fixture. Horizontal branch arms of lead or brass will not be allowed.
5. No waste or soil lines shall enter the vertical part or heel of a lead or cast iron closet bend. Waste lines may enter the horizontal part of the lead or cast iron closet bend. No sink or lavatory waste line shall enter any other waste line of two inch (2") size.
6. All waste connections shall be made of heavy brass threaded nipples or with copper tube with appropriate screw to sweat adapters for connecting to sanitary tee. All fixtures used in connection with the conveying of any waste substance to the sanitary sewer, shall be connected by means of a trap, waste and overflow. Slip joints will be permitted only on the house side of the trap, waste and overflow, or appliance which has such slip joints embodied in their original manufacture. Fixtures which have waste opening connected to the soil or waste

lines by the use of bolts or screws shall have such connections made by the use of the exact number of bolts or screws as provided for in their original manufacture.

7. Where waste and vents are exposed at fixtures, pipes shall be chrome plated brass or brass W.C.P. cover (iron pipe size) and shall have chrome plated escutcheons where they pass through floors, walls, or ceilings.

H. VENTS:

1. Vent pipes shall be carried up adjoining soil and waste pipes, and they shall be connected into the main stack at top and bottom as indicated on the plumbing riser diagrams on the Drawings.
2. Vent pipes shall be of hubless service weight cast iron pipe.
3. All vent lines shall be so constructed that they cannot be used for waste or soil lines. No fixture shall be double trapped.

I. CONNECTIONS FOR FLOOR MOUNTED WATER CLOSETS:

1. All connections for floor mounted water closets and waste piping shall be made with an appropriate cast iron closet flange and wax gaskets.

2.09 WATER SUPPLY SYSTEM:

- A. A complete system of hot and cold water supply to all plumbing fixtures and mechanical equipment shall be supplied and installed as shown on the Drawings. The water supply system shall be installed using the materials and methods as specified in the following paragraphs.

B. UNDERGROUND WATER PIPING SYSTEMS:

1. Pipe: All pipe used for underground water piping mains shall be Class 52 centrifugally cast, close grained cast iron pipe or Class 50 DUCTILE iron pipe arranged with bell and spigot mechanical joints.
2. Fittings: See Section 23 20 00.A.
3. Valves: See Section 23 20 00.A.
4. Valve Boxes:
 - a. For each underground valve installed by the Contractor, the Contractor shall provide and install a two-piece, screw adjustable type valve box. These valve boxes shall be designed for heavy roadway service and they

shall have a deep socket type of cover which prevents their being accidentally knocked out of position.

- b. The word "**WATER**" shall appear on each cover. The installation of these members shall be such that by the use of the adjustable screw type bodies the tops are just flush with the finished grade. These valve boxes shall be Tyler Pipe Industries #6850, or approved equal.

5. Lead: It is forbidden that lead in any form be used in any water system other than waste. If lead is used in the fabrication or installation of any water system other than waste, then ALL of the installed equipment and material, which may have come in contact with the lead, shall be marked with bright red or orange spray paint, and shall be removed from the project site. The system(s) shall then be restored and reinstalled using ALL NEW MATERIALS.

C. FIRE HYDRANTS:

1. Furnish and install U.L. approved fire hydrants at locations indicated on the Drawings.
2. Fire hydrants shall be equal to Kennedy Valve Manufacturing Company with two (2) 2-1/2" and one (1) 4-1/2" threaded nozzles. Threads are to be per local Fire Department requirements. Each fire hydrant supply connection shall be preceded with a six-inch (6") gate valve and valve box as specified for underground water systems.
3. Fire hydrants shall be firmly supported underground all around the standpipe. Lower part of standpipe shall be surrounded with coarse gravel for drainage.

D. IRRIGATION PROVISIONS:

1. Furnish and install capped and/or valved water lines under paving, through retaining walls in paved plaza areas and as indicated on Drawings for connections and extensions under work of Section Irrigation (Sprinkler) System.

E. BUILDING ENTRANCE:

1. A metallic sleeve shall be inserted in the forms of the building wall through which the water service enters the building. The interior diameter of such sleeve shall be four inches (4") greater than the exterior diameter of the water service.
2. The water service pipe from within the building shall be extended to a point three feet outside the building wall through this sleeve. The position of the water service in this sleeve shall be concentric and the intervening space shall be

packed in a flexible manner to avert the flow of water from outside of the building into the basement.

3. The interior pipe extended outside the building shall be provided with a protective wrapping of "Tape Coat" SP warmed with hand torch. This protective tape shall be applied with "half-lap" coverage in strict accordance with the manufacturer's published instructions. The cast iron pipe connected to the pipe extending from the building wall shall contain two caulked joints within four feet of the union of the cast iron pipe and the interior pipe from the building.

2.10 INTERIOR DOMESTIC WATER PIPING SYSTEMS:

- A. ALL piping within confines of building walls shall be a part of the interior water piping system. Interior domestic water piping material and installation shall be as specified in the following paragraphs.

B. PIPE:

1. Interior domestic water piping larger than six inches (6") shall be Schedule 40 galvanized steel pipe. See Section 23 20 00.A.
 - a) When approved by the Owner in writing, the use of roll-grooved copper pipe may be used.
2. Unless otherwise shown on the Drawings, all interior domestic water piping four inches (4") and smaller shall be fabricated of Type K, hard drawn, copper pipe made of deoxidized copper (99.9% pure). See Section 23 20 00.A.
No pipe smaller than three-fourths inches (3/4") shall be used in this project except at local connections or as detailed for laboratory areas.

C. FITTINGS:

1. See Section 23 20 00.A.

D. HEADERS:

1. Suitable headers of the nature detailed on the accompanying Drawings shall be provided for the distribution of the cold water systems. These headers shall be fabricated by a fusion welding process by the use of extra strong black steel pipe and fittings of the same character. All flanges used in the case of such headers shall be dimensioned, faced, drilled and spot faced to conform to the Class 150 American Standard for Steel Pipe Flanges and Flanged Fittings (B16e-1939). The header outlets shall be effected by welding to the header full length welding

couplings of the proper size. These header outlets shall be carefully aligned to be "square" and parallel.

2. Upon being completed, these headers shall be subjected to a hydrostatic test of 300 pounds per square inch gauge. All defects noted upon inspecting the headers thus tested shall be repaired by chipping, machining and burning out defects, and re-welding. After repairs have been made, the headers shall be retested as described above.
3. After the headers have been tested and found to be tight, they shall be galvanized by a "double-dip" process. The manufacturer shall be required to provide certificates assuring the fact that the headers were so "double-dipped". Both exterior and interior surfaces shall receive a heavy zinc coating by a hot dipping process. Galvanized steel nipples shall be used to extend the various header outlets to the valves placed in each outgoing water line near the header. These nipples shall be of such a length that the valves in the outgoing water lines are neatly lined up in a horizontal plane. At a point just beyond these valves, a three-fourths inch (3/4") valved drain line shall be installed in each outgoing branch leaving the header. The purpose of such valve branches shall be to drain the system into which the flow of water is controlled by the valves previously mentioned. These three-fourths inch (3/4") drain line valves from the various branches leaving the headers shall be likewise lined up in a straight horizontal line. These three-fourths inch (3/4") drain lines shall terminate in a common "drain line". That one inch (1") drain line shall be the header drain line. Headers fabricated from copper pipe and roll grooved fittings may be substituted only with the written approval of the owner.

NOTE TO SPECIFICATION WRITER: AT ENGINEER'S OPTION THE HEADER SPECIFICATION MAY BE REWRITTEN TO USE GALVANIZED NIPPLES AND FLANGED FITTINGS ON SIX INCH (6") AND LARGER AND COPPER SWEAT ON FOUR INCH (4") AND SMALLER.

E. CONTROL VALVES:

1. Control valves shall be installed where indicated on Drawings and/or wherever necessary for controlling the several sections of the domestic water system. Valves shall be provided on all inlet (and outlet where applicable) connections to all kinds of apparatuses, all risers and all groups of fixtures. Groups of fixtures shall be arranged to have their group valves in one location. Access shall be provided to all concealed valves by means of an access door. Coordinate the location of valves with the architectural features of the building in order that the access doors will be located symmetrically with other features.

2. The hot and/or cold water supply lines to each and every fixture hereinafter specified shall be equipped with stop valves which shall be chromium plated where exposed chrome plated pipe is used.

F. CROSS CONNECTIONS:

1. Care shall be exercised in fabricating plumbing lines to avoid all cross connections and to construct the piping systems in a manner which eliminates the possibility of water contamination.
2. The piping systems have been designed in every case to avoid the possibility of reverse flow or back siphoning. Care shall be exercised in constructing plumbing lines to make certain that not only the letter, but the spirit, of these safety precautions is carried out to the fullest possible extent.

G. REQUIREMENTS OF INTERIOR WATER PIPING SYSTEMS:

1. All piping shall have reducing fittings used for reducing or increasing where any change in the pipe sizes occurs. No bushing of any nature shall be allowed in piping.
2. All exposed chrome plated, polished or enameled connections from fixtures shall be put up with special care, showing no tool marks or threads at fittings, and supported by neat racks or hangers with round head screws of same material and finish.
3. Wade Shokstop, or approved equal, sealed air chambers shall be provided in all water branches to fixtures, sized in accordance with manufacturer's recommendations, concealed, accessible, and located so as to protect each group of plumbing fixtures.
4. The fabrication of copper pipe and fittings shall in every detail conform to the recommendations and instructions of the fitting manufacturer. The tools used shall be the tools adapted to that specific purpose.
5. Refer to other parts of this Section and Section 23 00 00 and 23 20 00.A for other information concerning installation of piping.

H. TESTING AND STERILIZATION:

1. All water piping systems shall be properly tested to assure their being absolutely tight. In the case of pipes which are to be insulated, these tests shall be completed and the piping system proven to be absolutely tight before any insulation is applied. Wherever pipes are placed so that they will ultimately be concealed, these tests shall be conducted and the absolute tightness of each piping system shall be demonstrated before the system is concealed.
2. The procedure of these tests shall consist of subjecting a piping system to a hydrostatic pressure per Section 23 00 00. During the test period, all pipe, fittings and accessories in the particular piping system which is being tested shall be carefully inspected. If leaks are detected, such leaks shall be stopped by means designated by the Owner's duly authorized representative and the hydrostatic test shall again be applied. This procedure shall be repeated until, for an entire twenty-four hour period, no leaks can be found while the system being tested is subjected to the pressure mentioned above.
3. Wherever conditions permit, each piping system shall thereafter be subjected to its normal operating pressure and temperature for a period of no less than five (5) days. During that period, it shall be kept under the most careful observation. The piping systems must demonstrate the propriety of their installation by remaining absolutely tight during this period. Even though the completion of these tests is satisfactory, there is a continuing responsibility for the ultimate, proper, and satisfactory operation of such piping systems and their accessories.
4. After completion of the testing, the entire cold and hot water piping systems, with attached equipment, shall be thoroughly sterilized with a solution containing not less than 50 parts per million of available chlorine. The chlorinating materials shall be either liquid chlorine conforming to U. S. Army Specification No. 4-1 or calcium hypochlorite or chlorinated lime conforming to the requirements of Federal Specification O-C-114. The sterilizing solution shall be allowed to remain in the system for a period of eight (8) hours during which time all valves and faucets shall be opened and closed several times. After sterilization, the solution shall be flushed from the system with clean water until the residual chlorine content is not greater than 0.2 parts per million.
5. The sterilization process shall be conducted as required by the Health Department of the City of _____, and the specifications above, and upon completion of the process, the Health Department shall test and certify the cleanliness of the water piping system. The Mechanical Subcontractor shall pay all costs and charges incidental to this test and certification.

2.11 NATURAL GAS DISTRIBUTION SYSTEM:

- A. The gas distribution system shall be installed as indicated on the Drawings, complete with all valves, regulators, meters and other required items.
- B. The Contractor shall make all arrangements and pay for all services and material which are required to have the gas company extend its gas main to the property line and to install the regulator and/or meter required for this project. This Contractor shall, moreover, pay all fees and deposits which are required to have the meter "set" by the Gas Company. This Contractor shall then extend the gas service into the buildings. This Contractor shall make all arrangements and pay all fees which are required for odorizing the entire gas distribution system. At every entrance of gas piping into a building, the piping shall first rise above grade on the building exterior to prevent upstream gas leaks from following the piping inside the building. Provide wrench operated shutoff valve in the horizontal portion of this exterior piping at each location.
- C. Verify and coordinate, with the actual various users on the site, all the times and timing involved with modification, additions to, or alterations thereof, of gas piping serving these users.
- D. The natural gas system shall be installed using the materials and methods as specified herein and in the following paragraphs.
- E. VALVES:
 - 1. The gas regulator bypass globe valve shall be sized to pass only a slightly larger maximum flow rate than the gas regulator. It shall include provision for locking shut with a large padlock.
- F. GAS CUTOFFS:
 - 1. On the inlet and discharge side of the meter and pressure regulators and at building entrance, install a wrench operated plug cock valve. The flanges of this stop valve shall be dimensioned, drilled, faced and spot faced to conform to the Class 125 American Standard for Cast Iron Flanges (B16.1-1948). Install zone valves on each floor accessible to occupants for shutting off areas of the building under emergency conditions. Gas piping shall be welded up to these zone valves.
- G. PIPING:
 - 1. All pipe used for the fabrication of gas piping systems shall be Schedule 40 black steel pipe. See Section 23 20 00.A.

2. Unless otherwise specifically required, all steel pipe provided for gas piping systems shall be provided with plain ends and assembled with weld fittings on all pipe 1-1/4" and larger and 3/4" and larger if before the emergency shut off valve. No pipe smaller than 3/4", except as detailed for laboratory furniture, shall be used. From the emergency shutoff valve to the outlets the pipe shall be assembled with threaded fittings provided all joints are exposed or within the confines of the laboratory furniture.
3. All gas piping within the building shall be installed exposed to view.
4. In lieu of wrapped steel pipe, poly pipe may be used for outside lines if it is the standard of the serving gas company. Installation standards and procedures of the utility company shall be strictly followed. At a point 6' from the building and the final riser to meter or building entrance point shall be wrapped steel.

H. FITTINGS:

1. Unless otherwise specifically shown or called for, gas piping systems installed throughout the building shall be fabricated by a fusion welding process making use of welding fittings. These fittings shall be fittings as specified in other Sections. In no case shall the wall thickness of a fitting incorporated in a gas piping system be less than that of the pipe to which it is jointed.

I. FLANGES:

1. In all instances in which flanges are required for the installation of flanged fittings for gas lines, the Contractor shall provide Crane or Walworth weld neck pattern, Class 150 forged steel flanges. See Section 23 20 00.A for additional requirements for flanges.

J. HEADERS:

1. The gas distribution header installed by this Contractor in the building shall be fabricated of Schedule 40 steel pipe. The pipe and welding materials for this header shall be carefully selected, and the welding operations shall be carefully supervised.
2. Welding nipples neatly aligned shall be provided for the outlets of the header. After the header has been completely fabricated, it shall be temporarily sealed and subjected to a pneumatic test pressure of 100 pounds per square inch. While the header is subjected to this pressure, all welded joints shall be given an application of soapy water for the purpose of detecting minute leaks which might not otherwise be observed. These leaks shall not be repaired by any peening

operations. Such leaks shall be remedied by chipping and re-welding until the header is devoid of leaks at that pressure. The header shall then be subjected to a hydrostatic test pressure of 200 pounds per square inch. Under these circumstances, the test pressure of the water confined in the header shall not decrease in a four hour period of observation. If leaks are encountered, they shall be repaired and re-tested until proven tight.

3. The header shall be provided with a one-half inch (1/2") drain connection "taken off" the bottom of the header and terminated in a suitable stop cock. This one-half inch (1/2") drain connection shall have its origin in a 2" x 1/2" welding reducer having its two inch (2") end so welded to the header as to completely drain that member. Each outgoing branch from the header shall be provided with a gas stop valve or gas cock. The nature of the outgoing welding nipples shall be such that these cocks shall be aligned in a neat horizontal line.

K. COCKS:

1. Near the point at which each outgoing line leaves the gas header, the Contractor shall install a gas stop valve or gas cock. These wrench operated valves shall each be provided with an appropriate wrench. Cocks of the same type shall, moreover, be installed at each other point indicated on the Drawings.

L. DRIP PIPES:

1. Drip pipes shall be provided throughout the gas piping systems for the purpose of accumulating moisture and condensate. They shall be sized no smaller than the gas piping to which they are connected in each instance. These drip pipes shall be U-shaped providing an effective water seal of no less than twelve inches (12") of water. The extremity of each U-shaped drip pipe shall be threaded and capped with a suitably sized, screwed pattern, black, standard weight, malleable iron cap.
2. All drip pipes shall be located in an accessible position so that the condensate may either be pumped from the system or so that a water seal shall be provided in the event that the water forming the seal evaporates.

M. FABRICATION METHODS:

1. All interior gas piping shall, wherever possible, be installed so as to grade back toward the gas header in the basement. In all cases where such grading is impracticable and it is necessary to grade the house piping away from the inlet, drip pipes of adequate capacity must be installed where traps are formed by such changes in grade. Drip pipes shall terminate with a screwed pattern, malleable iron black cap. No drip pipes shall be used as outlets for the attachment of any

fixture or gas appliance. Drip pipes must, moreover, be placed at the bottom of all vertical pipes which rise from and connect to the end of any horizontal pipe.

2. All house piping must be securely fastened in place in such a manner as to maintain its grading. Under no circumstances shall extension bars be used for supporting gas piping. Under no circumstances shall any gas piping be used to support any weight other than its own weight.
3. All branch outlet pipes shall be taken from the top or sides of running horizontal lines and not from the bottom. No crosses shall be installed in any horizontal gas line. No unions, gas cocks, or valves shall be used in any concealed location. Every gas cock and valve shall be accessible for inspection and repair.
4. The general arrangement of all gas piping shall be such that the number of threaded joints involved is reduced to an absolute minimum. If obstructions are encountered, pipe shall not be bent to circumvent such obstructions. Welding fittings shall be used for this purpose in the case of welded lines, and if threaded lines are involved, screwed fittings shall be used. Wherever gas pipes run through outside brick, stone, or other walls, the opening around the pipe shall be securely and rigidly sealed. Gas pipe sizes shall be at least one pipe size larger than the inlet of the gas appliance which they supply. No bushings shall be used in conjunction with any gas piping.
5. Refer to Section 23 00 00 for other information concerning installation of piping.

N. PROTECTIVE COATING:

1. Gas piping systems installed underground shall utilize pipe which has been factory coated with Scotchkote protective resin No. 212. All materials, surface preparation, application and testing shall conform to Federal Specification L-C-530 B-Type 2, dated June 4, 1970. This coating shall be applied by A&A Coating Company, Lone Star, Texas.
2. Underground welded joints and fittings shall be coated with Scotchkote No. 306 epoxy resin and taped with vinyl Scotchwrap-50 brand tape. Flanged joints shall be given two coats of Koppers Company No. 300M Catalyzed Coal Tar Epoxy. Flanged joints will not be allowed under ground.
3. Under no circumstances shall any backfilling operations be begun until these pipe protection operations have been completed.

O. TESTING:

1. All gas piping systems shall be completely tested by the Contractor. These piping systems shall first be subjected to a pneumatic test pressure per Section 23 00 00. All hydro and pneumatic tests shall be dead weighted, recorded, and countersigned by the project inspector. While the systems are subjected to this air pressure, all welded joints shall have a soapy water solution applied for the purpose of detecting minute, as well as larger leaks, and shall be witnessed by Owner. A final test shall be performed after casework and lab hook up are completed at 15 psi for a minimum of 4 hours. If leaks are found, they shall be repaired by chipping and re-welding operations. Alternate testing and re-welding operations shall be repeated until gas piping systems are absolutely tight at the pneumatic test pressure indicated above. If leaks occur in the case of threaded joints, such leaks shall be eliminated by legitimate means, i.e., either by replacing leaking fittings or by tightening them properly. Leaking flanged joints shall have flange bolts appropriately tightened or have gaskets causing leaks replaced.
2. Then the entire gas piping systems shall be re-subjected to a pneumatic test pressure per Section 23 00 00. Such gas piping systems must be demonstrated to be absolutely tight when subjected to this pressure for a period of twenty-four hours. In all instances in which leaks are then found, they shall be eliminated in the manner designated by the Owner's duly authorized representative. A one-half inch (1/2") test connection and cap shall be provided in each branch of the gas piping system.
3. After all pneumatic testing of the entire gas piping system has been completed and all leaks have been repaired and at a time deemed suitable by the Owner's duly authorized representative, the Contractor shall have the gas supply turned on and the gas odorant chemical added by a representative of the gas company. The Contractor shall then bleed gas from every riser and every runout until the odor is present in the proper quantity at every gas outlet.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify excavations under provisions of Section 23 00 00.
- B. Verify that excavations are to required grade, dry, and not over-excavated.

3.02 PREPARATION

- A. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.
- B. Remove scale and dirt, on inside and outside, before assembly.

C. Prepare piping connections to equipment with flanges or unions.

3.03 INSTALLATION

A. Provide non-conducting dielectric connections wherever jointing dissimilar metals.

B. Route piping in orderly manner and maintain gradient.

C. Install piping to conserve building space and not interfere with use of space.

D. Group piping whenever practical at common elevations.

E. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.

F. Provide clearance for installation of insulation and access to valves and fittings.

G. Provide access where valves and fittings are not exposed. Coordinate access door location with architectural features.

H. Establish elevations of buried piping outside the building to ensure a minimum of cover. Refer to Section 23 00 00.

I. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welding.

J. Provide support for utility meters in accordance with requirements of utility companies.

K. Prepare pipe, fittings, supports, and accessories not prefinished, ready for finish painting. Refer to Division 09.

L. Excavate in accordance with Section 23 00 00 for work of this Section.

M. Backfill in accordance with Section 23 00 00 for work of this Section.

N. Install bell and spigot pipe with bell end upstream.

O. Install valves with stems upright or horizontal, not inverted.

P. Provide one plug valve wrench for every ten plug valves sized 2 inches and smaller, minimum of one. Provide each plug valve sized 2-1/2 inches and larger with a wrench with set screw.

- Q. Pipe vents from gas pressure reducing valves to outdoors and terminate in weather proof hood.

3.04 APPLICATION

- A. Install unions downstream of valves and at equipment or apparatus connections.
- B. Install brass male adapters each side of valves in copper piped system. Sweat solder adapters to pipe.
- C. Install ball or butterfly valves for shut-off and to isolate equipment, part of systems, or vertical risers.
- D. Install globe or plug valves for throttling, bypass, or manual flow control services.
- E. Provide spring loaded check valves on discharge of water pumps.
- F. Provide plug valves in Natural gas systems for shut-off service.
- G. Provide flow controls in water recirculating systems where indicated.

3.05 ERECTION TOLERANCES

- A. Establish invert elevations, slopes for drainage to 1/8 inch per foot (one percent) minimum. Maintain gradients through each joint of pipe and throughout system.
- B. Slope water piping and arrange to drain at low points.

3.06 DISINFECTION OF DOMESTIC WATER PIPING SYSTEM

- A. Prior to starting work, verify system is complete, flushed and clean.
- B. Ensure PH of water to be treated is between 7.4 and 7.6 by adding alkali (caustic soda or soda ash) or acid (hydrochloric).
- C. Inject disinfectant, free chlorine in liquid, powder, tablet or gas form, throughout system to obtain 50 to 80 mg/L residual.
- D. Bleed water from outlets to ensure distribution and test for disinfectant residual at minimum 15 percent of outlets.
- E. Maintain disinfectant in system for 24 hours.
- F. If final disinfectant residual tests less than 25 mg/L, repeat treatment.

- G. Flush disinfectant from system until residual equal to that of incoming water or 1.0 mg/L.
- H. Take samples no sooner than 24 hours after flushing, from 10 percent of outlets and from water entry, and analyze in accordance with AWWA C651.

3.07 EQUIPMENT CONNECTIONS:

- A. Under this section, water lines shall be run to and connected to the pumps, quick fills, and other items of equipment as indicated. Provide suitable shutoff valves, check valves, and, if required by the drawings, bypass valves at each and every such point of connection.

3.08 CONNECTIONS FOR GENERAL CONTRACTOR FURNISHED EQUIPMENT:

- A. Route lines as indicated on the Drawings to serve various items of equipment specified elsewhere. Rough-in accordance with detailed drawings furnished by the equipment supplier, and make final connections to the equipment when it is installed. Rough-in shall terminate where noted on Drawings. All pressure lines shall be provided with shutoff valves or cocks. Drain lines shall be provided where required. It shall be assumed that the equipment supplier will provide and install valves and pipe specialties, etc. only as specified herein or called for on the Drawings.
- B. Laboratory and/or other special equipment and trim are specified in another section under which the equipment shall be furnished and installed. Trim, sink strainers and tail pieces shall be furnished only as indicated to the contractor who shall receive, store and install them. In addition, furnish the sink P-traps and all materials and labor to rough-in and make final connections.

3.09 CONNECTIONS FOR OWNER FURNISHED EQUIPMENT:

- A. The Owner will be furnishing various pieces of equipment. The Contractor shall provide the rough-in indicated on the Drawings. Final connections are also included as part of this contract.

END OF SECTION

SECTION 22 13 16.A
PLUMBING SPECIALTIES

PART 1 GENERAL

1.00 The following sections are to be included as if written herein:

- A. Section 23 00 00 – Basic Mechanical Requirements
- B. Section 23 05 29 – Sleeves, Flashings, Supports and Anchors
- C. Section 23 05 53 – Mechanical Identification

1.01 SECTION INCLUDES

- A. Roof and drains
- B. Cleanouts
- C. Backflow preventers
- D. Water hammer arrestors
- E. Interceptors
- F. Catch basins and manholes

1.02 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION

- A. Section [____ - _____]:

1.03 PRODUCTS INSTALLED BUT NOT FURNISHED UNDER THIS SECTION

- A. Section 01 11 00 - Summary of Work: Owner furnished [Kitchen equipment] [Laboratory casework] [_____].
- B. Section [____ - _____]: Supply of grease interceptors for placement by this Section.
- C. Section 23 38 16 - Fume Hoods, [____ - _____]: Laboratory casework, for connection of sinks, fixtures, and drains.
- D. Section 11 53 23 - Environmental Rooms: Supply of environmental rooms, for connection of sinks, fixtures, and drains by this Section.

1.04 RELATED SECTIONS

- A. Section 01 11 00 - Summary of Work
- B. Section 33 05 13 - Manholes and Structures
- C. Section [] - [] Roofing: Roof Drains
- D. Section 22 13 16. - Plumbing Piping
- E. Section 22 40 00 - Plumbing Fixtures
- F. Section 22 11 23 - Plumbing Equipment

1.05 REFERENCES

- A. ANSI/ASSE 1011 - Hose Connection Vacuum Breakers
- B. ANSI/ASSE 1012 - Backflow Preventers with Immediate Atmospheric Vent
- C. ANSI/ASSE 1013 - Backflow Preventers, Reduced Pressure Principle
- D. ANSI/ASSE 1019 - Wall Hydrants, Frost Proof Automatic Draining Anti-Backflow Types
- E. ANSI A112.21.1 - Floor Drains
- F. ANSI A112.21.2 - Roof Drains
- G. ANSI A112.26.1 - Water Hammer Arrestors
- H. ASTM C478 - Precast Reinforced Concrete Manhole Sections
- I. AWWA C506 - Backflow Prevention Devices - Reduced Pressure Principle and Double Check Valve Types
- J. PDI WH-201 Water Hammer Arresters

1.06 SUBMITTALS

- A. Submit under provisions of Section 23 00 00.
- B. Shop Drawings: Indicate dimensions, weights, and placement of openings and holes.

- C. Product Data: Provide component sizes, rough-in requirements, service sizes, and finishes.
- D. Manufacturer's Installation Instructions: Indicate assembly and support requirements.
- E. Manufacturer's Certificate: Certify that oil interceptors meet or exceed specified requirements.

1.07 PROJECT RECORD DOCUMENTS

- A. Submit under provisions of Section 23 00 00.
- B. Record actual locations of equipment, cleanouts, backflow preventers, etc.

1.08 OPERATION AND MAINTENANCE DATA

- A. Submit under provisions of Section 23 00 00.
- B. Operation Data: Indicate frequency of treatment required for interceptors.
- C. Maintenance Data: Include installation instructions, spare parts lists, exploded assembly views.

1.09 DELIVERY, STORAGE, AND HANDLING

- A. Deliver, store, protect and handle products to site under provisions of Section 23 00 00.
- B. Accept specialties on site in original factory packaging. Inspect for damage.

1.10 EXTRA MATERIALS

- A. Furnish under provisions of Section 23 00 00.
- B. Provide two loose keys for each type of manhole cover and valve box.

PART 2 PRODUCTS

2.01 ROOF AND AREA DRAINS:

- A. All roof and area drains will be furnished and installed by the Mechanical Contractor with all accessories required for the particular construction in which they are to be mounted. Area drains shall be as manufactured by Wade, Josam, Zurn, or approved equal.

- B. Roof Drain Type A (RD "A"): Wade Series W-3000, cast iron, flashing clamp, mushroom cast iron dome strainer and large sump.
- C. Area Drain Type A (AD "A"): Wade No. 1100, cast iron drain body with clamping collar, 8" x 8" Type "J" polished bronze strainer, three inch (3") Type "EA" extension adapter.
- D. Area Drain Type B (AD "B"): Same as AD "A", except no extension or clamping collar.
- E. Area Drain Type C (AD "C"): Wade No. W-3220-PA area drain with brass screen on aluminum dome.
- F. Area Drain Type D (AD "D"): Wade No. 1100, cast iron drain body, six inch (6") diameter Type "K" bronze dome strainer.
- G. Area Drain Type E (AD "E"): Same as AD "A", except with six inch (6") Type "K" bronze dome strainer.

2.02 TREE WELL DRAINS AND CATCH BASINS:

- A. All tree well drains and catch basins shall be furnished and installed by the Mechanical Contractor with all accessories as indicated on the Drawings.
- B. Tree Well Drain: Wade No. W-3270 parapet scupper drain with oblique strainer, cast iron body and cast iron strainer.
- C. Catch Basin Type A (CB "A"): Neenah No. R4346 cast iron grate. Concrete work shall be provided under this section of the Specifications.
- D. Catch Basin Type B (CB "B"): McKinley No. JGL cast iron grate and frame. Concrete basin and stabilizer apron as detailed on the Drawings shall be provided under this section of the Specifications.

2.03 SUMP PUMP:

- A. Mechanical Contractor shall furnish and install duplex sump pump complete with a cast iron mounting cover and curb ring which will mount on the floor over the sump. Sump will be constructed by the General Contractor but this Contractor shall coordinate his work so that mounting cover will set properly on the floor opening provided.

- B. Sump pumps as scheduled on Drawings or approved equal. Each motor shall be provided with an across the line magnetic starter having three pole protection. Each pump shall be equipped with copper float and float switch for automatic operation. Provide mechanical or electrical alternator to switch the starting of the pumps from one to the other. Mechanical alternator is preferred, but if electrical alternator is used, it shall be Allen Bradley.
- C. Provide high level alarm switch complete with transformer, bell and one set of 120 volt A.C. rated normally open contact for connection to owners FCMS system.
- D. Provide a complete wiring diagram for this installation with submittal data.

2.04 FLOOR DRAINS:

- A. Floor drains (F.D.) shall be sized to conform to the information indicated on the Drawings or contained elsewhere in these Specifications. Extreme care shall be used to set the elevation of the drain to meet the low point elevation of the finished floor. Each floor drain shall be provided with a P-trap unless noted otherwise. Note that a deep seal type trap may be required under other Sections of these Specifications.
- B. All floor drains will be furnished and installed with all accessories required for the particular construction in which they are to be mounted; and shall be as manufactured by Wade, Josam, Zurn, or approved equal.
- C. Floor Drain (or Shower Drain) Type A (FD "A"): Wade W-1100, cast iron floor drain with integral reversible clamp device, caulk device, caulk outlet and round adjustable nickel brass strainer.
- D. Floor Drain (FD "B"): Wade W-1100-TS cast iron floor drain with integral reversible clamp device, caulk device, caulk outlet and seven inch (7") diameter adjustable cast iron strainer.
- E. Floor Drain Type C (FD "C"): Same as FD "B" except no trap.
- F. Floor Drain Type D (FD "D"): Wade W-1100-EF6 cast iron floor drain with integral reversible clamp device, caulk device, caulk outlet and round adjustable nickel brass strainer with six inch (6") diameter funnel.
- G. Floor Drain Type E (FD "E"): Wade W-1700 cast iron floor drain with flange, caulk outlet and hinged grate.
- H. Floor Drain Type (FD "F"): Wade W-1100-D cast iron floor drain with integral reversible clamp device, caulk outlet and six inch (6") diameter adjustable hinged nickel brass strainer.

2.05 HUB DRAINS (H.D.):

- A. Hub drains (H.D.) located at, or near, Owner furnished equipment shall be cast iron soil pipe hubs or hub adaptors set flush with finished floor. Install in all such hubs or hub adaptors a Wade WL-8450-R cast iron cleanout ferrule with slotted head plug and round stainless steel access cover. Each hub drain shall be provided with a P-trap.
- B. Hub drains for other services shall be cast iron soil pipe hubs or hub adaptors set with top of hub one-half inch (1/2") above finished floor. Each hub drain shall be provided with a P-trap.

2.06 CLEANOUTS:

- A. At each change in direction, at the end of each continuous waste line, at the foot of each riser in the building and at 50' intervals in long horizontal runs, of lines of four inch (4") size and smaller, and not more than 95' intervals for larger lines, cleanouts shall be placed in soil and waste lines. The size of the cleanouts shall be identical with the size of the soil or waste line in which they are placed for four inch (4") and smaller lines. The size of cleanouts in lines larger than four inches (4") shall be six inches (6") in all cases. All cleanouts shall be placed to be easily accessible for servicing. Where they occur in pipe chases, they shall be placed above the floor in such a location so they will be easily accessible through access doors, or they shall be brought through the walls and be provided with covers. All horizontal soil and waste lines shall have a cleanout placed in the end of the line by the use of a wye and a 1/8 bend, or by a combination tee-wye and made easily accessible by extending the cleanout through the wall and be covered as described above. The screw plug of all cleanouts shall be of cast brass.
- B. The bodies of floor cleanouts shall be tapped for iron pipe threads. The brass tap screws shall have flange caps with raised nuts. Wherever such cleanouts occur in finished floor slabs or terminate in finished walls, they shall be provided with scoriated nickel bronze cleanout covers of such a size as to make the plugs over which they are installed readily accessible. These cleanouts shall be cast iron floor cleanout with cut-off ferrule, tapered brass plug with eight inch (8") round screwed brass access cover with three-eighths inches (3/8") diameter Allen Head Screw.
- C. Finished Floors and Concrete Floors, Round Top. Primer coated cast iron floor cleanout with SV hub outlet, taper thread bronze plug, threaded adjustable housing and ferrule, membrane flange, secured/vandal proof, round-heavy duty satin finished nickel bronze scoriated top that adjusts to finished floor after concrete has set. For cleanouts located under carpet floors provide an integral carpet marker to indicate location after floor carpeting is installed. Reference Architectural drawings for areas with carpet floors. Jay R. Smith No. 4033L (service weight Speedi-Set hub outlet)-F-

C-U (-Y, where applicable), Josam 5600-15-22-41-MODIFIED for Heavy Duty Top (-14, where applicable)-Y, Wade W-6030-D-X-5-26-75-Threaded/Machined for Clamp Device (-72, where applicable) or Zurn ZN-1400 (Neo-Loc)-BP-HD-KC-VP (-CM, where applicable). Set top of floor cleanouts such that top is flush with finished floor.

- D. Outside Areas, Round Top. Primer coated cast iron, extra heavy traffic duty floor cleanout with taper thread bronze plug, threaded adjustable housing with flanged ferrule, secured/vandal proof, round, extra heavy duty, gasketed satin finished nickel bronze scoriated top that adjusts to finished grade in field after installation. Cast cleanouts flush in a 16" by 16" by 6" thick concrete pad. Concrete pad and cleanout shall be installed such that the top of pad and cleanout top are both set with top flush with finished grade. Jay R. Smith No.4113L~U (service weight Speedi-Set hub outlet), Josam 56040-1-15-22-Y, Wade W-6030-Z-XS-1-5-75 or Zurn ZN-1400 (Neo-Loc)-BP-MODIFIED for Extra Heavy Duty Top-VP. Set top of exterior floor cleanouts such that top is flush with finished grade.
- E. Finished Walls. Primer coated cast iron cleanout tee with countersunk head, taper treaded bronze plug, No-Hub connections and 6-inch diameter-smooth-stainless steel secured access cover with secured/vandal proof screw. Jay R. Smith 4532S-U-Y, Josam 58790-15-MODIFIED for No Hub connections, Wade W-8460-R6-5-MODIFIED for No-Hub connections or Zurn Z-1446-NH-BP-VP.
- F. Unfinished Areas. Primer coated cast iron cleanout tee with countersunk head, taper thread bronze plug and No-Hub connections. Jay R. Smith 4512S-Y, Josam 58910-Z, Wade W-8560-MODWIED for No-Hub connections-D or Zurn-1445-NH-BP.
- G. Lab Waste Floor Cleanouts, Finished Floors, Outside Graded Areas and Exterior Cleanouts. 10 inch diameter, secured/vandal proof, round, heavy duty, satin finished nickel bronze scoriated top type cleanout access frame and cover. Jay R. Smith No. 4810-08-U, Josam 58610-MODIFIED for 10-inch diameter cover-10-15, Wade W-8300-C10-5 or Zurn ZNAB-1463-11-inch diameter cover-VP. Set top of floor cover such that top is flush with finished floor (including tile). Installation shall be exact, top of cleanout cover shall be set to the exact finished floor level, No tolerance will be allowed on this item. Extend lab waste cleanout to bottom of cleanout top, caulk annular space between cleanout and concrete floor watertight with sleeve, insulation, tape and Linkseal per Section 22 66 00. Secure cover to concrete floor with expansion bolts and - top flush with finished floor. Cleanout shall be same material as piping.
- H. Lab Waste Wall Cleanouts, Finished Walls. 8-inch square, secured/vandal proof, satin finished nickel bronze scoriaed face-of-wall cover type access frame and cover. Jay R. Smith No. 4730-08X08-NB-U, Josam 58631-15, Wade W-8480-ST8-5 or Zurn ZNAB-1462 (7-1/2 inch cover)-VP. Set on wall such that cover is flush with finished

wall. Extend lab waste cleanout to within 3-inches (in depth) from access door and center in respect to access door opening for easy access. Installation shall be exact, cleanout cover shall be set exact, and no tolerance will be allowed on this item. Adequately secure frame and cover to wall studs or CMU block. Provide additional blocking in wall to ensure a rigid and permanent installation Cleanout shall be same material as piping.

2.07 STRAINERS:

- A. Strainers, 2" and smaller, bronze body, screwed ends, No. 10 mesh strainer, screwed cap with bronze blow-off valve (size to be determined by standard tap size in cap). Cast iron body, 2 1/2" and larger, isolating type flanged ends where installed in copper lines, No. 7 perforated monel strainer, flanged cap with bronze ball blow-off valve (size of blow-off valve shall be determined by standard tap size in cap). Special Note: All strainers 6" and larger shall have studs mounted in the body flange in lieu of bolts for removal of cap. Baskets for strainers 6" and larger shall have stainless steel reinforcing bands at ends to prevent collapsing.
- B. Suction diffusers shall be Paco or approved equal, cast iron body and cover, steel diffuser, and stainless steel strainer, 125 pound ASA (flat face) flange for a working pressure of 175 psi and temperature of 300°F.

2.08 BACKFLOW PREVENTERS:

- A. Backflow preventers (BFP) shall be reduced pressure type, Febco 825, or approved equal. A BFP shall be installed to isolate all non-potable water requirements from the building domestic water system. (All BFP's shall be installed within the building.)

2.09 SEWAGE EJECTOR:

- A. Furnish and install a cast iron basin minimum forty-two inch (42") diameter and four feet (4') deeper than lowest inlet entering it. Furnish and install a steel basin cover with openings for pumps, float rods, full-size manhole and vent connection. All parts to be machine-fit, gasketed gas-tight.
- B. Duplex sewage ejector, as scheduled on Drawings, shall be as manufactured by Weil, or approved equal. Each motor shall be provided with an across the line magnetic starter having 3-pole overload protection. Each pump shall be equipped with enclosed drip-proof automatic float switches, pedestal mounted. Float switches to have complete automatic accessories, including a heavy copper float, a guided float rod and adjustable stop. Provide mechanical or electrical alternator to switch the starting of the pumps from one to the other. Mechanical alternator is preferred but if electrical alternator is used it shall be Allen Bradley Company.

- C. Provide high-level alarm switch complete with transformer, bell and one set of 120 VAC rated normally open contacts for connection to future Central Data Acquisition System.
- D. Provide a complete wiring diagram for this installation with submittal data.
- E. Valve Boxes:
 - 1. For each underground valve installed by the Contractor, the Contractor shall provide and install a two-piece, screw adjustable type valve box. These valve boxes shall be designed for heavy roadway service and they shall have a deep socket type of cover which prevents their being accidentally knocked out of position.
 - 2. The word "**WATER**" shall appear on each cover. The installation of these members shall be such that by the use of the adjustable screw type bodies the tops are just flush with the finished grade. These valve boxes shall be Tyler Pipe Industries #6850, or approved equal.

2.10 MANHOLES:

- A. Manholes shall be constructed in accordance with the Drawings, of reinforced concrete or sewer brick. The flow channel shall be true to line and grade and shall be built of concrete or 1/2 section of pipe. If made of concrete, it shall be trowelled to a smooth, hard finish. Cast iron frames and covers shall be imbedded in a full bed of mortar and shall have a full bearing with top at the established grade. Cast iron steps shall be placed fifteen inches (15") on centers vertically, and staggered twelve inches (12") on centers horizontally, securely imbedded in the wall. Where pipe sewers are connected to manholes, the connection shall be made by cutting an opening into the wall of the structure, inserting the end of the pipe until it is flush with the inside face of the structure and completely filling the space between the pipe and structure with concrete or mortar.
- B. Reinforced concrete pipe shall conform to the current Specifications for "Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe", ASTM Designation C-76, Class III. Concrete shall have an average compressive strength at 28 days equal to or greater than 3000 psi (pounds per square inch). Proportion concrete shall be composed of one (1) part cement and twelve (12) parts aggregate.
- C. Sewer brick made from clay or shale shall conform to the current Specifications for "Sewer Brick," ASTM Designation C-32, Grade NA.
- D. Sewer brick made from concrete shall conform to the current Specifications for "Concrete Building Brick", ASTM Designation C-55, Grade A.

PART 3 EXECUTION

3.01 PREPARATION

- A. Coordinate cutting and forming of roof and floor construction to receive drains to required invert elevations.

3.02 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Extend cleanouts to finished floor or wall surface. Lubricate threaded cleanout plugs with mixture of graphite and linseed oil. Ensure clearance at cleanout for rodding of drainage system.
- C. Encase exterior cleanouts in concrete flush with grade.
- D. Pipe relief from back flow preventer to nearest drain.
- E. Install water hammer arrestors complete with accessible isolation valve [on hot and cold water supply piping to lavatories, sinks, and washing machine outlets].
- F. Lead: It is forbidden that lead in any form be used in any water system other than waste. If lead is used in the fabrication or installation of any water system other than waste, then all of the installed equipment and material, which may have come in contact with the lead, shall be marked with bright red or orange spray paint, and shall be removed from the project site. The system(s) shall then be restored and re-installed using all new materials.

END OF SECTION

**SECTION 22 15 13
COMPRESSED AIR SYSTEM**

PART 1 GENERAL

1.00 The following sections are to be included as if written herein:

- A. Section 23 00 00 – Basic Mechanical Requirements
- B. Section 23 05 29 – Sleeves, Flashings, Supports and Anchors
- C. Section 23 05 53 – Mechanical Identification

1.01 SECTION INCLUDES

- A. Pipe and Pipe Fittings
- B. Reciprocating Air Compressor
- C. Air Receiver and Accessories
- D. Aftercooler
- E. Refrigerated Air Dryer
- F. Pressure Reducing Station

1.02 PRODUCTS INSTALLED BUT NOT FURNISHED UNDER THIS SECTION

- A. Section 01 11 00 - Summary of Work: Owner furnished [air compressor] [air outlet fittings] [_____].

1.03 RELATED SECTIONS

- A. Section 03300 - Cast-in-Place Concrete
- B. Section 23 05 48.UT - Vibration Isolation
- C. Section 22 13 16.UT - Plumbing Piping
- D. Section 26 05 19 - Cable, Wire and Connectors, 600 Volt: Electrical characteristics, cable, wire, materials
- E. Section 26 27 26.UT - Wiring Devices and Floor Boxes: Wiring connections

1.04 REFERENCES

- A. ASME - Boiler and Pressure Vessel Code
- B. ASME B16.3 - Malleable Iron Threaded Fittings
- C. ASME B16.18 - Cast Bronze Solder-Joint Pressure Fittings
- D. ASME B16.22 - Wrought Copper and Bronze Solder-Joint Pressure Fittings
- E. ASME B16.26 - Cast Bronze Fittings for Flared Copper Tubes
- F. ASME B31.1 - Power Piping
- G. ASME B31.9 - Building Services Piping
- H. ASTM A53 - Pipe, Steel, Black and Hot-Dipped Zinc Coated, Welded and Seamless
- I. ASTM A120 - Pipe, Steel, Black and Hot-Dipped Zinc Coated (Galvanized), Welded and Seamless, for Ordinary Uses
- J. ASTM A234 - Pipe Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and Elevated Temperatures
- K. ASTM B32 - Solder Metal
- L. ASTM B88 - Seamless Copper Water Tube
- M. ASTM D2513 - Thermoplastic Gas Pressure Pipe, Tubing and Fittings
- N. ASTM D2683 - Socket-Type Polyethylene Fittings for Outside Diameter-Controlled Polyethylene Pipe
- O. NFPA 70 - National Electrical Code

1.05 SUBMITTALS

- A. Submit under provisions of Section 23 00 00.
- B. Shop Drawings: Indicate piping system schematic with electrical characteristics and connection requirements.

- C. Product Data: Provide manufacturers catalog literature with capacity, weight, and electrical characteristics and connection requirements.
- D. Test Reports: Submit inspector's certificate for air receiver for inclusion in Operating and Maintenance Manuals.
- E. Manufacturer's Installation Instructions: Indicate hoisting and setting requirements, starting procedures.

1.06 PROJECT RECORD DOCUMENTS

- A. Submit under provisions of Section 23 00 00.
- B. Record actual locations of equipment and components. Modify shop drawings to indicate final locations.

1.07 OPERATION AND MAINTENANCE DATA

- A. Submit under provisions of Section 23 00 00.
- B. Operation Data: Submit for air compressor, air receiver and accessories, after cooler, refrigerated air dryer, and pressure reducing station.
- C. Maintenance Data: Submit for air compressor, air receiver and accessories, after cooler, refrigerated air dryer, and pressure reducing station.

1.08 REGULATORY REQUIREMENTS

- A. Conform to ASME codes for installation of pressure vessels.
- B. Provide certificate of compliance from Factory Mutual indicating approval of air receiver.
- C. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories, Inc., as suitable for the purpose specified and indicated.

1.09 DELIVERY, STORAGE, AND HANDLING

- A. Deliver, store, protect and handle products to site under provisions of Section 23 00 00.
- B. Accept air compressors, refrigerated air dryer on site in factory fabricated containers with shipping skids and plastic pipe end protectors in place. Inspect for damage.

- C. Protect piping and equipment from weather and construction traffic.

1.10 WARRANTY

- A. Provide five-year warranty under provisions of Section 23 00 00.
- B. Warranty: Include coverage for reciprocating air compressors, [_____].

1.11 MAINTENANCE MATERIALS

- A. Provide maintenance materials under provisions of 23 00 00.
- B. Provide [two] [_____] quart containers of compressor oil.

PART 2 PRODUCTS

2.01 LABORATORY FITTINGS:

- A. Laboratory fittings will be furnished to the job site by the Laboratory Equipment Supplier, with necessary holes cut in the laboratory equipment. The Contractor shall receive, store, and install the fittings and make all necessary connections thereto.

2.02 PIPING:

- A. Compressed air piping shall be ASTM Specification B-88, Type K, hard drawn, seamless copper tubing with wrought copper solder fittings. No ferrous piping will be permitted in the system. Where threaded nipples are required these shall be I.P.S. brass.
- B. All piping shall be pitched back so as to drain to the point shown on the Drawings. All branch air take-offs shall be made from the top of the mains.

2.03 VALVES:

- A. Compressed air and laboratory or medical gas valves shall be Spirax Sarco Model 60, stainless steel ball valves, with screwed joint and Teflon seats.

2.04 PRESSURE SYSTEM:

NOTE TO PHYSICAL PLANT REVIEWER: IF YOU HAVE A PREFERRED ALTERNATIVE SPECIFICATION, SUBMIT IT WITH YOUR COMMENTS FOR

INSERTION HERE. (SEVERAL CAMPUSES HAVE EXPRESSED A STRONG PREFERENCE FOR INGERSOL RAND COMPRESSORS, FOR EXAMPLE.)

- A. Furnish and install a Duplex Automatic NASH Engineering Company Central Pressure System. *(Note: Engineer shall contact Physical Plant personnel to verify that this is the preferred specification.)*
- B. The compressors shall be of the rotary liquid sealed, positive displacement, non-pulsating type capable of delivering oil-free, clean, cool air without filters or aftercoolers. The pumps shall be from internal metallic contact, providing for long life and low maintenance. Each compressor shall be of cast iron, bronze fitted construction with a capacity of _____ CFM (to be filled in by Engineer) of free air measure at _____ PSIG pressure, (to be filled in by Engineer) and directly connected to a _____ HP (to be filled in by Engineer) _____ RPM Motor, (to be filled in by Engineer) suitable for 3 phase, 60 Hz, _____ volt operation (to be filled in by Engineer).
- C. The horizontal control tank shall be of welded steel, A.S.M.E. construction _____ " (to be filled in by Engineer) x _____ " (to be filled in by Engineer), galvanized inside and out; equipped with gauge glass, pressure gauge, and constant pressure valve.
- D. The system provided shall be completely automatic. Control of compressors shall be by means of pressure switches which will automatically start and stop the pumps between desired limits.
- E. Each pump shall be provided with a magnetic across-the-line type starter for wall mount, with thermal overload protection in each leg, and under voltage release. Accessories for each compressor shall include: seal water solenoid valve, seal water adjusting valve, strainer, discharge separator with gauge glass and relief valve, inlet silencer, backflow preventer in the seal water line, and a drain funnel.

2.05 TESTS:

- A. All air lines shall be tested at 150 pounds per square inch and proved tight at this pressure. All tests shall be observed by a representative of the Architect before the tests are removed.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install equipment in accordance with manufacturer's instructions.

- B. Install compressor unit on concrete housekeeping pad. Refer to Section 23 00 00.
- C. Install compressor unit on vibration isolators. Level and bolt in place. Refer to Section 23 05 48.
- D. Make air cock and drain connection on horizontal casing.
- E. Install line size gate or ball valve (depending on size), and a check valve on compressor discharge.
- F. Install replaceable cartridge type filter silencer of adequate capacity for each compressor.
- G. Place shut off valve on water inlet to aftercooler. Pipe drain to floor drain.
- H. Connect condensate drains to nearest floor drain.
- I. Install valved bypass around air dryer. Factory insulate inlet and outlet connections.
- J. Install valved drip connections at low points of piping system.
- K. Install take offs to outlets from top of main, with shut off valve after take off. Slope take-off piping to outlets.
- L. Install compressed air couplings, female quick connectors, and pressure gauges where outlets are indicated.
- M. Install tees instead of elbows at changes in direction of piping. Fit open end of each tee with plug.
- N. Identify and label piping system and components. Refer to Section 23 05 53.

3.02 FIELD QUALITY CONTROL

- A. Field inspection and testing will be performed under provisions of Section 23 00 00.UT (including Uniform General Conditions as referenced therein), and Section 22 13 16.
- B. Compressed Air Piping Leak Test: Prior to initial operation, clean and test compressed air piping in accordance with ANSI B31.1.
- C. Repair or replace compressed air piping as required to eliminate leaks, and retest to demonstrate compliance.
- D. Cap (seal) ends of piping when not connected to mechanical equipment.

END OF SECTION

SECTION 22 15 13
COMPRESSED AIR SYSTEM

SECTION 22 15 19.13
RECIPROCATING AIR COMPRESSORS

PART 1 GENERAL

1.00 The following sections are to be included as if written herein:

- A. Section 23 00 00 – Basic Mechanical Requirements
- B. Section 23 05 29 – Sleeves, Flashings, Supports and Anchors
- C. Section 23 05 53 – Mechanical Identification

1.01 **WORK INCLUDED**

- A. Reciprocating air compressor
- B. Air receiver and accessories
- C. After cooler
- D. Refrigerated air dryer
- E. Pressure reducing station

1.02 **RELATED WORK**

- A. Section 21 11 0 - Pipe and Pipe Fittings

1.03 **REFERENCES**

- A. Air receivers shall meet requirements of ASME Code for Unfired Pressure Vessels and carry ASME approval stamp.

1.04 **SUBMITTALS**

- A. Submit inspector's certificate for air receiver for inclusion in Operating and Maintenance Manuals.

PART 2 PRODUCTS

2.01 **ACCEPTABLE MANUFACTURERS**

- A. [_____.]

B. [_____.]

C. [_____.]

D. Substitutions: Under provisions of Section 23 00 00.UT.

2.02 TYPE

A. Provide [simplex] [duplex] compressor unit consisting of air-cooled motor-compressor, air receiver, aftercooler, refrigerated air dryer, pressure reducing station, spring isolators, and operating controls.

2.03 COMPRESSOR CONSTRUCTION

A. Construct compressor unit with cast iron housing and head, heat treated forged steel or ductile iron shaft, aluminum alloy connecting rods, aluminum pistons with non-lubricated carbon rings, high-strength alloy suction and discharge valves. Statically and dynamically balance rotating parts.

B. Equip compressor with oil pressure switch to automatically shut down compressor in event of oil pressure failure.

C. Provide compressor with automatic capacity reduction equipment consisting of suction valve unloaders. Lifting mechanism operated by [oil pressure.] [gas discharge pressure.] [solenoid valve.] [centrifugal force.] Provide for unloaded compressor start.

D. Mount motor and compressor on one-piece ribbed cast iron or welded steel base with provision for V-belt adjustment.

E. Provide thermostatically controlled water valve on compressor to work in conjunction with control circuit to maintain water temperature through compressor at 98 degrees F to 109 degrees F.

2.04 AFTERCOOLER

A. Provide air compressor with air aftercooler suitable for operation under 135 psig working pressure.

B. Construct with removable tube nests of non-ferrous metal tubes and corrosion resistant tube plates, safety valves, pressure gauge, moisture separator, moisture drain valve, water inlet piping with automatic water valve, automatic condensate trap, and overflow piping with open funnel.

C. Aftercooler capacity to cool discharge air to within 12 degrees F of ambient air temperature with compressors operating at specified capacity.

2.05 AIR DRYER

- A. Provide refrigerated air dryer of self-contained mechanical refrigeration type complete with heat exchanger, refrigeration compressor, automatic controls, moisture removal trap, internal wiring and piping, and full refrigerant charge.
- B. Design air inlet and air outlet connections at same level and factory insulated.
- C. Heat exchangers to consist of air-to-air and refrigerant-to-air coils. Provide centrifugal-type moisture separator located at discharge of heat exchanger. Provide heat exchangers with automatic control system to bypass refrigeration system on low or no load condition.
- D. Refrigeration unit of hermetically sealed type to operate continuously to maintain specified 21 degrees F dew point. House unit in steel cabinet provided with access door and panel for maintenance and inspection.
- E. Dryer shall be provided with air inlet temperature gauge, air inlet pressure gauge, on/off switch, high temperature light, power on light, refrigerant gauge, air outlet temperature gauge, air outlet pressure gauge.

2.06 AIR RECEIVER

- A. Provide [vertical] [horizontal] receiver built to [_____] regulations for working pressure of 125 psi. Flange or screw inlet and outlet connections.
- B. Fittings to include adjustable pressure regulator, safety valve, pressure gauge, drain cock, and automatic condensate trap.
- C. Tank Finish: Hot-dipped galvanized.

2.07 PRESSURE REDUCING VALVE

- A. Provide pressure-reducing stations complete with automatic reducing valve and bypass, and low-pressure side relief valve and gauge. [Provide oil separator where indicated.]
- B. Valve capacity suitable to reduce pressure from 200 psi to 30 psi PRV to be adjustable upwards from reduced pressure.

2.08 CONTROLS

- A. Pressure switch to cut out at 100 psi with minimum differential of 20 psi.
- B. Compressor regulation to be thru lead-lag switch with time delay relay.

- C. Provide electrical alternation set to operate each compressor for 12 hours. In the event one compressor fails, another compressor automatically maintains air pressure.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install compressor unit on concrete foundation with sole plates and isolators. Level, grout, and bolt in place.
- B. Make air cock and drain connection on horizontal casing.
- C. Install line size gate valve and anti-return valve on compressor discharge.
- D. Install replaceable cartridge type filter silencer of adequate capacity for each compressor.
- E. Place shut-off valve on water inlet to aftercooler. Pipe drain to floor drain.
- F. Connect condensate drains to nearest floor drain.
- G. Install valved bypass around air dryer. Factory insulate inlet and outlet connections.
- H. Install valved drip connections at low points of piping system.
- I. Install take-offs to outlets from top of main, with shut-off valve after take-off.
- J. Install compressed air couplings, 3/8 inch female speed couplers, and pressure gages where outlets are indicated.
- K. Install "T" pieces instead of elbows at changes in direction of piping. Fit open end of each "T" with plug.

3.02 PERFORMANCE

- A. Compressors to operate at specified air volume without oil creep, overloading, and within 10 percent of peak efficiency.
- B. Each compressor shall continuously deliver [_____] cfm of free air at intake conditions compressed to [_____] psi at [_____] ft altitude, when driven by [_____] HP ([_____] phase) electric motor.
- C. Water cooled after cooler shall have capacity to cool [_____] cfm at [_____] psi.

- D. Refrigerated air dryer shall have capacity to dry air to an atmospheric dew point [] degrees F at the rated airflow [] cfm at [] psig inlet air pressure. Pressure differential from inlet to outlet shall not exceed [] psi.
- E. Provide [] diameter by [] long, [] gallon capacity air receiver.

END OF SECTION

**SECTION 22 40 00
PLUMBING FIXTURES**

PART 1 GENERAL

1.00 The following sections are to be included as if written herein:

- A. Section 23 00 00 – Basic Mechanical Requirements
- B. Section 23 05 29 – Sleeves, Flashings, Supports and Anchors
- C. Section 23 05 53 – Mechanical Identification

1.01 SECTION INCLUDES:

- A. Lavatories
- B. Sinks
- C. Service Sinks
- D. Water Closets
- E. Urinals
- F. Faucets
- G. Showers
- H. Bathtubs
- I. Electric Water Coolers / Drinking Fountains
- J. Hose Bibbs
- K. Thermostatic Mixing Valves
- L. Vacuum Breakers
- M. Laboratory Fittings
- N. Eyewash Fountains
- O. Emergency Showers

P. Food Service Fittings

1.02 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION

- A. Section [____ - _____]: Placement of [terrazzo service sinks] [mop hangers] [shower curtains] [Shower bases] [reinforced glass fiber tubs and showers] [_____].

1.03 PRODUCTS INSTALLED BUT NOT FURNISHED UNDER THIS SECTION

- A. Section 01 11 00 - Summary of Work: Owner furnished fixtures including [_____].
- B. Section 10 28 00 - Toilet and Bath Accessories: Supply of [integral lavatory counter tops] [marble bath tubs] [_____] for placement by this Section.
- C. Section 11 40 00- Food Services Equipment: Supply of kitchen fixtures [_____] for placement by this Section.

1.04 RELATED SECTIONS

- A. Section 06410 - Custom Casework: Preparation of Counters for Sinks
- B. Section 06410 - Custom Casework: Lavatory Tops
- C. Section 07 90 00 - Joint Sealers: Seal Fixtures to Walls and Floors
- D. Section 11 40 00 - Food Services Equipment
- E. Section 23 05 29 - Supports and Anchors
- F. Section 22 13 16 - Plumbing Piping
- G. Section 22 13 16.A - Plumbing Specialties
- H. Section 22 11 23 - Plumbing Equipment
- I. Section 23 38 16 - Fume Hoods
- J. Section 11 53 23 - Environmental Room

1.05 ALLOWANCES

SECTION 22 40 00
PLUMBING FIXTURES

- A. Cash Allowance: Include under provisions of Section 23 00 00.
- B. Allowance includes purchase and delivery of owner-selected fixtures. Installation is included in this section and is part of the Contract Sum/Price.

1.06 REFERENCES

- A. ANSI/ASME A112.6.1 - Supports for Off-the-Floor Plumbing Fixtures for Public Use.
- B. ASME A112.18.1 - Finished and Rough Brass Plumbing Fixture Fittings.
- C. ANSI/ASME A112.19.1 - Enameled Cast Iron Plumbing Fixtures.
- D. ANSI/ASME A112.19.2 - Vitreous China Plumbing Fixtures.
- E. ANSI/ASME A112.19.3 - Stainless Steel Plumbing Fixtures (Designed for Residential Use).
- F. ANSI/ASME A112.19.4 - Porcelain Enameled Formed Steel Plumbing Fixtures.
- G. ANSI/ASME A112.19.5 - Trim for Water-Closet Bowls, Tanks, and Urinals (Dimensional Standards).
- H. IAPMO/ANSI Z124.1 - Plastic Bathtub Units.
- I. IAPMO/ANSI Z124.2 - Plastic Shower Receptors and Shower Stalls.
- J. ANSI Z358.1 - Emergency Eyewash and Shower Equipment.
- K. ANSI/ARI 1010 - Drinking-Fountains and Self-Contained, Mechanically-Refrigerated Drinking-Water Coolers.

1.07 SUBMITTALS

- A. Submit under provisions of Section 23 00 00.
- B. Product Data: Provide catalogue illustrations of fixtures, sizes, rough-in dimensions, utility sizes, trim, and finishes.
- C. Manufacturer's Installation Instructions.

1.08 OPERATION AND MAINTENANCE DATA

- A. Submit under provisions of Section 23 00 00.

- B. Maintenance Data: Include fixture trim exploded view and replacement parts lists.

1.09 MOCKUP

- A. Provide mockup of typical bathroom group under provisions of Section 23 00 00.
- B. Mockup may [not] remain as part of the Work.

1.10 DELIVERY, STORAGE, AND HANDLING

- A. Deliver, store, protect and handle products to site under provisions of Section 23 00 00.
- B. Accept fixtures on site in factory packaging. Inspect for damage.
- C. Protect installed fixtures from damage by securing areas and by leaving factory packaging in place to protect fixtures and prevent use.

1.11 FIELD MEASUREMENTS

- A. Verify that field measurements are either as indicated on shop drawings or as instructed by the manufacturer, and designate in the submittal both that it has been verified, and which measurements are the basis for construction.
- B. Confirm that millwork is constructed with adequate provision for the installation of countertop lavatories and sinks.

1.12 WARRANTY

- A. Provide five-year warranty under provisions of Section 23 00 00.
- B. Warranty: Include coverage of electric water cooler compressor, [_____].

1.13 EXTRA MATERIALS

- A. Furnish under provisions of Section 23 00 00.
- B. Provide two each of each type of faucet service kits, flush valve service kits, [_____].

PART 2 PRODUCTS

2.01 GENERAL

- A. The Contractor shall provide plumbing fixtures where indicated on the Drawings. These plumbing fixtures shall be standard products as manufactured by Kohler, Crane, American Standard or Eljer. The fixtures shall be free from marks or chips and shall be new, first quality and shall be furnished with sufficient supports in order to adequately hang each and every unit. The space between fixtures and masonry walls shall be grouted with White General Electric Silicone flexible grout. The space between fixtures and sheetrock or wood panel walls shall not be grouted but the fixture shall fit flat against the wall surface with no more than 1/16" gap.
- B. All faucets, fittings, supply stops and similar devices shall be of one manufacturer unless otherwise specified. All water faucets and valve bodies shall be cast brass with a minimum copper content of 85%. They shall contain standardized interchangeable operating units constructed of a removable and replaceable unit containing all parts subject to wear. All water faucets shall contain an adjustable internal volume control unit. All exposed parts shall be chromium plated.
- C. All fixtures shall meet the requirements of ADA, ANSI A117.1, ANSI Z124.2 and the State of Texas Accessibility Standards (TAS).
- D. See drawings for schedule of fixtures.

2.02 FITTINGS AND PIPES:

- A. Fittings and piping shall be brass and, wherever exposed, shall be polished chrome-plated. Provide tight fitting wall or floor escutcheons of chrome-plated brass wherever pipes pass through floors, walls or ceilings.
- B. Furnish and install all required water, waste, soil and vent connections to all plumbing fixtures, together with all fittings, supports, fastening devices, cocks, valves, traps, etc., leaving all in complete working order.
- C. Supplies for all lavatories, sinks, tank type water closets and drinking fountains shall be loose key angle stops with 1/2" I.P.S. female inlets and shall include wall flanges, and 1/2" O.D. flexible risers with bull-nose or flared end outlets. All components to be chrome plated. In all cases, all piping, tubing, fittings, and faucets shall be installed using a mechanical non-slip connection, such as bull-nose, flared, flanged, ferrule, or threaded fittings. Fittings requiring a friction fit using slip-on or gasketed connections are not acceptable.

NOTE TO SPECIFICATION WRITER: EITHER SELF-RIMMING COUNTERTOP, OR WALL HUNG LAVATORIES MAY BE USED. EDIT THIS SECTION AS REQUIRED. BE SURE TO ADVISE THE ARCHITECT THAT FIXTURE-MOUNTED SOAP DISPENSING IS NO LONGER AVAILABLE. IF SOAP DISPENSERS ARE REQUIRED, THEN THEY SHALL BE EITHER COUNTER OR WALL MOUNTED.

NOTE TO SPECIFICATION WRITER: THE FOLLOWING SCHEDULES ARE INCLUDED MORE FOR INFORMATION. PROJECT PLUMBING SCHEDULES ARE TO APPEAR ON THE DRAWINGS RATHER THAN IN THE SPECIFICATIONS. NOTE THAT THERE ARE MULTIPLE FIXTURES AND TRIM LISTED. EDIT AS APPROPRIATE FOR THE SPECIFIC PROJECT.

2.03 LAVATORIES - General Toilet Rooms - Lavatory Type "A":

- A. American Standard "AQUALYN" No. 0475.020(or equal as manufactured by Crane, Kohler or Eljer). ADA compliant, white vitreous china, self-rimming, counter top, oval lavatory. Lavatory fixture shall measure 20-inches wide by 17-inches deep, shall have faucet holes on 8-inch centers and shall be equipped with integral front-overflow ports.
- B. Chicago Faucet 785-E3-245/T&S Brass B2867-4-119-ADA-LF ADA compliant, 8-inch center spread, concealed fitting lavatory faucet with No. GN1A/119X-ADA 3-1/2 inch gooseneck spout, No. 317/BWH 4-inch blade handles, E3/B119-2 aerator and No. 245/LF integral flow control cartridges with monel seats. The force required to activate the faucet controls shall be no greater than 5 lbf. Faucet shall meet the requirements of ADA, ANSI A117.1 and the State of Texas Accessibility Standards (TAS). Acceptable alternative manufacturers: Water Saver, by approval only. Manufacturer must equal specification.
- C. McGuire No. 155WC, or approved equal, ADA compliant, chrome plated offset lavatory strainer, with heavy cast brass grid drain strainer, heavy cast base elbow and 1-1/4 inch 17-gauge tubular brass offset tailpiece. Acceptable alternative manufacturers: Water Saver, by approval only. Manufacturer must equal specification.
- D. Chicago Faucet 1006/T&S Brass B1342M supplies, with loose key angle stops, lock shield caps, 1/2" I.P. female inlets 12" long, 1/2" O.D. flexible risers, wall flanges, and 1/2" O.D. flexible tube risers with bull-nose outlets. Acceptable alternative manufacturers: Water Saver, by approval only. Manufacturer must equal specification.
- E. American Standard 7723.018/McGuire 8088 with 1127 nipple grid drain, (or equal as manufactured by Crane, Kohler or Eljer) 1-1/4" inlet and 1-1/4" outlet adjustable cast

brass P-traps with cleanout plug, brass threaded nipple from trap to tapped sanitary tee behind wall, chrome-plated cover tubing to wall and chrome plated wall escutcheon.

- F. Insulate all exposed drain and supply piping with Plumberex Specialty Products "HANDY SHIELD," or approved equal, drain line and supply line safety covers.

2.04 LAVATORIES - Exam. Area - Lavatory Type "B":

- A. American Standard "WHEELCHAIR PATIENT" No. 9140.013 (or equal as manufactured by Crane, Kohler or Eljer). ADA compliant, rectangular, white vitreous china, wall-hung lavatory. Lavatory fixture shall measure 20-inches wide by 27-inches deep, shall have faucet holes on 12-inch centers and shall be equipped with integral front-overflow ports. Fixture size, design and mounting height shall meet the requirements of ADA, ANSI A117.1 and the State of Texas Accessibility Standards (TAS).
- B. Wade W-520-07-M19-UT (or equal by Zurn, Josam or J.R. Smith) concealed arm carrier.
- C. Chicago Faucet 786-WC-245/T&S Brass B2865-4L-120X-ADA-LF ADA compliant, 12-inch center spread, concealed fitting lavatory faucet with No. GN2B/120X-ADA 5-3/8 inch gooseneck spout, No. 317/BWH-4 4-inch blade handles, E4/B130 spray outlet and No. 245/LF integral flow control cartridges. The force required to activate the faucet controls shall be no greater than 5 lbf. Faucet shall meet the requirements of ADA, ANSI A117.1 and the State of Texas Accessibility Standards (TAS). Acceptable alternative manufacturers: Water Saver, by approval only. Manufacturer must equal specification.
- D. McGuire No. 155WC, or approved equal, ADA compliant, chrome plated offset lavatory strainer, with heavy cast brass grid drain strainer, heavy cast base elbow and 1-1/4 inch 17-gauge tubular brass offset tailpiece. Acceptable alternative manufacturers: Water Saver, by approval only. Manufacturer must equal specification.
- E. Chicago Faucet 1006/T&S Brass B1342M supplies, with loose key angle stops, lock shield caps, 1/2" I.P. female inlets 12" long, 1/2" O.D. flexible risers, wall flanges, and 1/2" O.D. flexible risers with bull-nose outlets. Acceptable alternative manufacturers: Water Saver, by approval only. Manufacturer must equal specification.
- F. American Standard 7723.018/McGuire 8088 with 1127 nipple grid drain, (or equal as manufactured by Crane, Kohler or Eljer) 1-1/4" inlet and 1-1/4" outlet adjustable cast brass P-traps with cleanout plug, brass threaded nipple from trap to tapped sanitary tee behind wall, chrome-plated cover tubing to wall and chrome plated wall escutcheon.

- G. Insulate all exposed drain and supply piping with Plumberex Specialty Products "HANDY SHIELD," or approved equal, drain line and supply line safety covers.

2.05 LAVATORIES - Gen. HC - Lavatory Type "C"

- A. American Standard 'COMRADE-MODIFIED" No. 0124.131M (or equal as manufactured by Crane, Kohler or Eljer). ADA compliant, rectangular, white vitreous china, wall-hung lavatory. Lavatory fixture shall measure 20-inches wide by 18-1/4 inches deep, shall have faucet holes on 8-inch centers and shall be equipped with integral rear-overflow ports. Fixture size, design and mounting height shall meet the requirements of ADA, ANSI A117.1 and the State of Texas Accessibility Standards (TAS).
- B. Wade W-520-07-M19-UT (or equal by Zurn, Josam or J.R. Smith) concealed arm carrier.
- C. Chicago Faucet 785-E3-245/T&S Brass B2867-4-119-ADA-LF ADA compliant, 8-inch center spread, concealed fitting lavatory faucet with No. GN1A/119X-ADA 3-1/2 inch gooseneck spout, No. 317/BWH 4-inch blade handles, E3/B119-2 aerator and No. 245/LF integral flow control cartridges with monel seats. The force required to activate the faucet controls shall be no greater than 5 lbf. Faucet shall meet the requirements of ADA, ANSI A117.1 and the State of Texas Accessibility Standards (TAS). Acceptable alternative manufacturers: Water Saver, by approval only. Manufacturer must equal specification.
- D. Chicago Faucet 1006/T&S Brass B1342M supplies, with loose key angle stops, lock shield caps, 1/2" I.P. female inlets 12" long, 1/2" O.D. flexible risers, wall flanges, and 1/2" O.D. flexible tube risers with bull-nose outlets. Acceptable alternative manufacturers: Water Saver, by approval only. Manufacturer must equal specification.
- E. American Standard 7723.018/McGuire 8088 with 1127 nipple grid drain, (or equal as manufactured by Crane, Kohler or Eljer) 1-1/4" inlet and 1-1/4" outlet adjustable cast brass P-traps with cleanout plug, brass threaded nipple from trap to tapped sanitary tee behind wall; chrome-plated cover tubing to wall and chrome plated wall escutcheon.
- F. Insulate all exposed drain and supply piping with Plumberex Specialty Products "HANDY SHIELD" or approved equal, drain line and supply line safety covers.

2.06 LAVATORIES - Handicapped - Lavatory Type "D":

- A. American Standard "Aqualyn" 0475.020 self-rimming 20" x 17" oval counter lavatory punched for 8" center faucets. Equal lavatories by Eljer, Crane and Kohler will be

acceptable. Lavatory shall be mounted in counter with top surface 36" (91 cm) above finished floor and with 29-1/2" (75 cm) clear underneath.

- B. Wheelchair lavatory drain shall be McGuire No. 155WC or equal.
- C. Chicago Faucet 785-E3-245 lavatory faucet with gooseneck spout, 4" wrist blade handles, and Chicago 245 Control-a-Flo cartridges. Acceptable alternative manufacturers: Water Saver, Speakman, by approval only. Manufacturer must equal specification.
- D. Chicago Faucet 1006 supplies, with loose key angle stops, lock shield caps, 1/2" I.P. female inlets, 12" long, 1/2" O.D. flexible risers and wall flanges. Acceptable alternative manufacturers: Water Saver, Speakman, by approval only. Manufacturer must equal specification.
- E. American Standard 7723.018, or McGuire 8088 with 1127 nipple grid drain, (or equal as manufactured by Crane, Kohler or Eljer) 1-1/4" inlet and 1-1/4" outlet adjustable cast brass P-traps with cleanout plug, brass threaded nipple from trap to tapped sanitary tee behind wall, chrome-plated cover tubing to wall and chrome plated wall escutcheon. Acceptable alternative manufacturers: Water Saver, Speakman, by approval only. Manufacturer must equal specification.

2.07 LAVATORIES - Handicapped - Lavatory Type "E":

- A. American Standard "Regalyn" 04867.024 20" x 18" rectangular cast iron wall-hung lavatory punched for 8" center faucets, and Wade W-520-07-M19-UT (or equal by Zurn or J.R. Smith) concealed arm carrier. Equal lavatories by Eljer, Crane and Kohler, with equal carriers by Wade, Zurn, or J.R. Smith will be acceptable. Lavatory shall be hung with top surface 36" (91 cm) above finished floor and with 29-1/2" (75 cm) clear underneath.
- B. Chicago Faucet No. 785-E3-245 lavatory faucet with gooseneck spout, Chicago 245 Control-a-Flo cartridges, and 4" wrist blade handles. Acceptable alternative manufacturers: Water Saver, Speakman, by approval only. Manufacturer must equal specification.
- C. Chicago Faucet 1006 supplies, with loose key angle stops, lock shield caps, 1/2" I.P. female inlets, wall flanges, and 12" long, 1/2" O.D. flexible risers with bull-nose outlets. Acceptable alternative manufacturers: Water Saver, Speakman, by approval only. Manufacturer must equal specification.
- D. American Standard 7723.018, or McGuire 8088 with 1127 nipple grid drain, (or equal as manufactured by Crane, Kohler or Eljer) 1-1/4" inlet and 1-1/4" outlet adjustable cast brass P-traps with cleanout plug, brass threaded nipple from trap to tapped

sanitary tee behind wall, chrome-plated cover tubing to wall and chrome plated wall escutcheon. Acceptable alternative manufacturers: Water Saver, Speakman, by approval only. Manufacturer must equal specification.

2.08 SERVICE SINKS - Jan. Closets - Service Sink Type "A":

USE ONLY WHEN SPECIFICALLY REQUESTED BY INSTITUTION

- A. American Standard 7692.023 Crane 7-569, Kohler K-6718, or Eljer 242-0135, 22" x 18" acid-resisting, enameled cast iron service sink with rim guard bolted to rim, wall hanger, grid drain to trap standard and adjustable trap standard.
- B. Chicago Faucet 897-245 RCF/T&S Brass B667-RC-LF rough chrome plated service sink faucet with vacuum breaker spout, 3/4" hose thread on spout, adjustable wall brace, pail hook, integral stops in supply arms, and No. 245/LF integral flow control cartridges. Acceptable alternative manufacturers: Water Saver, by approval only. Manufacturer must equal specification.
- C. Stern-Williams No. T-35 or equal by C.I.T., Fiat or Oberon. 36-inch long hose with 3/4-inch polished chrome coupling and stainless steel wall bracket with rubber grip.
- D. Stern-Williams No. T-40 or equal by C.I.T., Fiat or Oberon. 24-inch long stainless steel mop hanger with three rubber spring loaded grips.

2.09 MOP SINKS - Jan. Closets - Mop Sink Type "A":

- A. Stern-Williams "SERVICEPTOR" No. SB-702-BP2, or equal by C.I.T., Fiat or Oberon, 32-inch x 32-inch x 12-inch deep corner type terrazzo mop sink with continuous stainless steel cap on all four sides and tilting flange on two sides. Equip fixture complete with nickel bronze strainer and stainless steel splash catcher panels on two sides.
- B. Chicago Faucet 897-245 RCF/T&S Brass B667-RC-LF rough chrome plated service sink faucet with vacuum breaker spout, 3/4" hose thread on spout, adjustable wall brace, pail hook, integral stops in supply arms, and No. 245/LF integral flow control cartridges. Acceptable alternative manufacturers: Water Saver, by approval only. Manufacturer must equal specification.
- C. Stern-Williams No. T-35 or equal by C.I.T., Fiat or Oberon. 36-inch long hose with 3/4-inch polished chrome coupling and stainless steel wall bracket with rubber grip.
- D. Stern-Williams No. T-40 or equal by C.I.T., Fiat or Oberon. 24-inch long stainless steel mop hanger with three rubber spring loaded grips.

2.10 SINKS - General Use - Single Comp. Type "A":

- A. Elkay ADAR-2522-3, Just or approved equal, ADA compliant, 25-inch x 22-inch x 5-3/8 inch deep self-rimming, single compartment, 18-gauge type 302 stainless steel sink with 3-faucet holes, one 3-1/2 inch drain hole and fully undercoated underside.
- B. Chicago Faucet 201A-GN2A-E3-317-245/T&S Brass B2866-4-133X-ADA-LF ADA compliant, 8-inch center spread, concealed fitting lavatory faucet with No. GN2A/133X-ADA 5-3/8 inch by 9-3/4 inch tall rigid/swing convertible gooseneck spout, No. 317/BWH-4 4-inch blade handles, E3/B199-2 aerator and No. 245/LF integral flow control cartridges. The force required to activate the faucet controls shall be no greater than 5 lfb. Faucet shall meet the requirements of ADA, ANSI A117.1 and the State of Texas Accessibility Standards (TAS). Acceptable alternative manufacturers: Water Saver, by approval only. Manufacturer must equal specification.
- C. Chicago Faucet 1006/T&S Brass B1342M supplies with loose key angle stops, lock shield caps, 1/2" I.P.S. female inlets, wall flanges and 1/2" O.D. flexible risers with bull-nose outlets. Acceptable alternative manufacturers: Water Saver, by approval only. Manufacturer must equal specification.
- D. McGuire No. 1151AWC, or approved equal, ADA compliant, chrome plated offset sink strainer with stainless steel strainer fitting, stainless steel conical strainer basket, neoprene stopper and 1-1/2 inch 17-gauge tubular brass offset tailpiece.
- E. Crane 8-5272, Kohler K-9010, or Eljer 804-1110, 1-1/2" inlet and 1-1/2" outlet adjustable cast brass p-trap with cleanout plug, Type "L" hard drawn copper pipe with IPS brass threaded adapters on both ends to connect from trap to tapped sanitary tee behind wall and CHROME PLATED escutcheon at wall.

2.11 SINKS - General Use - Double Comp. Type "B":

- A. Elkay ADAR-3322-3, Just or approved equal, ADA compliant, 33-inch x 22-inch x 5-3/8 inch deep self-rimming, double compartment, 18-gauge type 302 stainless steel sink with 3-faucet holes, two 3-1/2 inch drain holes and fully undercoated underside.
- B. Chicago Faucet 201A-GN8A-E3-317-245/T&S Brass B2866-4-135X-LF ADA compliant, 8-inch center spread, concealed fitting lavatory faucet with No. GN8A/135X 11-1/4 inch by 8-inch tall rigid/swing convertible gooseneck spout, No. 317/BWH-4 4-inch blade handles, E3/B199-2 aerator and No. 245/LF integral flow control cartridges. The force required to activate the faucet controls shall be no greater than 5 lb. Faucet shall meet the requirements of ADA, ANSI A117.1 and the State of

Texas Accessibility Standards (TAS). Acceptable alternative manufacturers: Water Saver, by approval only. Manufacturer must equal specification.

- C. Chicago Faucet 1006/T&S Brass B1342M supplies with loose key angle stops, lock shield caps, 1/2" I.P.S. female inlets, wall flanges and 1/2" O.D. flexible risers with bull-nose outlets. Acceptable alternative manufacturers: Water Saver, by approval only. Manufacturer must equal specification.
- D. American Standard 4331.013, Crane 8-5240, Kohler K8801 or Eljer 803-0580 crumb cup strainer with tailpiece.
- E. Elkay No. LK-53, or equal by Just or McGuire, 1-1/2 inch polished chrome plated, brass, continuous waste or drain connection tubing with end outlet for double compartment sink interconnection.
- F. Crane 8-5272, Kohler K-9010, or Eljer 804-1110, 1-1/2" inlet and 1-1/2" outlet adjustable cast brass p-trap with cleanout plug, Type "L" hard drawn copper pipe with IPS brass threaded adapters on both ends to connect from trap to tapped sanitary tee behind wall and CHROME PLATED escutcheon at wall.

2.12 SINKS - laboratory Use - Single Comp. Type "C":

- A. Elkay ADAR-2522M-4, Just or approved equal, ADA compliant, 25-inch x 22-inch x 5-3/8 inch deep self-rimming, single compartment, 18-gauge type 302 stainless steel sink with 4-faucet holes, one 3-1/2 inch drain hole and fully undercoated underside. Locate fourth faucet hole at location suitable for deionized water faucet operation.
- B. Chicago Faucet 201A-GN2BVB-E7-317-245/T&S Brass B2866-4-B407-2-B198-LF ADA compliant, 8-inch center spread, concealed fitting lavatory faucet with No. GN2B/B407-2 5-3/8 inch by 9-3/4 inch tall rigid/swing convertible gooseneck spout with vacuum breaker, serrated laboratory hose nozzle, No. 317/BWH-4 4-inch blade handles, and No. 245/LF integral flow control cartridges. The force required to activate the faucet controls shall be no greater than 5 lbf. Faucet shall meet the requirements of ADA, ANSI A117.1 and the State of Texas Accessibility Standards (TAS). Acceptable alternative manufacturers: Water Saver, by approval only. Manufacturer must equal specification.
- C. Chicago Faucet 828 (For Deionized water), 6-inch by 12-1/2-inch tall PVDF ultra pure water fitting with serrated nozzle, brass riser, flange and inlet shank with PFA tube, chrome plated spout and flange and PVDF compression inlet. Acceptable alternative manufacturers: Water Saver, by approval only. Manufacturer must equal specification.

- D. Chicago Faucet 1006/T&S Brass B1342M supplies with loose key angle stops, lock shield caps, 1/2" I.P.S. female inlets, wall flanges and 1/2" O.D. flexible risers with bull-nose outlets. Acceptable alternative manufacturers: Water Saver, by approval only. Manufacturer must equal specification.
- E. McGuire No. 1151AWC, or approved equal, ADA compliant, chrome plated offset sink strainer with stainless steel strainer fitting, stainless steel conical strainer basket, neoprene stopper and 1-1/2 inch 17-gauge tubular brass offset tailpiece.
- F. Crane 8-5272, Kohler K-9010, or Eljer 804-1110, 1-1/2" inlet and 1-1/2" outlet adjustable cast brass p-trap with cleanout plug, Type "L" hard drawn copper pipe with IPS brass threaded adapters on both ends to connect from trap to tapped sanitary tee behind wall and CHROME PLATED escutcheon at wall.

2.13 SINKS - laboratory Use - Double Comp. Type "D":

- A. Elkay ADAR-3322M-4, Just or approved equal, ADA compliant, 33-inch x 22-inch x 5-3/8 inch deep self-rimming, double compartment, 18-gauge type 302 stainless steel sink with 4-faucet holes, two 3-1/2 inch drain holes and fully undercoated underside. Locate fourth faucet hole at location suitable for deionized water faucet operation.
- B. Chicago Faucet 201A-GN8BVB-E7-317-245/T&S Brass B2866-4-B407-3-B198-LF ADA compliant, 8-inch center spread, concealed fitting lavatory faucet with No. GN8B/B407-3 8-inch by 11-1/4 inch tall rigid/swing convertible gooseneck spout with vacuum breaker, serrated laboratory hose nozzle, No. 317/BWH-4 4-inch blade handles, and No. 245/LF integral flow control cartridges. The force required to activate the faucet controls shall be no greater than 5 lbf. Faucet shall meet the requirements of ADA, ANSI A117.1 and the State of Texas Accessibility Standards (TAS). Acceptable alternative manufacturers: Water Saver, by approval only. Manufacturer must equal specification.
- C. Chicago Faucet 828 (For Deionized water), 6-inch by 12-1/2-inch tall PVDF ultra pure water fitting with serrated nozzle, brass riser, flange and inlet shank with PFA tube, chrome plated spout and flange and PVDF compression inlet. Acceptable alternative manufacturers: Water Saver, by approval only. Manufacturer must equal specification.
- D. Chicago Faucet 1006/T&S Brass B1342M supplies with loose key angle stops, lock shield caps, 1/2" I.P.S. female inlets, wall flanges and 1/2" O.D. flexible risers with bull-nose outlets. Acceptable alternative manufacturers: Water Saver, by approval only. Manufacturer must equal specification.
- E. American Standard 4331.013, Crane 8-5240, Kohler K8801 or Eljer 803-0580 crumb cup strainer with tailpiece.

- F. Elkay No. LK-53, or equal by Just or McGuire, 1-1/2 inch polished chrome plated, brass, continuous waste or drain connection tubing with end outlet for double compartment sink interconnection.
- G. Crane 8-5272, Kohler K-9010, or Eljer 804-1110, 1-1/2" inlet and 1-1/2" outlet adjustable cast brass p-trap with cleanout plug, Type "L" hard drawn copper pipe with IPS brass threaded adapters on both ends to connect from trap to tapped sanitary tee behind wall and CHROME PLATED escutcheon at wall.

2.14 SINKS - General Use - Single Comp. Type "E":

- A. Elkay ADAR-2522-3, Just or approved equal, ADA compliant, 25-inch x 22-inch x 5-3/8 inch deep self-rimming, single compartment, 18-gauge type 302 stainless steel sink with 3-faucet holes, one 3-1/2 inch drain hole and fully undercoated underside.
- B. Chicago Faucet 745-VO/T&S Brass B475LKS-OMNI A 710-B473 knee action mixing valve with white enameled wall bracket, no. 699 loose key straight stops and No. 1021/Omni A710 1.6 GPM steady-flow valves on inlets. Provide polished chrome plated brass piping supplies and pipe escutcheons for each stop. Acceptable alternative manufacturers: Water Saver, by approval only. Manufacturer must equal specification.
- C. Chicago Faucet 636-E3/T&S Brass B431-133X-ADA-B199-2 deck mounted faucet fitting with No. GN2A/133X-B199-2 5-3/8 inch by 10-3/4 inch tall rigid/swing convertible gooseneck spout. Acceptable alternative manufacturers: Water Saver, by approval only. Manufacturer must equal specification.
- D. McGuire No. 1151AWC, or approved equal, ADA compliant, chrome plated offset sink strainer with stainless steel strainer fitting, stainless steel conical strainer basket, neoprene stopper and 1-1/2 inch 17-gauge tubular brass offset tailpiece.
- E. Crane 8-5272, Kohler K-9010, or Eljer 804-1110, 1-1/2" inlet and 1-1/2" outlet adjustable cast brass p-trap with cleanout plug, Type "L" hard drawn copper pipe with IPS brass threaded adapters on both ends to connect from trap to tapped sanitary tee behind wall and CHROME PLATED escutcheon at wall.

2.15 SINKS - General Use - Double Comp. Type "F":

- A. Elkay ADAR-3322-3, Just or approved equal, ADA compliant, 33-inch x 22-inch x 5-3/8 inch deep self-rimming, double compartment, 18-gauge type 302 stainless steel sink with 3-faucet holes, two 3-1/2 inch drain holes and fully undercoated underside.

- B. Chicago Faucet 745-VO/T&S Brass B475LKS-OMNI A 710-B473 knee action mixing valve with white enameled wall bracket, No. 699 loose key straight stops and No. 1021/OMNI A 710 1.6 GPM steady-flow valves on inlets. Provide polished chrome plated brass piping supplies and pipe escutcheons for each stop. Acceptable alternative manufacturers: Water Saver, by approval only. Manufacturer must equal specification.
 - C. Chicago Faucet 636-E3-MODIFIED/B431-135X-B199-2 deck mounted faucet fitting with No. GN8A/X135-B199-2 8-inch by 11-1/4 inch tall rigid/swing convertible gooseneck spout. Acceptable alternative manufacturers: Water Saver, by approval only. Manufacturer must equal specification.
 - D. American Standard 4331.013, Crane 8-5240, Kohler K8801 or Eljer 803-0580 crumb cup strainer with tailpiece.
 - E. Elkay No. LK-53, or equal by Just or McGuire, 1-1/2 inch polished chrome plated, brass, continuous waste or drain connection tubing with end outlet for double compartment sink interconnection.
 - F. Crane 8-5272, Kohler K-9010, or Eljer 804-1110, 1-1/2" inlet and 1-1/2" outlet adjustable cast brass p-trap with cleanout plug, Type "L" hard drawn copper pipe with IPS brass threaded adapters on both ends to connect from trap to tapped sanitary tee behind wall and CHROME PLATED escutcheon at wall.
- 2.16 WATER CLOSETS - General Toilet Rooms (Note: All water closets shall be installed 16 1/2" to 17 1/2" from finished floor to the top of the china rim.)
- A. American Standard "AFWALL" No. 2257.103 (or equal as manufactured by Crane, Kohler, or Eljer) ADA compliant, 1.6-gpf, white vitreous china, direct-fed siphon jet flushing action, elongated-front, wall-hung, flush valve water closet fixture with 1-1/2 inch top spud. Provide a wall hung bowl meeting the requirements of ADA, ANSI A117.1 and the State of Texas Accessibility Standards (TAS). Water closet fixture shall be designed to flush efficiently with a maximum 1.6-gallons of water total per flush. Fixture shall be listed in the State of Texas Water Commission List of Approved Plumbing Fixtures. No wax rings will be permitted on fixtures. Sealing rings shall be resilient rubber.
 - B. Zurn Aquaflush Z-6000-1-WS-YK-ADA or Sloan Royal 110-YK ADA compliant, diaphragm operated, quiet flush, exposed water closet flush valve made of brass with metal oscillating non-hold-open type handle, 1-inch IPS screw driver operated back check angle stop with protective cap, renewable main valve seat, adjustable threaded union tailpiece, vacuum breaker, 1-1/2 inch by 11-1/2 inch flush tube and connection with spud coupling for 1-1/2 inch top spud, spud securing nut, wall and spud flanges, 1-1/2 gallon flush regulator, solid ring pipe support all with polished chrome finish.

Flush control shall be mounted on the wide side of the toilet area. The force required to activate the control shall be no greater than 5 lfb. Flush valve assembly shall meet the requirements of ADA, ANSI A117.1 and the State of Texas Accessibility Standards (TAS). Flush valve shall be designed to flush efficiently with a maximum 1.5-gallons of water total per flush. Flush valve shall be listed in the State of Texas Water Commission List of Approved Plumbing Fixtures.

- C. Olsonite 95-CCSS, Church 5321.112 or Beneke 527-SSCH white open front seat with concealed stainless steel check.
- D. Wade, Zurn, J.R. Smith or Josam adjustable carrier system, single or double, as required by waste line locations conforming to piping system used. Equip each carrier with a flush valve supply support for exposed flush valves, J.R. Smith Suffix-M12, Wade number AM1 or Josam Suffix-6.

2.17 URINALS - General Toilet Rooms - Urinal Type "A":

- A. All urinals shall be mounted with rim at 24" above finished floor. In toilet rooms designated to be accessible to the handicapped, and no water closets are provided within the same room, all urinals shall be installed with rim at 17" above finished floor. Submittal data shall show height of basin opening and rough-in height. Fixture size, design and mounting height shall meet the requirements of ADA, ANSI A117.1 and the State of Texas Accessibility Standards (TAS). Fixture-to-wall sealing rings shall be resilient rubber. Wax sealing rings will not be acceptable.
- B. American Standard "ALLBROOK" No. 6541.132, Crane, Eljer or Kohler ADA compliant, 1-gallon per flush, white vitreous china, siphon jet flushing action, compact, space-saving, wall-hung, flush valve urinal fixture with 3/4 inch top spud. Provide a urinal fixture measuring a minimum of 14-inches from finished wall to front of flare. Fixture shall meet the requirements of ADA, ANSI A117.1 and the State of Texas Accessibility Standards (TAS). Urinal fixture shall be designed to flush efficiently with a maximum 1-gallon of water total per flush. Fixture shall be listed in the State of Texas Water Commission List of Approved Plumbing Fixtures.
- C. Zurn AQUAFLUSH Z-6001-1-WS-YK-ADA or Sloan ROYAL 186-1-YK ADA compliant, diaphragm operated, quiet flush, exposed water closet flush valve made of brass with metal oscillating non-hold-open type handle, 1-inch IPS screw driver operated back check angle stop with protective cap, renewable main valve seat, adjustable threaded union tailpiece, vacuum breaker, 3/4-inch by 11-1/2 inch flush tube and connection with spud coupling for 3/4-inch top spud, spud securing nut, wall and spud flanges, 1-gallon flush regulator, solid ring pipe support all with polished chrome finish. The force required to activate the control shall be no greater than 5 lfb. Flush valve assembly shall meet the requirements of ADA, ANSI A117.1 and the State of Texas Accessibility Standards (TAS). Flush valve shall be designed to flush

efficiently with a maximum 1-gallon of water total per flush. Flush valve shall be listed in the State of Texas Water Commission List of Approved Plumbing Fixtures.

- D. Wade W-451, Zurn, J.R. Smith or Josam concealed carrier with bearing plate. Equip each carrier with a flush valve supply support for exposed flush valves, J.R. Smith Suffix-M12, Wade number AM1 or Josam Suffix-6.

2.18 SHOWER STALL - Standard Type "A":

- A. Crane No. ADA-3636S, or approved equal, ADA compliant, white, 36-inch by 36-inch, one piece, seamless, acrylic shower module with three (3) walls with molded self-draining soap ledges at showering height and ASTM F-462 slip resistant safety floor. Equip complete with ADA compliant teak wood folding seat, ADA compliant stainless steel grab bars, vinyl curtain with stainless steel curtain rod and drain/waste assembly. Resin shall be fire retardant contact molding type having a flame spread rating of 25 or less and a smoke density rating of 450 or less in accordance with ASTM E-84 test method. Shower walls shall be reinforced with stiffeners for additional structural strength and reducing sound transmission. The floor of each unit shall be reinforced. Unit shall be reinforced at both sides of the opening for attachment of curtain rods or enclosure. Plumbing wall of unit shall be reinforced for the attachment of shower valve and shower arm.
- B. Chicago Faucet 1762-IS-VOC/Symmons S96-300-B30-XLV built in anti-scald pressure balanced shower valve with integral stops, chrome plated cast brass lever handle, 778-9K wall spout with vacuum breaker and No. 151 hand and wall shower with 59" flexible rubber lined metal hose, nylon and chrome plated hand spray and 24" adjusting bar with hand shower slide bracket. Pressure balanced shower shall have a piston type cartridge that operates by opening initially through the range of colder temperatures, up to an adjustable maximum high temperature position. Diaphragm type pressure balancing valves are not acceptable. Acceptable alternative manufacturers: Watersaver, by approval only. Manufacturer must equal specification.

2.19 SHOWER STALL - Handicapped:

- A. Kimstock, Inc., 3837-H-INS institutional fiberglass shower stall with steel reinforcing ribs, 1-1/2" curb for wheel chair entry, reinforced floor, brass drain with stainless steel strainer plate, No. 12 soap dish, No. C-2 grab bar, No. 36 stainless steel curtain rod and FS-35-N folding shower seat.
- B. Chicago Faucet 1762-IS-VOC built in anti-scald pressure balanced shower valve with integral stops, chrome plated cast brass lever handle, 778-9K wall spout with vacuum breaker and No. 151 hand and wall shower with 59" flexible rubber lined metal hose, nylon and chrome plated hand spray and 24" adjusting bar with hand shower slide bracket. Pressure balanced shower shall have a piston type cartridge that operates by

opening initially through the range of colder temperatures, up to an adjustable maximum high temperature position. Diaphragm type pressure balancing valves are not acceptable. Acceptable alternative manufacturers: Symmons, by approval only. Manufacturer must equal specification.

2.20 COMBINATION TUB AND SHOWER:

- A. Kohler K-745-S or K-746-S, or equal by Eljer, American Standard, or Crane, 5-ft. white, enameled cast iron tub with slip resistant standing area surface.
- B. Chicago Faucet 1760-IS built-in anti-scald, balanced pressure tub and shower valve with integral stops, chrome plated cast brass lever handle, ball joint head, bent arm, flange and 749-S chrome plated cast brass diverter spout. Pressure balanced tub and shower valve shall have a piston type cartridge that operates by opening initially through the range of colder temperatures, up to a maximum high temperature position. Shower head shall be chrome plated, vandal resistant, stream adjustable, flow restricting to 3.0 GPM, aerating type, and shall be by the same manufacturer of the shower valve. Diaphragm type pressure balancing valves are not acceptable. Acceptable alternative manufacturers: Symmons, by approval only. Manufacturer must equal specification.
- C. American Standard 1541.170, pop-up waste and overflow with spud and stopper made of chrome-plated nickel silver.

2.21 ELECTRIC DRINKING FOUNTAINS - Two Level Type "A":

- A. Elkay ERP2-8-C, or approved equal, ADA compliant, lead free, two level wheel chair access electric drinking fountain with Flexi-Guard safety bubbler, in-line flow regulator, louvered front grille enclosure, bottom cover plate, wall mounting box, self closing front push bar and all stainless steel finish. Unit shall have a capacity characteristic of 8.0 GPH of 50 degrees F. water 90 degrees F. ambient and 80 degrees F. inlet water.
- B. P-trap and supply stop same as specified for lavatory.

2.22 DRINKING FOUNTAINS (Remote Cooling Systems): (NOTE: USE ONLY WHEN THIS TYPE OF SYSTEM HAS BEEN APPROVED FOR USE.)

- A. American Standard 8310.112, Crane 6-520, Kohler K-5264-A or Eljer 191-0510 vitreous china surface mounted drinking fountain with anti-squirt self-closing supply, volume regulator, screwdriver stop and P-trap as specified for lavatory.

2.23 DRINKING FOUNTAINS (Self-contained):

- A. Elkay EBFS-8, Halsey Taylor BFC-8FS electric drinking fountain with stainless steel fountain top, stainless steel cabinet apron and self-closing push bar located on front and both sides of cabinet. Units shall be ARI certified, with capacity of 6.7 GPH of 50 degrees F. water 90 degrees F. ambient and 80 degrees F. inlet water. Push bar(s) shall be adjusted for a maximum of 5 pounds pressure to operate.
- B. P-trap as specified for lavatory.

2.24 HOSE BIBBS (HB-1):

- A. Chicago Faucet 952/T&S Brass B-720 hose bibb, with vacuum breaker, 3/4" hose thread outlet, 3/4" flanged female inlet and removable tee handle with lock shield cap. Acceptable alternative manufacturers: Water Saver, by approval only. Manufacturer must equal specification.

2.25 VACUUM BREAKERS:

- A. All outlets with hose threads shall be provided with vacuum breakers. Where vacuum breakers have not been specified with fixture trim and on all hose faucets not associated with plumbing fixtures both inside and outside of buildings, contractor shall furnish and install 3/4" hose thread vacuum breakers attached to the hose outlet threads with tamper proof set screw. Vacuum breaker shall be as manufactured by Chicago Faucet (E-27 or E-22), or by Watts.

2.26 LABORATORY FITTINGS:

- A. All laboratory fittings specified under Laboratory Furniture and Casework, or Plumbing Fixtures and Equipment shall contain standardized operating valve units which are interchangeable with plumbing faucets and fittings specified under Plumbing Fixtures and Equipment and shall be T&S, Water Saver or Chicago Faucet ONLY. Contractor shall furnish and install threaded and/or flared ferrule fittings for all faucets and fixtures specified for this project. Fittings requiring a friction fit using a slip on gasketed fitting are not acceptable.
- B. All laboratory fittings, including those within fume hoods shall have a sepia bronze and epoxy finish to resist solvents, fumes and chemical materials.
- C. The following standard color-coded index buttons shall be used on laboratory fitting handles:

Service	Indexing	Button Color	Letter Color
Cold Water	CW	Green	White
Hot Water	HW	Red	White

Gas	GAS	Blue	White
Air	AIR	Orange	White
Vacuum	VAC	Yellow	White
Distilled Water	DW	White	Black
Steam	STEAM	Black	White
Oxygen	OXY	Light Green	White
Nitrogen	N2	Gray or Brown	Black or White

2.27 EMERGENCY SHOWER:

- A. Emergency shower shall be Haws 8169, or Speakman SE-235 concealed wall-mounted shower. Furnish complete with flanged deluge shower head, stay-open valve with pull bar, flanged through ceiling, interconnecting fittings. All exposed parts shall be polished chrome-plated.

2.28 EMERGENCY EYEWASH - Lab. Area- Eyewash Type "A":

- A. Haws No. 8902-VB hand held, deck mounted, laboratory emergency eye and face spray unit with 1/2-inch supply connection, eight foot stainless steel safety hose, soft flow polished chrome plated spray unit with quick opening lever valve, automatic flow compensation device, polished chrome plated hand grip with large integral base, base flange, positioning deck flange, metal hose bracket, vacuum breaker and "EMERGENCY EYEWASH" identification sign. Locate where directed by Owner. All exposed surfaces shall be polished chrome plated brass. Support eyewash and hose with bracket as recommended by manufacturer, to ensure a rigid installation. Stop valve and supply same as for lavatory.
- B. Equip each emergency eyewash unit with a 3/4-inch pressure type vacuum breaker valve with ball valve shut-offs. Mount valve on wall with back of valve to wall and front of valve towards room for inspection/testing. Adequately secure valve to wall. Provide polished chrome plated brass escutcheons per specification section 22 05 29 Hangers and Supports for Plumbing Piping and Equipment where piping penetrates wall, inlet and outlet. Maintain amount of exposed piping to an absolute minimum and paint all exposed piping to match adjacent wall. Watts No. 800-QT or equal by Febco, Conbraco or Wilkins. Install at 7'-6" above finished floor.
- C. Chicago Faucet 1006/T&S Brass B1342M supplies with loose key angle stops, lock shield caps, 1/2" I.P.S. female inlets, wall flanges and 1/2" O.D. flexible risers with bull-nose outlets. Acceptable alternative manufacturers: Water Saver, by approval only. Manufacturer must equal specification.

2.29 FOOD SERVICE EQUIPMENT FAUCETS AND FITTINGS:

- A. All food service equipment faucets and fittings specified under Food Service Equipment or Plumbing Fixtures and Equipment shall contain standardized operating valve units which are interchangeable with plumbing faucets and fittings specified under Plumbing Fixtures and Equipment.
- B. Food service equipment faucets and fittings shall be as catalogued in Chicago Faucet Co. or Water Saver. Contractor shall furnish and install threaded and/or flared ferrule fittings for all faucets and fixtures specified for this project. Fittings requiring a friction fit using a slip on gasketed fitting are not acceptable. They shall have polished chrome-plated finish. Vacuum breakers shall be provided on all faucets with hoses. All hoses shall be flexible, stainless steel covered.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that walls and floor finishes are prepared and ready for installation of fixtures.
- B. Verify that electric power is available and of the correct characteristics.

3.02 PREPARATION

- A. Rough-in fixture piping connections in accordance with minimum sizes indicated in fixture rough-in schedule for particular fixtures.

3.03 INSTALLATION

- A. Furnish and install all labor, materials, equipment, tools and services and perform all operations required in connection with or properly incidental to the installation of complete plumbing fixtures, as indicated on the Drawings, reasonably implied therefrom, or as specified herein, unless specifically excluded.
- B. Plumbing fixtures shall be supplied, set and connected as listed herein and as shown on the Drawings. Fixtures shall be protected from damage during construction, and shall be thoroughly cleaned of all tape and adhesives prior to final acceptance.
- C. Coordinate special mounting heights of plumbing fixtures with architectural details of each toilet area.

- D. Install in accordance with manufacturer's instructions.
- E. Install each fixture with trap, easily removable for servicing and cleaning.
- F. Install components level and plumb.
- G. Install and secure all fixtures in place with specified wall carriers and bolts.
- H. Solidly attach water closets to floor with lag screws. Lead flashing is not intended hold fixture in place.

3.04 INTERFACE WITH OTHER PRODUCTS

- A. Review millwork shop drawings. Confirm location and size of fixtures and openings before rough-in and installation.

3.05 ADJUSTING

- A. Adjust work under provisions of Section 23 00 00.
- B. Adjust stops or valves for intended water flow rate to fixtures without splashing, noise, or overflow.

3.06 CLEANING

- A. Clean work under provisions of 23 00 00.
- B. At completion clean plumbing fixtures and equipment.

3.07 PROTECTION OF FINISHED WORK

- A. Protect finished Work under provisions of Section 23 00 00.
- B. Do not permit use of fixtures during construction, until after Substantial Completion has been announced by Owner.

3.08 FIXTURE HEIGHTS

Fixture size, design and mounting height shall meet the requirements of ADA, ANSI A117.1 and the State of Texas Accessibility Standards (TAS).

- A. Install fixtures to heights above finished floor as indicated.
- B. Water-Closet

1. Standard 17 inches to top of bowl rim.

C. Urinal

1. Standard 24 inches to top of bowl rim.
2. Handicapped 17 inches to top of bowl rim (one and only one urinal shall be installed at this height in each location where urinals are installed).

D. Lavatory (wall hung)

1. Standard 32 inches to top of basin rim.

E. Drinking Fountain

1. Standard 36 inches to top of basin rim.

F. Water Closet Flush Valves

1. Standard 10 inches min. above bowl rim.

G. Shower Heads

1. [Adult male] [Standard] 69.5 inches from to bottom of head.
2. [Adult female 64.5 inches to bottom of head.]
3. [Child 58.5 inches to bottom of head.]

H. Emergency Eye Wash

1. Standard 38 inches to receptor rim.

I. Emergency Shower

1. Standard 84 inches to bottom of head.

3.09 FIXTURE ROUGH-IN SCHEDULE

	<u>Hot Water</u>	<u>Cold Water</u>	<u>Waste</u>	<u>Vent</u>
Lavatory:	1/2 inch	1/2 inch	1-1/2 inch	1-1/4 inch
Service Sink:	1/2 inch	1/2 inch	3 inch	1-1/2 inch
Sink:	1/2 inch	1/2 inch	1-1/2 inch	1-1/4 inch
Drinking Fountain:		1/2 inch	1-1/4 inch	1-1/4 inch
Water Closet		1 inch	4 inch	2 inch
Urinal		3/4 inch	2 inch	1-1/2 inch

END OF SECTION

**SECTION 22 63 13
MEDICAL GAS SYSTEMS**

PART 1 GENERAL

1.00 The following sections are to be included as if written herein:

- A. Section 23 00 00 – Basic Mechanical Requirements
- B. Section 23 05 29 – Sleeves, Flashings, Supports and Anchors
- C. Section 23 05 53 – Mechanical Identification

1.01 SECTION INCLUDES

- A. Medical Oxygen Gas System
- B. Medical Compressed Air System
- C. Medical Vacuum System
- D. Nitrous Oxide System
- E. Nitrogen System

1.02 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION

- A. Section 01 11 00 - Summary of Work: Owner installed [oxygen tank] [_____].
- B. Section [_____ - _____]: Placement of [ceiling mounted outlets] [oxygen bulk storage facilities].

1.03 PRODUCTS INSTALLED BUT NOT FURNISHED UNDER THIS SECTION

- A. Section 01 11 00 - Summary of Work: Owner furnished liquid oxygen bulk storage.
- B. Section [_____ - _____]: Supply of [bottled medical gases] [integrated wall systems] for placement by this section.

1.04 RELATED SECTIONS

- A. Section 31 23 16 - Excavating

- B. Section 31 23 23.13 - Backfilling
- C. Section [] - Hospital Equipment: Prefabricated Patient Bedside Units
- D. Section 23 05 48.UT - Vibration Isolation
- E. Section 23 07 19.UT - Piping Insulation
- F. Section 22 13 16.UT - Plumbing Piping
- G. Section 26 27 26.UT - Wiring Devices
- H. Section 26 05 00 - Equipment Wiring Systems

1.05 ALLOWANCES

- A. Cash Allowance: Include under provisions of Section 23 00 00.
- B. Allowance includes purchase and delivery of bottled gases. Installation is included in this section and is part of the Contract Sum/Price.
- C. Allowance includes cost of testing and certifying systems in accordance with cross connection tests.

1.06 REFERENCES

- A. ANSI B16.18 - Cast Copper Alloy Solder-Joint Pressure Fittings
- B. ANSI B16.22 - Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
- C. ANSI B40.1 - Gauges, Pressure and Vacuum, Indicating Dial Type-Elastic Element
- D. ASME Boiler and Pressure Vessel Code
- E. ASTM A167 - Stainless and Heat-Resisting Chromium - Nickel Steel Plate
- F. ASTM A269 - Stainless and Welded Austentic Stainless Steel Tubing for General Service
- G. ASTM A403 - Wrought Austentic Stainless Steel Piping Fittings
- H. ASTM B32 - Solder Metal
- I. ASTM B88 - Seamless Copper Water Tube

- J. ASTM B280 - Seamless Copper Tube for Air Conditioning and Refrigeration field Service
- K. ASTM D1785 - Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120
- L. ASTM D2466 - Poly (Vinyl Chloride) (PVC) Plastic Pipe and Fittings.
- M. ASTM D2564 - Solvent Cements for Poly (Vinyl Chloride) (PVC) Plastic Pipe and Fittings
- N. AWS A5.8 - Brazing Filler Metal
- O. CGA G-7 - Compressed Air for Human Respiration
- P. CGA P-2.1 - Medical-Surgical Vacuum Systems in Health Care Facilities
- Q. CGA V-5 - Diameter Index Safety System Non Interchangeable Low Pressure Connections for Medical Gas Applications
- R. FM - Factory Mutual System - Approval Guide
- S. FS TT-P-645 - Primer, Paint, Zinc Chromate, Alkyd Type
- T. FS W-C-596 - Electrical Power Connector, Plug, Receptacle, and Cable Outlet
- U. FS WW-V-35 - Valve Ball
- V. FS WW-V-54 - Valve, Gate, Bronze (125, 150 and 200 Pound, Screwed, Flanged, Solder End, For Land Use)
- W. MIL-R-36557 - Regulator, Pressure, Medical Gas Administration Apparatus
- X. MIL-V-82026 - Valves, Diaphragm, Stop
- Y. MSS SP-58 - Pipe Hangers and Supports - Materials, Design and Manufacture
- Z. MSS SP-69 - Pipe Hangers and Supports - Selection and Application
- AA. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum)
- BB. NFPA 50 - Bulk Oxygen Systems at Consumer Sites
- CC. NFPA 99 - Standard for Health Care Facilities

1.07 SUBMITTALS

- A. Submit under provisions of Section 23 00 00.
- B. Shop Drawings: Indicate general assembly of components, mounting and installation details, and general layout of control and alarm panels. Submit detailed medical wall assembly drawings.
- C. Product Data: Provide manufacturers literature and illustrations for all components indicating size, dimensions and configuration.
- D. Samples: Submit [two] [] of [each outlet] [each valve] [].
- E. Independent Testing Agency Reports: Indicate systems are complete, zone valves installed, alarm systems functional, and pressure and cross connections tests performed. Document tests.
- F. Manufacturer's Installation Instruction: Indicate requirements for equipment and systems.

1.08 PROJECT RECORD DOCUMENTS

- A. Submit under provisions of Section 23 00 00.
- B. Record actual locations of piping, valving, and outlets.

1.09 OPERATION AND MAINTENANCE DATA

- A. Submit under provisions of Section 23 00 00.
- B. Operation Data: Include installation instructions, assembly views, lubrication instructions, and assembly views.
- C. Maintenance Data: Include maintenance and inspection data, replacement part numbers and availability, and service depot location and telephone.

1.10 QUALITY ASSURANCE

- A. Perform Work in accordance with NFPA 99 **and these specifications.**
- B. Maintain one copy of each document on site.

1.11 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing the products specified in this Section with minimum three years documented experience.
- B. Installer: Company specializing in performing the work of this Section with minimum three years documented experience. **All installing mechanics shall hold current (within six months) certification for medical gas as issued by the State Board of Plumbing Examiners. Evidence of certification shall be presented to the OFPC RCM prior to any work on the medical gas systems.**
- C. Testing Laboratory: Company specializing in performing the testing of this Section with minimum three years documented experience.

1.12 REGULATORY REQUIREMENTS

- A. Conform with applicable codes for medical gas systems.
- B. Provide certificate of compliance from [] indicating approval of systems.

1.13 MOCKUP

- A. Provide mockup of typical medical wall unit under provisions of Section 23 00 00.
- B. Mockup may [not] remain as part of the Work.

1.14 DELIVERY, STORAGE, AND HANDLING

- A. Delivery, store, protect and handle products to site under provisions of Section 23 00 00.
- B. Accept material on site in factory containers and packing. Inspect for damage.
- C. Protect from damage and contamination by maintaining factory packaging and caps in place until installation.

1.15 SCHEDULING

- A. Schedule work under the provisions of Section 23 00 00.
- B. Schedule Work to ensure equipment is installed and systems tested and certified prior to substantial completion.

1.16 EXTRA MATERIALS

- A. Furnish under provisions of Section 23 00 00.
- B. Provide [two] [_____] of [each size of valve] [_____].

1.17 SCOPE:

- A. Provide all labor, materials, equipment, tools and services and perform all operations required in connection with or properly incidental to the installation and testing of oxygen, nitrogen, nitrous oxide, compressed air and vacuum piping systems including fittings, valves, medical gas outlets, air compressors, nitrogen and nitrous oxide manifolds, vacuum pumps, alarms, etc. for complete operable systems.
- B. The stock and model numbers of equipment listed hereinafter identify equipment manufactured by NCG Division of Chemetron Corp., Chicago, Ill. Equal equipment by Nash Engineering Company will be acceptable.

PART 2 PRODUCTS

NOTE TO SPECIFICATION WRITER: CONSIDERABLE EDITING WILL BE REQUIRED FOR THIS SECTION TO DELETE REFERENCES TO INAPPLICABLE EQUIPMENT AND TO ADD DETAILED SPECIFICATIONS FOR APPLICABLE EQUIPMENT NOT INCLUDED IN THIS GUIDELINE.

2.01 PIPING:

- A. All piping for vacuum and gases of every character shall be ASTM Specification B-88, Type L, hard drawn, seamless copper tubing with wrought copper solder fittings. No ferrous piping will be permitted in the system. Where threaded nipples are required these shall be I.P.S. brass. All vacuum and oxygen piping shall be purged with dry nitrogen while being soldered.
- B. All piping shall be pitched back so as to drain to the point shown on the Drawings. All branch takeoffs shall be made from the top of the mains.
- C. Oxygen piping buried in the ground shall be Type K, hard drawn and installed in trenches not less than 42" deep.
- D. Fittings for copper tube shall be wrought copper fittings and attached with silver solder alloy containing not less than 50% silver. All **joining operations** shall be done with **pure** dry nitrogen flowing through the pipe to prevent oxidation and scale information. **During joining operations, nitrogen flow shall be verified by an oxygen sensor at the free end of the piping and by a pressure alarm on the nitrogen supply. When**

there are no active joining operations being performed, the system shall be securely sealed and maintained with a nitrogen charge in the sealed system.

- E. Before erection, all pipe, tubing, valves and fittings (except those supplied expressly cleaned for oxygen, nitrogen, nitrous oxide, air-and-vacuum service by manufacturer) shall be thoroughly cleansed of all grease, oil and other combustible materials by washing in a hot solution of sodium carbonate or trisodium phosphate mixed in equal proportions of one pound to three gallons of water. Scrubbing and continuous agitation of the parts shall be employed where necessary to remove all deposits and to insure complete cleansing. After washing, all materials shall be rinsed thoroughly in clean, hot water. After rinsing, great care must be exercised in the storage and handling of all materials and in the condition of tools used in cutting and reaming to prevent oil or grease being introduced into the tubing. Where such contamination is known to have occurred, the materials affected must be rewashed and then rinsed.
- F. Where screwed connections are required at equipment, suitable adapters shall be provided with threaded connections. A thin paste of litharge and glycerin shall be applied to the external threads only.
- G. After erection of pipe and tubing, but prior to installation of the service outlet valves, each system shall be blown clear of moisture and foreign matter by means of dry nitrogen or oil free air.
- H. After installing service outlet valves, each system shall be subjected to a test pressure of 150 psig by means of water-pumped (oil free) nitrogen or air. This test pressure shall be maintained until each joint has been thoroughly examined for leaks by means of soapy water. A soap solution mixed in the following proportions should be used: one ounce of Castile or palm oil soap, eight ounces of water, and four ounces of glycerin. Dissolve the soap in the water, add the glycerin and mix thoroughly. Wipe joints clean after test. All leaks shall be properly repaired and the system retested.
- I. A final test shall be 24 hours standing pressure test with water pumped (oil free) air or dry nitrogen at 150 psig to check the completeness of prior joint pressure tests. If water pumped nitrogen is used, particular care must be exercised to assure that it is all flushed out with oxygen before placing the system in service.
- J. Oxygen, nitrogen, nitrous oxide, and medical air systems shall be finally cleaned using the high-pressure pulse-purge procedure described in NFPA 99. During this procedure, sufficient volume of dry nitrogen shall be provided to insure a minimum velocity of 2000 fpm in the largest section of pipe being cleaned. Note: It is not required that the entire system be tested at one time. The system can be divided into convenient sections. Upon the successful completion of the operation on a section, it shall be sealed and left with a holding charge of dry nitrogen.

2.02 SERVICE OUTLETS:

- A. Wall type service outlets shall be installed where indicated on Drawings approximately 50" above finished floor unless otherwise directed. Outlets shall be modified NCG 378 D.I.S.S. series, quick release type as listed by Underwriters Laboratories, designed for recessed piping. Each service shall be housed in a special designed back box, assembled complete with special stainless steel cover plate, plaster flanges and tubing guards ready for rough wall mounting, and with an 8" of 1/4" nominal I.D. Type "K" copper tubing for completing the connection to the service line. Check Units shall be safety keyed to prevent interchangeability of services. They shall have a self sealing dust plug and a primary and secondary check, both of which shall seal simultaneously when equipment is not attached. The Check Units for each service shall be pressure tested at the factory and furnished completely assembled except for the stainless steel cover plates. A color coded nameplate identifying the gas service shall be affixed to each Check Unit to minimize the possibility of interchanging gas services during installation. Check Units shall be furnished with a protective cover imprinted with installation instructions and covering the inlet to prevent plaster dust or other foreign matter from contaminating the internal parts of the unit during installation. Check Units shall be designed so as to be completely serviceable from the front including removal of the secondary check and the filter screen without the use of special tools. Check Units shall be so designed that attachment or removal of equipment is a one hand operation and release mechanism shall be such that inadvertent pushing or bumping of the attached equipment will not tend to release it. The outlet, when installed, shall have no projections beyond the finishing cover plate. Where more than one service is indicated at a single location, they shall be combined into a multiple unit under a single cover plate. See Drawings for details of special cover plates and for special service panels which combine gas service outlets and electrical items.
- B. Ceiling type recessed service outlets shall be installed where indicated on Drawings. Outlets shall be modified NCG 376 D.I.S.S. series and shall meet the requirement for wall type service outlets specified hereinbefore, including special cover plates, back boxes, pin indexing between fascia and matching, keyed slot in channel slot box saddle. Coupler for attachment of hose and adaptor connecting thereto, shall be threaded type meeting Compressed Gas Association (CGA) D.I.S.S. specifications. Hose shall be of plastic, conductive type, color coded for identity of service and terminating at a point 7'-0" above finished floor, in quick release, color coded female couplers, safety keyed for gas service supplied. (Note: Ceilings in new addition at 10'-0", ceilings in remodel building at 9'-0".) Outlet back boxes shall be supported from overhead structure utilizing anti-sway bars as required to prevent movement of the outlets. Connect all ceiling outlets to an established common ground.
- C. High pressure ceiling or wall type recessed nitrogen outlets shall be installed where indicated on Drawings. Outlets shall be modified NCG 239590-64 and shall meet requirements for ceiling type recessed service outlets hereinbefore specified, including

special cover plates, back boxes, etc. Outlet stations are to incorporate a quick disconnect valve mechanism functioning as follows:

1. Service attachment without opening pressure.
2. Pressure actuation in a succeeding mechanical function.
3. Pressure shutoff and bleed of entrapped pressure while holding hose secure.
4. Release of adapter and hose, a succeeding mechanical function, without high pressure entrapment. Provide a NCG No. 000606-63 nitrogen hose assembly with DynaCon male and female adapters. Length as required for termination at a point 7'-0" above finished floor.

2.03 MEDICAL GASES VALVES:

- A. Valves not in boxes shall be NCG bronze bodied, double seal, full flow ball type, with Teflon seat seals and O-ring packing designed for working pressures up to 300 psi with a chrome plated brass ball which seals in both directions. The valves shall be so designed that only a quarter turn of the lever type handle is necessary between the open and closed positions. Valves shall be supplied and properly washed for oxygen service. Gas service labels shall be provided for each service as required.
- B. Shutoff valves in recessed boxes shall be installed in boxes with back box constructed of 18 gauge Paintlok steel with a gray baked on semi gloss finish and with plaster flanges on all four sides for securing to wall. The valves shall be bronze bodied, double seal, full flow ball type with Teflon seat seals, O-ring packing designed for working pressures up to 300 psi, chrome plated bronze balls which seal in both directions, and adjustable Teflon stem seals and bearings, self compensating to guard against leakage due to wear. Tubing extensions shall be factory soldered to the valve flanges for connection to piping outside the box. Valves and tubing extensions shall be chrome plated, preassembled, pressure tested and rigidly mounted to the box for ease of installation. The valves shall require only a quarter turn of the handle to completely open or close. A color coded gas label shall be supplied with each valve, which can be marked to indicate the area controlled. The cover shall be of 18 gauge stainless steel with No. 4 brushed finish, and shall incorporate an internal service identification cover and shield, providing shutoff directions. The combination internal and external fascia shall attach to the box assembly without the use of screws, and shall compensate for variations in plastic thickness. Mounted in the finishing frame shall be a clear, rigid, vinyl window for easy access to the valve. Window shall contain a caution label reading: "CAUTION, CLOSE ONLY IN EMERGENCY" and "PULL RING TO BREAK WINDOW".

2.04 OXYGEN SUPPLY:

- A. The bulk oxygen storage and control equipment are existing. This Contractor shall connect to existing oxygen main and reroute as shown on the Drawings and extend as required to serve the new building. The system shall be complete in every respect.

2.05 NITROUS OXIDE MANIFOLD:

- A. The central supply of nitrous oxide shall be Chemetron Nitrous Oxide Manifold 90049.62, and shall consist of a wall mounted M800HF control unit and the necessary header connections and pigtailed for 20 cylinders. The controls shall be so arranged as to have 10 cylinders in service and 10 cylinders in reserve. Automatic switchover from service to reserve bank shall be accomplished without fluctuation in the hospital line pressure. Design and operation shall be consistent with good engineering practice and with current NFPA regulations. Three pressure gauges shall indicate bank and hospital line pressures. A green indicator light shall indicate when the service bank is in use and a red light shall indicate when the reserve bank is in use. Terminal block connections shall be provided for remote alarms. A visible indicator shall designate the service bank.

2.06 NITROGEN MANIFOLD:

- A. Shall be a Chemetron Duplex Nitrogen Manifold, 900010-62, and shall consist of a wall mounted M800HF control unit and the necessary header connections and pigtailed for 10 cylinders. The controls shall be so arranged as to have 5 cylinders in service and 5 cylinders in reserve. Automatic switchover from service to reserve bank shall be accomplished without fluctuation in the hospital line pressure. Design and operation shall be consistent with good engineering practice and with current NFPA regulations. Three pressure gauges shall indicate bank and hospital line pressures. A green indicator light shall indicate when the service bank is in use and a red light shall be provided for remote alarms. A visible indicator shall designate the service bank.

2.07 VACUUM PUMP AND ACCESSORIES:

- A. Provide vacuum pumping units for hospital service as scheduled on the drawings. Each unit shall be arranged for duplex operation and shall be complete with driving motors, tanks, automatic controls including alternates and accessories as hereinafter specified.
- B. Pumps shall have capacity as scheduled on the Drawings and shall be rotary liquid sealed type, cast iron body, bronze fitted; Nash Series OV, Ohmeda, or approved equal.
- C. Tank shall be welded steel, hot dipped galvanized after fabrication, inside and out; size as scheduled with gauge and necessary taps for pipe connections.

- D. Provide automatic control consisting of tank mounted adjustable vacuum switches, motor starters and disconnect switches, automatically starting and stopping vacuum pumps in duplex operation. Provide controls as required for automatic alternating of each pump.
- E. Provide vacuum relief valve, silencer and solenoid valve for water seal line to each vacuum pump. Wire solenoid valve to open and close with starting and stopping of motor. Install Crane No. 8H-550 backflow preventer in water seal line to vacuum pump.
- F. Pipe air and water discharge from each pump to nearest floor drain with silencer and pipe trap installed as shown on the Drawings.
- G. A vacuum exhaust line shall be installed to exhaust vapors and odors to outside of building to point approved by Architect/Engineer. The exhaust line shall terminate adjacent to pumps in a drip leg of minimum 10" length with cock valve drain, for purpose of trapping condensates. Flexible hose connections and in-line exhaust mufflers shall be installed as shown on Drawings.

2.08 AIR COMPRESSOR AND ACCESSORIES:

- A. Provide central compressed air units for hospital service, each consisting of single stage rotary air compressors with driving motors, control tanks, automatic controls, and accessories as specified and scheduled.
- B. Each compressor shall be rotary liquid sealed positive displacement type cast iron pump bronze fitted; Nash Series OC or approved equal.
- C. Provide welded steel control tank hot dipped galvanized after fabrication, inside and out, for each unit. Provide vertical tank, size as scheduled; with gauge and necessary taps for pipe connections, equipment with gauge glass, pressure gauge and constant pressure valve.
- D. Provide automatic controls consisting of tank mounted adjustable pressure switches, motor starters, and disconnect switches automatically starting and stopping pumps between desired limits in duplex operation. Provide controls as required for automatic alternating of compressors.
- E. Filter and dehydrate air by non-cycling mechanical refrigeration type dehydrator, as scheduled, Hankinson Refrigifilter, or approved equal for each addition. Provide hydrator complete with heat exchanger, condenser evaporator integral moisture and oil separator, mechanical cartridge of acetate fiber construction enclosed in an ASME coded pressure vessel designed for maximum operating pressure of 200 psig. Furnish unit complete with automatic condensate discharge valve, temperature and pressure

gauges, running lights and compound gauge to indicate chiller performance. Dehydrator shall be capable of reducing the dew point to 35 degrees F. at pressure, with minimum pressure drop across the unit.

2.09 AIR AND VACUUM VALVES:

- A. Stop valves at compressors, tanks, vacuum pumps, and in air and vacuum piping shall be Jenkins 32A bronze ball valves with screwed connections and Teflon seats.

2.10 FINAL CHECKING AND OPERATING INSTRUCTIONS:

- A. A representative of the equipment manufacturer shall periodically check with the Contractor during initial installation of the pipeline systems equipment. He shall assist the Contractor in final check to make certain that all systems are in perfect operating condition. The equipment manufacturer's representative shall provide 8 hours of instruction to the personnel in the use of the piping systems and the related equipment which is operated from those systems.

2.11 LABORATORY FITTINGS:

- A. Laboratory fittings will be furnished to the job site by the laboratory equipment supplier, with necessary holes cut in the laboratory equipment. The Mechanical Contractor shall receive, store and install the fittings and make all necessary connections thereto.

2.12 STANDARDS AND CODES:

- A. The recommendations of the National Fire Protection Association (NFPA) as set forth in Pamphlet No. 56, 565 and 566, and the "Standard for Medical/Surgical Vacuum Systems in Hospitals" as set forth in Compressed Gas Association (CGA) Pamphlet No. P-2.1, Second Edition 1967, shall apply to this installation and shall be adhered to in all respects.

2.13 ALARM SYSTEMS:

- A. The alarm systems for all services shall be consolidated into one integrated panel and shall be installed complete with all necessary sensing, sending and display devices. All signals shall be flush mounted with facility for job site service identification and shall incorporate:
 1. Brushed stainless steel fascia.
 2. Visual indication of whether circuit is energized.

3. Audible buzzer recording of all signal impulses.
4. Not Used.
5. Reset permitting silencing of audible buzzer but not allowing cancellation of visual identify until situation has been corrected.
6. Shall be listed as an assembly by Underwriters Laboratories, Inc.
7. Ability to receive and properly record by audible buzzer of any combination of sequential signal.
8. The signal panel shall be equipped with a "test" button which shall actuate for test, all visual and audible alarms.
9. The panel shall be of modular construction, facilitating service and maintenance.
10. Power supply boxes shall remain mounted and connected as required by manufacturer.
11. Pressure switches shall be mounted in the pipe lines to be sensed and shall be connected as required by manufacturer.

NOTE TO SPECIFICATION WRITER: SEVERAL ALARM PANELS WITH MORE OR LESS SIGNALS MAY BE REQUIRED BY CODE FOR DIFFERENT SECTIONS OF THE BUILDING. THE FOLLOWING IS AN EXAMPLE AND IS NOT INTENDED TO BE REPRESENTATIVE OF THE NEEDS FOR THE PROJECT.

B. Signal panel with ten alarms:

1. Signal panel with ten alarms shall NCG No. 180210-64 and shall contain the following alarms:

NOTE TO REVIEWER: YOU WILL SEE THAT TWO SETS OF ALARM POINTS ARE LISTED BELOW. THE FIRST SET IS INCLUDED IN THE ORIGINAL FORM OF THE U.T. SYSTEM MECHANICAL GUIDELINE SPECIFICATION. THE SECOND IS SUGGESTED BY CSI, AND MAY BE WORTH CONSIDERING. PLEASE SUBMIT YOUR THOUGHTS WITH YOUR COMMENTS.

ORIGINAL

Oxygen line pressure	high
Oxygen line pressure	low
Nitrous Oxide line pressure	high

Nitrous Oxide line pressure	low
Nitrous Oxide reserve supply	reorder
Nitrogen line pressure	high
Nitrogen line pressure	low
Nitrogen reserve supply	reorder
Air line pressure	low
Vacuum line pressure	low
Push to test	

CSI Suggested

- a. Oxygen reserve supply in use.
- b. Oxygen line pressure high.
- c. Oxygen line pressure low.
- d. Air line pressure high.
- e. Air line pressure low.
- f. Air lag pump on.
- g. Vacuum line pressure above normal.
- h. Vacuum line pressure below normal.
- i. Vacuum lag pump on
- j. Nitrous oxide reserve supply in use.
- k. Nitrous line pressure high.
- l. Nitrous line pressure low.
- m. Nitrogen reserve supply in use.
- n. Nitrogen line pressure high.
- o. Nitrogen line pressure low.

A. Monitoring Gauges:

1. Monitoring gauges shall be NCG No. 480991-64 and shall be complete with brushed stainless steel fascia with services identified, plastic protective dial free, back box, check valves, and 3/8" sensing line. Provide valves to isolate gauge from pressure line. These gauges shall be installed in the locations as required by NFPA Code and where indicated on the Drawings.

PART 3 EXECUTION

- 3.01 Install in complete compliance with governing Codes and manufacturers instructions.
- 3.02 Except for piping and pipe fittings, all components shall be supplied by a single manufacturer and shall be fully compatible with Owner's existing system and service devices.
- 3.03 Tests to include procedures described in NFPA 99, Sections 4-3 through 4-10 and the procedures contained elsewhere in these specifications. See 2.01 G-J. Provide to Owner a notarized letter of certification from equipment manufacturer certifying the following:
 - A. No cross connections exist.
 - B. Alarm system is adjusted and performing to manufacturer's design.
 - C. All components have been installed, adjusted and are functioning in accordance with manufacturer's recommendations.
- 3.04 Verify compatibility of all new components with existing system and services.

END OF SECTION

**SECTION 22 66 00
LAB WASTE SYSTEM**

PART 1 GENERAL

1.00 The following sections are to be included as if written herein:

- A. Section 23 00 00 – Basic Mechanical Requirements
- B. Section 23 05 29 – Sleeves, Flashings, Supports and Anchors
- C. Section 23 05 53 – Mechanical Identification

1.01 SECTION INCLUDES

- A. Acid Waste Piping System

1.02 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION

- A. Section [____ - _____]: Placement of pipe sleeves.

1.03 RELATED SECTIONS

- A. Section 31 23 16 - Excavating
- B. Section 31 23 23.13 - Backfilling
- C. Section 31 23 16.13 - Trenching
- D. Section 08 31 13 - Access Doors and Frames

1.04 REFERENCES

- A. ANSI [_____]
- B. ASTM [_____]
- C. AWWA [_____]

1.05 SUBMITTALS

- A. Submit under provisions of Section 23 00 00.

- B. Product Data: Provide data on pipe materials, pipe fittings, valves, and accessories. Provide manufacturers catalog information. Indicate valve data and ratings.

1.06 PROJECT RECORD DOCUMENTS

- A. Submit under provisions of Section 23 00 00.
- B. Record actual locations of [_____].

1.07 OPERATION AND MAINTENANCE DATA

- A. Submit under provisions of Section 23 00 00.
- B. Maintenance Data: Include installation instructions, spare parts lists, exploded assembly views.

1.08 QUALITY ASSURANCE

- A. Maintain one copy of each document on site.

1.09 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience.
- B. Installer: Company specializing in performing the work of this section with minimum three years documented experience.

1.10 REGULATORY REQUIREMENTS

- A. Perform Work in accordance with Uniform Plumbing Code.
- B. Conform with applicable code for installation of piping.

1.11 DELIVERY, STORAGE, AND HANDLING

- A. Deliver, store, protect and handle products to site under provisions of Section 23 00 00.
- B. Accept materials on site in shipping containers with labeling in place. Inspect for damage.
- C. Provide temporary protection for all materials from the elements and corrosive nature of the environment.

D. Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.

E. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed system.

1.12 ENVIRONMENTAL REQUIREMENTS

A. Do not install underground piping when bedding is wet or frozen.

1.13 EXTRA MATERIALS

A. Furnish under provisions of Section 23 00 00.

PART 2 PRODUCTS

2.01 WALL, FLOOR AND CEILING PLATES:

A. Except as otherwise noted, provide C.P. (Chrome plated) brass floor and ceiling plates around all pipes, conduits, etc., passing exposed through walls, floors, or ceilings, in any spaces except underfloor and attic spaces. Plates shall be sized to fit snugly against the outside of the pipe or against the insulation on lines which are insulated and positively secured to such pipe or insulation. Plates will not be required for piping where pipe sleeves extend 3/4" above finished floor. All equipment rooms are classified as finished areas. Round and rectangular ducts shall have closure plates (NOT chrome plated) made to fit accurately at all floor, wall and ceiling penetrations.

2.02 SLEEVES, INSERTS, AND FASTENINGS:

A. General: All openings through all floors, walls, and roofs, etc., regardless of material for the passage of piping, ductwork, conduit, cable trays, etc., shall be sleeved. All penetrations must pass through sleeves except soil pipe installed under concrete slabs on fill. Sleeves shall be set in new construction before concrete is poured, as cutting holes through any part of the concrete will not be permitted unless acceptable to the Architect/Engineer. If a penetration is cored into an existing concrete, masonry or stone structure, then the installation of a sleeve will not be necessary.

B. The minimum clearance between horizontal penetrations including insulation where applicable, and sleeve shall be 1/4", except that the minimum clearance shall accommodate a Thunderline Link-seal closure where piping exits the building, or penetrates a wall below ground level. Contractor shall be responsible for the accurate location of penetrations in the slab for his pipe, duct, etc. All penetrations shall be of ample size to accommodate the pipe, duct, etc. plus any specified insulation. Sleeve materials shall be rigid metal of adequate strength. Void between sleeve and pipe shall be filled with Nelson Flameseal Firestop or approved equal caulk or putty.

- C. Installation of sleeves in walls shall be the same as for floors. Refer to the details on the project drawings. Where the details differ from these specifications, the drawings take precedence.
- D. Sleeves for penetrations passing through walls or floors on or below grade shall be removed, if practical, and after the pipes have been installed, the void space around the pipe shall be caulked with a suitable material to effect a waterproof penetration. Note that the practicality of the removal of the sleeve shall be the decision of the Construction Inspector. The decision of the Inspector shall be final.
- E. Inserts: Suitable concrete inserts for pipe and equipment hangers shall be set and properly located for all pipe and equipment to be suspended from concrete construction. If the inserts are later found not to be in the proper location for the placement of hangers, then drilled anchors shall be installed. Drilled anchors in concrete or masonry shall be submitted for the approval by the Owner.
- F. Fasteners: Fastening of pipes, conduits, etc., in the building shall be as follows: To wood members - by wood screws; to masonry - by threaded metal inserts, metal expansion screws, or toggle bolts, whichever is appropriate for the particular type of masonry; to steel - machine screws or welding (when specifically permitted or directed), or bolts, and to concrete by suitable inserts anchored to reinforcing steel, and poured in place unless other means are indicated on the plans. Power-actuated fasteners (shooting) will not be acceptable under any circumstances. If it is necessary to install a method of fastening a hanger after the structure has been installed, then only clamps or drilled anchors shall be used.

Note: Under no circumstances will the use of plastic anchors or plastic expansion shields be permitted for any purpose whatsoever.

- G. Rat Proofing: The open space around all ductwork, piping, etc., passing through the ground floor and/or exterior walls shall be rat-proofed in a manner acceptable to the Architect/Engineer.
- H. Weatherproofing: The annular space between a pipe and its sleeve in exterior walls or through floor to below grade shall be filled with polyurethane foam rods 50 percent greater in diameter than the space as backing and fill material and made watertight with a permanent elastic polysulfide compound. Seal both surfaces of wall or floor.
- I. Air Plenums: The space around piping, ductwork, etc., passing through air plenums shall be made airtight in a manner acceptable to the Architect/Engineer.
- J. Fireproofing: Each mechanical and electrical contractor shall seal all cable trays, pipe, conduit, duct, etc., penetrations through roof, fire rated walls and floors with a foam or

sealant as described below, that will form a watertight, vermin-tight barrier that is capable of containing smoke and fire up to 2000 degrees F for two hours. Sealing of cable trays, and conduits that extend through rated walls from ends of cable tray shall be done after conductors have been installed. For wet locations, the foam material shall be a silicone RTV foam or an approved equal. For dry locations a premixed putty equal to Nelson Flameseal Firestop putty may be used.

2.03 HANGERS:

- A. Entire system shall be installed free of stress. Horizontal lines shall allow for lateral movement of pipe and shall be supported by a padded hanger every 4' to 6'. Vertical lines shall be supported by a padded riser clamp under bottom most coupling in the stack. This riser clamp shall restrict sideward as well as downward movement. Three-inch and larger diameter stacks shall be supported at each floor by a riser clamp on the pipe O.D., smaller diameter stacks shall be supported at every other floor. All riser clamps shall be padded with 1/4" thick solid neoprene or buna-N rubber.

2.04 ACID WASTE AND VENT PIPING:

- A. All material shall be chemically resistant borosilicate glass drain line serviceable from 0 degrees to 250 degrees F. and from full vacuum to 15 psi. All joints shall be made using bead to bead [or bead to plain end] **(ENGINEER SHALL DELETE THE BRACKETED WORDS FOR PROJECTS IN GALVESTON)** joint couplings of stainless steel with Teflon liners which have leak free deflection characteristics of 3 degrees. Stainless steel shall capture the joint sealing and cushioning material to avoid the extrusion of sealing material from the coupling. Odd lengths shall be fabricated by externally or internally scoring the glass and forming a hot glass beaded end when required. Piping shall be equal to Kimex, as manufactured by O-I/Schott, or Pyrex, as manufactured by Owens-Corning.
- B. Buried pipe shall be encased in 1.5 lbs. per cubic foot density expanded polystyrene. Traps below grade shall have plug cleanouts. Installation to be in accordance with manufacturer's recommendations.
- C. Pipes passing through foundation walls and slabs on grade shall be fitted with pipe sleeves a minimum of 2" greater diameter than the pipe. Insert glass drain line armored stub-ups or short field fabricated lengths protected with tape or insulation. The annular space between the pipe and sleeve shall be sealed using Link-Seal or equivalent. Piping shall not be installed in direct contact with concrete. Piping shall be protected against weld splatter. All fabrication and installations to be in accordance with manufacturers' recommendations.

- D. The joining of the cup sink tailpieces and other sink outlets and strainers to the acid waste piping system shall be the responsibility of the Mechanical Contractor. Sink traps shall be 3-piece glass.

2.05 TESTING:

- A. Refer to Section 15M for testing requirements. The acid waste system shall be tested as specified for sanitary waste system.

2.06 ACID TREATMENT BASIN:

- A. Acid treatment basin shall be constructed complete as shown on Drawings.
- B. Mechanical Contractor shall furnish and install manhole covers and mounting frames, equal to Neenah Foundry Company's No. R-5900-1 Series, heavy duty cover and frame.
- C. Mechanical Contractor shall apply two coats of coal-tar epoxy to a total minimum thickness of 15 mil to all interior surfaces of basin. Interior of basin must be dry and clean prior to first coat. Second coat should be applied within 24 hours after first coat. Allow 6 to 18 hours for first coat to dry. Coal tar epoxy shall be applied per manufacturer's instructions and shall be equal to Mobil No. 78-J-2 or Sherwin-Williams C-200 two-part epoxy.

2.07 ACID WASTE PUMP STATION:

- A. Furnish and install a D & H Custom Waste Handler Pump Station No. 200-PPY 3' x 3' x 4' deep, or equal, duplex pumping station as indicated. Pump station shall be a complete package operating unit including pumps, motors, automatic controls, alarm, sump, etc., shall include the following:
 - 1. Pumps shall be two (2) FLOTEC, Inc., or equal, Marathon 50 Series Model S8P8-1396V CPVC, seal-less, immersible centrifugal pumps. Capacity each pump 40 GPM at 25' TDH; 2 HP, 460 volt, 3 phase, 60 Hz totally enclosed fan cooled motors, 3450 R.P.M.
 - 2. Tank shall be D & H Model 200-PPY, or equal, 3' x 3' x 4' deep constructed from 1/2" thick polypropylene with 3" inlet. Approximate capacity of 260 gallons.
 - 3. Liquid level controls shall be D & H Model LL-5, or equal, liquid level controller for each pump.
 - 4. Control panel shall be a duplex pump control panel and shall include:

- a. Main fused disconnect switch.
 - b. Two (2) motor starters.
 - c. Two (2) pump hand-off-automatic selector switches.
 - d. Pump run lights.
 - e. Control circuit transformer.
 - f. All necessary contacts and relays.
 - g. High Tank Level Alarm including: alarm horn, alarm light, silence switch, and relay for automatic reset of alarm circuit.
 - h. Redundant High Level Alarm including: alarm horn, alarm light, relay for automatic reset of alarm circuit, utilizing the alarm silence switch from the primary high level alarm.
 - i. Above items shall be installed in a Hoffman NEMA 12 enclosure.
 - j. Alternator shall have facility to start second pump if first "on" pump fails to handle load or operate.
- B. A factory trained service technician shall supervise installation and startup after Contractor makes the required inlet and outlet plumbing connections and runs power to the pumps and control panel._

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify excavations under provisions of Section 23 00 00.
- B. Verify that excavations are to required grade, dry, and not over-excavated.

3.02 INSTALLATION

- A. All the various piping systems shall be made up straight and true and run at proper grades to permit proper flow of the contained material. Lines shall also be graded for proper drainage.
- B. Piping shall follow as closely as possible the routes shown on Drawings which take into consideration conditions to be met at the site.

- C. Should any unforeseen conditions arise, lines shall be changed or rerouted as required after proper approval has been obtained.
- D. All piping shall be installed with due regard to expansion and contraction and so as to prevent excessive strain and stress in the piping, in connections, and in equipment to which the lines are connected.
- E. All piping shall be clean when it is installed. Before installation it shall be checked, upended, swabbed, if necessary, and all dirt from storage or from lying on the ground shall be removed.
- F. Procedure for Assembling Other Joints: For the assembly of the materials included in this section, consult the manufacturers for the recommended procedures.

END OF SECTION

**SECTION 22 67 13.19
DEIONIZED WATER SYSTEM**

PART 1 GENERAL

1.00 The following sections are to be included as if written herein:

- A. Section 23 00 00 – Basic Mechanical Requirements
- B. Section 23 05 29 – Sleeves, Flashings, Supports and Anchors
- C. Section 23 05 53 – Mechanical Identification

1.01 SECTION INCLUDES

- A. Pipe and Pipe Fittings

1.02 PRODUCTS INSTALLED BUT NOT FURNISHED UNDER THIS SECTION

- A. Section 01 11 00 - Summary of Work: Owner furnished purified water polishers, [_____].

1.03 RELATED SECTIONS

- A. Section 03300 - Cast-in-Place Concrete
- B. Section 21 05 48.UT - Vibration Isolation
- C. Section 22 13 16.UT - Plumbing Piping
- D. Section 26 05 19 - Cable, Wire and Connectors, 600 Volt: Electrical characteristics, cable, wire, materials
- E. Section 26 27 26.UT - Wiring Devices and Floor Boxes: Wiring connections

1.04 REFERENCES

- A. ASME - Boiler and Pressure Vessel Code
- B. ASME B16.3 - Malleable Iron Threaded Fittings
- C. ASME B16.18 - Cast Bronze Solder-Joint Pressure Fittings
- D. ASME B16.22 - Wrought Copper and Bronze Solder-Joint Pressure Fittings

- E. ASME B16.26 - Cast Bronze Fittings for Flared Copper Tubes
- F. ASME B31.9 - Building Services Piping
- G. ASTM A53 - Pipe, Steel, Black and Hot-Dipped Zinc Coated, Welded and Seamless
- H. ASTM A120 - Pipe, Steel, Black and Hot-Dipped Zinc Coated (Galvanized), Welded and Seamless, for Ordinary Uses
- I. ASTM A234 - Pipe Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and Elevated Temperatures
- J. ASTM B32 - Solder Metal
- K. ASTM B88 - Seamless Copper Water Tube
- L. ASTM D2683 - Socket-Type Polyethylene Fittings for Outside Diameter-Controlled Polyethylene Pipe
- M. NFPA 70 - National Electrical Code

1.05 SUBMITTALS

- A. Submit under provisions of Section 23 00 00.
- B. Shop Drawings: Indicate piping system schematic with electrical characteristics and connection requirements.
- C. Product Data: Provide manufacturers catalog literature with capacity, weight, and electrical characteristics and connection requirements.
- D. Test Reports: Submit inspector's certificate for air receiver for inclusion in Operating and Maintenance Manuals.
- E. Manufacturer's Installation Instructions: Indicate hoisting and setting requirements, starting procedures.

1.06 PROJECT RECORD DOCUMENTS

- A. Submit under provisions of Section 23 00 00.
- B. Record actual locations of equipment and components. Modify shop drawings to indicate final locations.

1.07 OPERATION AND MAINTENANCE DATA

- A. Submit under provisions of Section 23 00 00.
- B. Operation Data: Submit for air compressor, air receiver and accessories, after cooler, refrigerated air dryer, and pressure reducing station.
- C. Maintenance Data: Submit for air compressor, air receiver and accessories, after cooler, refrigerated air dryer, and pressure reducing station.

1.08 REGULATORY REQUIREMENTS

- A. Conform with applicable ASME codes for installation of pressure vessels.
- B. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories, Inc., as suitable for the purpose specified and indicated.

1.09 DELIVERY, STORAGE, AND HANDLING

- A. Deliver, store, protect and handle products to site under provisions of Section 23 00 00.
- B. Accept delivery of packaged deionized water equipment, storage vessel, etc. on site in factory fabricated containers with shipping skids and pipe end protectors in place. Inspect for damage.
- C. Protect piping and equipment from weather and construction traffic.

1.10 WARRANTY

- A. Provide five-year warranty under provisions of Section 23 00 00.
- B. Warranty: Include coverage for deionized water system, storage tank, [_____].

1.11 MAINTENANCE MATERIALS

- A. Provide maintenance materials under provisions of 23 00 00.

PART 2 PRODUCTS

- 2.01 The Reverse Osmosis Unit shall be furnished and installed by Continental Water Conditioning Corporation who shall also furnish and install the miscellaneous pipe and electrical work from points shown on the Drawings to complete the installation.

2.02 The deionized water cartridge units shall be furnished and installed by Continental Water Conditioning Corporation who shall also furnish the water quality controller that operates solenoid valves, local alarm for used-up cartridge bank, solenoid valves, miscellaneous piping and electrical work from points on the Drawings to complete the installation.

2.03 The Contractor's work shall include furnishing and installing the following items:

- Fiberglass Storage Tanks and Fittings
- Level Controllers
- Pumps
- Pressure Tanks
- Pressure Switch
- Pressure Gauges
- Valves
- Piping and Sleeving
- Mechanical Pump Alternator

2.04 SYSTEM CAPACITY:

- A. System shall have a capacity of [] gallons per day in a [] hour period and shall be capable of [] GPM maximum flow rate.
- B. Reverse Osmosis Unit shall have a capacity of [] GPM, requires [] PSI minimum entering pressure, power for [] volt, 3 phase, 60 Hz, [] HP motor, power from a [] amp, 115 volt single phase control circuit and provision for [] GPM to drain when unit is operating.
- C. Deionized cartridge system shall have a capacity of [] GPM [] PSI maximum pressure drop and requires power from a [].
- D. The Mechanical Contractor will not be responsible for system capacity or system water quality since he does not furnish the prime equipment. He shall be responsible for the equipment piping, etc., that he furnishes and installs to meet the provision of Drawings and Specifications.

2.05 PIPING, VALVES AND FITTINGS (Polypropylene):

- A. Pipe valves and fittings for purified water service shall be Schedule 40, virgin, unpigmented polypropylene.
- B. Installation practices, including support spacing and joint fusion, shall be in compliance with manufacturer's printed recommendations.

- C. Materials from which pipe, fittings and valves are manufactured shall have been tested and approved for conveying potable water by the National Sanitation Foundation (NSF). All pipe, fittings and valves shall bear the NSF hallmark indicating that the material has been tested and approved for conveying deionized water by the national Sanitation Foundation, and shall be as manufactured by Enfield Industrial Corporation, GSR R&G Sloane Manufacturing Company ("PPRO-SEAL") or approved equal.
- D. To ensure installation uniformity, all system piping components shall be the products of one manufacturer.
- E. All piping shall be thoroughly rinsed and flushed to remove all dirt and debris before installation. After installation the Contractor shall flush the entire piping system with deionized water to the satisfaction of the Owner.
- F. The piping shall be sleeved only in return air plenums. Contractor shall provide a sleeved system through the installation of grooved Schedule 10 galvanized piping and couplings. The sleeve piping shall be no less than 2 inches greater diameter than the polypropylene piping contained within it. Only rolled groove piping may be used. The Victaulic "Fit" fittings and piping system, or any similar set screw type fitting system is specifically prohibited. Vic-Let and Vic-O-Well or similar type fittings are specifically prohibited for use on this project. Where a reduced tee fitting is required, then a reducing tee or regular tee with bell reducer shall be used. If any of the above described prohibited materials or installation methods are used, then the material or installation method shall be corrected at the contractor's expense.
- G. Valves shall be ball valve type and shall be manufactured of the same virgin, unpigmented molding compound as the fittings to assure compatibility.
- H. All ball valves shall have Viton seals, and PTFE seats. Ball valves shall carry a pressure rating of 150 psi at a minimum of 68F, and shall be of True Union design as manufactured by Enfield Industrial Corporation, GSR R&G Sloane Manufacturing Company ("PPRO-SEAL") or approved equal.
- I. The contractor shall supply a fusion welding machine to the owner prior to completion of the project. The contractor shall also furnish training for a minimum of two of the owners personnel on the operation of the fusion machine, installation of the piping and fittings, and the maintenance required for the machine and piping systems. The training shall consist of a minimum of 4 hours at a location convenient to the owner, preferably on the owner's premises at the Physical Plant of the institution where this project is constructed. The training shall consist of actual course material designed for the training of maintenance and installation personnel, where actual hands-on training is involved. This training shall not be a sales session consisting of only sales literature and without hands-on training.

2.06 PIPING, VALVES AND FITTINGS (PVC):

- A. Pipe and fittings shall be polyvinyl chloride (PVC) Schedule 80, Type 1.
- B. Pipe, fittings and valves shall be manufactured from a PVC compound which meets the requirements of Type 1, Grade 1 polyvinyl chloride as outlined in ASTM D-1784. A Type 1, Grade 1 compound is characterized as having the highest requirements for mechanical properties and chemical resistance.
- C. Compound from which pipe is produced shall have a design stress rating of 2000 psi at 73 degrees F., listed by the Plastics Pipe Institute (PPI).
- D. Materials from which pipe, fittings and valves are manufactured shall have been tested and approved for conveying potable water by the National Sanitation Foundation (NSF).
- E. Pipe shall conform to the requirements of ASTM D-1785, as manufactured by Cabot Piping Systems, Louisville, Kentucky, or approved equal.
- F. Fittings shall conform to the requirements of ASTM D-2464 for solvent type, as manufactured by Cabot Piping Systems, Louisville, Kentucky, or approved equal.
- G. Manual valves shall be stainless steel ball type with Teflon seats, packing and gasket, Jenkins Figure 1336 or approved equal.
- H. Solenoid valve is to be especially designed for pure water service. Body is stainless steel with ethylene propylene elastomers. ASCO No. 8210C87E or approved equal.
- I. Installation practices, including support spacing and joint threading, shall comply with manufacturer's printed recommendations. In general, socket weld joints are preferred over threaded joints.
- J. To insure installation uniformity, all system piping components shall be the products of one manufacturer.
- K. The piping shall be sleeved only in return air plenums. Contractor shall provide a sleeved system through the installation of grooved Schedule 10 galvanized piping and couplings. The sleeve piping shall be no less than 2 inches greater diameter than the polypropylene piping contained within it. Only rolled groove piping may be used. The Victaulic "Fit" fittings and piping system, or any similar set screw type fitting system is specifically prohibited. Vic-Let and Vic-O-Well or similar type fittings are specifically prohibited for use on this project. Where a reduced tee fitting is required, then a reducing tee or regular tee with bell reducer shall be used. If any of the above

described prohibited materials or installation methods are used, then the material or installation method shall be corrected at the contractor's expense.

2.07 DEIONIZED WATER PUMPS:

- A. Pumps shall be heavy duty plastic centrifugal type.
- B. Pump heads, sleeve and impeller shall be polypropylene. Seal shall be mechanical type.
- C. Capacity of each of the pumps shall be _____ GPM (to be filled in by Engineer) at _____ foot head (to be filled in by Engineer). Pump motor shall be _____ HP (to be filled in by Engineer), _____ volt (to be filled in by Engineer), 3 phase, 60 Hz.
- D. Each pump shall be provided with a fused safety switch and a magnetic starter providing overload and under voltage protection. A mechanical alternator shall automatically alternate the operation of the pumps.
- E. Pumps shall be furnished completed with Vanton, or approved equal, suction and discharge pressure gauge isolator-activators to separate gauge from deionized water.

2.08 LEVEL CONTROLLER:

- A. Level controller shall be full plastic body type with no metal parts in contact with deionized water. Controls shall be as manufactured by Plastomatic, or approved equal.

2.09 PRESSURE TANKS:

- A. Furnish and install four (4) heavy duty plastic pressure tanks with interior rubber sleeve. Each tank shall be approximately _____" diameter (to be filled in by Engineer) and _____" long (to be filled in by Engineer).
- B. Tanks shall be suitable for 75 psi pressure and 120 degree F. temperature.
- C. Tanks shall be Hydro-cell tanks as manufactured by Jacuzzi Brothers, or approved equal.

2.10 FLOW CONTROL VALVES:

- A. The Mechanical Contractor shall furnish and install a 3/8" PVC flow control valve in each and every deionized water outlet that limits the flow to 1/2 GPM. The Contractor shall supply and install a 2 GPM a natural, virgin, un-pigmented polypropylene flow control valve in each deionized water connection to washers.

- B. Flow control valves shall maintain a constant flow regardless of inlet pressure changes between 15 and 100 psig. No metal shall be in contact with the liquid.
- C. The flow control valves shall be Series "FC," as manufactured by Plastomatic Valves, Inc., or approved equal.

2.11 PRESSURE REGULATING VALVES

- A. Contractor shall supply and install, where shown on the drawings, socket fusion natural, virgin, un-pigmented polypropylene pressure regulating valves.
- B. Valves shall accurately reduce and regulate steady or varying inlet pressures and maintain a constant predetermined outlet pressure.
- C. Pressure regulating valves shall be Series "PR", as manufactured by Plastomatic Valves, Inc., or approved equal.

2.12 PRESSURE GAUGES

- A. Pressure gauges shall be 2-1/2" diameter, dual calibrated for 0 to 100 psi and SI units, having 316 stainless steel bourdon tube. The gauges supplied and/or installed for the service specified shall be manufactured by Ashcroft, Fig. No. 1079-S or approved equal.

NOTE TO THE ENGINEER: THE FOLLOWING TWO PARAGRAPHS MUST BE EITHER EDITED OR DELETED TO APPLY TO THE CURRENT PROJECT AT HAND.

2.13 PURIFIED WATER STORAGE TANK (Type "A"):

- A. Tank shall be vertical cylindrical type, stainless steel or FRP-jacketed polyethylene, of _____ gallon/_____ liter capacity (to be filled in by Engineer), with dished or conical bottom. Tank shall have a tight-fitting removable cover, a steel floor stand, an air filter capable of removing particles as small as 0.5 micron, and rounded interior corners. All tank penetrations shall be factory made. Stainless steel tanks shall be No. 4 finish; polyethylene tanks shall be made of FDA approved resin. Tank shall be Nalgene Series 17000, United Utensils Series VT, or approved equal. Air filter shall be American Sterilizer No. P-41648091 or approved equal.

2.14 PURIFIED WATER STORAGE TANKS (Type "B"):

- A. Tank capacities for each of two vertical closed top atmosphere tanks with manway is _____ diameter (to be filled in by Engineer) by

_____ high (to be filled in by Engineer), and _____
gallons (to be filled in by Engineer).

- B. Manway shall be 18" round and fittings shall be of size and location shown on the Drawings.
- C. Tanks shall be as manufactured by RAMCO, Beatle Plastics Manufacturing Company, or approved equal. Mandrel tanks with oriented fiber construction, as manufactured by Owens-Corning, Justin, or approved equal, will be acceptable.

2.15 LEVEL SENSORS

- A. Level sensors shall have only stainless steel and Viton in contact with the fluid. Each shall have a snap action switch rated for 125 volts, with an adjustable dead band initially set by the Contractor at 3 inches (8 cm). ASCO Tri-Point Catalog No. SAxOA1/TAxOA32 _____ (Engineer to fill in complete number) or approved equal.
- B. One level sensor, as shown on the Drawing, shall be wired with the solenoid valve to automatically maintain the liquid level in the tank. The other is to be connected to the Central Data Acquisition System.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install equipment on concrete housekeeping pad. Refer to Section 23 00 00.
- C. Install line size isolation and check valves on circulation pump discharge.
- D. Install valved bypass around purification equipment.
- E. Install manual air vent valves at all high points of piping system, including piping direction changes from horizontal to vertical drops (ells only).
- F. Install take offs to outlets with shut off valve after take off. Slope take-off piping to outlets.
- G. Identify piping system and components. Refer to Section 23 05 53.

3.02 FIELD QUALITY CONTROL

- A. Field inspection and testing will be performed under provisions of Section 23 00 00.
- B. Repair or replace piping as required to eliminate leaks, and retest to demonstrate compliance.
- C. Cap (seal) ends of piping when not connected to mechanical equipment.

END OF SECTION

SECTION 23 00 00
BASIC MECHANICAL REQUIREMENTS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Basic Mechanical Requirements specifically applicable to Division 23 sections, in addition to Division 01 - General Requirements.

1.02 RELATED DOCUMENTS

- A. THE UNIFORM GENERAL CONDITIONS, SUPPLEMENTARY GENERAL CONDITIONS, and Division 01 of the specifications apply to the work specified in this section.
- B. All work covered by this section of these specifications shall be accomplished in accordance with all applicable provisions of the Contract Documents and any addenda or directives which may be issued herewith, or otherwise.

1.03 GENERAL

- A. The Contractor shall execute all work hereinafter specified or indicated on accompanying drawings. Contractor shall provide all equipment necessary and usually furnished in connection with such work and systems whether or not mentioned specifically herein or on the drawings.
- B. The Contractor shall be responsible for fitting his material and apparatus into the building and shall carefully lay out his work at the site to conform to the structural conditions, to avoid all obstructions, to conform to the details of the installation and thereby to provide an integrated satisfactory operating installation.
- C. The mechanical, electrical, and associated drawings are necessarily diagrammatic by their nature, and are not intended to show every connection in detail or every pipe or conduit in its exact location. These details are subject to the requirements of standards referenced elsewhere in these specifications, and structural and architectural conditions. The Contractor shall carefully investigate structural and finish conditions and shall coordinate the separate trades in order to avoid interference between the various phases of work. Work shall be organized and laid out so that it will be concealed in furred chases and suspended ceilings, etc., in finished portions of the building, unless specifically noted to be exposed. All exposed work shall be installed parallel or perpendicular to the lines of the building unless otherwise noted.

- D. When the mechanical and electrical drawings do not give exact details as to the elevation of pipe, conduit and ducts, the Contractor shall physically arrange the systems to fit in the space available at the elevations intended with proper grades for the functioning of the system involved. Piping, exposed conduit and the duct systems are generally intended to be installed true and square to the building construction, and located as high as possible against the structure. The drawings do not show all required offsets, control lines, pilot lines and other location details. Work shall be concealed in all finished areas.

1.04 DEFINITIONS (Note: These definitions are included here to clarify the direction and intention of this specification. The list given here is not by any means complete. For further clarification as required, contractor shall contact the designated Owner's representative.)

- A. Concealed/exposed: Concealed areas are those that cannot be seen by the building occupants. Exposed areas are all areas that are exposed to view by the building occupants, including under counters, inside cabinets and closets, plus all mechanical rooms.
- B. General Requirements: The provisions of requirements of other Division 01 sections apply to entire work of contract and, where so indicated, to other elements that are included in project. Basic contract definitions are included in the General Conditions.
- C. Indicated: The term "indicated" is a cross reference to graphic representations, notes or schedules on drawings, to other paragraphs or schedules in the specifications, and to similar means of recording requirements on contract documents. Where terms such as "shown," "noted," "scheduled," and "specified" are used in lieu of "indicated," it is for the purpose of helping reader locate the cross reference, and no limitation of location is intended except as specifically noted.
- D. Directed, requested, etc.: Where not otherwise explained, terms such as "directed," "requested," "authorized," "selected," "approved," "required," "accepted," and "permitted" mean "directed by Architect/Engineer," "requested by Architect/Engineer" and similar phrases. However, no such implied meaning will be interpreted to extend Architect's/Engineer's responsibility into Contractor's area of construction supervision and job safety.
- E. And/Or: Where "and/or" is used in these specifications or on the drawings, it shall mean "that situations exist where either one or both conditions occur or are required and shall not be interpreted to permit an option on the part of the Contractor.
- F. Approve: Where used in conjunction with Architect's/Engineer's response to submittals, requests, applications, inquiries, reports and claims by Contractor, the meaning of term "approved" will be held to limitations to Architect's/Engineer's

responsibilities and duties as specified in General and Supplementary Conditions. In no case will "approval" by Architect/Engineer be interpreted as a release of Contractor from responsibilities to fulfill requirements of contract documents or to extend Architect's/Engineer's responsibility into Contractor's area of construction supervision and job safety.

- G. As required: Where "as required" is used in these specifications or on the drawings, it shall mean "that situations exist that are not necessarily described in detail or indicated that may cause the contractor certain complications in performing the work described or indicated. These complications entail the normal coordination activities expected of the Contractor where multiple trades are involved and new or existing construction causes deviations to otherwise simplistic approaches to the work to be performed. The term shall not be interpreted to permit an option on the part of the Contractor to achieve the end result."
- H. Furnish
 - 1. The term "furnish" is used to mean "supply and deliver to project site, ready for unloading, unpacking, assemble, installation, and similar operations."
 - 2. Where "furnish" applies to work for which the installation is not otherwise specified, "furnish" in such case shall mean "furnish and install."
- I. Install: The term "install" is used to describe operations at project site including "unloading, unpacking, assembly, erection, placing, anchoring, applying, working to dimension, finishing, curing, protecting, cleaning and similar operation."
- J. Provide: The term "provide" means "to furnish and install, complete and ready for intended use."

1.05 PERMITS, UTILITY CONNECTIONS AND INSPECTIONS

- A. General: Refer to Division 01 for construction phasing and time increments.
- B. Fees and Costs: If, during the course of the construction, a need arises to buy utilities, the Contractor shall pay all fees attendant thereto. If city or privately owned utility piping or electrical cable needs to be extended, relocated, or terminated, the Contractor will pay all permits and construction/inspection fees associated with that particular work.
- C. All work performed on this project is under the authority of the State of Texas, therefore no local construction fees or construction permits will be required except as may be required for new service taps, or new or modified connections to city controlled services. If inspections by city personnel are specifically required by this

document, then the Contractor is responsible for any fees or permits in connection to those requirements.

- D. Compliance: The Contractor shall comply in every respect with all requirements of National Fire Protection Association, local Fire Department regulations and utility company requirements. In no case does this relieve the Contractor of the responsibility of complying with these specifications and drawings where specified conditions are of higher quality than the requirements of the above-specified authorities. Where requirements of the specifications and drawings are more lenient than the requirements of the above authorities having jurisdiction, the Contractor shall make installations in compliance with the requirements of the above authorities with no extra compensation.

1.06 CONTRACT DOCUMENTS

- A. All dimensional information related to new structures shall be taken from the appropriate drawings. All dimensional information related to existing facilities shall be taken from actual measurements made by the Contractor on the site.
- B. The interrelation of the specifications, the drawings, and the schedules are as follows: The specifications determine the nature and setting of the several materials, the drawings establish the quantities, dimensions and details, and the schedules give the performance characteristics. If the Contractor requires additional clarification, he shall request it in writing, following the contractually prescribed information flow requirements.
- C. Should the drawings or specifications conflict within themselves, or with each other, the better quality, or greater size or quantity of work or materials shall be performed or furnished.

1.07 WORK BY OWNER

- A. The Owner [has awarded] [will award] [a contract] [contracts] which [will commence] [commences] on [_____]. Specifically this work [will include] [includes]:
 - 1. Refrigerated Coolers: Supply and installation of compressor/condenser units, integral controls, heat recovery refrigerant diverting valves.
 - 2. [[_____]:] [_____].]

1.08 OWNER FURNISHED PRODUCTS

- A. Products furnished to the site and paid for by Owner:

1. Centrifugal chillers.
2. [_____].]

1.09 WORK SEQUENCE

- A. Install work in [stages] [phases] [to accommodate Owner's occupancy requirements] [_____] during the construction period coordinate mechanical schedule and operations with [Owner] [Architect/Engineer]:
 1. [Stage] [Phase] 1: [_____].]
 2. [Stage] [Phase] 2: [_____].]

1.10 FUTURE WORK

- A. Provide for future work under requirements of Section 01 11 00.
- B. Project is designed for future expansion of [_____] system [as specified] [and] [as indicated].
- C. [_____].]

1.11 ALLOWANCES

- A. Cash Allowance: Refer to Division 01 of the Construction Documents for information and requirements.

1.12 ALTERNATES

- A. Alternates quoted on Bid Forms will be reviewed and accepted or rejected at the Owner's option. Accepted Alternates will be identified in Owner Contractor Agreement.
- B. Coordinate related work and modify surrounding work as required.
- C. Schedule of Alternates: See "Special Conditions" and Bid Form.
- D. Any Alternate Proposals are summarized in Division 01 of the specifications. The Contractor is directed to refer to all sections of the specifications and drawings for this project to determine the exact extent and scope of the various Alternate Proposals as each pertains to the work of all trades.

1.13 SUBMITTALS

A. Refer to Uniform General Conditions.

B. Proposed Products List: Include Products specified in the following sections:

NOTE TO SPECIFICATION WRITER: DELETE THE SECTIONS BELOW THAT DO NOT APPLY TO THE PROJECT, AND ADD ANY THAT MAY BE NEEDED. SECTION NUMBERS SHALL FOLLOW CSI MASTERFORMAT, LATEST EDITION.

1. Section 11 53 23 – Environmental Rooms
2. Section 11 53 53 – Biological Safety Cabinets
3. Section 13 48 00 - Sound Attenuators
4. Section 21 13 13 - Fire Protection Systems
5. Section 21 30 00 - Fire Pumps
6. Section 22 11 23 - Plumbing Equipment
7. Section 22 13 16 - Plumbing Piping
8. Section 22 13 16.A - Plumbing Specialties
9. Section 22 15 13 - Compressed Air System
10. Section 22 15 19.13 - Reciprocating Air Compressors
11. Section 22 40 00 - Plumbing Fixtures
12. Section 22 63 13 - Medical Gas System
13. Section 22 66 00 – Lab Waste System
14. Section 22 67 13.19 - Deionized Water System
15. Section 23 05 13 - Motors
16. Section 23 05 16 - Expansion Compensation
17. Section 23 05 29 - Sleeves, Flashings, Supports and Anchors
18. Section 23 05 48 - Vibration Isolation

SECTION 23 00 00
BASIC MECHANICAL REQUIREMENTS

19. Section 23 05 53 - Mechanical Identification
20. Section 23 05 93 – Testing, Adjusting, and Balancing
21. Section 23 05 93.A – Testing, Adjusting, and Balancing – Contractor Responsibilities
22. Section 23 06 20.13 - Hydronic Specialties
23. Section 23 07 13 - Ductwork Insulation
24. Section 23 07 16 - Equipment Insulation
25. Section 23 07 19 - Piping Insulation
26. Section 23 09 23 - Direct Digital Control Systems
27. Section 23 09 43 - Pneumatic Controls
28. Section 23 11 13 - Fuel Oil Piping System
29. Section 23 20 00 - HVAC Pumps
30. Section 23 20 00.A - Piping, Valves and Fittings
31. Section 23 21 00 - Hydronic Piping
32. Section 23 22 00 - Steam and Steam Condensate Piping
33. Section 23 22 00.A - Steam and Steam Condensate Specialties
34. Section 23 29 23 – Variable Frequency Drives
35. Section 23 31 00 - Ductwork
36. Section 23 33 00 - Ductwork Accessories
37. Section 23 34 16 - Fans
38. Section 23 36 00 - Air Terminal Units
39. Section 23 36 00.A – Air Terminal Units (FPVAV)
40. Section 23 37 00 - Air Inlets and Outlets

SECTION 23 00 00
BASIC MECHANICAL REQUIREMENTS

41. Section 23 38 16 – Fume Hoods
 42. Section 23 41 00 – Filters
 43. Section 23 57 00 - Heat Exchangers
 44. Section 23 73 00 - Air Handling Units (Up to 10,000 CFM)
 45. Section 23 73 23 - Air Handling Units
 46. Section 23 73 23.A – Built Up Air Handling Units (Above 50,000 CFM)
 47. Section 23 81 23 - Computer Room Air Conditioning Units
 48. Section 23 81 23.A – Computer Room Air Conditioning Units –
Unitary Cooling
 49. Section 23 82 16 - Air Coils
 50. Section 23 82 19 - Terminal Heat Transfer Units
 51. Section 23 84 13 - Steam Grid Humidifiers
- C. Submit shop drawings and product data grouped to include complete submittals of related systems, products, and accessories in a single submittal.
- D. Mark dimensions and values in units to match those specified.
- E. Submit fabrication drawings whenever (1) equipment proposed varies in physical size and arrangement from that indicated on the drawings, thus causing rearrangement of equipment space, (2) where tight spaces require extreme coordination between ductwork, piping, conduit, and other equipment, (3) where called for elsewhere in these specifications; and (4) where specifically requested by the Architect/Engineer. Fabrication drawings shall be made at no additional charge to the Owner or the Architect/Engineer.
- F. All required fabrication drawings, except as noted otherwise, shall be prepared at a scale of not less than 1/4" = 1'-0." Fabrication drawings for ductwork, air handling units, and sections in Mechanical Rooms shall be drawn at a minimum scale of 3/8" = 1'-0." Submit three blue-line prints of each fabrication drawing to the Architect/Engineer for review. Reproduction and submittal of the Construction Documents is not acceptable. The Architect/Engineer will review the drawing and return one print with comments.

SECTION 23 00 00
BASIC MECHANICAL REQUIREMENTS

1.14 SUBSTITUTION OF MATERIALS AND EQUIPMENT

- A. Refer to General Conditions for substitution of materials and equipment.
- B. General: Within thirty days after the date of contract award or work order, whichever is later, and before purchasing or starting installation of materials or equipment, the Contractor shall submit for review, a complete list of suppliers, contractors and manufacturers for all materials and equipment that will be submitted for incorporation into the project. The list shall be arranged in accordance with the organization of the specifications. This initial list shall include the manufacturer's name and type or catalog number as required to identify the quality of material or equipment proposed. This list will be reviewed by the Engineer and the Owner and will be returned to the Contractor with comments as to which items are acceptable without further submittal data and which items will require detailed submittal data for further review and subsequent approval. The initial list shall be submitted as herein specified. Materials and equipment requiring detailed submittal data shall be submitted with sufficient data to indicate that all requirements of these specifications have been met and samples shall be furnished when requested. All manufacturers' data used as part of the submittal shall have all inapplicable features crossed out or deleted in a manner that will clearly indicate exactly what is to be furnished.
- C. It is not the intent of the drawings and/or specifications to limit products to any particular manufacturer nor to discriminate against an "APPROVED EQUAL" product as produced by another manufacturer. Some proprietary products are mentioned to set a definite standard for acceptance and to serve as a reference in comparison with other products. When a manufacturer's name appears in these specifications, it is not to be construed that the manufacturer is unconditionally acceptable as a provider of equipment for this project. The successful manufacturer or supplier shall meet all of the provisions of the appropriate specification(s).
- D. The specified products have been used in preparing the drawings and specifications and thus establish minimum qualities with which substitutes must at least equal to be considered acceptable. The burden of proof of equality rests with the Contractor. The decision of the designer is final.
- E. When requested by the Architect/Engineer, the Contractor shall provide a sample of the proposed substitute item. In some cases, samples of both the specified item and the proposed item shall be provided for comparison purposes.
- F. Timeliness: The burden of timeliness in the complete cycle of submittal data, shop drawings, and sample processing is on the Contractor. The Contractor shall allow a minimum of six (6) weeks time frame for review of each submission by the office of the design discipline involved after receipt of such submissions by that design discipline. The Contractor is responsible for allowing sufficient time in the

construction schedule to cover the aforementioned cycles of data processing, including time for all resubmittal cycles on unacceptable materials, equipment, etc. covered by the data submitted. Construction delays and/or lack of timeliness in the above regard are the responsibility of the Contractor and will not be considered in any request for scheduled construction time extensions and/or additional costs to the Owner.

- G. All equipment installed on this project shall have local representation, local factory authorized service, and a local stock of repair parts.
- H. Acceptance of materials and equipment will be based on manufacturer's published data and will be tentative subject to the submission of complete shop drawings indicating compliance with the contract documents and that adequate and acceptable clearances for entry, servicing, and maintenance will exist. Acceptance of materials and equipment under this provision shall not be construed as authorizing any deviations from the specifications, unless the attention of the Architect/Engineer has been directed in writing to the specific deviations. Data submitted shall not contain unrelated information unless all pertinent information is properly identified.
- I. Certification: The Contractor shall carefully examine all data forwarded for approval and shall sign a certificate to the effect that the data has been carefully checked and found to be correct with respect to dimensions and available space and that the equipment complies with all requirements of the specifications.
- J. Physical Size of Equipment: Space is critical; therefore, equipment of larger sizes than shown, even though of specified manufacturer, will not be acceptable unless it can be demonstrated that ample space exists for proper installation, operation, and maintenance.
- K. Materials and Equipment Lists: Eight (8) copies of the list of materials and equipment, the name of manufacturer, trade name, type, and catalog number shall be submitted to the Architect/Engineer. The lists shall be accompanied by eight (8) sets of pictorial and descriptive data derived from the manufacturers' catalogs, sales literature, or incorporated in the shop drawings. Such lists shall include but will not be limited to the following items:
 - L. Should a substitution be accepted, and should the substitute material prove defective, or otherwise unsatisfactory for the service intended within the guarantee period, this material or equipment shall be replaced with the material or equipment specified at no additional cost to the Owner.

1.15 MATERIALS AND WORKMANSHIP

- A. All materials, unless otherwise specified, shall be new, free from all defects, suitable for the intended use, and of the best quality of their respective kinds. Materials and

equipment shall be installed in accordance with the manufacturer's recommendations and the best standard practice for the type of work involved. All work shall be executed by mechanics skilled in their respective trades, and the installations shall provide a neat, precise appearance. Materials and/or equipment damaged in shipment or otherwise damaged prior to installation shall not be repaired at the job site but shall be replaced with new materials and/or equipment.

- B. The responsibility for the furnishing of the proper equipment and/or material and seeing that it is installed as intended by the manufacturer, rests entirely upon the Contractor who shall request advice and supervisory assistance from the representative of specific manufacturers during the installation.

1.16 FLAME SPREAD PROPERTIES OF MATERIALS

- A. Materials and adhesives incorporated in this project shall conform to NFPA Standard 255, "Method of Test of Surface Burning Characteristics of Building Materials" and NFPA 90. The classification shall not exceed a flame spread rating of 25 for all materials, adhesives, finishes, etc., specified for each system, and shall not exceed a smoke developed rating of 50.

1.17 REGULATORY REQUIREMENTS

- A. The "Authority Having Jurisdiction" over the project described by these documents is the Owner, as an Agency of the State of Texas. As such, it is required that the installation shall meet the minimum standards prescribed in the latest editions of the following listed codes and standards, which are made a part of these specifications. All referenced codes and standards shall be those current at the date of issue of the design documents.

NOTE TO SPECIFICATION WRITER: THE 'CURRENT AT THE DATE OF ISSUE' ABOVE SHALL APPLY UNLESS OTHER DATES ARE SPECIFICALLY APPROVED BY THE OFPC PROJECT MANAGER.

- B. National Fire Protection Association Standards (NFPA)
 - 1. NFPA No. 13, Sprinkler System, Installation
 - 2. NFPA No. 14, Standpipes and Hose Systems
 - 3. NFPA No. 20, Centrifugal Fire Pumps
 - 4. NFPA No. 37, Stationary Combustion Engines & Gas Turbines
 - 5. NFPA No. 45, Fire Protection for Laboratories Using Chemicals

6. NFPA No. 51, Welding & Cutting, Oxygen-Fuel Gas Systems
7. NFPA No. 54, Gas Appliances, Piping, National Fuel Gas Code
8. NFPA No. 70, National Electrical Code
9. NFPA No. 72D, Proprietary Signaling Systems
10. NFPA No. 78, Lightning Protection Code
11. NFPA No. 88A, Standard for Parking Structures
12. NFPA No. 90A, Air Conditioning Systems
13. NFPA No. 91, Blower & Exhaust Systems
14. NFPA No. 99, Health Care Facilities
15. NFPA No. 101, Life Safety Code
16. NFPA No. 200, Series, Building Construction
17. NFPA No. 211, Chimneys, Fireplaces, Vent Systems
18. NFPA No. 241, Standard for Safeguarding Construction, Alteration and Demolition Operations
19. NFPA No. 255, Method of Test of Surface Burning Characteristics of Building Materials
20. NFPA No. 258, Standard Research Test Method for Determining Smoke Generation of Solid Materials

C. American National Standards Institute (ANSI)

1. A40.8, National Plumbing Code
2. B31.1, Power Piping
3. B9.1, Safety Code for Mechanical Refrigeration

D. American Gas Association Publications (AGA): Directory of Approved Gas Appliances and Tested Accessories

- E. American Society of Mechanical Engineers (ASME): Boiler and Pressure Vessel Codes
- F. Air Conditioning and Refrigeration Institute Standards (ARI): All standards related to refrigeration and air conditioning equipment and piping furnished under these specifications.
- G. Sheet Metal and Air Conditioning Contractors National Association, Inc. (SMACNA): All current editions of applicable manuals and standards (See Sections 23 31 00 and 23 33 00.UT).
- H. Air Moving and Conditioning Association (AMCA): All current editions of applicable manuals and standards.
- I. American Society of Testing Materials (ASTM): All current editions of applicable manuals and standards.
- J. American Water Works Association (AWWA): All current editions of applicable manuals and standards.
- K. National Electrical Manufacturers' Association (NEMA): All current editions of applicable manuals and standards.
- L. City of [___*___], Fire Department as may be applicable to construction on this site.

NOTE TO THE SPECIFICATION WRITER: DELETE ASTERISK AND FILL IN NAME OF APPLICABLE DEPARTMENT.

- M. Uniform Building Code, (Includes the International Mechanical and International Plumbing Codes)
- N. Texas Occupational Safety Act: All applicable safety standards
- O. Occupational Safety and Health Act (OSHA)
- P. ADA and ANSI Standards: All work shall be in accord with all regulations and requirements of the Standards and Specifications for Handicapped and Disabled for the Construction of Public Buildings and Facilities in the State of Texas Usable by Physically Handicapped and Disabled persons, ANSI Standards and the requirements of the American Disabilities Act.
- Q. Refer to specification sections hereinafter bound for additional Codes and Standards.
- R. All materials and workmanship shall comply with all applicable state and national codes, specifications, and industry standards. In all cases where Underwriters

Laboratories, Inc. has established standards for a particular type material, such material shall comply with these standards. Evidence of compliance shall be the UL "label" or "listing" under Re-Examination Service.

- S. The Contract Documents are intended to comply with the aforementioned rules and regulations; however, some discrepancies may occur. Where such discrepancies occur, the Contractor shall immediately notify the Architect/Engineer in writing of said discrepancies and apply for an interpretation. Should the discovery and notification occur after the execution of a contract, any additional work required for compliance with said regulations shall be paid for as covered by Division 01 of these Contract Documents, providing no work of fabrication of materials has been accomplished in a manner of noncompliance. Should the Contractor fabricate and/or install materials and/or workmanship in such a manner that does not comply with the applicable codes, rules and regulations, the Contractor who performed such work shall bear all costs arising in correcting these deficiencies to comply with said rules and regulations.

1.18 GENERAL MATERIALS AND EQUIPMENT REQUIREMENTS

- A. Storage at Site: The Contractor shall not receive material or equipment at the job site until there is suitable space provided to properly protect equipment from rust, drip, humidity, and dust damage.
- B. Capacities shall be not less than those indicated but shall be such that no component or system becomes inoperative or is damaged because of startup or other overload conditions.
- C. Conformance with Agency Requirements: Where materials or equipment are specified to be approved, listed, tested, or labeled by the Underwriters Laboratories, Inc., or constructed and/or tested in accordance with the standards of the American Society of Mechanical Engineers or the Air Moving and Conditioning Association, the Contractor shall submit proof that the items furnished under this section of the specifications conform to such requirements. The label of the Underwriters Laboratories, Inc., applied to the item will be acceptable as sufficient evidence that the items conform to such requirements. The ASME stamp or the AMCA label will be acceptable as sufficient evidence that the items conform to the respective requirements.
- D. Nameplates: Each major component of equipment shall have the manufacturer's name, address, and catalog number on a plate securely attached to the item of equipment. All data on nameplates shall be legible at the time of Final Inspection.
- E. Prevention of Rust: Standard factory finish will be acceptable on equipment specified by model number; otherwise, surfaces of ferrous metal shall be given a rust inhibiting coating. The treatment shall withstand 200 hours in salt spray fog test, in

accordance with Method 6061 of Federal Standard No. 141. Immediately after completion of the test, the specimen shall show no signs of wrinkling or cracking and no signs of rust creepage beyond 1/8" on either side of the scratch mark. Where rust inhibitor coating is specified hereinafter, any treatment that will pass the above test is acceptable unless a specific coating is specified except that coal tar or asphalt type coating will not be acceptable unless so stated for a specific item. Where steel is specified to be hot dip galvanized, mill galvanized sheet steel may be used provided all raw edges are painted with a zinc-pigmented paint conforming to Military Specification MIL-P-26915.

- F. Protection from Moving Parts: Belts, pulleys, chains, gears, couplings, projecting set screws, keys, and other rotating parts shall be fully enclosed or properly guarded for personnel protection.
- G. Verification of Dimensions: The Contractor shall be responsible for the coordination and proper relation of his work to the building structure and to the work of all trades. The Contractor shall visit the premises and become thoroughly familiar with all details of the work and working conditions, to verify all dimensions in the field, and to advise the Architect/Engineer of any discrepancy before performing any work. Adjustments to the work required in order to facilitate a coordinated installation shall be made at no additional cost to the Owner or the Architect/Engineer.

1.19 WALL, FLOOR AND CEILING PLATES

- A. See Section 23 05 29 – Sleeves, Flashings, Supports and Anchors.

1.20 SLEEVES, INSERTS, AND FASTENINGS

- A. See Section 23 05 29 – Sleeves, Flashings, Supports and Anchors.

1.21 PROJECT/SITE CONDITIONS

- A. Install Work in locations shown on drawings, unless prevented by Project conditions.
- B. Prepare drawings showing proposed rearrangement of Work to meet Project conditions, including changes to Work specified in other sections. Obtain permission of [Owner] [Architect/Engineer] before proceeding.

1.22 MANUFACTURER'S RECOMMENDATIONS

- A. The manufacturer's published directions shall be followed in the delivery, storage, protection, installation, piping, and wiring of all equipment and material. The Contractor shall promptly notify the Architect/Engineer, in writing, of any conflict

between the requirements of the Contract Documents and the manufacturer's directions, and shall obtain the Architect/Engineer's instructions before proceeding with the work. Should the Contractor perform any such work that does not comply with the manufacturer's directions or such instructions from the Architect/Engineer, he shall bear all costs arising in connection with the deficiencies.

1.23 SPACE AND EQUIPMENT ARRANGEMENT

- A. The size of mechanical and electrical equipment indicated on the drawings is based on the dimensions of a particular manufacturer. While other manufacturers may be acceptable, it is the responsibility of the Contractor to determine if the equipment he proposes to furnish will fit in the space. Fabrication drawings shall be prepared when required by the Architect/Engineer or Owner to indicate a suitable arrangement.
- B. All equipment shall be installed in a manner to permit access to all surfaces. All valves, motors, drives, filters, and other accessory items shall be installed in a position to allow removal for service without disassembly of another part.

1.24 LARGE APPARATUS

- A. Any large piece of apparatus that is to be installed in any space in the building, and that is too large to permit access through stairways, doorways, or shafts shall be brought to the job and placed in the space before the enclosing structure is completed. Following placement in the space, such apparatus shall be thoroughly, completely protected from damage as hereinafter specified.

1.25 PROTECTION

- A. The Contractor shall at all times take such precautions as may be necessary to properly protect all materials and equipment from damage from the time of delivery until the completion of the work. This shall include the erection of all required temporary shelters and supports to adequately protect any items stored in the open on the site from the weather, the ground and surrounding work; the cribbing of any items above the floor of the construction; and the covering of items in the incomplete building with tarpaulins or other protective covering; the installation of electric heaters in electrical switchgear and similar equipment to prevent moisture damage. Failure on the part of the Contractor to comply with the above will be sufficient cause for the rejection of the items in question.
- B. Take particular care not to damage the building structure in performing work. All finished floors, step treads, and finished surfaces shall be covered to prevent any damage by workers or their tools and equipment during the construction of the building.

- C. Equipment and materials shall be protected from rust both before and after installation. Any equipment or materials found in a rusty condition at the time of final inspection must be cleaned of rust and repainted as specified elsewhere in these specifications.

1.26 COOPERATION BETWEEN TRADES AND WITH OTHER CONTRACTORS

- A. Each trade, subcontractor, and/or Contractor must work in harmony with the various other trades, subcontractors and/or Contractors on the job as may be required to facilitate the progress to the best advantage of the job as a whole. Each trade, subcontractor, and/or Contractor must pursue its work promptly and carefully so as not to delay the general progress of the job. This Contractor shall work in harmony with Contractors working under other contracts on the premises.

1.27 ELECTRICAL WIRING OF MOTORS AND EQUIPMENT

- A. The Contractor shall note that the electrical design and drawings are based on the equipment scheduled and indicated on the drawings, and should any mechanical equipment be provided requiring changes to the electrical design, the required electrical changes shall be made at no cost to the Owner.
- B. The electrical trades shall provide all interconnecting wiring for the installation of all power. The electrical trades shall provide all disconnect switches as required for proper operation, as indicated on the drawings or required by applicable code. All combination starters, individual starters, and other motor starting apparatus not specifically scheduled or specified as provided by the equipment manufacturer under the scope of Division 23, shall be provided under the scope of Division 26.
- C. The Mechanical Trades shall provide complete wiring diagrams indicating power wiring and interlock wiring. Diagrams shall be submitted to the Architect/Engineer for review within thirty (30) days after the submittals for equipment have been reviewed. Diagrams shall be based on accepted equipment and shall be complete full phase and interlock control drawings, not a series of manufacturer's individual diagrams. After these diagrams have been reviewed by the Architect/Engineer, copies shall be transmitted to the electrical trades by the Contractor. They shall be followed in detail. See Section 15E, TEMPERATURE CONTROLS, for additional clarification.

1.28 SUPERVISION

- A. Each Contractor and subcontractor shall keep a competent superintendent or foreman on the job at all times. (Refer to the Uniform General Conditions for additional information concerning supervision.)
- B. It shall be the responsibility of each superintendent to study all drawings and familiarize himself with the work to be done by other trades. He shall coordinate his work with other trades and before material is fabricated or installed, make sure that his work will not cause an interference with another trade. Where interferences are encountered, they shall be resolved at the job site by the superintendents involved. Where interferences cannot be resolved without major changes to the drawings, the matter shall be referred to the A/E for ruling.

1.29 SITE OBSERVATION

- A. Site observation by the Architect/Engineer is for the express purpose of verifying compliance by the Contractor with the Contract Documents, and shall not be construed as construction supervision nor indication of approval of the manner or location in which the work is being performed as being a safe practice or place.

1.30 PRECEDENCE OF MATERIALS

- A. The specifications determine the nature and setting of materials and equipment. The drawings establish quantities, dimensions and details.
- B. The installation precedence of materials shall be as follows. Note that if an interference is encountered, this shall guide the contractor in the determination of which trade shall be given the "Right-of-Way."

Building lines
Structural Members
Soil and Drain Piping
Condensate Drains
Vent Piping
Supply, Return, and Outside Air Ductwork
Exhaust Ductwork
HVAC Water and Steam Piping
Steam Condensate Piping
Fire Protection Piping
Natural Gas Piping
Domestic Water (Cold and Hot)
Refrigerant Piping
Electrical Conduit

1.31 CONNECTIONS FOR OTHERS

- A. The Mechanical Contractor shall rough in for and make all gas, water, steam, sewer, etc. connections to all fixtures, equipment, machinery, etc., provided by others in accordance with detailed roughing in drawings provided by the equipment suppliers, by actual measurements of the equipment connections, or as detailed.
- B. After the equipment is set in place, this Contractor shall make all final connections and shall provide all required pipe, fittings, valves, traps, etc.
- C. Provide all air gap fittings required, using materials hereinbefore specified. In each service line connected to an item of equipment or piece of machinery, provide a shutoff valve. On each drain not provided with a trap, provide a suitable trap.
- D. All pipe fittings, valves, traps, etc., exposed in finished areas and connected to chrome plated lines provided by others shall be chrome plated to match.
- E. Provide all sheet metal ductwork, transition pieces, etc., required for a complete installation of vent hoods, fume hoods, etc., provided by others.

1.32 INSTALLATION METHODS

- A. Where to Conceal: All pipes, conduits, etc., shall be concealed in pipe chases, walls, furred spaces, or above the ceilings of the building unless otherwise indicated.
- B. Where to Expose: In mechanical rooms, janitor's closets tight against pan soffits in exposed "Tee" structures, or storage spaces, but only where necessary, piping may be run exposed. All exposed piping shall be run in the most aesthetic, inconspicuous manner, and parallel or perpendicular to the building lines.
- C. Support: All piping, ducts and conduits shall be adequately and properly supported from the building structure by means of hanger rods or clamps to walls as herein specified.
- D. Maintaining Clearance: Where limited space is available above the ceilings below concrete beams or other deep projections, pipe and conduit shall be sleeved through the projection where it crosses, rather than hung below them in a manner to provide maximum above floor clearance. Sleeves shall be as herein specified. Approval shall be obtained from the Architect/Engineer for each penetration.
- E. All pipe, conduits, etc., shall be cut accurately to measurements established at the building and shall be worked into place without springing or forcing. All ducts, pipes and conduits run exposed in machinery and equipment rooms shall be installed parallel to the building lines, except that piping shall be sloped to obtain the proper pitch. Piping, ducts and conduits run in furred ceilings, etc., shall be similarly installed, except as otherwise shown. Conduits in furred ceilings and in other concealed spaces shall be neatly grouped and racked indicating good workmanship.

All conduit and pipe openings shall be kept closed until the systems are closed with final connections.

1. All piping not directly buried in the ground shall be considered as "interior piping."
2. Prior to the installation of any ceiling material, gypsum, plaster, or acoustical board, the Contractor shall notify the construction inspector so that arrangement can be made for an inspection of the above ceiling area about to be "sealed" off. The Contractor shall give as much advance notice as possible no less than 10 working days.
3. All above ceiling areas will be subject to a formal inspection before ceiling panels are installed, or installation is otherwise concealed from view. All mechanical and electrical work at and above the ceiling, including items supported by the ceiling grid, such as air inlets or outlets and lighting fixtures, shall be complete and installed in accordance with contract requirements, including power to lighting fixtures, fans, and other powered items. Adequate lighting shall be provided to permit thorough inspection of all above ceiling items. The inspection will include representatives of the following: General Contractor and each Subcontractor having work above the ceiling, Architect/Engineer, Physical Plant, Resident Construction Manager's Construction Inspector(s), the Resident Construction Manager, and Office of Facilities Planning and Construction (OFPC). Areas to be included and time of inspection shall be coordinated with the Construction Inspector.
4. The purpose of this inspection is to verify the completeness and quality of the installation of the air conditioning systems, the electrical systems, the plumbing systems, and any other special above ceiling systems such as pneumatic tube, vacuum systems, fire sprinkler piping and cable tray systems. The ceiling supports (tee bar or lath) shall be in place so that access panel and light fixture locations are identifiable and so that clearances and access provisions may be evaluated.
5. No ceiling materials may be installed until the resulting deficiency list from this inspection is worked off and the Construction Inspector has given approval.

1.33 RECORDS FOR OWNER

NOTE TO THE ENGINEER: COORDINATE THIS SECTION WITH DIVISION 01 REQUIREMENTS FOR RECORDS AND "AS BUILTS."

- A. The Contractor shall maintain a set of "blueline" prints in the Field Office for the sole purpose of recording "installed" conditions. Daily note all changes made in

these drawings in connection with the final installation including exact dimensioned locations of all new underground utilities, services and systems and all uncovered existing active and inactive piping outside the building.

- B. At contract completion, the Contractor shall provide a set of reproducible photographic mylar drawings, plus the photo negatives of the revised drawings. The contractor shall transfer the information from the "blue-line" prints maintained as described above, and turn over this neatly marked set of reproducible drawings representing the "as installed" work to the Architect/Engineers for verification and subsequent transmittal to the Owner. The Contractor shall refer to Division 01 of these specifications, and to the Uniform General Conditions, for additional information. These drawings shall include as a minimum:
1. Addendum written drawing changes.
 2. Addendum supplementary drawings.
 3. Accurate, dimensioned locations of all underground utilities, services and systems.
 4. Identification of equipment work shown on Alternates as to whether alternates were accepted and work actually installed.
 5. Change Order written drawing changes.
 6. Change Order supplementary drawings.
- C. Electronic Media
1. In lieu of the drawings described above in 1.33B, it is preferred the contractor submit one set of blue-line prints, one set of vellum reproducible, and one set of discs containing all the drawings in AUTOCAD 12 or 14 format.
- D. "As installed" mylars shall bear a stamp, "stick-on decal" or lettered title block generally located in lower right hand corner of drawing entitled "AS INSTALLED DRAWING" with Company name of the installing trade Subcontractor and with a place for the date and the name of the responsible company representative.
- E. In addition to the above, the Contractor shall accumulate during the progress of the job the following data, in duplicate, prepared in a neat brochure or packet folder and turn over to the Architect/Engineer for review, and subsequent delivery to the Owner.
1. All warranties and guarantees and manufacturers' directions on equipment and material covered by the Contract.

2. Two sets of operating instructions for heating and cooling and other mechanical and electrical systems. Operating instructions shall also include recommended preventative maintenance and seasonal changeover procedures.
 3. Valve tag charts and diagrams specified herein.
 4. Approved wiring diagrams and control diagrams representing "as installed" conditions.
 5. Copies of approved shop drawings.
 6. Any and all other data and/or drawings required as submittals during construction.
 7. Repair parts list of all major items and equipment including name, address and telephone number of local supplier or agent.
- F. All of the above data shall be submitted to the Architect/Engineer for approval, and shall be corrected as instructed by the Architect/Engineer prior to submission of the final request for payment.

1.34 CUTTING AND PATCHING

- A. General: Cut and patch walls, floors, etc., resulting from work in existing construction or by failure to provide proper openings or recesses in new construction.
- B. Methods of cutting: Openings cut through concrete and masonry shall be made with masonry saws and/or core drills and at such locations acceptable to the Architect/Engineer. Impact type equipment shall not be used except where specifically acceptable to the Architect/Engineer. Openings in precast concrete slabs for pipes, conduits, outlet boxes, etc., shall be core drilled to exact size.
- C. Restoration: All openings shall be restored to "as new" condition under the appropriate specification section for the materials involved, and shall match remaining surrounding materials and/or finishes.
- D. Masonry: Where openings are cut through masonry walls, provide and install lintels or other structural supports to protect the remaining masonry. Adequate supports shall be provided during the cutting operation to prevent any damage to the masonry occasioned by the operation. All structural members, supports, etc., shall be of the proper size and shape, and shall be installed in a manner acceptable to the Architect/Engineer.

- E. Plaster: All mechanical work in areas containing plaster shall be completed prior to the application of the finish plaster coat. Cutting of finish plaster coat will not be permitted.
- F. Special Note: No cutting, boring, or excavating that will weaken the structure shall be undertaken.

1.35 ROOF PENETRATIONS AND FLASHING

- A. Pipe, conduit and duct sleeves, pitch pockets, and flashings compatible with the roofing installation shall be provided and installed by a qualified contractor for all roof penetrations. This shall be the responsibility of the General Contractor.

1.36 EXCAVATION, TRENCHING AND BACKFILL

- A. Excavation (See Divisions 00 and 01 for special requirements related to excavation and trenching.):
 - 1. The mechanical and electrical subcontractors shall perform all excavations of every description, for their particular installations and of whatever substances encountered, to the depths indicated on the drawings and/or required for the installation of piping, conduit, utility systems, etc. All exterior lines shall be installed with a minimum cover of 24," unless otherwise indicated. Generally, more cover shall be provided if grade will permit. All excavation materials not required for backfill or fill shall be removed and wasted as acceptable to the Construction Inspector. All excavations shall be made only by open cut. The banks of trenches shall be kept as nearly vertical as possible and where required, shall be properly sheeted and braced. Trenches shall be not less than 12" wider nor more than 16" wider than the outside edges of the pipe to be laid therein, and shall be excavated true to line so that a clear space not less than 6" nor more than 8" in width is provided on each side of the pipe. For sewers, the maximum width of trench specified applies to the width at and below the level of the pipe, and may be made as wide as necessary for sheeting and bracing and proper installation of the work.
 - 2. The bottom of trenches shall be accurately graded to provide proper fall and uniform bearing and support for each section of the pipe on undisturbed soil or 2" of sand fill at every point along its entire length, except for portions of the pipe sections where it is necessary to excavate for bell holes and for the proper sealing of pipe joints. Bell holes shall be dug after the trench bottom has been graded. Where inverts are not shown, grading shall be determined by the National Plumbing Code for the service intended and the size used. Bell holes for lead pipe joints shall be 12" in depth below the trench bottom and shall extend from a point 6" back of the face of the bell. Such bell holes shall be of sufficient width to provide ample room for caulking. Bell holes for sewer tile

and water pipe shall be excavated only to an extent sufficient to permit accurate work in the making of the joints and to insure that the pipe, for a maximum of its length, will rest upon the prepared bottom of the trench. Depressions for joints other than bell-and-spigot shall be made in accordance with the recommendations of the joint manufacturer for the particular type of joint used. In general, grading for electrical ductbanks and conduits shall be from building to manhole, and from a high point between manholes to each manhole. Special pipe beds shall be provided as specified hereinafter.

3. The lower 4" of the pipe trenches measuring from an overhead line set parallel to the grade line of the sewer shall be excavated only a few feet in advance to the pipe laying, by workers especially skilled in this type of work. Where damage is likely to result from withdrawing sheeting, the sheeting shall be left in place. Except at locations where excavation of rock from the bottom of trenches is required, care shall be taken not to excavate below the depths required. Where rock excavation is required, the rock shall be excavated to a minimum overdepth of 6" below the trench depths specified. The overdepth rock excavation and all excess trench excavation shall be backfilled with sand. Whenever wet or otherwise unstable soil is incapable of properly supporting the pipe is encountered in the trench bottom, such soil shall be removed to a depth and for the trench lengths required, and then backfilled to trench bottom grade, as hereinafter specified, with sand.
4. All grading in the vicinity of excavation shall be controlled to prevent surface ground water from flowing into the excavations. Any water accumulated in the excavations shall be removed by pumping or other acceptable method. During excavation, material suitable for backfilling shall be stacked in an orderly manner a sufficient distance back from edges of trenches to avoid overloading and prevent slides or cave-ins. Material unsuitable for backfilling shall be wasted and removed from the job site as directed by the Construction Inspector.
5. All shoring and sheeting required to perform and protect the excavations and to safeguard employees and/or adjacent structures shall be provided.
6. Excavate as required under the building in order that all piping, ductwork, etc., shall clear the ground a minimum of 12" for a distance of 24" on either side. Edges of such excavations shall slope at an angle of not over 45 degrees with the horizontal unless otherwise approved by the Construction Inspector. The bottom of such excavation shall be graded to drain in a manner acceptable to the Construction Inspector.
7. Trenches for cast iron drain, storm water and sewer lines inside the building shall be properly excavated, following, in general, the procedures set out for exterior lines. Where floors are to be poured over these lines, they shall be

backfilled, tamped and settled with water. Where no flooring is to cover the lines, they shall be backfilled to form a level grade.

8. All surplus materials removed in these trenching operations becomes the property of the contractor, and shall be disposed of at the expense of the contractor, at a legal disposal site, off of the campus.

B. Backfilling

1. Trenches shall not be backfilled until all required tests are performed and until the piping, utilities systems, etc., as installed are certified by the Owner's inspector to conform to the requirements specified hereinafter. The trenches shall be carefully backfilled with sand to a depth of 12 inches above the top of the pipe. The next layer and subsequent layers of backfill may be excavated materials approved for backfilling, consisting of earth, loam, sandy clay, sand and gravel, soft shale, or other approved materials free from large clods of earth or stones larger than 1 1/2" in diameter, flooded until the pipe has cover of not less than one foot. The remainder of the backfill material shall then be thrown into the trenches, moistened, and tamped or flooded in one-foot layers. Blasted rock, broken concrete or pavement, and large boulders shall not be used as backfill material. Any trenches improperly backfilled, or where settlement occurs, shall be reopened to the depth required for proper compaction, then refilled and mounded over, and smoothed off.
2. Backfill under concrete slabs-on-fill shall be as specified above, shall be gravel, or shall be other such materials more suitable for the application. Installation and compaction shall be as required for compatibility with adjacent materials.

- C. Opening and Re-closing Pavement and Lawns: Where excavation requires the opening of existing walks, streets, drives, other existing pavement, or lawns, such surfaces shall be cut as required to install new lines and to make new connections to existing lines. The sizes of the cut shall be held to a minimum, consistent with the work to be accomplished. After the installation of the new work is completed and the excavation has been backfilled and flooded, the area shall be patched, using materials to match those cut out. The patches shall thoroughly bond with the original surfaces and shall be level with them, and shall meet all the requirements established by the authorities having jurisdiction over such areas.

- D. Excavation in Vicinity of Trees: All trees including low hanging limbs within the immediate area of construction shall be adequately protected to a height of at least 5 ft. to prevent damage from the construction operations and/or equipment. All excavation within the outermost limb radius of all trees shall be accomplished with extreme care. All roots located within this outermost limb radius shall be brought to the attention of the Construction Inspector before they are cut or damaged in any

way. The Construction Inspector will give immediate instructions for the disposition of it. All stumps and roots encountered in the excavation, which are not within the outermost limb radius of existing trees, shall be cut back to a distance of not less than 18" from the outside of any concrete structure or pipeline. No chips, parts of stumps, or loose rock shall be left in the excavation. Where stumps and roots have been cut out of the excavation, clean compacted dry bank sand shall be backfilled and tamped.

NOTE TO SPECIFICATION WRITER: COORDINATE THE FOLLOWING WITH DIVISION 08 REQUIREMENTS.

1.37 ACCESS DOORS

- A. General: This Contractor shall provide wall or ceiling access doors for unrestricted access to all concealed items of mechanical equipment or devices.
- B. Doors: Access doors mounted in painted surfaces shall be of Milcor (Inland-Ryerson Construction Products Company) manufacture, Style K for plastered surfaces and Style M or DW for non-plastered surfaces. The Style K doors shall be set so that the finished surface of the door is even with the finished surface of the adjacent finishes. Access doors mounted on tile surfaces shall be of similar construction as noted above, except they shall be of stainless steel materials. Access doors shall be a minimum of 12" x 12" in size.

1.38 OPERATION PRIOR TO COMPLETION

- A. When any piece of mechanical equipment is operable and it is to the advantage of the Contractor to operate the equipment, he may do so, providing that he properly supervises the operation, and has the Construction Inspector's written permission to do so. The warranty period shall, however, not commence until the equipment is operated for the beneficial use of the Owner, or date of substantial completion, whichever occurs first.
- B. Regardless of whether or not the equipment has or has not been operated, the Contractor shall properly clean the equipment, install clean filter media, properly adjust, and complete all deficiency list items before final acceptance by the Owner. The date of acceptance and performance certification will be the same date.

NOTE TO SPECIFICATION WRITER: PARAGRAPHS 1.39 AND 1.40 SHALL BE EDITED TO SUIT PROJECT. COORDINATE OUTAGES (1.39E) WITH DIVISION 11 REQUIREMENTS.

1.39 EXISTING FACILITIES

- A. The Contractor shall be responsible for loss or damage to the existing facilities caused by him and his workers, and shall be responsible for repairing or replacing such loss or damage. The Contractor shall send proper notices, make necessary arrangements, and perform other services required for the care, protection and in service maintenance of all plumbing, heating, air conditioning, and ventilating services for the new and existing facilities. The Contractor shall erect temporary barricades, with necessary safety devices, as required to protect personnel from injury, removing all such temporary protection upon completion of the work.
- B. The Contractor shall provide temporary or new services to all existing facilities as required to maintain their proper operation when normal services are disrupted as a result of the work being accomplished under this project.
- C. Where existing construction is removed to provide working and extension access to existing utilities, Contractor shall remove doors, piping, conduit, outlet boxes, wiring, light fixtures, air conditioning ductwork and equipment, etc., to provide this access and shall reinstall them upon completion of work in the areas affected.
- D. Where partitions, walls, floors, or ceilings of existing construction are indicated to be removed, all Contractors shall remove and reinstall in locations approved by the Architect/Engineer all devices required for the operation of the various systems installed in the existing construction. This is to include but is not limited to temperature controls system devices, electrical switches, relays, fixtures, piping, conduit, etc.
- E. Outages of services as required by the new installation will be permitted but only at a time approved by the Owner. The Contractor shall allow the Owner two weeks in order to schedule required outages. The time allowed for outages will not be during normal working hours unless otherwise approved by the Owner. All costs of outages, including overtime charges, shall be included in the contract amount.

1.40 DEMOLITION AND RELOCATION

- A. The Contractor shall modify, remove, and/or relocate all materials and items so indicated on the drawings or required by the installation of new facilities. All removals and/or dismantling shall be conducted in a manner as to produce maximum salvage. Salvage materials shall remain the property of the Owner, and shall be delivered to such destination or otherwise disposed of as directed by the Owner. Materials and/or items scheduled for relocation and which are damaged during dismantling or reassembly operations shall be repaired and restored to good operative condition. The Contractor may, at his discretion, and upon the approval of the Owner, substitute new materials and/or items of like design and quality in lieu of materials and/or items to be relocated.

- B. All items that are to be relocated shall be carefully removed in reverse to original assembly or placement and protected until relocated. The Contractor shall clean and repair and provide all new materials, fittings, and appurtenances required to complete the relocations and to restore to good operative order. All relocations shall be performed by workers skilled in the work and in accordance with standard practice of the trades involved.
- C. When items scheduled for relocation and/or reuse are found to be in damaged condition before work has been started on dismantling, the Contractor shall call the attention of the Owner to such items and receive further instructions before removal. Items damaged in repositioning operations are the Contractor's responsibility and shall be repaired or replaced by the Contractor as approved by the Owner, at no additional cost to the Owner.
- D. Service lines and wiring to items to be removed, salvaged, or relocated shall be removed to points indicated on the drawings, specified, or acceptable to the Owner. Service lines and wiring not scheduled for reuse shall be removed to the points at which reuse is to be continued or service is to remain. Such services shall be sealed, capped, or otherwise tied off or disconnected in a safe manner acceptable to the Owner. All disconnections or connections into the existing facilities shall be done in such a manner as to result in minimum interruption of services to adjacent occupied areas. Services to existing areas or facilities that must remain in operation during the construction period shall not be interrupted without prior specific approval of the Owner as hereinbefore specified.

1.41 CHECKING AND TESTING MATERIALS AND/OR EQUIPMENT

- A. Before the work is accepted, an authorized representative of the manufacturer of the installed materials and/or equipment shall personally inspect the installation and operation of his materials and/or equipment to determine that it is properly installed and in proper operating order. The qualifications of the representative shall be appropriate to the technical requirements of the installation. The qualifications of the representative shall be submitted to the owner for approval. The decision of the owner concerning the appropriateness of the representative shall be final. Testing and checking shall be accomplished during the course of the work where required by work being concealed, and at the completion of the work otherwise. In addition, the Contractor shall submit to the Architect/Engineer a signed statement from each representative certifying as follows: "I certify that the materials and/or equipment listed below have been personally inspected by the undersigned authorized manufacturer's representative and is properly installed and operating in accordance with the manufacturer's recommendations."

- B. Check inspections shall include plumbing equipment, heating, air conditioning, insulation, ventilating equipment, controls, mechanical equipment and such other items hereinafter specified or specifically designated by the Architect/Engineer.

1.42 TESTS

- A. The Contractor shall make, at no additional cost to the Owner, any tests deemed necessary by the inspection departments having jurisdiction, and in the National Fire Protection Association, ASTM, etc. Standards listed. The Contractor shall provide all equipment, materials, and labor for making such tests. Reasonable amounts of fuel and electrical energy costs for system tests will be paid by the Owner. Fuel and electrical energy costs for system adjustment and tests that follow beneficial occupancy by the Owner will be borne by the Owner.
- B. Additional tests specified hereinafter under the various specification sections shall be made.
- C. The Construction Inspector shall be notified in writing at least 10 working days prior to each test and other specification requirements requiring action on the part of the Construction Inspector. All equipment shall be placed in operation and tested for proper automatic control requirements before the balancing agency starts their work.
- D. Maintain Log of Tests as hereinafter specified.
- E. See specifications hereinafter for additional tests and requirements.

1.43 LOG OF TESTS

- A. All tests shall have pertinent data logged by the Contractor at the time of testing. Data shall include date, time, personnel, description, and extent of system tested, test conditions, test results, specified results, and other pertinent data. Data shall be delivered to the Architect/Engineer as specified under "Requirements for Final Acceptance." All Test Log entries shall be legibly signed by the Project Contractor or his authorized job superintendent.

1.44 COOPERATION AND CLEANUP

- A. It shall be the responsibility of each trade to cooperate fully with the other trades on the job to help keep the job site in a clean and safe condition. At the end of each day's work, each trade shall properly store all of his tools, equipment and materials and shall clean his debris from the job. Upon the completion of the job, each trade shall immediately remove all of his tools, equipment, any surplus materials and all debris caused by that portion of the work.

1.45 CLEANING AND PAINTING

- A. All equipment, piping, conduit, ductwork, grilles, insulation, etc., furnished and installed in exposed areas under Divisions 23 and 26 of these specifications and as hereinafter specified shall be cleaned, prepared, and painted according to the following specification. In the event of a conflict between the specifications referenced, the provisions of this specification shall prevail only for Division 23 and Division 26 work.
- B. All purchased equipment furnished by the mechanical and electrical subcontractors shall be delivered to the job with a suitable factory protective finish with the colors hereinafter specified. The following materials shall not be painted: copper, galvanized metal, stainless steel, fiberglass, PVC, and PVDF.
- C. Before painting, materials and equipment surfaces shall be thoroughly cleaned of cement, plaster, and other foreign materials, and all oil and grease spots shall be removed. Such surfaces shall be carefully wiped and all cracks and corners scraped out. Exposed metalwork shall be carefully brushed down with the steel brushes to remove rust and other spots and left smooth and clean.
- D. Color of finish painting in Mechanical Rooms shall be painted in accordance with The University of Texas Standard Color Schedule for machinery spaces using Pratt and Lambert, Inc.'s "Effector" enamel, or approved equal. For painting purposes, the equipment and piping inside of built-up air handling units shall be painted the same as if they were within the walls of a Mechanical Room. Two coats shall be applied with a light tint first coat and deep color for final coat. Colors shall be as follows:

(NOTE TO ENGINEER: MODIFY THE MATERIAL OF THIS SECTION TO ACRYLIC LATEX IF PAINTING IS TO BE DONE IN A HAZARDOUS ENVIRONMENT.)

<u>ITEM</u>	<u>COLOR</u>	<u>"P and L" PAINT NUMBER</u>
Equipment Bases	Light Green	YG493M (Winter Pear)
Equipment	Green	YG511Y (Biscay Green)
Piping (Insulated and Uninsulated)	Light Gray	B798M (London Fog)
Hanger Rods	Same as "Piping" above	
Steam Traps and Metal Exposed to High Temperatures	Same as "Piping" above, high temp rated	
Atmospheric Relief Line	Same as "Piping" above	
Ductwork, AHU, Fans and Insulation	Buff	Y354M (Tawny Gold)
Valve Hand Wheels	Blue	B726M (Siam Blue)
Pump Couplings and Fuel Gas Piping (including natural gas, LPG, etc.)	Safety Yellow	Y361M (Daisy Yellow)
Fire Protection Equipment and Piping	Safety Red	R131R (Vibrant Red)

NOTE THAT THE PAINT SPECIFIED ABOVE IS INCLUDED FOR PURPOSES OF ESTABLISHING A QUALITY THAT SHALL BE USED ON THIS PROJECT. THE PROPOSED PAINT SHALL BE SUBMITTED, AND ALTERNATIVES WILL BE CONSIDERED USING THE SUBMITTAL PROCEDURES SPECIFIED IN THIS DOCUMENT.

**THE FOLLOWING PAINT SCHEME SHALL APPLY TO UT HEALTH SCIENCE CENTER
- SAN ANTONIO ONLY:**

Medical Air Tank & Compressors - White
Alkyd Semi-Gloss Enamel

Walls & Duct - Non-Yellowing White
Semi-Lustre Interior Acrylic Latex Enamel

Primer- Rust Inhibitive Metal Primer
Red Oxide

Motors - Dark Blue
Polyurethane Rust Inhibitive Enamel

Floor & Hot Water Pumps - Medium Gray
Polyurethane Gloss Enamel

Chilled Water Handles - Velour Interior Alkyd Semi-Gloss Green Enamel
Ultra Deep Base

Steam Lines & Air Compressor - Heavy Duty Aluminum
Industrial Enamel

Sewage & Drains, Steam Handles - Black
Satin Finish

Pump Guards & Fire Pumps - Fire Engine Red
Gloss Finish Oil Base

Base of Pumps & Air Handlers - Seminole Red
Oil Base Gloss

Air Handlers - Lime Green Base 4071 4A
Oil Base Semi-Gloss

Chilled Water Pumps - Tan Brown Base
Oil Base - Gloss

Laboratory Air Tank & Compressor - Safety Orange
Enamel - Semi-Gloss

Vacuum Pumps - Yellow
Oil Base - Gloss

- E. Jacketing on insulation shall not be painted.
- F. No nameplates on equipment shall be painted, and suitable protection shall be afforded to the plates to prevent their being rendered illegible due to the painting operation.
- G. Scope of painting for Divisions 23 and 26--work in areas other than those defined as "exposed" is as follows:
 - 1. All uncovered steel pipe, supports, exposed pipe and hanger rod threads, and hangers in underfloor spaces shall be cleaned and painted with two coats of Tropical Paint Co. No. 77-black asphaltic emulsion. Galvanized steel and copper lines in these spaces shall not be painted.
 - 2. All canvas finishes including those underfloor and in concealed spaces shall be painted with one sizing coat if not already sized, containing mildew resistant additive and Arabol adhesive prior to any other specified finish paint.
 - 3. All fuel piping (natural gas, LPG, etc.) and all fire protection piping shall be painted whether concealed or exposed, in all areas of the project without exception. Fuel piping shall be painted safety yellow, and fire protection piping shall be painted safety red. These "safety" colors shall be as defined by OSHA.
 - 4. If insulated, the piping shall be primed, only, prior to insulation, and the insulation jacketing shall be painted as specified for piping. The requirements of this paragraph are "primary" and have priority over any conflicting specification or instruction, should a conflict in the Construction Documents exist.
- H. In addition to painting in mechanical rooms, materials, piping, ductwork, conduit, gear, supports, foundations, equipment and appurtenances installed by the mechanical and electrical subcontractors in exposed areas shall be finish painted with two coats of Pratt and Lambert, Inc.'s "Effector" enamel of color selected by the Architect/Engineer.
- I. Additional areas to be defined as "exposed" for purposes of painting, are defined as follows: (Note that paragraph 1.3.10 of this section defines exposed areas for the balance of the project. The areas listed below are to be painted in addition to exposed areas as previously defined.)

SPECIFICATION WRITER: DEFINE AREAS WHERE FINISH PAINTING IS DESIRED OUTSIDE OF MECHANICAL ROOMS.

- J. The surfaces to be finish painted shall first be prepared as follows:
1. On canvas finishes pretreat as specified above. Insulated surfaces having vapor barrier jacket exposed to view shall first be painted with one (1) coat of sealer.
 2. Galvanized and black steel surfaces shall first be painted with one (1) coat of P&L galvanized metal primer. Primer may be eliminated on concealed fire and gas piping.
 3. Aluminum surfaces shall first be painted with one (1) coat of P&L zinc chromate primer. (See Section 1.51.5)
 4. Cast iron pipe shall first be primed with a "non-bleed" primer.
 5. The underside of all cast iron sinks not recessed in a cabinet are included as items to be painted in exposed areas.
- K. Electrical switchgear, disconnect switches, contactors, etc., with suitable factory applied finishes shall not be repainted; except for aesthetic reasons where located in finished areas as directed by the Architect/Engineer and in a color selected by the Architect/Engineer. Where factory applied finishes are damaged in transit, storage or installation, or before final acceptance, they shall be restored to factory fresh condition by competent refinishers using the spray process.

NOTE TO SPECIFICATION WRITER: FOR PROJECTS IN THE COASTAL AREA, ADD THE FOLLOWING PARAGRAPH.

- L. All ferrous metal surfaces without a protective finish and not galvanized in exposed and concealed areas including chases, underfloor and above ceilings shall be painted with two (2) coats of P&L zinc chromate primer as the construction progresses to protect against deterioration.

PART 2 PRODUCTS

2.01 Not Used.

PART 3 EXECUTION

3.01 PIPE PRESSURE TESTS

A. The following lines shall be tested at the stated pressure for the length of time noted:

NOTE TO SPECIFICATION WRITER: DELETE ANY INAPPLICABLE LINES AND ADD APPLICABLE LINES NOT ALREADY INCLUDED.

<u>Testing Service</u>	<u>Testing Medium</u>	<u>Pressure (PSIG)</u>	<u>Time in Hours</u>
Chilled Water / Heating Hot Water	Water	150	24
Steam M.P. & L.P.	Water	150	24
Steam Condensate M.P.	Water	150	24
Steam H.P.	Water	300	24
Steam Condensate H.P.	Water	300	24
Pumped Condensate Return	Water	150	24
Domestic Hot & Cold Water	Water	150	24
Sanitary & Storm Piping	Water	Fill to top	24
Natural Gas	Air	100	24
Compressed Air	Air	150	24
Medical Gases	Nitrogen	150	24
Medical Vacuum	Nitrogen	150	24

B. Where leaks occur, the pipe shall be repaired and the tests repeated. No leaks shall be corrected by peening. Defective piping and joints shall be removed and replaced.

END OF SECTION

SECTION 23 05 13
MOTORS

PART 1 - GENERAL

1.1 THE FOLLOWING SECTIONS ARE TO BE INCLUDED AS IF WRITTEN HEREIN:

- A. Section 23 00 00 – Basic Mechanical Requirements
- B. Section 23 05 29 – Sleeves, Flashings, Supports and Anchors
- C. Section 23 05 53 – Mechanical Identification

1.2 SECTION INCLUDES

- A. Single phase electric motors
- B. Three phase electric motors
- C. The Contractor shall provide all motors required for equipment supplied under this Division of the work

1.3 RELATED WORK

- A. Section 23 22 00.A - Steam and Steam Condensate Specialties: Condensate pumps
- B. Section 23 20 00 - HVAC Pumps
- C. Section 23 81 23 - Computer Room Air Conditioning Units
- D. Section 23 82 19 - Terminal Heat Transfer Units: Unit heaters, fan-coil units, and unit ventilators
- E. Section 23 73 00 - Air Handling Unit with Coils (Up to 10,000 CFM): Fan motors
- F. Section 23 73 23 - Air Handling Unit: Fan motors
- G. Section 23 34 16 - Fans

1.4 REFERENCES

- A. AFBMA 9 - Load Ratings and Fatigue Life for Ball Bearings
- B. AFBMA 11 - Load Ratings and Fatigue Life for Roller Bearings
- C. ANSI/IEEE 112 - Test Procedure for Polyphase Induction Motors and Generators
- D. ANSI/NEMA MG 1 - Motors and Generators
- E. ANSI/NFPA 70 - National Electrical Code

1.5 SUBMITTALS

- A. Submit product data under provisions of Section 23 00 00
- B. Submit test results verifying nominal efficiency and power factor for motors 1 horsepower and larger.
- C. Submit manufacturer's installation instructions under provisions of Section 23 00 00

1.6 OPERATION AND MAINTENANCE DATA

- A. Submit operation and maintenance data under provisions of Section 23 00 00
- B. Include assembly drawings, bearing data including replacement sizes, and lubrication instructions.

1.7 QUALIFICATIONS

- A. Baldor
- B. Century/Gould
- C. General Electric
- D. Louis Allis
- E. Reliance
- F. Siemens-Allis
- G. US Motors
- H. Westinghouse

1.8 REGULATORY REQUIREMENTS

- A. Conform to ANSI/NFPA 70.

1.9 DELIVERY, STORAGE, AND HANDLING

- A. Deliver products to site under provisions of Section 23 00 00.
- B. Store and protect products under provisions of Section 23 00 00.
- C. Protect motors stored on site from weather and moisture by maintaining factory covers and suitable weather-proof covering. For extended outdoor storage, remove motors from equipment and store separately.

1.10 WARRANTY

- A. Provide five year manufacturer's warranty under provisions of Section 23 00 00.
- B. Warranty: Include coverage for motors 1 horsepower and larger.

PART 2 - PRODUCTS

2.1 GENERAL CONSTRUCTION AND REQUIREMENTS

- A. Open Design Motors: Design for continuous operation in 40 degrees C environment, and for temperature rise in accordance with ANSI/NEMA MG 1 limits for insulation class, Service Factor, and motor enclosure type.
- B. Totally Enclosed Motors: Design for a service factor of 1.00 and an 80 degrees C maximum temperature rise in the same conditions.
- C. Explosion-Proof Motors: UL approved and labeled for hazard classification, with over temperature protection.
- D. Visible Nameplate: Indicating motor horsepower, voltage, phase, cycles, RPM, full load amps, locked rotor amps, frame size, manufacturer's name and model number, Service Factor, Power Factor, efficiency.
- E. Electrical Connection: Conduit connection boxes, threaded for conduit. For fractional horsepower motors where connection is made directly, provide threaded conduit connection in end frame.
- F. Motors shall be built in accordance with the latest ANSI, IEEE, and NEMA Standards, and shall be fully coordinated with the equipment served, shall be of sizes and electrical characteristics scheduled, and of approved manufacture as described herein or of the same manufacture as the equipment which they serve. All motors provided by the Contractor shall be of the same manufacture unless they are an integral part of the piece of equipment to which they are attached. Nameplate rating of motors shall match the characteristics scheduled.
- G. All motors shall be designed for NEMA Design B starting torque unless the driven machine requires high starting torque and shall be selected for quiet operation, free from magnetic hum.
- H. In addition, all motors shall be provided with adequately sized electrical connection box with threaded hub for attachment of flexible conduit, unless bus duct connection is indicated. Where motors are connected to driven equipment by the use of a V-belt drive, they shall be furnished with adjustable rails.
- I. Dynamic Balance shall be no greater than the vibration limits of the driven equipment.
- J. All motors shall be provided with all copper windings, terminal wiring, and copper or bronze lugs. AL/CU rated connectors are not allowed.

2.2 SINGLE PHASE POWER - SPLIT PHASE MOTORS

- A. Starting Torque: Less than 150 percent of full load torque.
- B. Starting Current: Up to seven times full load current.
- C. Breakdown Torque: Approximately 200 percent of full load torque.

- D. Drip-proof Enclosure: Class A (50 degrees C temperature rise) insulation, NEMA Service Factor, pre-lubricated sleeve or ball bearings.
- E. Enclosed Motors: Class A (50 degrees C temperature rise) insulation, 1.0 Service Factor, pre-lubricated ball bearings.
- F. Single phase motors, in general, shall be less than 3/4 horsepower and shall be permanent split phase, capacitor start, induction run, 120 volt, 60 hertz motors with drip-proof enclosures except as hereinafter specified. These motors shall have built-in thermal overload protection with automatic reset, and shall be rated for temperature rise as hereinbefore specified for 3-phase motors.

2.3 SINGLE PHASE POWER - PERMANENT-SPLIT CAPACITOR MOTORS

- A. Starting Torque: Exceeding one fourth of full load torque.
- B. Starting Current: Up to six times full load current.
- C. Multiple Speed: Through tapped windings.
- D. Open Drip-proof or Enclosed Air Over Enclosure: Class A (50 degrees C temperature rise) insulation, minimum 1.0 Service Factor, pre-lubricated sleeve or ball bearings, automatic reset overload protector.
- E. Single phase motors, in general, shall be less than 3/4 horsepower and shall be permanent split phase, capacitor start, induction run, 120 volt, 60 hertz motors. These motors shall have built-in thermal overload protection with automatic reset, and shall be rated for temperature rise as hereinbefore specified for 3-phase motors.

2.4 SINGLE PHASE POWER - CAPACITOR START MOTORS

- A. Starting Torque: Three times full load torque.
- B. Starting Current: Less than five times full load current.
- C. Pull-up Torque: Up to 350 percent of full load torque.
- D. Breakdown Torque: Approximately 250 percent of full load torque.
- E. Motors: Capacitor in series with starting winding; capacitor-start/capacitor-run motors shall have two capacitors in parallel with run capacitor remaining in circuit at operating speeds.
- F. Enclosures shall be of the open drip-proof type with a service factor of 1.15 and Class B insulation rated at 90 degrees C temperature rise measured above 40 degrees C room ambient condition at full load, unless otherwise noted.
- G. Enclosed Motors: Class A (50 degrees C temperature rise) insulation, 1.0 Service Factor, pre-lubricated ball bearings.

- H. Single phase motors, in general, shall be less than 3/4 horsepower and shall be permanent split phase, capacitor start, induction run, 120 volt, 60 hertz motors. These motors shall have built-in thermal overload protection with automatic reset, and shall be rated for temperature rise as hereinbefore specified for 3-phase motors.

2.5 THREE PHASE POWER - SQUIRREL CAGE MOTORS

- A. Acceptable Manufacturers: Subject to conformance with these specifications, furnish motors by one of the following manufacturers:
 - 1. Baldor
 - 2. TECO/Westinghouse
 - 3. Toshiba
 - 4. General Electric
- B. In general, all motors 3/4 horsepower and larger, unless smaller motors are indicated to be supplied as 3-phase, shall be 3-phase and shall be squirrel cage premium efficiency induction type with standard NEMA frame sizes.
- C. All three phase motors shall be inverter duty rated and equipped with a shaft grounding device. Inverter duty motors shall be capable of withstanding repeated peaks of 1600 volts at 0.1 microsecond rise time and comply with NEMA MG-1 Part 31.
- D. Motors 1 HP and larger shall have integral frames.
- E. Starting Torque: Between one and one and one-half times full load torque.
- F. Starting Current: Six times full load current.
- G. Power Output, Locked Rotor Torque, Breakdown or Pullout Torque: NEMA Design B Characteristics.
- H. Design, Construction, Testing, and Performance: Conform to ANSI/NEMA MG 1 for Design B motors.
- I. Insulation System: NEMA Class B or better.
- J. Testing Procedure: In accordance with ANSI/IEEE 112, Test Method B. Load test motors to determine freedom from electrical or mechanical defects and compliance with performance data. Test and balance motors to limits defined in 2.01J.
- K. Motor Frames: NEMA standard T-frames of steel, aluminum, or cast iron with end brackets of cast iron or aluminum with steel inserts.
- L. Thermistor System (Motor Frame Sizes 254T and Larger): Three PTC thermistors imbedded in motor windings and epoxy encapsulated solid state control relay for wiring into motor starter or VFD; refer to Division 26 for Starter Requirements. Refer to Specification Section 23 29 23 for Variable Frequency Drives.

- M. Bearings: Ball or roller type, double shielded with continuous grease relief to accommodate excessive pressure caused by thermal expansion or over lubrication. All motor bearings shall be factory pre-packed with a non-detergent lubricant, and shall be provided with lubrication fitting arranged to provide easy access when installed on the driven apparatus except as noted hereinafter. Permanently lubricated factory-sealed motors may be provided in fractional HP sizes only where they are an integral part of a piece of approved apparatus. All bearings shall be designed for L-10, 200,000 hour minimum life hours of continuous service. Calculate bearing load with NEMA minimum V- belt pulley with belt center line at end of NEMA standard shaft extension. Stamp bearing sizes on nameplate.
- N. Sound Power Levels: Refer to ANSI/NEMA MG 1.
- O. Weatherproof Epoxy Treated Motors (Where Indicated): Epoxy coat windings with rotor and starter surfaces protected with epoxy enamel. Bearings shall be double shielded with waterproof non-washing grease.
- P. Nominal Efficiency: Furnish all motors with minimum efficiency equal to or greater than Efficiency Level of Premium Efficiency Motors as defined in the latest version of NEMA MG-1.
- Q. Service Factor: M Furnish all motors with service factor equal to or greater than that required in the latest version of NEMA MG-1
- R. Motors 1 HP and larger shall be provided with a copper frame grounding lug of hydraulic compression design, for installation by the electrical subcontractor.
- S. Motors 3/4 HP and larger shall have 120V space heater that is energized only when motor is idle. This shall apply to motors that are exposed to unconditioned environments, or in high dew point air streams.

PART 3 - EXECUTION

3.1 APPLICATION

- A. Motors drawing less than 250 Watts and intended for intermittent service may be germane to equipment manufacturer and need not conform to these specifications.
- B. Motors shall be open drip-proof type, unless specified otherwise.
- C. Single phase motors for [shaft mounted fans] [oil burners] [centrifugal pumps] shall be split phase type.
- D. Single phase motors for shaft mounted fans or blowers shall be permanent split capacitor type.
- E. Single phase motors for [fans] [pumps] [blowers] [air compressors] shall be capacitor start type.

- F. Single phase motors for [fans] [blowers] [pumps] shall be capacitor start, capacitor run type.
- G. Motors located in [exterior locations] [wet air streams downstream of sprayed coil dehumidifiers] [air-cooled condensers] [humidifiers] [direct drive axial fans] [roll filters] [explosion proof environments] [dust collection systems] [_____] shall be totally enclosed type.
- H. Motors located in [exterior locations] [wet air streams downstream of sprayed coil dehumidifiers] [draw thru cooling towers] [humidifiers] [_____] shall be totally enclosed weatherproof epoxy-treated type.

END OF SECTION

SECTION 23 05 16
PIPING EXPANSION COMPENSATION

PART 1 GENERAL

1.00 The following sections are to be included as if written herein:

- A. Section 23 00 00 – Basic Mechanical Requirements
- B. Section 23 05 29 – Sleeves, Flashings, Supports and Anchors
- C. Section 23 05 53 – Mechanical Identification

1.01 SECTION INCLUDES

- A. Flexible pipe connectors
- B. Expansion joints and compensators
- C. Pipe loops, offsets, and swing joints

1.02 RELATED SECTIONS

- A. Section 21 13 13 - Fire Protection Systems
- B. Section 22 13 16 - Plumbing Piping
- C. Section 23 21 00 - Hydronic Pumping
- D. Section 23 22 00 - Steam and Steam Condensate Piping
- E. Section 23 23 00 - Refrigerant Piping and Specialties

1.03 REFERENCES

- A. MIL-E-17814E - Expansion Joints, Pipe, Slip-Type, Packed.

1.04 PERFORMANCE REQUIREMENTS

- A. Provide structural work and equipment required to control expansion and contraction of piping. Verify that anchors, guides, and expansion joints provided, adequately protect system.
- B. Expansion Calculations:

1. Installation Temperature: [50] [_____] degrees F.
2. Hot Water Heating: 210 degrees F.
3. Domestic Hot Water: 140 degrees F.
4. Safety Factor: 30 percent.

1.05 SUBMITTALS

- A. Submit under provisions of Section 23 00 00 .
- B. Product Data:
 1. Flexible Pipe Connectors: Indicate maximum temperature and pressure rating, face-to-face length, live length, hose wall thickness, hose convolutions per foot and per assembly, fundamental frequency of assembly, braid structure, and total number of wires in braid.
 2. Expansion Joints: Indicate maximum temperature and pressure rating, and maximum expansion compensation.
- C. Samples: Submit two low pressure compensators 1 inch in size.
- D. Design Data: Indicate selection calculations.
- E. Manufacturer's Installation Instructions: Indicate special procedures, and external controls.

1.06 PROJECT RECORD DOCUMENTS

- A. Submit under provisions of Section 23 00 00.
- B. Record actual locations of flexible pipe connectors, expansion joints, anchors, and guides.

1.07 OPERATION AND MAINTENANCE DATA

- A. Submit under provisions of Section 23 00 00.
- B. Maintenance Data: Include adjustment instructions.

1.08 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.
- B. Design expansion compensating system under direct supervision of a Professional Engineer experienced in design of this work and licensed in the State of Texas.

1.09 DELIVERY, STORAGE, AND HANDLING

- A. Deliver, store, protect and handle products to site under provisions of Section 23 00 00.
- B. Accept expansion joints on site in factory packing with shipping bars and positioning devices intact. Inspect for damage.
- C. Protect equipment from exposure by leaving factory coverings, pipe end protection, and packaging in place until installation.

1.10 WARRANTY

- A. Provide five-year warranty.
- B. Warranty: Include coverage for leak free performance of packed expansion joints.

1.11 EXTRA MATERIALS

- B. Provide two 12 ounce containers of packing lubricant and cartridge style grease gun.

PART 2 PRODUCTS

2.01 FLEXIBLE PIPE CONNECTORS

- A. Steel Piping:
 - 1. Manufacturers:
 - a) [_____] Model [_____].

b) [_____] Model [_____].

c) [_____] Model [_____].

2. Inner Hose: Stainless Steel.
3. Exterior Sleeve: Double braided stainless steel.
4. Pressure Rating: 200 psig WOG and 250 degrees F.
5. Joint: As specified for pipe joints.
6. Size: Use pipe sized units.
7. Maximum offset: 3/4 inch on each side of installed center line.

B. Copper Piping:

1. Manufacturers:

a) [_____] Model [_____].

b) [_____] Model [_____].

c) [_____] Model [_____].

2. Inner Hose: Bronze
3. Exterior Sleeve: Braided bronze.
4. Pressure Rating: [125 psig WSP and 450 degrees F] [200 psig WOG and 250 degrees F].
5. Joint: As specified for pipe joints.
6. Size: Use pipe sized units.
7. Maximum offset: 3/4 inch on each side of installed center line.

2.02 EXPANSION JOINTS

A. Stainless Steel Bellows Type:

1. Manufacturers:
 - a) [_____] Model [_____].
 - b) [_____] Model [_____].
 - c) [_____] Model [_____].
2. Pressure Rating: [125 psig WSP and 400 degrees F] [200 psig WOG and 250 degrees F].
3. Maximum Compression: 3 inch.
4. Maximum Extension: 1/4 inch.
5. Joint: As specified for pipe joints.
6. Size: Use pipe sized units.
7. Application: Steel piping 3 inch and under.

B. External Ring Controlled Stainless Steel Bellows Type:

1. Manufacturers:
 - a) [_____] Model [_____].
 - b) [_____] Model [_____].
 - c) [_____] Model [_____].
2. Pressure Rating: [125 psig WSP and 400 degrees F] [200 psig WOG and 250 degrees F] [225 psig and 70 degrees F].
3. Maximum Compression: [15/16 inch] [1-1/4 inch].
4. Maximum Extension: [5/16 inch] [3/8 inch].
5. Maximum Offset: [1/8 inch] [5/16 inch] [[_____] inch].

6. Joint: Flanged
7. Size: Use pipe sized units.
8. Accessories: Internal flow liner.
9. Application: Steel piping over 3 inch.

C. [Single] [Double] Sphere, [Elbow] [Flexible] Compensator:

1. Manufacturers:
 - a) [_____] Model [_____].
 - b) [_____] Model [_____].
 - c) [_____] Model [_____].
2. Body: [Teflon] [Neoprene and nylon] [_____].
3. Working Pressure: [_____] psi.
4. Maximum Temperature: [_____] degrees F.
5. Maximum Compression: [1/2 inch] [3/4 inch] [1 inch] [1-1/8 inch].
6. Maximum Elongation: [3/8 inch] [1/2 inch] [5/8 inch] [7/8 inch].
7. Maximum Offset: [3/8 inch] [1/2 inch] [3/4 inch] [7/8 inch].
8. Maximum Angular Movement: [15] [30] [45] degrees.
9. Joint: [Tapped steel flanges] [Galvanized flanges] [Galvanized unions].
10. Size: Use pipe sized units.
11. Accessories: [Control rods] [Control cables].
12. Application: Steel piping 2 inch and over.

D. Two-Ply Bronze Bellows Type:

1. Manufacturers:

- a) [_____] Model [_____].
- b) [_____] Model [_____].
- c) [_____] Model [_____].

- 2. Construction: Bronze with anti-torque device, limit stops, internal guides.
- 3. Pressure Rating: [125 psig WSP and 400 degrees F] [200 psi WOG and 250 degrees F].
- 4. Maximum Compression: [1-3/4 inch] [3 inch].
- 5. Maximum Extension: 1/4 inch.
- 6. Joint: [Soldered] [As specified for pipe joints].
- 7. Size: Use pipe sized units.
- 8. Application: Copper piping.

E. Low Pressure Compensator with Two-Ply Bronze Bellows:

- 1. Manufacturers:
 - a) [_____] Model [_____].
 - b) [_____] Model [_____].
 - c) [_____] Model [_____].
- 2. Working Pressure: [75 psig] [80 psig].
- 3. Maximum Temperatures: [250 degrees F] [400 degrees F].
- 4. Maximum Compression: 1/2 inch.
- 5. Maximum Extension: 5/32 inch.
- 6. Joint: Soldered
- 7. Size: Use pipe sized units.
- 8. Application: Copper or steel piping 2 inch and under.

F. Copper with Packed Sliding Sleeve:

1. Manufacturers:
 - a) [_____] Model [_____].
 - b) [_____] Model [_____].
 - c) [_____] Model [_____].
2. Working Pressure: 125 psi.
3. Maximum Temperature: 250 degrees F.
4. Joint: As specified for pipe joints.
5. Size: Use pipe sized units.
6. Copper or steel piping 2 inches and over.
7. Application: Copper or steel piping 2 inch and over.

2.03 ACCESSORIES

A. Pipe Alignment Guides:

1. Manufacturers:
 - a) [_____] Model [_____].
 - b) [_____] Model [_____].
 - c) [_____] Model [_____].
2. Two piece welded steel with enamel paint, bolted, with spider to fit standard pipe, frame with four mounting holes, clearance for minimum 1 inch thick insulation, minimum 3 inch travel.

B. Swivel Joints:

1. Manufacturers:
 - a) [_____] Model [_____].

- b) [_____] Model [_____].
 - c) [_____] Model [_____].
2. [Fabricated steel] [Bronze] [Ductile Iron] [Cast steel] [_____] body, double ball bearing race, field lubricated, with [rubber (Buna-N)] [_____] O-ring seals.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Construct spool pieces to exact size of flexible connection for future insertion.
- C. Install flexible pipe connectors on pipes connected to equipment supported by vibration isolation. Provide line size flexible connectors.
- D. Install flexible connectors at right angles to displacement. Install one end immediately adjacent to isolated equipment and anchor other end. Install in horizontal plane unless indicated otherwise.
- E. Rigidly anchor pipe to building structure where necessary. Provide pipe guides so movement is directed along axis of pipe only. Erect piping such that strain and weight is not on cast connections or apparatus.
- F. Provide support and equipment required to control expansion and contraction of piping. Provide loops, pipe offsets, and swing joints, or expansion joints where indicated.
- G. Provide expansion loops as indicated on drawings.

3.02 MANUFACTURER'S FIELD SERVICES

- A. Prepare and start systems under provisions of Section 23 00 00.
- B. Provide inspection services by flexible pipe manufacturer's representative for final installing and certify installation is in accordance with manufacturer's recommendations and connectors are performing satisfactorily.

END OF SECTION

SECTION 23 05 29
SLEEVES, FLASHINGS, SUPPORTS AND ANCHORS

PART 1 GENERAL

1.00 The following sections are to be included as if written herein:

- A. Section 23 00 00 – Basic Mechanical Requirements
- B. Section 23 05 53 – Mechanical Identification

1.01 SECTION INCLUDES

- A. Pipe and equipment hangers and supports
- B. Equipment bases and supports
- C. Sleeves and seals
- D. Flashing and sealing equipment and pipe stacks

1.02 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION

- A. Section [____ - _____]: Placement of [inserts] [sleeves] in concrete formwork.
- B. Section [____ - _____]: Placement of roofing [pipe] [duct] supports.
- C. Section [____ - _____]: Placement of equipment roof supports.
- D. Section [____ - _____]: Placement of roof sleeves, vents, and curbs.

1.03 PRODUCTS INSTALLED BUT NOT FURNISHED UNDER THIS SECTION

- A. Section [____ - _____]: Supply of roofing [pipe] [duct] [equipment] supports for placement by this Section.

1.04 RELATED SECTIONS

- A. Section 03300 - Cast-In-Place Concrete: Equipment bases
- B. Section 07 84 00 - Firestopping: Joint seals for piping and duct penetration of fire rated assemblies
- C. Section 09 91 00 - Painting

- D. Section 23 05 4 - Vibration Isolation
- E. Section 23 07 19 - Piping Insulation
- F. Section 23 07 16 - Equipment Insulation
- G. Section 23 07 16 - Ductwork Insulation
- H. Section 21 13 13 - Fire Protection Systems
- I. Section 22 13 16 - Plumbing Piping
- J. Section 23 21 00 - Hydronic Piping
- K. Section 23 22 00 - Steam and Steam Condensate Piping

1.05 REFERENCES

- A. ASME B31.1 - Power Piping
- B. ASME B31.2 - Fuel Gas Piping
- C. ASME B31.5 - Refrigeration Piping
- D. ASME B31.9 - Building Services Piping
- E. ASTM F708 - Design and Installation of Rigid Pipe Hangers
- F. MSS SP58 - Pipe Hangers and Supports - Materials, Design and Manufacturer
- G. MSS SP69 - Pipe Hangers and Supports - Selection and Application
- H. MSS SP89 - Pipe Hangers and Supports - Fabrication and Installation Practices
- I. NFPA 13 - Installation of Sprinkler Systems
- J. NFPA 14 - Installation of Standpipe and Hose Systems
- K. UL 203 - Pipe Hanger Equipment for Fire Protection Service

1.06 SUBMITTALS

- A. Submit under provisions of Section 23 00 00.
- B. Shop Drawings: Indicate system layout with location and detail of trapeze hangers.
- C. Product Data: Provide manufacturers catalog data including load capacity.
- D. Design Data: Indicate load carrying capacity of trapeze, multiple pipe, and riser support hangers.
- E. Manufacturer's Installation Instructions: Indicate special procedures and assembly of components.

1.07 REGULATORY REQUIREMENTS

- A. Conform to applicable code for support of plumbing, hydronic, steam and steam condensate piping.
- B. Supports for Sprinkler Piping: Shall be in conformance with NFPA 13.
- C. Supports for Standpipes: Shall be in conformance with NFPA 14.

PART 2 PRODUCTS

2.01 HANGERS AND SUPPORTS

- A. Manufacturers:
 - 1. Grinnell.
 - 2. Kindorf
 - 3. B-Line
 - 4. Power Strut
 - 5. Other acceptable manufacturers offering equivalent products.
 - a) [_____] Model [_____].
 - b) [_____] Model [_____].
 - c) [_____] Model [_____].

- B. Supports, hangers, anchors and guides shall be provided for all horizontal and vertical piping. Shop Drawings shall be provided, indicating locations and details of anchors, guides, expansion loops and joints, hangers, etc. The hanger design shall conform to the ASME Code for Pressure Piping.
- C. All auxiliary steel required for supports, anchors, guides, etc. shall be provided by the Mechanical Trades unless specifically indicated to be provided by others.
- D. The supports, hangers, anchors, and guides for the chilled water supply and return piping, steam piping, condensate return piping, etc. of the Campus Loop System routed through utility tunnels and below buildings shall be provided as indicated on the Drawings.
- E. Contractor shall review all Drawings, including Structural Drawings, for details regarding pipe supports, anchors, hangers, and guides.
- F. All Supports shall be of type and arrangement to prevent excessive deflection, to avoid excessive bending stresses between supports, and to eliminate transmission of vibration.
- G. All rod sizes indicated in this Specification are minimum sizes only. This trade shall be responsible for structural integrity of all supports, anchors, guides, etc. All structural hanging materials shall have a minimum safety factor of 5 built in.
- H. Anchor points as indicated on Drawings or as required shall be located and constructed to permit the piping system to take up its expansion and contraction freely in opposite directions away from the anchored points.
- I. Guide points shall be located and constructed wherever required or indicated on Drawings and at each side of an expansion joint or loop, to permit free axial movement only.
- J. Supports, hangers, anchors, and guides shall be fastened to the structure only at such points where the structure is capable of restraining the forces in the piping system.
- K. Hangers supporting and contacting brass or copper lines 3" in size and smaller shall be Grinnell Fig. CT-99c, adjustable, copper plated, tubing ring. Hangers supporting and contacting brass or copper lines 4" and larger shall be Grinnell Fig. 260, adjustable clevis, with a nut above and below the hanger, and approved neoprene isolating material between pipe (or tubing) and hanger on the support rod. For insulated copper or brass domestic water lines, hangers for all sizes of pipe shall be Grinnell Fig. 300, adjustable clevis, with a nut above and below the hanger, and approved neoprene isolating material between pipe (or tubing) and hanger on the support rod. Isolate all copper or brass lines from all ferrous materials with approved dielectric materials. Hangers supporting and contacting plastic or glass piping shall be of equal design, but shall be padded with neoprene material or equal. The padding material and the configuration of its installation shall be submitted for approval.
- L. Hangers supporting insulated lines where the outside diameter of the insulation is the

equivalent of 8" diameter pipe or smaller in size and supporting all ferrous lines 6" and smaller in size shall be Grinnell Fig. 260, adjustable clevis, with a nut above and below the hanger on the support rod.

- M. Hangers supporting and contacting ferrous lines larger than 6" in size and outside of insulation on lines with the outside diameter equivalent to 10" diameter pipe shall be Grinnell Fig. 260, adjustable clevis, with a nut above and below the hanger on the support rod.
- N. Other special type of hangers may be employed where so specified or indicated on the Drawings, or where required by the particular conditions. In any case, all hangers must be acceptable to the owner.
- O. Each hanger shall be properly sized to fit the supported pipe or fit the outside of the insulation on lines where specified. Hangers for dual or low temperature insulation pipes shall bear on the outside of the insulation, which shall be protected by support shields as specified in Section 23 07 19 - PIPING INSULATION. Protect insulation from crushing by means of a section of rigid insulation to be installed at hanger points. Hangers for high temperature insulated pipes and all insulated hot and cold domestic water pipes shall be encased in the insulation unless supported by trapezes in which case shield and rigid insulation shall be provided as specified above for low temperature insulated pipes.
- P. Supports for vertical piping in concealed areas shall be double bolt riser clamps, Grinnell Fig. 261, or other approved equal, with each end having equal bearing on the building structure, and located at each floor. Two-hole rigid pipe clamps at 4 ft. o.c. or Kindorf channels and Grinnell Fig. 261 riser clamps may be used to support pipe directly from vertical surfaces or members where lines are not subject to expansion and contraction. When piping is subject to expansion and contraction, provide spring isolators (see Section 23 05 48 - Vibration Isolation). Where brass or copper lines are supported on trapeze hangers or Kindorf channels the pipes shall be isolated from these supports with plastic tape with insulating qualities, or strut clamps as manufactured by Specialty Products Company, Stanton, California.
- Q. Supports for vertical piping in exposed areas (such as fire protection standpipe in stairwells) shall be attached to the underside of the building structure above the top of the riser, and the underside of the penetrated structure. The contractor shall use a drilled anchor as specified above, and use a Grinnell No. 595 Socket Clamp with Grinnell No. 594 Socket Clamp Washers, as a riser clamp. The top riser hanger shall consist of two (2) hanger rods (sized as specified) anchored to the underside of the building structure, supporting the pipe by means of the material specified. Risers penetrating floors shall be supported from the underside of the penetrated floor as specified for the top of the riser.
- R. Pipe Supports in Chases and Partitions: Horizontal and vertical piping in chases and partitions shall be supported by hangers or other suitable support. Pipes serving plumbing fixtures and equipment shall be securely supported near the point where pipes penetrate the finish wall. Supports shall be steel plate, angles, or special channels such as Unistrut mounted in vertical or horizontal position. Pipe clamps such as Unistrut P2426, P2008,

P1109 or other approved clamps shall be attached to supports. Supports shall be attached to wall or floor construction with clip angles, brackets, or other approved method. Supports may be attached to cast iron pipe with pipe clamp, or other approved method. All copper or brass lines shall be isolated from ferrous metals with dielectric materials to prevent electrolytic action.

- S. All electrical conduits shall be run parallel or perpendicular to adjacent building lines. Single conduits running horizontally shall be supported by "Caddy" or "Minerallac" type hangers from adequately sized rods (minimum 1/4") from the building structure. Where multiple conduits are run horizontally, they shall be supported on trapeze of "Unistrut" type channel suspended on rods or bolted to vertical building members. Conduit shall be secured to channel with galvanized "Unistrut" type conduit clamps or stainless steel "Unistrut" type "Uni-Clips." All hangers shall be fastened to the building structure in the same manner as specified above for pipe hangers. Spacing of hangers shall be adequate for the weight and rigidity of the conduits involved; in any case, no greater than 8' centers. Where feasible, conduits may be fastened to the concrete by one-hole straps thoroughly anchored to the concrete in an approved manner. Flexible conduit shall also be supported in an acceptable manner so as not to interfere with the maintenance of above-ceiling equipment, and to support it from touching the ceiling system. Conduit shall be located so as not to inhibit removal of ceiling tiles.

IMPORTANT EXCEPTION: If suspension system for the lay-in ceiling is of adequate strength, in the opinion of the Structural Engineer, one only, 3/4" maximum size flexible metallic conduit may be supported from a hanger wire by "Caddy" type clips. Conduit shall be so located so as not to inhibit removal of ceiling tiles.

NOTE TO SPECIFICATION WRITER: ADEQUACY OF CEILING SUSPENSION SYSTEM SHALL BE DETERMINED IN DESIGN PHASE. DO NOT INCLUDE ABOVE EXCEPTION IF INAPPROPRIATE.

Vertical conduits shall be supported as often as necessary for rigidity by clamps resting on adjacent beams or floor slabs, using a minimum of one support per floor.

- T. Perforated strap iron or wire will not, under any circumstances, be acceptable as hanger material.
- U. Vibration Isolation: Resilient hangers shall be provided on all piping connected to rotating equipment (pumps, etc.). Piping or ductwork that may vibrate and create an audible noise shall also be isolated. Spring hangers or supports shall be provided where indicated on the Drawings and/or specified under Section 23 05 48.
- V. Attachment:

1. The load and spacing on each hanger and/or insert shall not exceed the safe allowable load for any component of the support system, including the concrete which holds the inserts. Reinforcement at inserts shall be provided as required to develop the strength required.
2. Inserts shall be of a type which will not interfere with reinforcing as shown on the structural Drawings and which will not displace excessive amounts of structural concrete.
3. All supports shall be designed and installed to avoid interference with other piping, hangers, ducts, electrical conduit, supports, building structures, equipment, etc. All piping shall be installed with due regard to expansion and contraction and the type of hanger method of support, location of support, etc. shall be governed in part by this Specification.
4. Hangers shall be attached to the structure as follows:
 - a) Poured In Place Concrete: Where pipes and equipment are supported under poured in place concrete construction, each hanger rod shall be fitted with a nut at its upper end, which nut shall be set into an Underwriters Laboratories, Inc. listed universal concrete insert placed in the form work before concrete is poured. Where inserts are placed in the bottom faces of concrete joists which are too narrow to provide adequate strength of concrete to hold the insert properly or where a larger insert would require displacement of the bottom joist steel, the hanger rod shall be suspended from the center of a horizontal angle iron, channel iron, I-beam, etc. spanning across two adjacent joists. The horizontal support shall be bolted to nonadjustable concrete inserts of the "spot" type, of physical size small enough to avoid the bottom joist steel.
 - b) Steel Bar Joists: Where pipes and loads are supported under bar joists, hanger rods may be run through the space between the bottom angles and secured with a washer and two nuts. Where larger lines are supported beneath bar joists, hanger rods shall be secured to angle irons of adequate size; each angle shall span across two or more joists as required to distribute the weight properly and shall be welded to the joists or otherwise permanently fixed thereto.
 - c) Steel Beams: Where pipes and loads are supported under steel beams, approved type beam clamps shall be used.
 - d) Wood Framing: Where pipes and loads are supported from wood framing, hanger rods shall be attached to framing with side beam brackets or angle clips.
 - e) Pre-Cast Tee Structural Concrete: Hanger supports, anchors, etc. required for mechanical systems attached to the precast, double tee, structural concrete system are to be installed in accord with approved shop Drawings only. Holes required for hanger rods shall be core drilled in the "flange" of the double tee only; impact type tools are not allowed under any circumstances. Core drilling in the "stem"

portions of the double tee is not allowed. Holes core drilled through the "flange" for hanger rods shall be no greater than 1/4" larger than the diameter of the hanger rod. Hanger rods shall be supported by means of bearing plates of size and shape acceptable to the Architect/Engineer, with welded double nuts on the hanger rod above the bearing plate. Cinch anchors, lead shields, expansion bolts, and studs driven by explosion charges are not allowed under any circumstances in the lower 15" of each stem and in the "shadow" of the stem on the top side of the "double tees."

- f) If it is necessary to install a method of fastening a hanger after the structure has been installed, then only clamps or drilled anchors shall be used.

Power-actuated fasteners (shooting) will not be acceptable under any circumstances.

Note: Under no circumstances will the use of plastic anchors or plastic expansion shields be permitted for any purpose whatsoever.

- W. Trapezes: Where multiple lines are run horizontally at the same elevation and grade, they may be supported on trapezes of Kindorf, Uni-Strut, Power Strut, or approved equal, channel-suspended on rods or pipes. Trapeze members including suspension rods shall each be properly sized for the number, size, and loaded weight of the lines they are to support.
- X. Finishes: All hangers on piping including clevis hangers, rods, inserts, clamps, stanchions, and brackets, shall be dipped in Zinc Chromate Primer before installation. Rods may be galvanized or cadmium plated after threading, in lieu of dipping zinc chromate. Universal concrete inserts shall be cadmium plated.
- Y. Ductwork: All ductwork shall be supported in accordance with the SMACNA recommendation for the service involved; however, all horizontal ductwork shall be supported at intervals not to exceed the scheduled values indicated elsewhere in this section. Horizontal ducts shall be supported using galvanized steel bands extending up both sides and onto the construction above, where they shall turn over and be secured with bolts and nuts fitted in inserts set in the concrete bolted to angles secured to the construction above, or secured in another approved manner. For attaching methods for precast double tee structural concrete, refer to details on the Drawings and as specified herein.
- Z. Terminal units shall be supported by four 16 gauge, 1" wide sheet metal straps with ends turned under bottom of box at corners. Each band shall be secured by not over 3/4" in length, 1/4" diameter sheet metal screws - two on bottom of box and one on side. The other strap end shall be attached to the structure by 1/4" diameter threaded bolt into the concrete insert or into drilled-hole threaded concrete expansion anchor. Where interferences occur, overhead of the box, not allowing direct vertical support by straps, provide trapezes of Kindorf, Unistrut, or B-Line channel suspended by 1/4" diameter galvanized threaded rods providing such

channels do not block access panels of boxes. Threaded rods shall be supported from structure by concrete insert or by drilled-hole threaded concrete expansion anchor.

- AA. Miscellaneous: Provide any other special foundations, hangers and supports indicated on the Drawings, specified elsewhere herein; or required by conditions at the site. Hangers and supporting structures for suspended equipment shall be provided as required to support the load from the building structure in a manner acceptable to the Architect/Engineer.
- BB. Fire Protection Systems: All hangers and supports for fire standpipe systems and fire sprinkler systems shall be Factory Mutual and Underwriters Laboratories, Inc. listed and labeled. Construction of hangers shall be as described above for common piping, except for the above-mentioned requirements.

2.03 ACCESSORIES

- A. Hanger Rods: Galvanized mild steel threaded both ends, galvanized threaded one end, or galvanized continuous threaded.
- B. Inserts: Malleable iron case of galvanized steel shell and expander plug for threaded connection with lateral adjustment, top slot for reinforcing rods, lugs for attaching to forms; size inserts to suit threaded hanger rods. Suitable concrete inserts for pipe and equipment hangers shall be set and properly located for all pipe and equipment to be suspended from concrete construction. If the inserts are later found not to be in the proper location for the placement of hangers, then drilled anchors shall be installed. Drilled anchors in concrete or masonry shall be submitted for the approval by the Owner.

2.04 FLASHING AND EQUIPMENT CURBS

NOTE: Stainless steel to be used for Galveston projects only.

- A. Metal Flashing: 26 gauge galvanized (stainless steel) steel.
- B. Metal Counterflashing: 22 gauge galvanized (stainless steel) steel.
- C. Roofing Flashing: See specifications for Roofing, elsewhere in these Specifications.
- D. Caps: Steel, 22 gauge minimum; 16 gauge at fire resistant elements.
- E. Curbs: Welded 18 gauge galvanized steel shell and base, mitered 3 inch cant, variable step to match roof insulation, factory installed wood nailer.

NOTE TO ENGINEER - DELETE THIS PARAGRAPH FOR UT AUSTIN PROJECTS.

2.07 CONCRETE FOUNDATIONS ("Housekeeping Pads"):

- A. Concrete foundations for the support of equipment such as floor mounted panels, pumps, fans, air handling units, etc., shall extend 4" on all sides beyond the limits of the mounted equipment unless otherwise noted and shall be poured in forms built of new dressed 6" nominal lumber. All corners of the foundations shall be neatly chamfered by means of sheet metal or triangular wood strips nailed to the form. Foundation bolts shall be placed in the forms when the concrete is poured, the bolts being correctly located by means of templates. Each bolt shall be set in a sleeve of size to provide 1/2" clearance around bolt. Allow 1" below the equipment bases for alignment and grouting. After grouting, the forms shall be removed and the surface of the foundations shall be hand rubbed with Carborundum. Foundations for equipment located on the exterior of the building shall be provided as indicated. Foundations shall be constructed in accordance with Shop Drawings submitted by the Contractor for review by the Architect/Engineer.

2.08 WALL, FLOOR AND CEILING PLATES:

- A. Except as otherwise noted, provide C.P. (Chrome plated) brass floor and ceiling plates around all pipes, conduits, etc., passing exposed through walls, floors, or ceilings, in any spaces except underfloor and attic spaces. Plates shall be sized to fit snugly against the outside of the pipe or against the insulation on lines which are insulated and positively secured to such pipe or insulation. Plates will not be required for piping where pipe sleeves extend 3/4" above finished floor. All equipment rooms are classified as finished areas. Round and rectangular ducts shall have closure plates (NOT chrome plated) made to fit accurately at all floor, wall and ceiling penetrations. Floor penetrations in exposed (except in stair wells) areas shall be finished using 'bell' fitting to fit pipe or insulation and sleeve and shall be painted to match the pipe. Penetrations in stairwells shall have flat floor plate painted to match pipe.

2.09 SLEEVES

- A. General: All openings through all floors, walls, and roofs, etc., regardless of material for the passage of piping, ductwork, conduit, cable trays, etc., shall be sleeved. All penetrations must pass through sleeves. Sleeves shall be set in new construction before concrete is poured, as cutting holes through any part of the concrete will not be permitted unless acceptable to the Architect/Engineer. If a penetration is cored into an existing vertical solid concrete, masonry or stone structure, then the installation of a sleeve will not be necessary.
1. Sleeve material for floors and exterior walls shall be Schedule 40 galvanized steel with welded water stop rings.
 2. Sleeves through interior walls to be galvanized sheetmetal with gauge as required by wall fire rating, 20 gauge minimum.

- B. The minimum clearance between horizontal penetrations including insulation where applicable, and sleeve shall be 1/4", except that the minimum clearance shall accommodate a Thunderline Link-seal closure where piping exits the building, or penetrates a wall below ground level. Contractor shall be responsible for the accurate location of penetrations in the slab for his pipe, duct, etc. All penetrations shall be of ample size to accommodate the pipe, duct, etc., plus any specified insulation. Void between sleeve and pipe in interior penetrations shall be filled with Nelson Flameseal Firestop or approved equal caulk or putty.
- C. Floor sleeves shall extend above the finished floor as detailed on the drawings, except that floor sleeves in stairwells shall be flush with the finished floor. Sleeves in walls shall be trimmed flush with wall surface. Refer to the details on the project drawings. Where the details differ from these specifications, the drawings take precedence.
- D. Sleeves for penetrations passing through walls or floors on or below grade shall be removed, if practical, and after the pipes have been installed, the void space around the pipe shall be caulked with a suitable material to effect a waterproof penetration. Note that the practicality of the removal of the sleeve shall be the decision of the Construction Inspector. The decision of the Inspector shall be final.
- G. Vermin proofing: The open space around all ductwork, piping, etc., passing through the ground floor and/or exterior walls shall be vermin proofed in a manner acceptable to the Architect/Engineer.
- H. Waterproofing: The annular space between a pipe and its sleeve in interior floors shall be filled with polyurethane foam rods 50 percent greater in diameter than the space as backing and fill material and made watertight with a permanent elastic polysulfide compound. Seal both surfaces of floor.
- I. Air Plenums: The space around piping, ductwork, etc., passing through air plenums shall be made airtight in a manner acceptable to the Architect/Engineer.
- J. Fireproofing: Seal all cable trays, pipe, conduit, duct, etc., penetrations through roof, fire rated walls and floors with a foam or sealant as described below, that will form a watertight, vermin tight barrier that is capable of containing smoke and fire up to 2000° F for two hours. Sealing of cable trays and conduits that extend through rated walls from ends of cable tray shall be done after conductors have been installed. For wet locations, the foam material shall be a silicone RTV foam or an approved equal. For dry locations, a premixed putty equal to Nelson Flameseal Firestop putty may be used.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install in accordance with manufacturer's instructions.

3.02 INSERTS

- A. Provide inserts for placement in concrete formwork.
- B. Provide inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.
- C. Provide hooked rod to concrete reinforcement section for inserts carrying pipe over 4 inches.
- D. Where concrete slabs form finished ceiling, locate inserts flush with slab surface.
- E. Where inserts are omitted, drill through concrete slab from below and provide through-bolt with recessed square steel plate and nut recessed into and grouted flush with slab.

3.03 PIPE HANGERS AND SUPPORTS

- A. Support horizontal piping as scheduled.
- B. Install hangers to provide minimum 1/2 inch space between finished covering and adjacent work.
- C. Place hangers within 12 inches of each horizontal elbow.
- D. Use hangers with 1-1/2 inch minimum vertical adjustment.
- E. Support horizontal cast iron pipe adjacent to each hub, with 5 feet maximum spacing between hangers.
- F. Support vertical piping at every floor. Support vertical cast iron pipe at each floor at hub.
- G. Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.
- H. Support riser piping independently of connected horizontal piping.
- I. Provide copper plated hangers and supports for copper piping.
- J. Design hangers for pipe movement without disengagement of supported pipe.
- K. Prime coat exposed steel hangers and supports. Hangers and supports located in crawl spaces, pipe shafts, and suspended ceiling spaces are not considered exposed, but shall be corrosion protected with galvanized plating. Repair any damaged galvanized plating with a coating of 'Galvalum'.

- L. Hanger Rods: (NOTE: All hanger rods shall be trimmed neatly so that no more than 1 inch of excess hanger rod protrudes beyond the hanger nut. In the event a rod is intentionally but temporarily left excessively long (for sloped or insulated lines for example), the contractor shall take appropriate measures to protect the pipe or other materials from damage.)

3.04 FLASHING

- A. Provide flexible flashing and metal counterflashing where piping and ductwork penetrate weather or waterproofed walls, floors, and roofs.
- B. Flash vent and soil pipes projecting 3 inches minimum above finished roof surface with lead worked one inch minimum into hub, 8 inches minimum clear on sides with 24 x 24 inches sheet size. For pipes through outside walls, turn flanges back into wall and caulk, metal counterflash, and seal.
- C. Flash floor drains in floors with topping over finished areas with lead, 10 inches clear on sides with minimum 36 x 36 inch sheet size. Fasten flashing to drain clamp device.
- D. Seal floor, shower, mop sink, and [] drains watertight to adjacent materials.
- E. Provide acoustical lead flashing around ducts and pipes penetrating equipment rooms, installed in accordance with manufacturer's instructions for sound control.
- F. Provide curbs for mechanical roof installations 14 inches minimum high above roofing surface. Flash and counterflash with sheet metal; seal watertight. Attach counterflashing mechanical equipment and lap base flashing on roof curbs. Flatten and solder joints.
- G. Adjust storm collars tight to pipe with bolts; caulk around top edge. Use storm collars above roof jacks. Screw vertical flange section to face of curb.

3.05 SLEEVES

- A. Set sleeves in position in formwork. Provide reinforcing around sleeves.
- B. Size sleeves large enough to allow for movement due to expansion and contraction. Provide for continuous insulation wrapping.
- C. Extend sleeves through floors (except in stairwells) two inches above finished floor level. Sleeves through floors shall have welded waterstop rings. Sleeves shall be sealed watertight to floors and pipe.
- D. Where piping, ductwork or conduit penetrates floor, ceiling, or wall, close space between pipe or duct and adjacent work with fire stopping insulation and caulk airtight. Provide close fitting metal collar or escutcheon covers, as appropriate, at both sides of penetration.

E. Install chrome plated steel or stainless steel escutcheons at finished surfaces.

3.06 PIPE SUPPORT SCHEDULES

STEEL PIPE SIZE <u>Inches</u>	MAX. HANGER SPACING <u>Feet</u>	HANGER ROD DIAMETER <u>Inches</u>
1/2 to 1-1/4	6.5	3/8
1-1/2 to 2	10	3/8
2-1/2 to 3	10	1/2
4 to 6	10	5/8
8 to 12	14	7/8
14 and Over	20	1
PP, PVDF, PVC, CPVC (All Sizes)	4	3/8
C.I. Bell and Spigot (or No-Hub), <u>and at all Joints</u>	5	5/8
Glass, <u>and at all Joints</u>	4	1/2

3.07 LOW PRESSURE DUCT SUPPORT SCHEDULE:

- A. All horizontal ducts up to and including 40 inches in their greater dimension shall be supported by means of No. 18 U.S. gauge band iron hangers attached to the ducts by means of screws, rivets, or clamps and fastened to above inserts with toggle bolts, beam clamps or other approved means. Duct shall have at least one pair of supports 8' 0" on centers. Clamps shall be used to fasten hangers to reinforcing on sealed ducts.
- B. Horizontal ducts larger than 40 inches in their greatest dimension shall be supported by means of hanger rods bolted to angle iron trapeze hangers. Duct shall have at least one pair of supports 8' 0" on centers according to the following:

<u>Angle Length</u>	<u>Angle</u>	<u>Rod Diameter</u>
4' 0"	1-1/2" x 1-1/2" x 1/8"	1/4"
6' 0"	1-1/2" x 1-1/2" x 1/8"	1/4"
8' 0"	2" x 2" x 1/8"	5/16"
10' 0"	3" x 3" x 1/8"	3/8"

- C. Vertical ducts shall be supported where they pass through the floor lines with 1-1/2" x 1-1/2" x 1/4" angles for ducts up to 60." Above 60", the angles must be increased in strength and sized on an individual basis considering space requirements.

3.08 MEDIUM PRESSURE DUCT SUPPORT SCHEDULE:

- A. All horizontal rectangular ducts shall have duct hanger requirements as follows:

Minimum Hanger Size					
<u>Max. Duct Dimen.</u>	<u>Steel Rod</u>	<u>Galv. Steel Strap Width</u>	<u>Max. Spacing</u>	<u>Min.# Hngers</u>	<u>Trapeze Size</u>
0 through 18"	--	1" x 16 ga.	10'	2	--
19" through 36"	--	1" x 16 ga.	10'	2	--
37" through 60"	3/8"	1" x 16 ga.	8'	2	2" x 2" x 1/4"
61" through 120"	3/8"	1-1/2" x 12 ga.	8'	2	2" x 2" x 1/4"
121" through 240"	3/8"	--	4'	3	2-1/2" x 2-1/2" x 3/16"

- B. All horizontal round ducts shall have ducts hangers spaced 10' 0" maximum with requirements as follows:

<u>Duct Diameter</u>	<u>Min. Hanger Size</u>	<u>No. Hangers</u>	<u>Hanger Ring Size</u>
Up through 18"	1" x 16 gauge	1	1" x 16 ga.
19" to 36"	1" x 12 gauge	1	1" X 12 ga.
37" to 50"	1-1/2" x 12 gauge	1	1-1/2" x 12 ga.
51" to 84"	1-1/2" x 12 gauge	2	Support Bracing Angle

3.09 DUCT HANGERS - GENERAL NOTES (all pressures)

- A. Hanger straps on duct width of 60 inches and under shall lap under the duct a minimum of 1 inch and have minimum of one fastening screw on the bottom and two on the side.
- B. Hanger straps on duct widths over 60 inches shall be bolted to duct reinforcing with 3/8" bolts minimum.
- C. Use 3/8" minimum bolts for securing duct hanger to band straps.
- D. All round ducts shall be supported within 3 feet of all horizontal or vertical turns.

END OF SECTION

SECTION 23 05 48
VIBRATION ISOLATION

PART 1 GENERAL

1.00 The following sections are to be included as if written herein:

- A. 23 00 00 -- Basic Mechanical Requirements
- B. 23 05 29 -- Sleeves, Flashings, Supports and Anchors
- C. 23 05 53 -- Mechanical Identification

1.01 WORK INCLUDED

- A. Inertia bases
- B. Vibration isolation

1.02 SCOPE OF WORK:

- A. Furnish and install all labor, materials, equipment tools and service and perform all operations required in connection with or properly incidental to the construction of complete system of vibration and noise control, as indicated on the Drawings, reasonably implied therefrom or as specified herein, unless specifically excluded.

1.03 REFERENCES

- A. ASHRAE - Guide to Average Noise Criteria Curves

1.04 QUALITY ASSURANCE

- A. Maintain ASHRAE criteria for average noise criteria curves for all equipment at full load condition

1.05 SUBMITTALS

- A. Submit shop drawings and product data under provisions of Section 23 00 00.
- B. Indicate inertia bases on shop drawings.
- C. Indicate vibration isolator locations, with static and dynamic load on each, on shop

drawings and described on product data.

- D. Submit manufacturer's installation instructions under provisions of Section 23 00 00.

1.06 CERTIFICATES

- A. Submit a certificate from the manufacturer that isolators are properly installed and properly adjusted to meet or exceed specified requirements.

1.07 INTENT OF RESPONSIBILITY:

- A. It is the intent of this specification to provide for vibration isolation supports for all equipment, piping, and ductwork as set out below. The transmission of perceptible vibration, structural borne noise, or objectionable air borne noise to occupied areas by equipment installed under this contract will not be permitted. The Contractor shall be held responsible for installing the vibration isolators as specified herein or shown on the drawings or otherwise required to prevent the transmission of vibration which would create objectionable noise levels in occupied areas. The isolation supplier must be a firm capable of dealing effectively with vibration and noise characteristics effects and criteria, and one which can provide facilities and capabilities for measuring and evaluating the aforementioned disturbances.
- B. All vibration isolation devices, including auxiliary steel bases and pouring forms, shall be designed and furnished by a single manufacturer or supplier who will be responsible for adequate coordination of all phases of this work. Concrete housekeeping pads and inertia bases shall be included as part of mechanical work. Pads under electrical gear shall be included as part of electrical work. The concrete work shall meet the requirements specified in the General Contract Specifications.
- C. The Contractor shall furnish complete submittal data, including Shop Drawings, which shall indicate the size, type, and deflection of each isolator; and the supported weight, disturbing frequency, and efficiency of each isolator proposed; and any other information as may be required for the Architects and Engineers to check the isolator selection for compliance with the specification. All steel bases and concrete inertia bases shall be completely detailed, and shall show completely any reinforcing steel that may be required to provide a rigid base for the isolated equipment. Further, the submittal data shall indicate, clearly, outlined procedures for installing and adjusting the isolators and bases mentioned above.
- D. The vibration isolation manufacturer, or his qualified representative, shall be responsible for providing such supervision as may be required to assure correct and complete installation and adjustment of the isolators. Upon completion of the installation and after the system is put into operation and before acceptance by the Owner, the isolation manufacturer or his qualified representative, in company with the

Architect or his designated representative, shall make a final inspection and submit his report to the Architects and Engineers, in writing, certifying the correctness of the installation and compliance with approved submittal data. Any discrepancies or maladjustments found shall be so noted in the report. Should any noise or vibration be objectionable to the Owner, Architect or Engineer, a field instrumentation test and measurement must be made to determine the source, cause, and path of any such disturbance. Any variation or noncompliance with these specification requirements is to be corrected by the installing contractor in an approved manner.

- E. Vibration isolation devices shall be as manufactured by Amber/Booth Company, Consolidated Kinetics, Korfund Dynamics Corporation, or approved equal.

PART 2 PRODUCTS

2.01 GENERAL DESIGN FEATURES:

- A. All vibration isolators and bases furnished by the Contractor shall be designed for and treated for resistance to corrosion.
- B. Steel components shall be PVC coated or phosphated and painted with industrial grade enamel. All nuts, bolts and washers shall be zinc-electroplated or cad-plated. Structural bases shall be thoroughly cleaned of welding slag and primed with zinc-chromate or metal etching primer. A finish coat of industrial grade enamel shall be applied over the primer.
- C. All isolators exposed to the weather shall have steel parts PVC coated, hot-dip galvanized or zinc-electroplated plus coating of Neoprene or Bitumastic paint. Aluminum components for outdoor installation shall be etched and painted with industrial grade enamel.
- D. Required spring deflections for isolators supporting various items of equipment are shown on the Drawings or tabulated elsewhere in these specifications, but in no case shall be less than one inch. The springs shall be capable of 30% over-travel before becoming solid.
- E. Where height-saving brackets for side mounting of isolators are required, the height-saving brackets shall be designed to provide for an operating clearance of 2" under the isolated structure, and designed so that the isolators can be installed and removed when the operating clearance is 2" or less. When used with spring isolators having a deflection of 2-1/2" or more, the height-saving brackets shall be of the pre-compression type to limit exposed bolt length between the top of the isolator and the underneath side of the bracket.
- F. All isolators supporting a given piece of equipment shall limit the length of the exposed adjustment bolt between the top and base to a maximum range of 1" to 2".

- G. All isolators supporting a given piece of equipment shall be selected for approximately equal spring deflection.
- H. Isolators for equipment installed out-of-doors shall be designed to provide adequate restraint due to normal wind conditions and to withstand wind load of 55 PSF (pounds per square foot) applied to any exposed surface of the equipment without failure.

2.02 ISOLATOR TYPES: Isolator types and required deflections are specified under "Schedule of Isolated Equipment," paragraph 3.02. The isolators shall comply with the following descriptions for each type required on the project:

NOTE TO SPECIFICATION WRITER: DELETE INAPPLICABLE TYPES AND ADD DESCRIPTION OF TYPES APPLICABLE THAT ARE NOT ALREADY INDICATED.

- A. Type 1 - An adjustable, free-standing, open-spring mounting with combination leveling bolt and equipment fastening bolt. The spring(s) shall be rigidly attached to the mounting base plate and to the spring compression plate. The isolator shall be designed for a minimum K_x/K_y (horizontal to vertical spring rate) of 1.0. A Neoprene pad having a minimum thickness of 1/4" shall be bonded to the base plate. Base plates shall be sized to limit pad loading to 100 psi.
- B. Type 2 - An aluminum-housed, or cast iron housed, adjustable, spring mounting having telescoping top and bottom sections separated by resilient inserts of Neoprene or other suitable material to limit horizontal motion. The inserts shall be permanently lubricated to minimize vertical friction. Sheet or cast iron housings may be used if they are hot-dip galvanized after fabrication. A Neoprene pad having a minimum thickness of 1/4" shall be bonded to the base plate.
- C. Type 3 - An elastomeric mounting having steel base plate with mounting holes and a threaded insert at top of the mounting for attaching equipment. All metal parts shall be completely embedded in the elastomeric materials. The elastomer may be Neoprene or high synthetic rubber with anti-ozone and anti-oxidant additives. Mountings shall be designed for approximately 1/4" deflection and loaded so that deflection does not exceed 15% of the free height of the mounting.
- D. Type 4 - A pad-type mounting consisting of two layers of 3/8" thick, ribbed or waffled, Neoprene pads bonded to a 16 gauge galvanized steel separator plate. Bolting not required. Pads shall be sized for approximately 20 to 40 psi load, or a deflection of 0.10" to 0.16".
- E. Type 5 - A spring hanger consisting of a rectangular steel box, coil springs, spring cups, Neoprene impregnated fabric washer, steel washer, and Neoprene insert designed to prevent metal to metal contact between the hanger rod and bottom of the hanger box.

The hanger box shall be capable of supporting a load of 200% of rated load without noticeable deformation or failure.

- F. Type 6 - A spring hanger, as described in Type 5, with the addition of an elastomeric element at the top of the box for acoustic isolation. The design shall be such to prevent metal - to metal contact between the hanger rod and the top of the hanger box. The elastomeric element shall meet the design requirements for Type 3 mountings.
 - G. Type 7 - An elastomeric hanger, consisting of a rectangular steel box and an elastomeric isolation element, which shall be of Neoprene or high quality synthetic rubber with anti-ozone and anti-oxidant additive. The elements shall be so designed for approximately 1/4" deflection and loaded so that deflection does not exceed 15% of the free height of the element. The design shall be such as to prevent metal-to-metal contact between the hanger rod and the steel box.
 - H. Type 8 - 1/4" thick closed cell Neoprene ASTM Grade S.E.C. 44 in sheets cut to fit penetrations, as required.
- 2.03 BASE TYPES: Base types and required deflections are specified under "Schedule of Isolated Equipment," paragraph 7.8, or are indicated on the Drawings. The bases shall comply with the following descriptions for each type required on the project.
- A. Type B-1 - A structural steel fan and motor base with motor side rails and holes drilled to receive the fan and motor. The steel members shall be adequately sized to prevent distortion and misalignment of the drive, and specifically shall be sized to limit deflection of the beam on the drive side to 0.05" due to starting torque. Snubbers to prevent excessive motion on starting or stopping shall be furnished, if required; however, the snubbers shall not be engaged under steady running conditions.
 - B. Type B-2 - A concrete inertia base, consisting of a perimeter steel pouring forming, reinforcing bars welded in place, bolting templates, anchor bolts, and height-saving brackets for side mounting of the isolators. The perimeter steel members shall be structural channels having a minimum depth of 1/12 of the longest span, but not less than 6" deep. The inertia base for pumps shall be at least equal in weight to the pump with its driving motor and be sized for a minimum overlap of 4" around the base of the equipment. Concrete inertia bases for pumps shall be sized to support the suction elbow of end suction pumps and both the suction and discharge elbows of horizontal split-case pumps. The bases shall be T-shaped where necessary to conserve space.

PART 3 EXECUTION

3.01 GENERAL INSTALLATION REQUIREMENTS:

- A. Install vibration isolators for motor driven equipment.
- B. Set steel bases for 1-inch clearance between housekeeping pad and base. Set concrete inertia bases for 2-inch clearance. Adjust equipment level.
- C. Provide spring isolators on piping connected to isolated equipment as follows: Up to 4 inch diameter, first three points of support; 5 to 8 inch diameter, first four points of support; 10 inch diameter and over, first six points of support. Static deflection of first point shall be twice deflection of isolated equipment.
- D. Pumps:
 - 1. Each centrifugal pump and its driving motor shall be mounted on a common inertia base and the base, in turn, to be mounted on the scheduled vibration isolator type to prevent the transmission of vibration and noise to the building structure.
 - 2. In general, all inertia bases shall be formed and poured in place onto a hard, flat surface from which the base can be separated when cured. The base shall be shimmed, using flat material, to the intended final height prior to equipment mounting and piping connection.
 - 3. After the piping connections are made and the system filled with water and ready to put into service, the isolator adjustment bolts shall be extended until the shim blocks can be removed. The isolators may then be backed down slightly to restore the intended height. The locknuts should then be tightened on the isolators. Jack bolts shall be trimmed to a length which will allow no more than 1 inch of additional height adjustment. After final adjustment, the inertia base shall not support any piping load.
- E. Piping:
 - 1. Floor mounted supports shall have the same type of isolator or media as is used for the nearest isolated equipment connected to the piping.
 - 2. The pipe hanger system shall have provisions for all piping to be shimmed or blocked in place until all connections are made and the system filled with water; then, the isolators adjusted to support the weights, and the shim blocks removed.
 - 3. The first three support points from a piece of isolated equipment shall be of the positioning type and provide not less than the static deflection of the equipment isolators.

4. All springs supporting piping shall be capable of an additional 1/2" deflection prior to complete compression and springs supporting vertical risers shall have provisions for limit stops.

F. Resilient Sleeves:

1. Resilient sleeves shall be provided at all points where equipment room walls, floors, or ceilings are penetrated by ducts, piping, or refrigerant line, etc.

G. Fans and Air Handling Units:

1. Such units shall have electrical flexible connections not less than 36" long and the flexible duct connections with a free length of not less than 8".

3.02 SCHEDULE OF ISOLATED EQUIPMENT:

- A. Tabulated below is a schedule of equipment on this project requiring vibration isolation and base isolators of the types listed above. Any equipment, system, construction or condition that may be altered, added, or changed; or that is not specifically considered herein or on the plans shall be treated in a manner that is set out for similar equipment system or construction in order to comply with the above requirements heretofore cited.

EXAMPLE ONLY - Edit for specific project

	<u>EQUIPMENT</u>	<u>ISOLATOR EQUIP. TYPE</u>	<u>ISOLATOR DEFLECTION</u>	<u>BASE ISOL. TYPE</u>
A. Segment D				
1.	Supply Fans AC/D-1, 3, 5	1	2"	---
	AC/D-2, 4	1	3"	B-2
2.	Exhaust Fans EF/D-1,2,3,4,5,6,7,8,9	1	2"	B-2
	EF/D-suspended 10 thru 17	6	2"	B-1
3.	Transformers	8	---	B-1
4.	Piping	5	1"	---
5.	All piping and duct floor			

	penetrations in equipment room	8,9	---	---
B. Segment C				
1.	Supply Fans			
	AC/C-1,2,3,4,5	1	1.5"	---
	AC/A-1	1	1.5"	---
	AC/B-1,2,3			1
2.	Return Fans Serves			
	AC/A-1	1	3"	B-2
	AC/B-1,2,3	1	3"	B-2
	AC/C-5	1	3"	B-2
3.	Exhaust Fans			
	EF/C-1,2,3,4,5,6	1	2"	B-2
	EF/C-7,8	5	1"	---
	EF/C-9	1	1"	B-2
4.	Transformers	8	---	
B-1				
5.	Piping in Mechanical Rooms	5	1"	---
6.	All piping and duct floor penetrations	8,9	---	---
7.	All pipe and duct wall penetrations	9	---	---
8.	Pumps, etc.-----			

END OF SECTION

SECTION 23 05 53
MECHANICAL IDENTIFICATION

PART 1 GENERAL

1.00 The following sections are to be included as if written herein:

- A. Section 23 00 00 – Basic Mechanical Requirements
- B. Section 23 05 29 – Sleeves, Flashings, Supports and Anchors

1.01 SECTION INCLUDES

- A. Nameplates
- B. Tags
- C. Stencils
- D. Pipe Markers

1.02 PRODUCTS INSTALLED BUT NOT FURNISHED UNDER THIS SECTION

- A. Section 22 63 13 - Medical Gas Systems: Supply of pipe labels for placement by this Section

1.03 RELATED SECTIONS

- A. Section 09 91 00 - Painting: Identification painting

1.04 REFERENCES

- A. ASME A13.1 - Scheme for the Identification of Piping Systems

1.05 SUBMITTALS

- A. Submit under provisions of Section 23 00 00.
- B. Submit list of wording, symbols, letter size, and color coding for mechanical identification.
- C. Submit valve chart and schedule, including valve tag number, location, function, and valve manufacturer's name and model number.
- D. Product Data: Provide manufacturers catalog literature for each product required.

E. Samples: Submit two of each type of label, tag, etc., of the approximate size specified or implied in the specification.

F. Manufacturer's Installation Instructions: Indicate special procedures, and installation.

1.06 PROJECT RECORD DOCUMENTS

A. Submit under provisions of Section 23 00 00.

B. Record actual locations of tagged valves.

PART 2 PRODUCTS

2.01 NAMEPLATES

A. Manufacturers:

1. [] Model [].

2. Other acceptable manufacturers offering equivalent products

a) [] Model [].

b) [] Model [].

c) [] Model [].

B. Description: Laminated three-layer plastic with engraved [black] [] letters on light contrasting background color.

2.02 TAGS

A. Manufacturers:

1. [] Model [].

2. Other acceptable manufacturers offering equivalent products.

a) [] Model [].

b) [] Model [].

c) [] Model [].

- B. Plastic Tags: Laminated three-layer plastic with engraved [black] [] letters on light contrasting background color. Tag size minimum 1-1/2 inch (40 mm) [diameter] [square] [].

***** [OR] *****

- B. Metal Tags: [Brass] [Aluminum] [Stainless Steel] [] with stamped letters; tag size minimum 1-1/2 inch (40 mm) [diameter] [square] [] with smooth edges.
- C. Chart: Typewritten letter size list in anodized aluminum frame.

2.03 PIPE MARKERS

A. Manufacturers:

1. [] Model [].
2. Other acceptable manufacturers offering equivalent products.
 - a) [] Model [].
 - b) [] Model [].
 - c) [] Model [].

B. Color: Conform to ASME A13.1.

C. Plastic Pipe Markers: Factory fabricated, flexible, semi-rigid plastic, preformed to fit around pipe or pipe covering; minimum information indicating flow direction arrow and identification of fluid being conveyed.

D. Plastic Tape Pipe Markers: Flexible, vinyl film tape with pressure sensitive adhesive backing and printed markings.

E. Underground Plastic Pipe Markers: Bright colored continuously printed plastic ribbon tape, minimum 6 inches (150 mm) wide by 4 mil (0.10 mm) thick, manufactured for direct burial service.

2.04 CEILING TACKS

A. Manufacturers:

1. [] Model [].

2. Other acceptable manufacturers offering equivalent products.
 - a) [_____] Model [_____].
 - b) [_____] Model [_____].
 - c) [_____] Model [_____].

B. Description: Steel with 3/4 inch (20 mm) diameter color coded head.

C. Color code as follows:

1. Yellow - HVAC equipment
2. Red - Fire dampers/smoke dampers
3. Green - Plumbing valves
4. Blue - Heating/cooling valves

2.05 General: The Contractor shall make it possible for the personnel operating and maintaining the equipment and systems in this project to readily identify the various pieces of equipment, valves, piping, etc., by marking them. All items of equipment such as fans, pumps, etc., shall be clearly marked using engraved nameplates as hereinafter specified. The item of equipment shall indicate the same number as shown on the Drawings. For example, pumps will be identified as 3A, 3B, 3C, etc.; exhaust fans will be E-1, E-2, etc.; supply fans will be S-1, S-2, etc.

2.06 Mechanical: All items of mechanical equipment shall be identified by the attachment of engraved nameplates constructed from laminated phenolic plastic, at least 1/16" thick, 3-ply, with black surfaces and white core. Engraving shall be condensed Gothic, at least 1/2" high, appropriately spaced. Nomenclature on the label shall include the name of the item, its mark number, area, space, or equipment served, and other pertinent information. Equipment to be labeled shall include but not be limited to the following:

NOTE TO SPECIFICATION WRITER: DELETE ANY INAPPLICABLE EQUIPMENT AND ADD APPLICABLE ITEMS NOT ALREADY LISTED.

Pumps

Exhaust Fans

Fan and Coil Units

Hot Water Generators

Condensing Units	Storage Tanks
Converters	Compressors
Air Conditioning Control	Miscellaneous - similar
Panels and Switches	and/or related items

2.07 Piping: Pipe markers and arrow markers also shall be provided on but not limited to the piping of the following systems:

NOTE TO SPECIFICATION WRITER: DELETE ANY INAPPLICABLE ITEMS AND ADD APPLICABLE ITEMS NOT ALREADY LISTED.

Primary Chilled Water Supply	Steam Condensate	Natural Gas
Primary Chilled Water Return	Secondary Chilled Water Supply	Oxygen
Instrument Air	Deionized Water	Distilled Water
Atmospheric Relief	Secondary Chilled Water Return	Plumbing Piping Systems
Low Pressure Steam	Compressed Air	Roof Drain
Heating Hot Water Supply	Heating Hot Water Return	Domestic Hot Water Supply
Domestic Hot Water Return	Domestic Cold Water Supply	Domestic Cold Water Return
Medium Pressure Steam	Acid Waste	

2.08 Electrical: Nameplates shall be 2 or 3 ply laminated plastic, a minimum of 3/32" thick, such that letters will be white on black background. Letters shall be similar to Roman Gothic of a size that is legible and appropriate to the application. Attachment of nameplates shall be by screws. Rivets or adhesives are not acceptable.

- A. Electrical equipment to be identified includes: All switchgear, distribution panels, transformers, motor control centers, panel boards, disconnect switches, starters, contactors and time switches.

- B. Nameplates on distribution panels, motor control centers and panel boards shall give voltage characteristics.

Example:

PANEL LA
120/208V, 3 PH, 4 W
served from .

- C. Individual circuit breakers in distribution panels, individual units in motor control centers, disconnecting means, and motor starters, shall have nameplates showing the load served.
- D. Branch circuit panel boards shall have neatly typed circuit directories behind clean plastic. Identify circuits by room numbers. Room numbers shall be those finally selected by the Owner, not necessarily those given on contract Drawings. If a circuit serves more than one room, list each room. Spares and spaces shall be indicated with erasable pencil, not typed.

2.09 The Contractor shall prepare and install, in a suitable glazed frame, typewritten valve charts giving the number, location and function of each line valve installed under this Contract. Each valve shall be numbered on these charts in accordance with the system of which it is a part of its location. For example, valves in different systems would be designated as follows:

HPS-1-3 High Pressure Steam	1st Level - Valve No. 3
CHS-2-4 Chilled Water Supply	2nd Level - Valve No. 4

2.10 Valve Tags:

- A. The Contractor shall provide and install identification tags lettered and numbered to correspond to the information shown on the charts described above. These tags are to be affixed to all valves except simple service and drain valves located within 10' and within sight of the device or equipment served. For example, it would not be expected that valves at a pressure reducing station in a machine room would be tagged. These tags shall be 1/8" thick brass discs, 1 1/2" in diameter. Each tag shall be attached to its valve with copper clad annealed iron wire or other approved material.
- B. Valves at water headers and steam PRV stations, valves associated with condensate, gas, water meters, and other valves as specified shall also be tagged with standardized color coded plastic tags. These tags shall be 2 1/2" wide by 1 1/2" high with these color codings: Red = normally closed; Green = normally open; Blue = open in winter, closed in summer; and Yellow = closed in winter, open in summer. Tags should be engraved on both sides.

2.11 In addition, pipe runs throughout the building including those above lift out ceilings,

under floor, and those exposed to view when access doors or access panels are opened shall be identified by means of Seton Setmark or Brady Mechanical Pipe Markers. Concealed areas, for purposes of this identification section, are those areas which cannot be seen except by demolition of the building elements. In addition to the pipe markers, arrow markers shall be used to indicate direction of flow. The following specific instructions shall apply to the application of these markers:

- A. Provide a pipe marker at each valve to indicate proper identification of pipe contents. Where several valves exist on one header, it is necessary to mark only the header.
- B. Provide an arrow marker with each pipe marker pointing away from the pipe marker to indicate direction of flow.
- C. Provide a double ended arrow marker when flow can be in either or both directions.
- D. Provide a pipe marker and an arrow marker at every point of pipe entry or exit where line goes through a wall or service column.
- E. Provide pipe markers and arrow markers at intervals not exceeding 50 feet.
- F. Markers shall be located on the two lower quarters of the pipe where view is unobstructed.
- G. Use Seton Setmark Type SNA or Brady snap-on type identification for all piping systems, 3/4" thru 6". For piping systems larger than 6", use Seton or Brady strap on markers.
- H. Pipe Markers shall conform to ANSI A 13.1-1981 "Scheme for the Identification of Piping Systems." Arrow markers must have same ANSI background colors as their companion pipe markers, or be incorporated into the pipe identification marker.
- I. Locate markers to be visible from floor.

2.12 Specials: Refer to special requirements noted in the various sections hereinafter bound.

PART 3 EXECUTION

3.01 PREPARATION

- A. Degrease and clean surfaces to receive adhesive for identification materials.
- B. Prepare surfaces in accordance with Section 09 91 00 for stencil painting.

3.02 INSTALLATION

- A. Install plastic nameplates with corrosive-resistant mechanical fasteners, or adhesive. Apply with sufficient adhesive to ensure permanent adhesion and seal with clear lacquer.
- B. Install tags with corrosion resistant chain.
- C. Apply stencil painting in accordance with Section 09 91 00.
- D. Install plastic pipe markers in accordance with manufacturer's instructions.
- E. Install plastic tape pipe markers complete around pipe in accordance with manufacturer's instructions.
- F. Install underground plastic pipe markers 6 to 8 inches (150 to 200 mm) below finished grade, directly above buried pipe.
- G. Identify air handling units, pumps, heat transfer equipment, tanks, and water treatment devices with [plastic nameplates.] [stencil painting.] Small devices, such as in-line pumps, may be identified with tags.
- H. Identify control panels and major control components outside panels with plastic nameplates.
- I. Identify thermostats relating to terminal boxes or valves with nameplates.
- J. Identify valves in main and branch piping with tags.
- K. Identify air terminal units and radiator valves with numbered tags.
- L. Tag automatic controls, instruments, and relays. Key to control schematic.
- M. Provide ceiling tacks to locate valves, dampers or other concealed equipment above T-bar type panel ceilings. Locate in corner of panel closest to equipment.

END OF SECTION

SECTION 23 05 93
TESTING, ADJUSTING AND BALANCING

PART 1 - GENERAL

1.1 THE FOLLOWING SECTIONS CONTAIN INFORMATION REQUIRED TO FULFILL THE REQUIREMENTS OF THIS SECTION:

- A. 23 00 00 -- Basic Mechanical Requirements
- B. 23 06 20 – Hydronic Specialties
- C. 23 09 23 – Direct Digital Controls
- D. 23 20 00 – HVAC Pumps
- E. 23 22 10 – Steam and Steam Condensate Piping Specialties
- F. 23 29 23 – Variable Frequency Drives
- G. 23 31 00 – Ductwork
- H. 23 33 00 – Ductwork Accessories
- I. 23 34 16 - Fans
- J. 23 36 00 – Air Terminal Units (VAV)
- K. 23 36 10.A – Air Terminal Units (FPVAV)
- L. 23 37 00 – Air Inlets and Outlets
- M. 23 57 00 – Heat Exchangers
- N. 23 73 00 – Air Handling Units (up to 10,000 cfm)
- O. 23 73 23 – Air Handling Units
- P. 23 82 19 – Terminal Heat Transfer Units

1.2 SUMMARY

- A. **TESTING, ADJUSTING AND BALANCING (TAB) OF THE AIR CONDITIONING SYSTEMS AND RELATED ANCILLARY EQUIPMENT WILL BE PERFORMED BY AN IMPARTIAL, TECHNICALLY QUALIFIED TAB FIRM SELECTED AND EMPLOYED BY THE OWNER, SEPARATE AND APART FROM THE CONSTRUCTION CONTRACT.**
- B. The firm shall be capable of performing the services specified at the location of the facility described within the time specified, of preparing and submitting the detailed report of the actual field work performed, and following up the basic work as may be required.

1.3 QUALIFICATIONS

- A. The Firm shall be one which is organized to provide professional services of this specified type in the State of Texas and as a minimum shall have one (1) professional engineer

licensed in the State of Texas, with current registration, to perform such professional services. This engineer shall be personally responsible for developing the job site data as required in the test procedures outlined in these Specifications.

- B. The Firm shall have operated a minimum of five (5) years under its current Firm name, and shall be in good standing with the State of Texas, Franchise Tax Board. The firm shall submit their full incorporated name, Charter Number and Taxpayer's I.D. Number for proper verification of the firm's status.
- C. The Firm shall be capable of providing a performance bond, by a bonding company licensed to do business in the State of Texas, if determined by the Owner that such a bond is required. The amount of the bond which may be required shall be equal to the cost of the proposal submitted, or in the case of more than one proposal, the sum of all such proposals and any awarded work in progress.
- D. All personnel used on the job site shall be either professional engineers or certified TAB engineering technicians, who shall have been permanent, full time employees of the firm for a minimum of six (6) months prior to the start of work for this specific project.
- E. The TAB firm shall submit biographical data on the supervising Professional Engineer, the individual proposed who will directly supervise the TAB work, as well as other personnel scheduled to perform the technical work under the contract. It shall also submit a background record of at least five years of specialized experience in the field of air hydronic system balancing, and shall possess properly calibrated instrumentation. The supervisory personnel for the TAB firm shall be registered engineers in the mechanical field.

1.4 REFERENCES

- A. AABC - National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems, Seventh Edition.
- B. ASHRAE - 2015 HVAC Applications Chapter 34: Testing, Adjusting and Balancing.
- C. ANSI/ASHRAE Standard 111-2008 - Practices for Measurement, Testing, Adjusting and Balancing of Buildings, Heating, Ventilation, Air Conditioning and Refrigeration Systems.

1.5 DOCUMENTS

- A. The TAB firm shall, as a requirement of the TAB contract, arrange with the Architect to compile one set of mechanical specifications, all pertinent change orders, addenda and the following:
 - 1. One complete set of Drawings less the structural sheets.
 - 2. One set of mechanical floor plans of the conditioned spaces. These Drawings shall be blue or black on light background reproductions to facilitate marking.

- B. Approved submittal data on equipment installed, and related changes as required to accomplish the test procedures outlined in Paragraphs 1.06 through 1.10 of this Specification will be available through the Construction Inspector.

1.6 RESPONSIBILITIES OF THE TAB FIRM

- A. The TAB personnel shall check, adjust, and balance the components of the air conditioning system which will result in optimal noise, temperature, water flow and airflow conditions in the conditioned spaces of the building while the equipment of the system is operating economically. This is intended to be accomplished after the system components are installed and operating as provided for in the contract documents. It is the responsibility of the Mechanical Contractor to place the equipment into service. Variable air volume systems shall be balanced in accordance with AABC Standard, Seventh Edition.
- B. Liaison and Early Inspection:
 - 1. The TAB firm personnel on the job shall act as liaison between the Owner, Architect and Contractor. The following reviews (observations) and tests shall be performed by the TAB Agency:
 - a. During the design for Design Development (DD) and for two (2) Construction Document (CD) design stage submittals, at minimum, and before the documents are finalized, review the mechanical drawings and specifications for balance-ability and provide commentary.
 - b. During construction, at a minimum review HVAC submittals such as: Hydronic Specialties, Direct Digital Controls, HVAC Pumps, Steam and Condensate Piping Specialties, Ductwork, Ductwork Accessories, Fans, VAV and Fan Powered Boxes, Air Inlets and Outlets, Heat Exchangers, Air Handling Units, Terminal Heat Transfer Units, etc., that pertain to balance-ability and commissioning work. The TAB Consultant shall participate as a member of the Commissioning Team.
 - c. Allow for a fixed number of trips to the project site, over and above those required for testing and balancing for inspection of installation of the mechanical piping systems, ductwork, temperature controls mechanical equipment and other component parts of the heating, air conditioning and ventilating systems during the construction stage. These inspections shall be made prior to and/or at the above ceiling inspection. Written commentary will be provided to the Resident Construction Manager (RCM) or Construction Inspector (CI) of each observation.
 - d. Test and inspect one (1) 8" single duct terminal box for performance capability and leakage as described in Section 23 36 00 or 23 36 10. The shipment of the box to the TAB Agency's lab will be at the manufacturer's cost and the test

period will be for three (3) weeks (maximum) from receipt of the box. Submittal data will not be approved until box testing passes. If the sample box is rejected for any reason the second test will be at the Contractor's cost and the time allowed will restart when the box is received at the TAB Agency.

- e. Test and inspect one (1) 8" dual duct box for performance capability and leakage as described in Section 23 36 00. The shipment of the box to the TAB Agency's lab will be at the manufacturer's cost and the test period will be for three (3) weeks (maximum) from receipt of the box. Submittal data will not be approved until box testing passes. If the sample box is rejected for any reason the second test will be at the Contractor's cost and the time allowed will restart when the box is received by the TAB agency.
 - f. Test 10% of the single and dual duct boxes for casing and damper leakage when the shipment arrives at the project site. All testing (except for the initial boxes) shall be performed on site. Boxes requiring re-testing will be charged to the Contractor at the unit price provided to the Owner.
 - g. Testing of Air Handling Units (AHU): the TAB Consultant shall witness AHU casing deflection test at the AHU factory and AHU casing leakage testing in the field at the project site.
 - h. Test one (1) lab configuration including fume hood with air valve, general exhaust air with air valve and supply air with air valve for performance capability through a full range of inlet pressures. The tracking capability of the exhaust air versus the supply air will be with the submitted hood sash fully open and as the sash is closed in 2" increments until fully closed. Track the three (3) valves' response time in relation to sash movement and the lab differential.
2. During the balancing process, as abnormalities and malfunctions of equipment or components are discovered by the TAB personnel, the RCM and Construction Inspector shall be advised in writing so that the condition can be corrected by the Mechanical Contractor. The written document need not be formal, but must be clear, complete and legible. Data from malfunctioning equipment shall not be recorded in the final TAB report. The TAB firm shall not instruct or direct the Contractor in any of the work, but will make such reports as are necessary to the Owner.

1.7 FINAL AIR BALANCE

- A. General: When systems are complete and ready for operation, the TAB Consultant will perform a final air balance for all air systems and record the results. The supply, return, outside and exhaust air volume for each air handling unit, supply fan and exhaust fan and the supply, exhaust or return air volume for each distribution device shall be adjusted to within +5% of the value shown on the drawings. Air handling unit and fan volumes shall be adjusted by changing fan speed and adjusting volume dampers associated with the unit. Air distribution device volume shall be adjusted using the spin-in tap damper for

flexible duct connected devices or the damper-in-duct tap to air device. Air distribution devices shall be balanced with air patterns as specified. Duct volume dampers shall be adjusted to provide air volume to branch ducts where such dampers are shown. The general scope of balancing by the TAB Consultant will include, but is not limited to, the following:

1. Filters: Check air filters and filter media and balance only system with essentially clean filters and filter media. The Division 23 Contractor shall install new filters and filter media prior to the final air balance.
2. Blower Speed: Measure RPM at each fan or blower to design requirements. Where a speed adjustment is required, the Division 23 Contractor shall make any required changes.
3. Ampere Readings: Measure and record full load amperes for motors.
4. Static Pressure: Static pressure gains or losses shall be measured across each supply fan, cooling coil, heating coil, return air fan, air handling unit filter and exhaust fan. These readings shall be measured for this report at the furthest air device or terminal unit from the air handler supplying that device and recorded. Static pressure readings shall also be provided for systems which do not perform as designed.
5. Equipment Air Flow: Adjust and record exhaust, return, outside and supply air CFM (s) and temperatures, as applicable, at each fan, blower and coil.
6. Coil Temperatures: Set controls for full cooling and for full heating loads. Read and record entering and leaving dry bulb and wet bulb temperatures (cooling only) at each cooling coil, heating coil and HVAC terminal unit. At the time of reading record water flow and entering and leaving water temperatures (In variable flow systems adjust the water flow to design for all the above readings).
7. Zone Air Flow: Adjust each zone VAV Terminal Box serving an AHU, each HVAC terminal unit and AHU for design CFM.
8. Outlet Air Flow: Adjust each exhaust inlet and supply diffuser, register and grille to within +5% of design air CFM. Include all terminal points of air supply and all points of exhaust. Note: For Labs and Rooms that are negative exhaust air flow shall be set to design +10% and supply to design -5%. Positive areas will have opposite tolerances.
9. Pitot Tube Traverses: For use in future troubleshooting by maintenance personnel, all exhaust ducts, main supply ducts and return ducts shall have air velocity and volume measured and recorded by the traverse method. Provide a description of locations of these traverse test stations on the sheet containing the data.
10. Maximum and minimum air flow on terminal boxes.

1.8 FINAL CHILLED AND HEATING HOT WATER BALANCE

- A. General: When systems are completed and ready for operation, the TAB Consultant will perform a final water balance for each chilled and hot water system. The general scope of balancing by the TAB Consultant will include, but not be limited to, the following:
1. Adjusted System Tests: Adjust balancing valves at each coil and heat exchanger for design flow, +5%. Adjust balancing valves at pumps to obtain design water flow. Record pressure rise across pumps and GPM flow from pump curve. Permanently mark the balanced position for each valve (Note: If discharge valves on the pumps are used for balancing record the head being restricted by the valves).
 2. Temperature Readings: Read and record entering and leaving water temperature at each water coil, converter and heat exchanger. Adjust as necessary to secure design and conditions. Provide final readings at all thermometer well locations.
 3. Pressure Readings: Water pressure shall be recorded at all gauge connections. Pressure readings at coils and pumps shall be related to coil and pump curves in terms of GPM flow through flow measuring status, if provided and installed, at each air handler. The flow of water through all water coils shall be adjusted by manipulating valves until the rated pressure drops across each coil is obtained and total water flow is verified by flow measuring status. For coils equipped with 3 way valves, the rated pressure drop shall first be adjusted through the coils. The bypass valve shall then be adjusted on each coil until an equal pressure drop between supply and return connections is the same as with the flow through the coil.
 4. Ampere Readings: Reading and record full load amperes for each pump motor.

1.9 SOUND VIBRATION AND ALIGNMENT

- A. Sound: Read and record sound levels at up to 15 locations in the building designated by the Engineer. All measurements shall be made using an Octave Band Analyzer. All tests shall be conducted when the building is quiet in the presence of the Engineer, if he so desires.
- B. Vibration: Read and record vibration for all water circulating pumps, air handling units, and fans which have motors larger than 10 HP. Include equipment vibration, bearing housing vibration, foundation vibration, building structure vibration, and other tests as directed by the Engineer. Readings will be made using portable IRD (or approved equal) equipment capable of filtering out various unwanted frequencies and standard reporting forms. Maximum vibration at any point listed above, or specified, shall not exceed deflection allowed per Section 23 34 16 for fans and deflection allowed per Section 23 20 00 for pumps unless otherwise specified. Equipment manufacturers shall rectify all systems exceeding vibration tolerances.

1.10 TESTING OF TEMPERATURE CONTROL SYSTEMS

- A. In the process of performing the TAB work, the TAB Agency shall:

1. Work with the temperature control contractor to ensure the most effective total system operation within the design limitations, and to obtain mutual understanding of intended control performance.
2. Verify that all control devices are properly connected.
3. Verify that all dampers, valves and other controlled devices are operated by the intended controller.
4. Verify that all dampers and valves are in the position indicated by the controller (open, closed or modulating).
5. Verify the integrity of valves and dampers in terms of tightness of close-off and full-open positions. This includes terminal boxes and fire/smoke dampers.
6. Observe that all valves are properly installed in the piping system in relation to direction of flow and location.
7. Observe the calibration of all controllers.
8. Verify the proper application of all normally opened and normally closed valves.
9. Observe the locations of all thermostats and humidistats for potential erratic operation from outside influences such as sunlight, drafts or cold walls.
10. Observe the locations of all sensors to determine whether their position will allow them to sense only the intended temperatures or pressures of the media. Should an adjustment of the installation be required, the TAB Consultant will provide a recommendation to the RCM and/or CI to coordinate with the Controls subcontractor to resolve as required for proper operation.
11. Verify that the sequence of operation for any control mode is in accordance with approved shop drawings and specifications. Verify that no simultaneous heating and cooling occurs.
12. Verify that all controller setpoints meet the design control sequence..
13. Check all dampers for free travel.
14. Verify the operation of all interlock systems.
15. Perform variable volume system verification to assure the system and its components track with changes from full flow to minimum flow.

B. A systematic listing of the above testing and verification shall be included in the final TAB report.

1.11 STAIRWELL PRESSURIZATION SYSTEMS

- A. With all doors closed, measure the door pull to determine that the opening force required is below 30 pounds force.
- B. With all doors closed, measure the pressure differential across each door to verify the pressure differentials at each floor.
- C. Measure the air flow in the stairwell with the maximum number of doors fully open by pitot tube traverse, if traverse locations are available. If traverse locations are not available, measure air flow at each outlet.
- D. Verify with smoke that the smoke detector in the stair pressurization fan inlet shuts the fan down.
- E. Verify stairwell pressurization system complies with IBC.

1.12 REPORTS

- A. The activities described in this section shall culminate in a report to be provided on three (3) CDs and one (1) individually bound printed copy to the RCM. Neatly type and arrange data. Include with the data the date tested, personnel present, weather conditions, nameplate record of test instrument and list all measurements taken after all corrections are made to the system. Record all failures and corrective action taken to remedy incorrect situation. The intent of the final report is to provide a reference of actual operating conditions for the Owner's operations personnel.
- B. All measurements and recorded readings (of air, water, electricity, etc.) that appear in the reports must have been made onsite by the permanently employed technicians or Engineers of the firm.
- C. TAB personnel shall submit copies of preliminary field measurements on data sheets tabulated each day to the Commissioning Authority.
- D. Submit reports on forms from the AABC manual approved by the Owner & Engineer which will include the following information as a minimum:
 - 1. Title Page
 - a. Company Name
 - b. Company Address
 - c. Company telephone number
 - d. Project name
 - e. Project location
 - f. Project Manager
 - g. Project Engineer
 - h. Project Contractor
 - i. UT System Project Identification Number
 - 2. Instrument List
 - a. Instrument
 - b. Manufacturer

- c. Model
 - d. Serial Number
 - e. Range
 - f. Calibration date
 - g. What test instrument was used for
3. Fan Data (Supply and Exhaust)
 - a. Identification/location
 - b. Manufacturer
 - c. Model
 - d. Airflow, specified and actual
 - e. Total static pressure (total external), specified and actual
 - f. Inlet pressure
 - g. Discharge pressure
 - h. Fan RPM
 4. Return Air/Outside Air Data (If fans are used, same data as for 3 above)
 - a. Identification/location
 - b. Design return air flow
 - c. Actual return air flow
 - d. Design outside air flow
 - e. Return air temperature
 - f. Outside air temperature
 - g. Required mixed air temperature
 - h. Actual mixed air temperature
 5. Electric Motors
 - a. Manufacturer
 - b. HP/BHP
 - c. Phase, voltage, amperage, nameplate, actual
 - d. RPM
 - e. Service factor
 - f. Starter size, heater elements, rating
 6. V-Belt Drive
 - a) Identification/location
 - b) Required driven RPM
 - c) Driven sheave, diameter and RPM
 - d) Belt, size and quantity
 - e) Motor sheave, diameter and RPM
 - f) Center-to-center distance, maximum, minimum and actual
 7. Duct Traverse
 - a) System zone/branch/location
 - b) Duct size
 - c) Area
 - d) Design velocity
 - e) Design air flow
 - f) Test velocity

- g) Test air flow
 - h) Duct static pressure
 - i) Air temperature
 - j) Air correction factor
8. Air Monitoring Station Data
- a) Identification/location
 - b) System
 - c) Size
 - d) Area
 - e) Design velocity
 - f) Design air flow
 - g) Test velocity
 - h) Test air flow
9. Air Distribution Test Sheet
- a) Air terminal mark number
 - b) Room number/location
 - c) Terminal type
 - d) Terminal size
 - e) Area factor
 - f) Design velocity
 - g) Design air flow
 - h) Test (final) velocity
 - i) Test (final) air flow
10. Pump Data
- a) Identification/number
 - b) Manufacturer
 - c) Size/model
 - d) Impeller
 - e) Service
 - f) Design flow rate, pressure drop, BHP
 - g) Actual flow rate, pressure drop, BHP
 - h) Discharge pressure
 - i) Suction pressure
 - j) Total operating head pressure
 - k) Shut off, discharge and suction pressure
 - l) Shut off, total head pressure
 - m) Pressure differential settings
11. Cooling Coil Data
- a) Identification/number
 - b) Location
 - c) Service
 - e) Manufacturer
 - f) Entering air DB temperature, design and actual

- g) Entering air WB temperature, design and actual
 - h) Leaving air DB temperature, design and actual
 - i) Leaving air WB temperature, design and actual
 - j) Water pressure flow, design and actual
 - k) Water pressure drop, design and actual
 - l) Entering water temperature, design and actual
 - m) Leaving water temperature, design and actual
 - n) Air pressure drop, design and actual
12. Heating Coil Data
- a) Identification/number
 - b) Location
 - c) Service
 - d) Manufacturer
 - e) Air flow, design and actual
 - f) Water flow, design and actual
 - g) Water pressure drop, design and actual
 - h) Entering water or steam temperature, design and actual
 - i) Leaving water temperature, design and actual
 - j) Entering air temperature, design and actual
 - k) Leaving air temperature, design and actual
 - l) Air pressure drop, design and actual
13. Sound Level Report
- a) Location (Location established by the design engineer)
 - b) NC curve for eight (8) bands - equipment off
 - c) NC curve for eight (8) bands - equipment on
14. Vibration Test on equipment having 10 HP motors or above
- a) Location of points:
 - 1) Fan bearing, drive end
 - 2) Fan bearing, opposite end
 - 3) Motor bearing, center (if applicable)
 - 4) Motor bearing, drive end
 - 5) Motor bearing, opposite end
 - 6) Casing (bottom or top)
 - 7) Casing (side)
 - 8) Duct after flexible connection (discharge)
 - 9) Duct after flexible connection (suction)
 - b) Test readings:
 - 1) Horizontal, velocity and displacement
 - 2) Vertical, velocity and displacement
 - 3) Axial, velocity and displacement
 - c) Normally acceptable readings, velocity and acceleration
 - d) Unusual conditions at time of test
 - e) Vibration source (if non-complying)

15. Control verification indicating date performed and any abnormalities identified.
 - a) Point Location/Description
 - b) EMS Readout (Setpoint and Actual)
 - c) Interlocks
 - d) Safeties
 - 1) VFD Normal Operation
 - 2) VFD Bypass Operation
 - e) Alarms
 - f) Sequences of Operation

END OF SECTION

SECTION 23 06 00
BUILDING CONTROLS (BAS)

PART 1 – GENERAL

1.1 DIRECT-DIGITAL CONTROL (DDC) SYSTEM DESCRIPTION

- A. The Controls Contractor shall supply and install a complete Direct Digital Control (DDC) Building Automation System (BAS) as required to accomplish the Sequences of Control for heating, ventilating, air-conditioning and other building-level equipment and systems as described herein.

1.2 WORK INCLUDED

- A. Furnish all labor, materials, equipment and service necessary for a complete and operational DDC BAS pursuant with this specification and as shown on the associated contract drawings.
- B. Coordinate the existing conditions and requirements of all mechanical and electrical equipment that will be controlled by the DDC BAS.
- C. Coordinate interface requirements for integration into BAS of following building-level equipment and systems:
 - 1. Laboratory Airflow Controls.
- D. All labor, material, equipment and service not specifically referred to in this specification or on associated drawings that are required to fulfill the functional intent of this specification shall be provided at no additional cost to the Owner.

1.3 DDC SYSTEM REQUIREMENTS

DDC Systems installed under this specification shall strictly adhere to the following characteristics:

- A. Building Automation System (BAS) Direct Digital Controls (DDC) shall consist of native BACnet, microprocessor-based, peer-to-peer, networked, distributed devices utilizing the BACnet communication protocol in an open, interoperable system. The BAS also includes operator interface devices, programming and configuration software applications, DDC input/output devices, non-DDC automatic temperature controls, enclosures and interconnecting conduit and wire.
 - 1. The BACnet operating stack must be embedded directly in every Device at the board level, and in all operator interface software packages.
 - 2. No Gateways, Communication Bridges, Protocol Translators or any other device that translates any proprietary or other communication protocol to the BACnet communication protocol shall be permitted as a part of the BAS installation pursuant with this specification section. Gateways may only be used as required for communication to existing systems or systems installed pursuant with other specification sections.
 - 3. DDC controllers that are not BACnet compliant shall not be acceptable under this specification and are strictly prohibited.

- B. The BAS shall be modular in nature and comprised of a network of stand-alone DDC devices. The System shall be designed and implemented in such a way that it may be expanded in both capacity and functionality through the addition of DDC Devices, sensors, actuators, etc,
- C. All BAS controllers shall be tested, certified, clearly stamped and listed by the BACnet Testing Laboratories (BTL).
- D. Program database, data acquisition, and all control sequence logic shall reside in each DDC Device. The Building Level Communication Network (BLCN) shall not be dependent upon connection to a Server or Master Controller for performance of the Sequence of Control as outlined in this specification. Each individual Device shall, to the greatest possible extent, perform its programmed sequence without reliance on the BLCN.
- E. BAS shall be provided with a complete Web enabled operator interface. The Web enabled application shall operate on industry standard PC hardware. Proprietary server hardware or “Black Boxes” will not be acceptable. Third party Web enabled applications are acceptable if they are configured to be indistinguishable from the OWS applications.
- F. The Owner at the Owner’s expense shall provide connection to the Internet for the BAS. The LAN connection type and configuration (TCP/IP addressing scheme, etc.) will be information provided to the System Contractor from the Owner, or Owner’s representative.
- G. All BAS DDC Devices at all levels shall be fully custom-programmable in the field using the standard Operators Workstation Software. No configurable, canned program application specific controllers will be permitted.
- H. All BAS DDC Devices shall be capable of updating firmware using software via internet without replacing any hardware, microprocessors or chips.
- I. The BAS shall be capable of sending system alarms and Event Notifications to pagers, and email services.
- J. Actuation of control devices shall be electronic. Spring return fail-safe actuation shall be provided when loss of property and/or property damage is possible and where specified.
- K. DDC Automatic Temperature Control (ATC) System shall prevent all controlled equipment from simultaneously restarting after a power outage. The order in which equipment (or groups of equipment) is started; along with the time delay between starts shall be user-selectable.
- L. All binary output points shall be protected from short cycling via output configuration and/or programming. This feature shall allow minimum on time and off-time to be configurable.

1.4 BASIC SYSTEM ARCHITECTURE

- A. The DDC BAS as provided and installed under this specification shall be a complete system from a single manufacturer designed for use on intranets and the internet.
- B. The primary BAS components shall include but not be limited to:
 - 1. Web Server with operating software
 - 2. Operator Workstation Software (B-OWS)
 - 3. Remote Operator Workstation Software (Remote B-OWS)

4. Portable Operator Workstation Software (Portable B-OWS)
 5. Building Controllers (B-BC)
 6. Advanced Application Controllers (B-AAC)
 7. Application Specific Controllers (B-ASC)
- C. Enterprise Level Communication Network (ELCN) shall consist of high-speed BACnet/IP Local Area Network (LAN) and/or Wide Area Network (WAN) to host Operators Workstations (B-OWS), Building Controllers (B-BC), Building Level Communication Networks (BLCN) and Web-Enabled remote connectivity
- D. Building Level Communication Network (BLCN) shall consist of a BACnet internetwork to host field level DDC Controllers
- E. B-BC's shall automatically route BACnet communications to all configured available BACnet networks.
- F. B-OWS and B-BC's shall be fully IT-compatible devices that communicate directly on a TCP/IP Local Area Network (LAN).
1. LAN shall be 10/100Mbps TCP/IP with the following minimum requirements:
 - a. Cable: 10 base-T, UTP-8 wire, category 5e or greater
 - b. Minimum throughput: 10Mbps with the ability to increase to 100Mbps
 2. Enterprise Level Communication Network (ELCN) shall provide communication between B-BC's, B-OWS, remote B-OWS and Web Server using a B/IP LAN backbone.
 3. B-BC's shall connect directly to the LAN and communicate using B/IP without a TCP/IP Gateway or network server
 4. Owner shall be responsible for providing TCP/IP networking scheme, addressing, &c. It shall be the responsibility of the BAS Contractor to coordinate implementation of the BAS on the Owner's LAN without disruption.
- G. BAS Manufacturer must natively support the following BACnet data links as defined in the ANSI/ASHRAE Standard 135-2008, BACnet:
1. Point-to-Point (PTP)
 2. Master Slave/Token Passing (MS/TP)
 3. Ethernet (ISO 8802-3)
 4. BACnet IP (B/IP)
- H. Field sensors and control devices shall connect to peer-to-peer, fully programmable B-BC, B-AAC & B-ASC as required to achieve the point monitoring and Sequence of Control as specified herein. All devices are to be monitored by a B-OWS. Final control devices are to be electronic.
- I. Each Mechanical System and/or major piece of Mechanical Equipment shall have one (1) dedicated DDC controller with sufficient I/O capacity such that it shall be connected to ALL field devices and sensors associated with that system and/or piece of equipment. Distributed

control of one (1) single piece of major mechanical equipment shall not be performed by multiple controllers.

- J. All BAS controllers, sensors and devices shall be UL listed.
 - 1. All BAS controllers and interface devices must be UL 916 Listed
 - 2. Where required by the local Authority Having Jurisdiction (AHJ), all BAS controllers and interface devices must be UUKL-UL 864 Listed

1.5 MATERIAL FURNISHED UNDER THIS SECTION BUT INSTALLED UNDER OTHER SECTIONS

- A. Provide, supervise and coordinate the installation of components supplied under this Section but installed under other Divisions of the specification
- B. Automatic control valves, thermo-wells, liquid flow switches, and liquid flow sensors are to be installed by Mechanical Contractor.
- C. Automatic control dampers, airflow measuring stations, and duct-mounted airstream sensors and devices to be installed by Mechanical Contractor
- D. Air Terminal Unit (ATU) B-ASC with integral damper operators are to be installed at factory by ATU manufacturer.

1.6 RELATED SECTIONS

Work related to this Section but covered by other Sections include but are not limited to:

- A. “Integrated Automation System Specification”
- B. “Heating, Ventilating and Air-Conditioning Specification”
- C. “Electrical System Specification”
- D. “Lighting Control Systems”

1.7 QUALITY ASSURANCE

- A. The BAS Contractor shall be responsible for inspection and Quality Assurance (QA) for all materials and workmanship provided under this Specification Section.
- B. BAS components shall be manufactured by firms regularly engaged in the manufacture of equipment of the types, sizes and service required.
- C. The BAS Contractor shall be a factory certified contractor specializing and experienced in BAS installations and with experience in networked microprocessor based commercial HVAC, building and enterprise level control systems.
 - 1. BAS Contractor shall maintain a comprehensive service office location within 100 miles of project location prior to bid date and at a minimum until the completion of the warranty period.
- D. The BAS Contractor shall use technicians and application engineers certified by the manufacturer in the installation, configuration, programming and service of the BAS products

- E. The BACnet internetwork shall be based upon the Manufacturer's standard integrated hardware and software product design intent and in accordance with Manufacturer's installation and application documentation.
- F. To the highest extent practical, all BAS equipment of the same type serving the same function shall be identical and from the same manufacturer. All new B-ASC, B-AAC, B-BC, B-OWS software and web-server software shall be the products of a single manufacturer.
- G. The completed and operational BAS shall be in compliance with and meet the requirements of all governing bodies, Authorities Having Jurisdiction (AHJ), applicable local or national standards and codes, except where more stringent or detailed requirements are indicated by the Contract Documents, including the requirements set forth in this Specification and the following:
 - 1. American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE)
 - a. ASHRAE 135-2008: BACnet – Building Automation and Control Networking Protocol
 - 2. National Institute of Standards and Technology (NIST)
 - a. NIST IR 6392 Annex B: Profiles of Standard BACnet Devices
 - 3. Underwriters Laboratories (UL)
 - a. UL 916: Energy Management Systems (EMS)
 - b. UUKL-UL 864: Control Units and Accessories for Fire Alarm Systems
 - 4. Institute of Electrical and Electronic Engineers (IEEE)
 - a. IEEE 142: Recommended Practice for Grounding of Industrial and Commercial Power Systems
 - 5. Electronics Industries Association (EIA)
 - a. EIA-232: Interface Between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange
 - b. EIA-485: Standard for Electrical Characteristics of Generator and Receivers for Use in Balanced Digital Mutli-Point System
 - 6. Federal Communications Commission (FCC)
 - a. Part J: Class "A" Applications

1.8 SYSTEM PERFORMANCE

- A. The system shall conform at a minimum to the following performance standards:
 - 1. Graphics shall display with a minimum of 50 dynamic real-time data points and within 10 seconds of the request
 - 2. The maximum time between the command of a binary object by the operator and the reaction by the device shall be 10 seconds. Analog objects shall start to adjust within 10 seconds of being commanded to change.

3. All changes of state or change of analog values shall be transmitted such that no reporting of a value is more than 15 seconds old.
4. The maximum time from when an object goes into alarm to when it is annunciated at the B-OWS shall not exceed 20 seconds. Those points denoted as critical shall be annunciated within 5 seconds.
5. B-BC, B-AAC, & B-ASC shall be able to execute control loops at a selectable frequency at least 1 time every second. The controller shall scan and update the process value and output generated by this calculation at this same frequency at a minimum.
6. All B-OWS on the network shall receive alarms within 5 seconds of each other.
7. No devices utilizing mercury shall be acceptable for any application
8. Unless noted otherwise in these Specifications, the end-to-end accuracy from sensor to operator interface shall be as noted in Table 1.

Table 1 – System Accuracy	
Measured Variable	Reported Accuracy
Space temperature	+/-0.5 deg C (+/-1 deg F) +/-0.5 deg F
Ducted air	+/-1.0 deg C (+/-2 deg F)+/-0.5 deg F
Outside air	+/-1.0 deg C +/- 0.5 deg F
Water temperature	+/-0.5 deg C (+/-1 deg F)
Delta-T	+/-0.15 deg C (+/-0.25 deg F)
Relative humidity	+/-2% RH 10-90% RH
Water flow	+/-2% of actual value
Air flow (terminal)	+/-10% of actual value (Note 1)+/-5%
Air flow (measuring stations)	+/-2% for calibrated range.
Air pressure (ducts)	+/-25 Pa (+/-0.1 “WG)
Air pressure (space)	+/-3 Pa (+/-0.01 “WG)
Water pressure	+/-1PSI (Note 2)
Electrical Power	±2% of Range (Note 3)
Carbon Monoxide (CO)	+/-5% of Reading
Carbon Dioxide (CO ²)	+/- 50 PPM
Note 1: (10% to100% of scale) (cannot read accurately below 10%)	
Note 2: for both absolute and differential pressure	
Note 3: * not including utility supplied meters	

- a. Overall combined system repeatability of sensors, controllers and readout devices for a particular application shall be plus or minus 2% of full scale of the operating range. Repeatability of overall combined system of sensor, controller and readout device in a control loop application will be plus or minus 5% of full scale of the operating range.
- b. Long-term electronic drift shall not exceed 0.4% per year.

9. The system provided shall be expandable to at least 200,000 hard points without additional database licensing fees, or replacing any devices, software or wiring provided herein.
10. All components provided as part of this system shall operate under ambient environmental conditions of 0°C (32°F) to 40°C (104°F) dry bulb and 10% to 90% relative humidity, non-condensing as a minimum. Sensors and control elements shall operate under the ambient environmental temperature, pressure, humidity, and vibration conditions encountered for the installed location. B-OWS equipment (hardware only), such as CRTs and printers, shall, unless designated otherwise, operate properly under ambient environmental conditions of 7°C (45°F) to 32°C (90°F) and a relative humidity of 10% to 90%.
11. Networked components of the system shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80%.

1.9 SUBMITTALS

- A. Submit under provisions of and pursuant with the Division 15900 Specifications.
- B. All submittals and documentation including complete BAS System Engineering Design Submittal & Drawings, Project Record Documents, Application Engineering Documents and Owner's & Maintenance Manuals shall be submitted electronically in the form of an Adobe Portable Document Format (.pdf). All Control Schematics, Wiring Diagrams, Riser Diagrams, &c. shall be formatted for A3 11" x 17". All other documentation may be formatted for 8.5" x 11".
- C. Submit in writing and so delineated at the beginning of each submittal, known substitutions and deviations from requirements of Contract Documents. Deviation from Contract Documents must be approved by the **UT Health** Energy Management Environmental Controls Systems (EMECS) office prior to submittal.
- D. Complete BAS Engineering Design Submittal & Drawings shall be prepared pursuant with the following guidelines:
 1. Submittal documentation and drawings shall consistently use the same abbreviations, symbols, nomenclature and identifiers. Each control system element shall be assigned a unique identifier pursuant with the Contract Documents
 2. Submittal documentation and drawings shall have at the beginning an Index and Design Drawing Legend.
 - a. Index shall list all design drawings and elements including the drawing number, sheet number, drawing title, etc.
 - b. Legend shall show and describe all symbols, abbreviations and acronyms used on the Design Drawings
- E. Submit the following:
 1. A complete bill of materials of all equipment, controllers, devices and sensors to be provided and/or used indicating unique equipment identifier/tag, unique device/controller identifier/tag, manufacturer and model number.

SECTION 23 06 00
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2. Riser diagram of Building Level Communication Network (BLCN) and Enterprise Level Communication Network (ELCN) shall outline execution and details of all network cabling, BAS & Network Hardware including the following:
 - a. All BAS/DDC Hardware with controller number, unique identifier/tag, location, equipment and service
 - b. All Network Hardware with unique identifier, location and service
 - c. Network cabling configuration and execution specification
 - d. Location of all cabling termination points and End of Line (EOL) terminators
 - e. Location of all network interface jacks
 - f. A separate riser diagram shall be provided for each network segment
3. A schedule of all control valves including the unique equipment identifier/tag, valve size, dimensions and installation/maintenance clearance, model number (including pattern and connections), close-off rating, flow, CV, pressure drop, pressure rating and location. The valve schedule shall also contain actuator selection data supported by calculations of the force required to move, close and seal the valve at design conditions.
4. A schedule of all control dampers. This shall include the unique equipment identifier, unique damper identifier/tag, damper size, pressure drop, blade configuration, orientation and axis of frame, blade rotation, location and selection criteria of actuators, nominal and actual sizes, and manufacturer and model number. The Damper Schedule shall include the AMCA 500-D maximum leakage rate at the operating static-pressure differential.
5. Provide manufacturers cut sheets for major system components. When manufacturer's cut sheets apply to a product series rather than a specific product, the data specifically applicable to the project shall be highlighted or clearly indicated by other means. Include for every BAS component including but not limited to the following:
 - a. Operator Workstation (B-OWS)
 - b. Building Controllers (B-BC)
 - c. Advanced Application Controllers (B-AAC)
 - d. Application Specific Controllers (B-ASC)
 - e. Provide a BACnet Protocol Implementation Conformance Statement (PICS) or BIBB table for each BACnet device type in the submittal.
6. Provide shop drawings and/or manufacturer's standard specification submittal data sheets for all associated BAS equipment, sensors and control devices including unique identifier/tag, manufacturer model number and specific accessories, mounting, &c.
7. Sequence of Operation shall be submitted for every piece of equipment being controlled by and/or associated with the BAS. No operational deviation from specified Sequences of Operation as outlined in Contract Documents shall be permitted without prior written approval. Sequences of Operation shall include and conform to the following:
 - a. Refer to equipment and control devices by their specific unique identifiers/tags pursuant with the Contract Documents and BAS Submittal package.

- b. Clearly represent actual Application Programming methodology and functional control operation. Do not merely provide a copy of Contract Document specified Sequence of Control.
 - c. Include description of functional system operation under normal and failure conditions.
 - 8. BAS Control Schematics and Wiring Diagrams shall be submitted for every piece of equipment being controlled by and/or associated with the BAS. BAS Control Schematics and Wiring Diagrams shall include and conform to the following:
 - a. Control Schematic flow diagram of each system (air, water, gas, & etc.) being controlled showing actual physical configuration and control device/sensor location of all fans, coils, dampers, valves, pumps, heat exchangers, control devices, &c. including each hardware point type, controller and mnemonic.
 - b. Controller termination details showing every controller point termination, type and mnemonic.
 - c. Wiring Diagrams of all packaged equipment, motor starters, relay wiring, equipment interlock, safety circuits, & etc. clearly indicating all interconnecting wiring and termination of all conductors and cables including labels of all cables and point mnemonics.
 - d. Control Enclosure details for every enclosure including panel identifier, location, physical lay-out, dimensions, instrumentation, labels, & etc. Also include detail wiring (I/O, network and power) and power source for each panel, transformer and controller.
- F. Project Record Documents. Upon completion of installation and systems commissioning submit record documents for review. "As-Built" Project Record Documents should include:
 - 1. Project Record Application Engineering Drawings shall include all BAS System Engineering Design Submittal with Drawings updated to reflect actual field conditions, architecture and execution
 - 2. Operating & Maintenance (O&M) Manual including:
 - a. Operator's Manual with Manufacturers' complete operating instructions.
 - b. Programming Manual including:
 - 1) Documentation of all project specific Application and DDC programs
 - 2) All necessary system Administrator-Level passwords and/or required access credentials
 - 3) Information required for programming BAS
 - 4) Complete Final Point Schedule including all hardware and software data points and documentation of calibration and configuration values for all Inputs, Outputs, Variables and PID Loops at the conclusion of systems commissioning and functional testing.

- 5) Routine preventative maintenance procedures, corrective diagnostic troubleshooting procedures and calibration processes
 - 6) Final Bill of Material with all installed parts, manufacturers, manufacturers' part numbers and ordering information
 - 7) A schedule of recommended spare parts with part numbers and supplier
- c. Complete system database as functional at the conclusion of systems commissioning and functional testing including all graphics and images used by and/or created for BAS on electronic format as accepted by Owner.

1.10 CALIBRATION, COMMISSIONING, DEMONSTRATION AND ACCEPTANCE

A. Calibration and Commissioning

1. As a part of this contract, the BAS Contractor shall fully commission the entire BAS. All commissioning shall be fully documented and all documentation shall be submitted prior to Demonstration and Acceptance testing. Commissioning shall include a "point-to-point" check-out of the following at a minimum:
 - a. Verify that all Temperature Control Panels (TCP), BAS equipment, controllers, devices and sensors are installed and operational according to the specifications, submittals and manufacturer's installation and application instructions
 - b. Test, calibrate and bring on-line every control device
 - c. Calibrate all inputs by comparing the actual site condition with the B-OWS point display.
 - d. Verify all outputs from B-OWS command to observed response of controlled device.
 - e. Verify failure response and fail-safe conditions of all devices and safeties
 - f. Each control program shall be fully commissioned and tested for complete design intent compliance and functionality
 - g. Verify overall network performance of BAS for complete design intent compliance and functionality with all devices on-line, communicating and fully-operational
 - h. Subsystems not directly controlled by the BAS but associated with the ATC shall also be fully tested and commissioned as to design intent compliance and functionality

B. Demonstration and Acceptance

1. As a part of this contract, the BAS Contractor shall demonstrate compliance of the BAS with the contract documents and operational functionality pursuant with the design Sequences of Operation. Using the documented calibration and commissioning test data the Owner and/or his representative shall select, at random, results to be demonstrated. At least 95% of the results demonstrated must perform as specified and documented on commissioning data sheets or the system must be re-calibrated and re-commissioned before being re-tested.

2. When the Calibration, Commissioning, Demonstration and Acceptance process has been completed and approved by Owner, Contractor shall be provided with signed letter from Owner indicating Acceptance within ten (10) days of approval.

1.11 TRAINING

- A. As a part of this contract, the BAS Contractor shall provide instruction on the adjustment, operation and maintenance of the BAS as installed including all hardware and software provided by a manufacturer-trained, competent application engineer and/or technician with sufficient experience in the installation, programming and operation of the BAS. All training equipment and material shall be provided by this Contractor.
- B. Training shall be scheduled within thirty (30) days of BAS Acceptance and shall consist of a 1-day operational training program for up to 4 operators at the discretion of the owner. A training day shall be defined as an 8-hour day of instruction Monday through Friday during regular working hours, including two (2) 15-minute breaks and excluding lunchtime and travel.
- C. 1 day of on-site training shall cover the entire execution of the complete BAS and components. Training shall be performed on the Owner's ATC/BAS and shall include:
 1. Location of all TCP's, Control Enclosures, controllers, devices, sensors, &c.
 2. Equipment Layout
 3. Sequences of Operation
 4. Maintenance and Repair
 5. Troubleshooting
 6. Preventative Maintenance
 7. Sensor Calibration
 8. Proper Use of Service Tools and Materials
- D. At the discretion of the Owner, on-site training and installed system demonstration sessions may be video-taped
- E. Instructor shall provide one (1) copy of training materials for each attendee at the time of the training. Two additional copies of training materials shall be provided to Owner at time of training at the request of the Owner for archival. Training materials shall include:
 1. Agenda
 2. Defined objectives for each lesson
 3. Copies of audio-visuals and/or Power Point Presentations

1.12 WARRANTY, MAINTENANCE, NORMAL AND EMERGENCY SERVICE

- A. BAS manufacturer shall warranty all DDC controllers to be free of defect in material and workmanship under normal operation and expected service as published by the manufacturer in the unit's performance specifications for a period of five (5) years at a minimum.

1. BAS manufacturer shall warranty all DDC controller on-board integral carbon dioxide (CO2) sensing elements to be free of defect in material and workmanship under normal operation and expected service as published by the manufacturer in the unit's performance specifications for a period of two (2) years at a minimum
 2. BAS manufacturer shall warranty all DDC controller on-board integral relative humidity (RH) sensing elements to be free of defect in material and workmanship under normal operation and expected service as published by the manufacturer in the unit's performance specifications for a period of one (1) year at a minimum
- B. As a part of this contract, the BAS Contractor shall warranty all other components of the BAS and installation to be free of defects in workmanship and material under normal expected service and use for a period of one (1) year from the date of final acceptance of the BAS by the Owner.
- C. During the installation warranty period the Contractor shall provide all labor and materials required to repair or to replace all items or components that fail due to defects in workmanship or manufacture at no charge or reduction in service to the Owner.
- D. Except in the event of property loss or damage, warranty service shall be provided during regular working hours Monday through Friday at no charge unless otherwise explicitly outlined in the Contract Documents.
1. Emergency service performed outside of these parameters shall be performed for charge by BAS Contractor according to the provisions set forth in the Contract Documents.

PART 2 – PRODUCTS

2.1 ACCEPTIBLE MANUFACTURERS

- A. ,
- B.

Johnson Controls (Johnson Controls Inc.)
Chase Belamowicz

2.2 BACnet WEB SERVER

- A. The WEB Server Hardware shall comply with the following:
1. Operating System: Microsoft Windows Server 2003 Standard Edition or Microsoft Windows Server 2008 Standard Edition
 - a. Where multiple simultaneous user access is not required, hardware platform may alternately be at a minimum Microsoft Windows XP Professional SP2 or Vista
 2. Processor: Pentium Quad Core 2 GHz
 3. Memory: 2GB
- B. The WEB Server Database shall comply with the following:

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1. Complete controller database of each B-BC, B-AAC, and B-ASC shall reside (at a minimum) within the respective device. The Web Server Hardware may retain and utilize a backup of the database within each device; however, the complete and original database must reside in the B-BC, B-AAC, and B-ASC.
- C. The WEB Server Software shall comply with the following:
1. Provide licensed copy of the Control System WEB Enabled Application Software described in Section 2.4. This license shall allow unlimited isolated systems to be served, and access by an unlimited number of users.
 2. The Owner shall sign a copy of the manufacturer's standard software and firmware licensing agreement as a condition of this contract. Such license shall grant use of all programs and application software to Owner as defined by the manufacturer's license agreement, but shall protect manufacturer's rights to disclosure of trade secrets contained within such software.
 - a. Manufacturer's Standard Software and Firmware licensing agreement shall be executed by Owner in writing prior to software acquisition and/or installation

2.3 WEB ENABLED APPLICATION SOFTWARE

- A. The WEB Enabled Application software and Graphical User Interface (GUI) is to be stored on the WEB hard disk drive server. WEB Enabled Applications that require system graphics to be stored on the client machines will not be acceptable. The application shall support unlimited access by 5 simultaneous clients using standard Web browser such as Internet Explorer.
- B. The WEB enabled application shall perform native BACnet communications directly to all BACnet devices on the BACnet internetwork. Applications that require translation of data, gateways, or mapping of any kind shall not be acceptable.
- C. The WEB Enabled Application shall provide the same methodology as the B-OWS application when viewing the BACnet Internetwork in terms of network architecture, system graphics, calendars, logs, etc. Systems utilizing Web Enabled Applications and Control Operator Workstation Applications of different manufacturer shall implement both applications so that the methodology is the same. Control Systems that utilize different methodology between the WEB Enabled Application and the Control System Operator Workstation Application for network architecture views, system graphic presentation or request, object, schedule or alarm interaction will not be acceptable.
- D. Real-time values displayed on a Web page shall update automatically without requiring a manual "refresh" of the Web page.
- E. Users shall have administrator defined access privileges. Depending on the access privileges assigned, the user shall be able to utilize those features described herein at different levels of interface varying between View only and Modify.
- F. HTML programming shall not be required to create or display system graphics or data on a Web page.

- G. A new point displayed on a B-OWS graphic screen shall appear automatically on the identical graphic screen served by the web-server with no further programming or file transfer required.
- H. The WEB Enabled Application shall support via the Web Browser client the following as it is described in the Control System Operator Workstation Application as a minimum:
 - 1. Password Protection
 - 2. Alarming and Event Notification
 - 3. Weekly, Annual and Special Event Exception Scheduling
 - 4. Trend Log Graphing, and the capability to export in ASCII and Microsoft Excel format
 - 5. Runtime Log Information
 - 6. Ability to Manually Override any Database point
 - 7. Ability to Adjust any Setpoint
- I. The WEB Enabled Application shall support via the Web Browser client the following in addition to what is described above:
 - 1. Color Graphical User Interface (GUI)
 - a. All color graphic displays shall be dynamic with current point data automatically updated from the BACnet internetwork to the browser without operator intervention. Manual operator intervention shall use the same methodology as on the B-OWS application.
 - b. Depending upon configured access level; the operator shall be able to manually adjust digital, analog or calculated values in the system, adjust values of control loops, override points or release points to automatic mode.
 - 2. System Graphic screens developed for the B-OWS shall be the same image file used for the Web Browser Client. Systems, which require special translation or re-export of graphics to accommodate the web domain, will not be accepted. The Web Browser client shall support any System Graphic animation supported by the B-OWS. System Graphic screens on the Web Browser client shall support hypertext links to other location on the Internet or on Intranet sites by specifying the Uniform Resource Locator (URL) for the desired link.
- J. The WEB Enabled Application shall provide the capability to create a user's (as determined by the log-on user identification) home page. Provide the ability to limit a specific user to a defined home page. From the home page, links to other views, or pages in the system shall be possible, if allowed by the system administrator.
- K. The WEB Enabled Application shall include an Audit Trail feature that automatically records the time, date, and user, and action associated with all user changes made via Web Browser clients.
- L. The WEB Enabled Application shall store complete help files describing system configuration, and use of the Browser Client interface, The help files shall be served on-line as part of the Browser Client interface. Creation, storage and serving of custom-made help files by the owner shall be possible, in lieu of the manufacturer's help files.

2.4 OPERATORS WORKSTATION PLATFORM (B-OWS) (I'm guessing that workstation would need be approved by IT)

- A. Provide as specified herein complete all associated Operating System, Operators Workstation Application Software and Third-Party Software Applications preloaded and configured
- B. Local Operators Workstation (B-OWS) shall be PC-based desktop workstation. Common BAS database and graphic files shall be stored on workstation designated and acting as the system server. Workstation Hardware minimum requirements are as follows:
 - 1. Intel Pentium IV 3 GHz Processor
 - 2. 2 GB RAM
 - 3. 10 GB or larger hard disc drive with 12 millisecond access time
 - 4. 16x DVD+/-RW
 - 5. 22" Flat Panel LCD Monitor and 128 MB high performance graphics adapter with a minimum resolution performance of at least 1680 x 1050.
 - 6. Tower case with at least two spare drive slots and 3 spare board slots.
 - 7. At least one (1) Ethernet 10/100 Network Interface Card (NIC)
 - 8. At least four (4) USB 2.0 ports
 - 9. Enhanced style keyboard with 101 key layout, 10 function keys, numeric keypad and separate cursor control pads.
 - 10. Two button mouse with adjustable sensitivity and desk pad.
 - 11. All necessary cables
 - 12. A combination surge suppressor/UPS dedicated to this server and printer.
 - 13. Provide an integral audio tone generator to activate on detection of an alarm. Audio tone shall be capable of being enabled or disabled on operator command.
- C. Remote Operators Workstation (Remote B-OWS) shall be PC-based desktop workstation. Workstation Hardware minimum requirements are as follows:
 - 1. Remote B-OWS shall have the same hardware and software configuration and requirements of the B-OWS
- D. Portable Operators Workstation (Portable B-OWS) shall be notebook computer workstation. Portable Workstation Hardware minimum requirements are as follows: (I assume the laptop would need to be approved by IT)
 - 1. Intel Pentium IV 2 GHz Processor
 - 2. 1 GB RAM
 - 3. 10 GB or larger hard disc drive with 12 millisecond access time
 - 4. 8x DVD+/-RW
 - 5. 14.1" Flat Panel LCD Monitor and 128 MB high performance graphics adapter with a minimum resolution performance of at least 1280 X 800

6. At least one (1) Ethernet 10/100 Network Interface Card (NIC)
 7. At least four (4) USB 2.0 ports
 8. 87 key keyboard with touchpad and track stick pointing devices
 9. All necessary cables
 10. Provide an integral audio tone generator to activate on detection of an alarm. Audio tone shall be capable of being enabled or disabled on operator command.
- E. Communications and Protocols
1. B-OWS information access for the control system shall utilize the BACnet protocol only for communication to B-BC's, B-AAC's, B-ASC's and all other BAS DDC controllers
 2. B-OWS shall reside on the same LAN as B-BC's. B-OWS shall as a minimum support point-to-point (PTP) and BACnet/IP physical/data link layer protocols.
 3. The B-OWS specified here may, at the Owner's option, be located remote from the BACnet internetwork. Other than the difference in B-OWS communication speed, the system shall be capable of remote operation via BACnet LAN types with no degradation in application performance.
- F. B-OWS Operating System (OS) Software shall be consistent on all B-OWS hardware platforms provided.
1. The B-OWS hardware platform OS shall be Microsoft Windows XP Professional Service Pack 2 or newer or Microsoft Windows Vista Business
- G. B-OWS Application Software shall be provided and licensed to Owner. Provide latest versions of software available as follows at a minimum:
1. One (1) Copy of Microsoft Office 2007 Basic
 2. Adobe Acrobat 9.0 Standard

2.5 CONTROL SYSTEM OPERATORS WORKSTATION APPLICATION SOFTWARE

- A. The B-OWS Software shall be provided, licensed and installed on at least one B-OWS Platform. If more than one Platform is provided a licensed copy of the B-OWS Software shall be provided for every Platform.
- B. The Owner shall sign a copy of the manufacturer's standard software and firmware licensing agreement as a condition of this contract. Such license shall grant use of all programs and application software to Owner as defined by the manufacturer's license agreement, but shall protect manufacturer's rights to disclosure of trade secrets contained within such software.
1. Manufacturer's Standard Software and Firmware licensing agreement shall be executed by Owner in writing prior to software acquisition and/or installation
- C. The B-OWS Software shall be BTL listed as either a B-OWS or B-AWS.
- D. Password Protection
1. Multiple-level password access protection shall be provided.

2. Passwords shall be exactly the same for all software applications provided to communicate with the internetwork.
3. A minimum of 10 levels of access shall be supported with a configurable matrix of operator actions allowed for each access level, broken down into at least 200 possible operator actions
4. A minimum of 50 passwords shall be supported at each B-OWS.
5. Operators will be able to perform only those commands available for their respective passwords.
6. User-definable, automatic log-off timers of from 1 to 60 minutes shall be provided to prevent operators from inadvertently leaving B-OWS in an unsupervised logged-in state.

E. Alarming and Event Notification

1. B-OWS shall utilize BACnet Alarm Events and PICS shall support at a minimum the following BIBBs:
 - a. Alarm and Event – Acknowledge-A (AE-ACK-A)
 - b. Alarm and Event – Notification-A (AE-N-A)
 - c. Alarm and Event – Alarm Summary View-A (AE-AS-A)
 - d. Alarm and Event – View and Modify-A (AE-VM-A)
 - e. Alarm and Event – View Notifications-A (AE-VN-A)
2. B-OWS terminal shall provide audible, visual, and printed means of alarm and event notification
3. System shall provide log of notification messages. Complete Alarm log of all system and operator transactions shall be archived to the hard disk of the system B-OWS.
4. Alarm messages shall be in user-definable text (English or other specified language) and shall be entered either at the B-OWS terminal or via remote communication.
5. An alarm summary shall be available to show all alarms whether including but not limited to whether or not they have been acknowledged.
6. System shall provide ability to prioritize and differentiate communications for at least 20 different levels of alarms
7. Alarm messages shall be fully customizable in size, content, behavior and sound.

F. Weekly Annual and Special Event Scheduling

1. B-OWS Software shall utilize BACnet Schedules and PICS shall support at a minimum the following BIBBs:
 - a. Scheduling – Advanced View and Modify-A (SCH-AVM-A)
2. Provide ability to view and modify the schedule for the calendar week and up to 255 special events in a graphical format. Each calendar day and special event shall provide at least six time/value entries per day.

3. Provide the ability for the operator to select scheduling for either binary, analog, or multi-state object values.
4. Provide the ability for the operator to designate days, date ranges, or repeating date patterns as exception schedules.
5. Provide the capability for the operator to define special or holiday schedules and to link the BACnet schedule to a BACnet calendar, thereby over-riding weekly schedule programming on holidays defined in the BACnet calendar.
6. There shall be a provision with proper password access to manually override each schedule.
7. Provide the capability to designate any exception schedule to be “Executed Once” then automatically cleared.
8. Provide the ability to name each exception schedule with a user defined term to describe each special event.

G. Trend Log Graphing

1. B-OWS Software shall allow viewing of BACnet Trend Logs and PICS shall support at a minimum the following BIBBs:
 - a. Trending – View-A (T-V-A)
2. All data points (both hardware and software) system-wide shall be assignable to a historical trending program by gathering configurable historical samples of object data stored in the local controller (B-BC, B-AAC, B-ASC).
3. All trend log information shall be displayable in text or graphic format. All information shall be able to be printed in black & white or color and exported directly to a Microsoft Excel Spreadsheet.
4. Long-term archives shall be automatically stored on the B-OWS platform or automatically stored onto a dedicated machine or server using an SQL database data acquisition service. The B-OWS and/or SQL Database Application shall perform the following at a minimum:
 - a. Be capable of automatically retrieving any trend-log from any device on the network without user-intervention
 - b. Manage connection to internetwork automatically based upon configurable data acquisition thresholds; retrieving data only when necessary rather than streaming data
 - c. Generate standard, secure SQL database accessible by third-party applications
 - d. Shall operate as a Microsoft Windows service
 - e. Archived data shall be limited only by SQL license and hard disk space available
 - f. Be capable of exporting data directly to Microsoft Excel

- b. All color graphic displays shall be dynamic with current point data automatically updated from the BACnet internetwork to the B-OWS workstation without operator intervention.
 - c. The operator shall be able to manually adjust all data point values (hardware or software) in the system, adjust values of control loops, and command points to local mode or release points to automatic mode.
 - d. The windowing environment of the B-OWS shall allow the user to simultaneously view several graphics at the same time to analyze total building operation, and/or to allow the display of a graphic associated with an alarm to be viewed without interrupting work in progress.
 - e. Pre-packaged animations for display of fans, pumps, dampers, etc., and shall allow custom user-created .swf and .gif animations to be used to display objects on graphic displays.
 - f. The contractor shall submit all new graphics to **University of Houston** for approval.
- K. The BAS shall be provided with fully automatic diagnostic procedures for verification of internetwork communication. In the event of communications failure, the system shall automatically Alarm the condition. B-OWS Software shall be capable of remote annunciation to printer, pager and e-mail
- L. Control Summaries, Reports and Logging:
- 1. The system shall provide self-documentation reporting to summarize control strategies for any point or any user selected group of points within the Control System.
 - 2. The B-OWS reporting package shall allow the user to configure the point information display in custom format.
 - 3. The B-OWS shall enable operator to perform Wild Card data point sorting and searches
 - 4. The B-OWS shall perform automated network back-up of runtime databases in all devices on the BACnet network according to operator configurable schedule and storage directory structure

2.6 BUILDING CONTROLLERS (B-BC)

- A. B-BC shall comply with all aforementioned BAS System Requirements and shall comply with the BACnet profile for Building Controllers (B-BC)
- B. Furnish B-BC(s) as necessary to control large point count major mechanical equipment, and execution of BAS global strategies, and as noted in the execution portion of this specification.
 - 1. Each Mechanical System and/or major piece of Mechanical Equipment (e.g., Chilled Water, Heating Water, Large AHU, etc.) shall have one (1) dedicated DDC controller with sufficient I/O capacity such that it shall be connected to ALL field devices and sensors associated with that system and/or piece of equipment. Distributed control of one (1) single piece of major mechanical equipment shall not be performed by multiple controllers.

2. Each B-BC shall support local hardware Inputs and Outputs (I/O) by the use of on-board I/O and/or I/O expansion modules.
- C. B-BC shall be capable of locally executing global strategies for the BAS based on information from any object in the internetwork. Control Systems that require a higher-level host processor for update, time stamps, global point data, COS transfer, on-line control instruction, or communications control between B-BC panels shall not be acceptable.
- D. BAS shall communicate with all B-OWS, B-BC, B-AAC & B-ASC on a peer-to-peer basis, and shall provide real-time clock functions for scheduling and network-wide time synchronization
- E. B-BC shall have sufficient memory to support its operating system, database, and programming requirements. Battery/capacitor shall retain static RAM memory and clock functions for a minimum of 72 hours.
1. B-BC operating system, field database, and application programs shall reside in EEPROM.
 2. B-BC run-time field database and application programs shall reside in battery backed-up on-board memory or EEPROM.
- F. B-BC shall comply with the following Hardware Configuration:
1. B-BC shall have integral power switch. If the device manufacturer provides no on-board switch then the System Contractor shall provide a separate dedicated transformer and switch within each enclosure for each controller present
 2. B-BC shall provide diagnostic LEDs for power, communications and processor status. The B-BC shall continually check the status of its processor and memory circuits
 3. Controller wiring terminals shall be removable terminal strips for ease of installation and service replacement
 4. All hardware inputs shall be Universal (i.e., binary or analog) configured on hardware and/or in software.
 - a. Inputs shall accept dry-contact, thermistor, 4-20 mA, and 0-5VDC
 - b. Pulse accumulation shall accommodate a maximum frequency of 40Hz
 - c. Inputs shall have a minimum 10 Bit A/D conversion resolution
 - d. 24VAC over-voltage protection
 - e. Proportional voltage/brightness status LED indicators for each input
 5. All hardware outputs shall be Universal and configured on hardware and/or in software.
 - a. Outputs shall provide configurable modulating voltage signal to industry standard 0-5VDC and 0-10VDC analog control devices and relays
 - b. Outputs shall be capable of sourcing 75mA at 12VDC
 - c. Outputs shall have a minimum 8 Bit D/A conversion resolution
 - d. 24VAC over-voltage and short protection

- e. On-board integral physical Hand-Off-Auto (H-O-A) Switch for every output. H-O-A switch position shall be monitored and displayed by B-BC.
 - 1) In addition to H-O-A switch, Universal Outputs shall be provided with on-board integral potentiometer for manual adjustment of analog modulating voltage signal in conjunction with the Hand position
 - f. Proportional voltage/brightness status LED indicator for each output
- G. B-BC shall interact with the Control System Application Software in compliance with the following:
- 1. Database programming, configuration and modification shall be accomplished through the B-OWS online with the B-BC. The complete database and application program shall reside in the B-BC. The System Contractor shall configure the software to attain the proper sequence of control and to accomplish all other control system functions indicated in the Contract Documents.
 - 2. The B-BC shall function in a real-time, multi-tasking networked operating environment; able to display database values, programs, and control loops in real-time while functional and online using the B-OWS. The user shall be able to add, delete, or modify objects on-line as required without taking the B-BC offline. The programming shall provide all the necessary mathematics, logic, utility and control functions necessary to execute the specified sequence of control.
 - 3. All required application programming shall be resident in the B-BC, B-AAC & B-ASC, and third party BACnet devices, and not in the B-OWS.
 - 4. B-BC shall manage system-wide alarms by performing distributed, independent alarm analysis and filtering. At no time shall the B-BC panel's ability to report alarms be affected by either operator activity at a B-OWS or local I/O device, or communications with other B-BC on the network.
 - a. B-BCs shall have capability to broadcast alarm conditions automatically across the BLCN. Alarm Event notifications shall be sent to off-site computer or serial printer. A minimum of one B-BC per site shall be capable of sending SMTP email messages to an email server for configured alarm conditions.
 - b. Active Alarm Events log shall be stored on the B-BC and may be viewed locally or remotely.
 - c. All alarm or point change reports shall include the point's English language description, and the time and date of occurrence.
 - d. The user shall be able to define the specific system reaction for each point alarm and shall be able to customize reaction and filtering to minimize nuisance reporting. Each B-BC panel shall automatically inhibit the reporting of selected alarms during the standby power modes of operation, loss of power, fire alarm mode, and normal system shutdown and start-up. Users shall have the ability to manually inhibit alarm reporting for each point.
 - e. Alarm reports, messages, and files can be directed to a user-defined list of operator devices, or PCs used for archiving alarm information.

5. B-BC shall perform and manage historical data collection. Minimum sampling time shall be configurable with a minimum sample rate of once per second.
 - a. B-BC panels shall store point history files for all analog and binary inputs and outputs.
 - b. Measured and calculated analog and binary data shall also be assignable to user-definable trends.
 - c. Up to six points of any type can be assigned to a single trend log
 - d. Trend data shall be stored at the stand-alone B-BC panels, and uploaded to hard disk storage automatically at preconfigured intervals when archival is desired. Separate archival application software will be accepted.
6. Stand-alone B-BC panels shall automatically accumulate and store runtime hours for binary input and output points.
7. B-BC panels shall automatically sample, calculate and store consumption totals on a daily, weekly, or monthly basis for user-selected analog and binary pulse input-type points.
8. B-BC panels shall have the ability to count and/or execute events on a daily, weekly, or monthly basis.

H. Communication and Protocols

1. The B-BC shall continuously scan the BACnet network and maintain a current database of field data in on board battery/capacitor backed RAM or EEPROM, including alarms, passwords, binding tables, device status, etc. The B-BC shall communicate with BACnet devices on the BLCN using the BACnet physical data link MS/TP at a baud rate of 76.8 Kbps where not limited by third party BACnet devices such as drives, utility meters, ect.
2. The B-BC shall provide a communications port for connection of the Portable Operators Terminal using Point-to-Point BACnet physical data link layer protocol or a connection to the network using BACnet/IP.
3. B-BC shall support and be capable of monitoring and controlling a network of communicating remote space sensors. These networked sensors shall not consume input/output hardware points in the B-BC.
4. Provide all functions that will allow remote communications via modem to off-site locations. Include modem along with all cabling necessary for installation.
5. B-BC shall support at a minimum of two (2) distinct dedicated BACnet/IP (B/IP) data link networks using TCP/IP and one (1) BACnet/Ethernet data link network simultaneously
6. B-BC shall support integral communication using Modbus RTU and TCP protocols as both a Slave and Master for building systems third-party integration.
7. B-BC shall support SMTP and provide stand-alone remote annunciation of alarms via e-mail without additional hardware, B-OWS, or web-server.

8. B-BC shall support, transmit, and receive of segmented messages.

2.7 ADVANCED APPLICATION CONTROLLERS (B-AAC)

- A. B-AAC shall comply with all aforementioned BAS System Requirements and shall comply with or exceed the BACnet profile for Advanced Application Controllers (B-AAC).
- B. Furnish one dedicated B-AAC(s) for each small or medium sized mechanical system, as noted in the execution portion of this specification. Each B-AAC shall acquire, process, and store point input data on a real time basis for internal use and for sharing with other controllers. Each B-AAC shall also maintain and supervise digital and analog output signals to the control devices and have a real time operating system capable of time of day scheduling and other time based functions.
 - 1. If the hardware point requirements of any medium-sized system should exceed the I/O configuration of available B-AAC offerings then a B-BC must be used. Control of one piece of mechanical equipment may not performed by more than one controller.
- C. B-AAC shall provide microprocessor based self-contained stand-alone fully programmable operation of local process control loops. All local level application programs shall be installed on individual controllers in non-volatile memory.
- D. Each B-AAC shall be capable of sharing point information with other B-BC, B-AAC, or B-ASC on a peer-to-peer basis via the BACnet BLCN.
- E. Control systems that utilize 'canned' programs or programmable read only memory (PROM) level application programming are not acceptable.
- F. Once downloaded, a B-AAC shall not require further communication with the B-OWS except for data base changes, operator commands, and requests from the B-OWS for B-AAC data. Programming of B-AACs shall be completely modifiable in the field, over the installed BACnet network or remotely via the internet.
- G. Each B-AAC shall be provided with the ability to prevent unauthorized access to its software program.
- H. B-AAC shall have sufficient memory to support its operating system, database, and programming requirements.
 - 1. B-AAC operating system, field database, and application programs shall reside in EEPROM.
- I. B-AAC run-time field database and application programs shall reside in on-board memory or EEPROM.
- J. B-AAC shall feature real-time 24-hour clock and 365-day calendar. Battery or capacitor back-up of these functions is required where the B-AAC is installed as a standalone controller.
- K. B-AAC shall be designed for wall-mounting to a single or double-device box in the space
- L. B-AAC shall include on-board integral LCD User Interface for display and modification of local and/or networked BAS data points as follows:
 - 1. LCD screen shall be a minimum of 128 x 64 pixels in a viewable area no smaller than 62mm x 44mm (2.4" x 1.7")

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2. LCD screen shall feature back-lighting configurable for constantly lit or user-defined time out periods with user-adjustable contrast
 3. B-AAC shall feature push-buttons on the face of the controller for user navigation of the local display screens and for entering values and overriding points.
 4. LCD interface shall be capable of displaying and acknowledging local Alarms
 5. LCD interface shall provide as a minimum eight (8) configurable display screens each capable of displaying a minimum of six (6) local and/or networked data points
 - a. All displayed data points shall be configurable as display only or capable of being modified via the interface
 - b. Display shall support at a minimum three (3) user-defined password-protected security permission levels restricting read/write privileges of all displayed data points
 - c. Ability to edit the annual and weekly schedules from the display
- M. B-AAC shall feature a software configurable audible enunciator which shall be configured to trigger on the occurrence of selected alarms, and shall be audible and acknowledgeable either to all users, or only to those users with sufficient password authority.
- N. B-AAC shall comply with the following Hardware Configuration:
1. B-AAC shall provide diagnostic LEDs for power, communications and processor status. The B-AAC shall continually check the status of its processor and memory circuits
 2. Universal field device hardware inputs shall be provided and configured on hardware and/or in software and comply with the following:
 - a. Inputs shall accept dry-contact, thermistor, 4-20 mA, and 0-5VDC
 - b. Pulse accumulation shall accommodate a maximum frequency of 100Hz
 - c. Inputs shall have a minimum 10 Bit A/D conversion resolution
 - d. 24VAC over-voltage protection
 3. In addition to field device Hardware inputs, the B-AAC shall feature the following on-board integral hardware inputs at a minimum:
 - a. Temperature sensor (local or remote)
 - 1) 10k Thermistor
 - 2) 0°C to 40°C (32°F to 104°F) range
 - 3) +/- 0.1°C (+/- 0.18°F) resolution
 - 4) User calibrated +/- 0.1°C (+/- 0.18°F)
 - b. Setpoint Adjustment Slider
 - 1) 20k potentiometer
 - 2) Range defined, limited and configured via Application Software

- c. Relative Humidity (RH)
 - 1) 10% – 90% range
 - 2) 0.1% resolution
 - 3) +/- 2% accuracy
 - 4) Replaceable sensing element
 - 5) User calibrated as necessary
 - d. Occupancy
 - 1) Passive Infrared Radiation (PIR)
 - 2) 5m/16.4' detection distance
 - 3) 100° horizontal / 82° vertical detection
 - 4) 64 detection zones
 - e. Carbon Dioxide (CO2)
 - 1) 0 – 2000ppm
 - 2) +/- 30ppm Accuracy
 - 3) Auto-Drift Calibration
4. Hardware Outputs shall be configured as to be modular in nature and support the following characteristics:
- a. Universal Output
 - 1) 0 – 12 VDC @ 75 mA
 - 2) Digital or Analog functional operation
 - b. Single Stage Relay
 - 1) SPDT Form C Dry Contact
 - 2) Minimum 0.5 A @ 24 VAC/VDC Contact Rating
 - 3) NO/NC Selectable
 - c. Single Stage TRIAC
 - 1) Single NO Contact for Switching AC Loads
 - 2) Minimum 0.5 A @ 24 VAC/VDC Contact Rating
 - 3) Minimum Switching Current of 20 mA
5. Universal hardware outputs shall be provided and configured on hardware or in software and comply with the following:

- a. Universal Outputs shall provide configurable modulating voltage signal to industry standard 0-5VDC and 0-10VDC analog control devices and relays
 - b. Outputs shall be capable of sourcing 75mA at 12VDC
 - c. Outputs shall have a minimum 8 Bit D/A conversion resolution
 - d. 24VAC over-voltage and short protection
- O. Control System Application Software:
1. The B-AAC application software shall be the same as and indistinguishable from the B-BC specified interaction with the Control System Application Software.
 2. The controller software shall reside in a real time, multi-tasking, networking operating environment. Database definition shall be accomplished through the B-OWS online with the B-AAC. The complete database and application program shall reside in the B-AAC. The System Contractor shall configure the software to attain the proper sequence of control and to accomplish all other control system functions indicated in the Contract Documents.
 3. The user shall be able to add, delete, or modify objects on-line as required. The programming shall provide all the necessary mathematics, logic, utility and control functions necessary for proper sequence of control.
- P. Communications and Protocols
1. The B-AAC shall communicate with field devices and controllers on the BLCN using the BACnet physical data link MS/TP at 76.8 Kbps where not limited by third party devices such as variable speed drives, utility meters, ect.
 2. The B-AAC shall provide a communications port for connection of the Portable Operators Terminal using Point-to-Point BACnet physical data link layer protocol or a connection to the network.
 3. B-AAC shall support and be capable of monitoring and controlling a network of a minimum of four (4) communicating remote space sensors. These networked sensors shall not consume input/output hardware points in the B-AAC.
- Q. B-AAC shall perform and manage historical data collection. Minimum sampling time shall be configurable with a minimum sample rate of once per second.
1. B-AAC panels shall store point history files for all analog and binary inputs and outputs.
 2. Measured and calculated analog and binary data shall also be assignable to user-definable trends.
 3. Up to six points of any type can be assigned to a single trend log.
 4. Trend data shall be stored at the stand-alone B-AAC panels, and uploaded to hard disk storage automatically at preconfigured intervals when archival is desired. Separate archival application software will be accepted.
- R. Stand-alone B-ASC panels shall automatically accumulate and store runtime hours for binary input and output points.

- S. B-ASC panels shall automatically sample, calculate and store consumption totals on a daily, weekly, or monthly basis for user-selected analog and binary pulse input-type points.
- T. B-ASC panels shall have the ability to count and/or execute events on a daily, weekly, or monthly basis.
- U. B-AAC shall support, transmit, and receive of segmented messages.

2.8 APPLICATION SPECIFIC CONTROLLERS (B-ASC)

- A. B-ASC shall comply with all aforementioned BAS System Requirements and shall comply with the BACnet profile for Application Specific Controllers (B-ASC).
- B. Provide one dedicated B-ASC for each Terminal Unit Mechanical Device on the project. Those include Variable Air Volume (VAV) Air Terminal Units (ATU), Serial and Parallel Fan-Powered (FP) VAV ATU's, Unit Heaters (UH), Unit Ventilators (UV), Fan Coil Units (FCU), Roof-Top Units (RTU) and Individual Fans. Terminal Units specifically called out in the sequence of operation, as "Non-DDC" shall be excluded from this requirement.
- C. B-ASC shall provide microprocessor based self-contained stand-alone fully programmable operation of local process control loops. All local level application programs shall be installed on individual controllers in non-volatile memory.
- D. Each B-ASC shall be capable of sharing point information with other B-BC, B-AAC, or B-ASC on a peer-to-peer basis via the BACnet BLCN.
- E. Control systems that utilize 'canned' programs or programmable read only memory (PROM) level application programming are not acceptable.
- F. Once downloaded, a B-ASC shall not require further communication with the B-OWS except for data base changes, operator commands, and requests from the B-OWS for B-ASC data. Programming of B-ASCs shall be completely modifiable in the field, over installed BACnet Internetwork or remotely via modem.
 1. Each B-ASC shall be provided with the ability to prevent unauthorized access to its software program.
 2. B-ASC shall have sufficient memory to support its operating system, database, and programming requirements.
 3. B-ASC operating system, field database, and application programs shall reside in EEPROM.
 4. B-ASC run-time field database and application programs shall reside in on-board memory or EEPROM.
- G. ASC shall perform and manage historical data collection. Minimum sampling time shall be configurable with a minimum sample rate of once per second.
 1. B-ASC panels shall store point history files for all analog and binary inputs and outputs.
 2. Measured and calculated analog and binary data shall also be assignable to user-definable trends.
 3. Up to six points of any type can be assigned to a single trend log.

4. Trend data shall be stored at the stand-alone B-ASC panels, and uploaded to hard disk storage automatically at preconfigured intervals when archival is desired. Separate archival application software will be accepted.
- H. Stand-alone B-ASC panels shall automatically accumulate and store runtime hours for binary input and output points.
- I. B-ASC panels shall automatically sample, calculate and store consumption totals on a daily, weekly, or monthly basis for user-selected analog and binary pulse input-type points.
- J. B-ASC panels shall have the ability to count and/or execute events on a daily, weekly, or monthly basis.
- K. B-ASC for VAV ATU's application shall comply with the following:
 1. B-ASC shall be provided with integral damper actuator. Actuator shall feature the following at a minimum:
 - a. 35 in-lbs of torque
 - b. Brushless DC Operator
 - c. Actual damper position feedback. Drive time or other software calculated damper position shall not be accepted
 - d. Damper End Switch using motor current sense or equivalent for positive feedback of both end stop positions
 - e. Software selectable rotation
 2. B-ASC shall be provided with integral differential pressure transducer, with range of 0–1 inwc, +/-5% FS.
 3. Universal field device hardware inputs shall be provided and configured on hardware and/or in software and comply with the following:
 - a. Inputs shall accept dry-contact, thermistor, 4-20 mA, and 0-5VDC
 - b. Pulse accumulation shall accommodate a minimum frequency of 40Hz
 - c. Inputs shall have a minimum 10 Bit A/D conversion resolution
 - d. 24VAC over-voltage protection
 4. Hardware outputs for field devices shall be provided as follows:
 - a. Three (3) Universal Outputs or One (1) Universal Output, one (1) single stage TRIAC Output, and one (1) Dual Stage TRIAC Output
 5. Hardware Outputs shall be configured on hardware and/or in software and comply with the following:
 - a. Universal Outputs shall provide configurable modulating voltage signal to industry 0-5VDC and 0-10VDC analog control devices and relays
 - b. Each TRIAC Output shall source 500 mA current, 24 VAC 0.5 ACA
 - c. Universal Output shall be capable of sourcing 75mA at 12VDC

- d. Outputs shall have a minimum 8 Bit D/A conversion resolution
- e. 24VAC over-voltage and short protection
- 6. Airflow Calibration, Test and Air Balance, etc. shall be performed via dedicated handheld configuration tool connected directly to communication port located at ATU B-ASC sensor] **and/or [via the integral SS Flow Calibration interface of each space mounted SS.** Special proprietary software and/or applications loaded on a computer or PDA shall not be acceptable to perform this function.
- 7. B-ASC shall provide diagnostic LEDs for power, communications and processor status. The B-ASC shall continually check the status of its processor and memory circuits
- 8. Controller wiring terminals shall be 5mm space between poles with removable terminal strips for ease of installation and service replacement
- 9. B-ASC Enclosure shall be rated as follows:
 - a. NEMA 1
 - b. UL 94-5V
- L. B-ASC for unitary applications shall comply with the following:
 - 1. B-ASC shall provide diagnostic LEDs for power, communications and processor status. The B-ASC shall continually check the status of its processor and memory circuits
 - 2. Controller wiring terminals shall be removable terminal strips for ease of installation and service replacement
 - 3. Universal field device hardware inputs shall be provided and configured on hardware and/or in software and comply with the following:
 - a. Inputs shall accept dry-contact, thermistor, 4-20 mA, and 0-5VDC
 - b. Pulse accumulation shall accommodate a minimum frequency of 40Hz
 - c. Inputs shall have a minimum 10 Bit A/D conversion resolution
 - d. 24VAC over-voltage protection
 - 4. Hardware outputs for field devices shall be provided as follows:
 - a. Four (4) Universal Outputs, or Four (4) TRIAC Outputs or One (1) Universal Output, one (1) single stage TRIAC Output, and two (2) Dual Stage TRIAC Output
 - 5. Hardware Outputs shall be configured on hardware and/or in software and comply with the following:
 - a. Universal Outputs shall provide configurable modulating voltage signal to industry standard 0-5VDC and 0-10VDC analog control devices and relays
 - b. Each TRIAC Output shall source 500 mA current, 24 VAC 0.5 ACA
 - c. Universal Output shall be capable of sourcing 75mA at 12VDC
 - d. Outputs shall have a minimum 8 Bit D/A conversion resolution
 - e. 24VAC over-voltage and short protection

M. Control System Application Software:

1. The B-ASC application software shall be the same as and indistinguishable from the B-BC specified interaction with the Control System Application Software.
2. The controller software shall reside in a real time, multi-tasking, networking operating environment. Database definition shall be accomplished through the B-OWS online with the B-ASC. The complete database and application program shall reside in the B-ASC. The System Contractor shall configure the software to attain the proper sequence of control and to accomplish all other control system functions indicated in the Contract Documents.
3. The user shall be able to add, delete, or modify objects on-line as required. The programming shall provide all the necessary mathematics, logic, utility and control functions necessary for proper sequence of control.

N. Communications and Protocols

1. The B-ASC shall communicate with field devices and controllers on the BLCN using the BACnet physical data link MS/TP at 76.8 Kbps where not limited by third party devices such as variable speed drives, utility meters, ect.
2. The B-ASC shall provide a communications port for connection of the Portable Operators Terminal using Point-to-Point BACnet physical data link layer protocol or a connection to the inter-network.
3. B-ASC shall support and be capable of monitoring and controlling a network of a minimum of four (4) communicating remote space sensors, each with capability of a local LCD Display, adjustable set-point and outputs for zone controls. These networked sensors shall not consume input/output hardware points in the B-ASC.
4. B-ASC shall support, transmit, and receive of segmented messages.

2.9 NETWORKED COMMUNICATING SPACE SENSORS

- A. Wall-Mounted Networked Communicating Space Sensors (SS) shall communicate on a daisy-chained network connected to any BAS DDC controller and shall provide additional ambient space condition sensing without the use of hardware I/O at the host controller.
- B. Each SS shall provide a , where indicated on the drawings, with the following minimum features: (we normally don't use stats with a display)
1. 36mm x 36mm (1.4" x 1.4") display area
 2. Display four (4) 0.6" digits and six (6) 0.3" characters simultaneously
 3. Capable of displaying icons, time, analog, and digital engineering units
 4. Programmable to display up to ten (10) data points in any combination of local and/or networked values from any device on the internetwork
- C. Each SS shall provide a local keypad for local user interface to perform navigation and adjustment of points configured as adjustable.

- D. Each SS shall provide a point of access for a B-OWS, Service Tool, etc. to the BACnet internetwork via the SS communication network.
- E. Where indicated on the drawings each SS shall provide at a minimum the following on-board integral I/O without the consumption of any inputs and/or outputs at the host DDC controller:
 - 1. Temperature sensor (local or remote)
 - a. 10k Thermistor
 - b. 12 Bit A/D Conversion
 - c. 0°C to 40°C (32°F to 104°F) range
 - d. +/- 0.1°C (+/- 0.18°F) resolution
 - e. User calibrated +/- 0.1°C (+/- 0.18°F)
 - 2. Relative Humidity (RH)
 - a. 10% – 90% range
 - b. 0.1% resolution
 - c. +/- 2% accuracy
 - d. Replaceable sensing element
 - e. User calibrated
 - 3. Occupancy
 - a. Passive Infrared Radiation (PIR)
 - b. 5m/16.4' detection distance
 - c. 100° horizontal / 82° vertical detection
 - d. 64 detection zones
 - 4. Additional Space/Zone I/O
 - a. Two (2) thermistor or dry-contact inputs
 - b. Two (2) TRIAC Outputs (24VAC @ 0.5A)

2.10 TEMPERATURE CONTROL PANELS (TCP), ENCLOSURES & SUB-PANELS

- A. Provide pedestal base or wall mounted local control enclosure to house all control components associated with each area, system or mechanical equipment room
 - 1. The enclosures shall be minimum 16 gauge steel or aluminum, totally enclosed on all sides and painted with a baked enamel finish.
 - 2. Enclosures located in wet indoor conditions or located outdoors shall meet NEMA 4X.
 - 3. Penetrations are permitted on bottom of enclosure only. Do not make conduit penetrations in top or side of enclosure. Each enclosure shall be equipped with a wire gutter below with a minimum of six ¾" minimum conduit penetrations into the bottom of the enclosure to accommodate system wiring.

4. Where required by AHJ, enclosures located in mechanical or electrical rooms shall meet NEMA 2 requirements
 5. Enclosures located in all other locations including but not limited to mechanical or electrical rooms not requiring NEMA 2, occupied spaces, above ceilings and plenums shall be the same NEMA classification as all other enclosures located in the same environment, except if location requires additional protection due to potential vandalism or environmental conditions and shall at a minimum meet NEMA 1 requirements
 6. Enclosures provided as an integral (pre-packaged) part of another product and/or piece of equipment are acceptable
 7. Provide a continuous piano hinged door, keyed locking latch and removable sub-panel. A single key shall be common to all control enclosures.
- B. Provide each DDC panel with a surge suppressor, electrical disconnect, control fuse, and control transformer. All sized and provided by the control system contractor.
 - C. Provide power supplies located inside control enclosures shall be fully enclosed with external 24 Vac terminals, on/off control, equipment overcurrent protection, power indication, high/low voltage separation, and convenience 120VAC outlets.
 - D. Provide insulated, modular, feed-through, clamp-style terminal blocks suitable for rail-mounting with end plates and partitions for the termination of all field wiring in control enclosures. Field wiring to equipment with integral terminals and/or unitary equipment (i.e., VAV ATU's, EF's, &c.) shall not be required to have terminal blocks.
 - E. Rail mounted terminal blocks shall be color coded to match the associated conductor colors adhering to the **UT Health** standard wire recognition coloring scheme as scheduled in section 2.11.

2.11 INTERCONNECTING WIRE & CABLE

- A. All wiring regardless of service and/or voltage shall comply with the Contract Document Division 26 Project Electrical System Specifications, the National Electric Code (NEC), and any/all applicable local codes and/or Authorities Having Jurisdiction (AHJ).
- B. Where required all wiring regardless of service and/or voltage shall be in conduit in accordance with Division 26 "Raceways and Boxes for Electrical Systems" and "Cable Trays for Electrical Systems" and shall be routed parallel to or at right angles with the structure, properly supported every six (6) feet at a minimum and installed in a workmanlike manner.
- C. Where permitted by all applicable specifications, local codes, NEC and AHJ; plenum-rated control cabling may be used where final application will be concealed but accessible. Where plenum-rated cable is allowed, it shall be routed parallel to or at right angles with the structure, properly supported every six (6) feet at a minimum and installed in a workmanlike manner.
- D. The UT Health Energy Management Controls System wiring color shall be as below:

Low Voltage Wiring	
BACnet Communications	blue wire
24 VAC Power	Red and black jacketed conductors with black jacketed sheath over the

	pair
Input/Output	White and black jacketed conductors and white jacketed sheath over the pair.
Communicating Sensor	Green jacketed sheath

2.12 GENERAL FIELD DEVICES

- A. All control relays shall be UL listed with contacts and coils rated for the application
 - 1. Relays used for in-line control start/stop of line voltage motors and shall have a current rating at least 150% full load amps.
- B. Control transformers shall be CSA and UL listed. Primary and secondary sides shall be fused in accordance with the NEC or shall be class 2 current limiting type. Transformers shall be sized such that the connected load is not greater than 80% of the transformer rated capacity.
- C. Voltage/Current to Pneumatic Transducer shall be non-bleed type 0-5V or 0-10V input and output pressure to match spring range of controlled device.
- D. Emergency shut-off switches shall be heavy duty, two-position push-pull, maintained contact, and illuminated 1-3/8 inch in diameter mushroom style push button switch. Provide hinged easy open protective clear cover to prevent accidental operation of switch.

2.13 ANALOG SENSORS

- A. Temperature Sensors:
 - 1. Temperature sensors shall be linear precision element Thermistor type.
 - 2. Single point duct temperature sensor shall consist of 316 stainless steel or platinum sensing element, junction box for wiring connections and gasket to prevent air leakage and vibration noise.
 - 3. Averaging duct temperature sensor shall consist of a copper or stainless steel averaging element, junction box for wiring connections and gasket to prevent air leakage or vibration noise.
 - 4. Liquid immersion temperature sensor shall include thermowell, sensor and connection head for wiring connections.
 - 5. Outside air temperature sensor shall consist of a single device sensor, ventilated non-metallic sun shield, utility box for terminations, and watertight gasket to prevent water seepage.
 - 6. Space temperature sensor shall consist of an element within a ventilated cover. Sensors located in mechanical areas, plenums, lobbies, or other public spaces shall be simple sensor with no setpoint adjustment.
 - a. Terminal Unit space temperature sensors shall be provided in accordance with the drawings at the locations indicated with the following options as indicated on drawings:
 - 1) Standard Wall-Mount Space Sensor

- 2) Setpoint Adjustment Buttons (“+” & “-”)
 - 3) Override/Bypass
 - 4) Occupancy
 - 5) CO2
 - 6) RH
 - 7) Network Jack
- b. All sensors not located in public spaces and associated with B-ASC or B-AAC that is located in normally inaccessible locations shall be the same.
 - c. Sensors shall be manually calibrated on site so that the wiring length does not detract from the sensor accuracy specified.
7. Where necessary due to structural cavities, masonry walls, proximity to exterior openings, and unconditioned spaces an insulated mounting base shall prevent temperature of mounting location from affecting sensor temperature reading.
 8. Sensor guards shall protect sensor from damage in all public areas such as gymnasiums, classrooms, vestibules, restrooms, and corridors or as indicated at locations on the drawings.
 9. Provide brass or stainless steel thermowells for each immersion type temperature sensor and switch.
- B. Wet Bulb temperature and humidity station shall be suitable for duct or outside mounting and consist of sensors, ventilated non-metallic sun shield, utility box for terminations, and watertight gasket to prevent water seepage.
- C. Pressure
1. Static Air Pressure Sensor shall have linear output voltage signal. Zero and span shall be field-adjustable. Tubing shall be connected to a Pitot tube or other pressure/airflow sensing device. Under no circumstances shall tubing pass through equipment housing or ductwork.
 2. Pitot tube probe shall be at least 4 inches allowing for internal duct insulation.
 3. Steam and water gauge pressure sensor shall include connections secured to a stainless steel diaphragm sensor with a gasketed, dust and watertight housing for remote mounting.
 - a. All steam devices and sensors shall incorporate a “pig-tail” in installation
 4. The differential pressure sensor for air applications shall provide a linear output voltage signal. The device shall be capable of over-pressurization to 10 PSI without a zero-shift and shall have a field adjustable zero and span. The assembly shall consist of pressure connections that secure pressure sensor to a housing for duct or remote mounting.

5. Differential Pressure Sensor for water shall consist of a differential pressure tap secured to a stainless steel diaphragm and an electronic sensor enclosed in a gasketed, dust and watertight case.
 6. Five-valve manifold assembly shall be required to allow isolation and bypass of operating pressures from differential pressure sensor.
 7. Snubbers shall be required to prevent system pressure hammers and surges from being fully transmitted to the pressure sensor.
- D. Position
1. Damper Position indication consists of a potentiometer mounted in housing.
 - a. Damper Position End Switches shall employ mechanical position proving. Mercury style end switches shall not be accepted.
 2. Control valve Position indicator consists of a potentiometer mounted on the valve actuator.
 3. Float type level switch with SPDT snap acting contacts. Electronics shall be housed in a watertight enclosure.
 4. Proximity Limit Switch shall be oil-tight, roller type, SPDT snap-acting switch with adjustable trim arm.
- E. Flow
1. Electronic Air Flow Monitoring System (Type II): Other installations: Airflow monitoring systems shall be a solid state electronic device comprised of a thermistor based sensing grid and microprocessor based electronics panel for flow averaging, temperature compensation and signal transmission. **[Ebtron,] [Paragon,] [Tek-Air] or [Air Monitor].**
 2. Water Flow In-Line Type: (For Pipe Sizes up to 1 ½ inches): In-line type flow sensor shall have a nonmagnetic spinning impeller. Sensor shall be Data Industrial Model 250B or equal.
 3. Water Flow Insertion Type: (For Pipe Sizes 1 ½ inch to 10 inches): Provide a probe-mounted insertion type turbine sensor.
- F. Gas
1. Refrigerant Vapor Detection System
 - a. Provide a refrigerant vapor detection system to meet ASHRAE 15-1994 and the applicable local codes. The system shall sample and monitor a minimum of two (2) remote sampling points per Chiller.
 - b. Provide the following accessories:
 - 1) One alarm relay for each level of alarm and one relay for flow failure or horn silence. Failure relay output that shall energize upon failure of monitor system operation. Failures include but are not limited to the following: low airflow through monitor, power circuit failure, and a saturated or absent sensor signal.

- 2) Analog Output 4-20 mA or 0-5 VDC.
- 3) Sample Pump shall be capable of drawing 0.25-1 liter/minute through 3/16 inch ID tubing for distances up to 100 ft.
- 4) Enclosure type: NEMA 4X.
- c. Sampling Tubing shall be Type L or hard drawn copper tubing.
- d. The read out/control unit shall be wall mounted pursuant with contract drawings. Remote sampling points shall be located within the central plant area according to the drawings.
- e. If the equipment and installation procedures are in accordance with these Specifications, products and services from Mine Safety Appliances Instruments Company (MSA) or approved equal will be acceptable.
- f. The water chilling unit manufacturer shall provide refrigerant data.
2. Indoor Air Quality Sensors shall measure both VOCs and CO₂ in PPM. Sensors shall be mounted as indicated on the drawings.
3. Carbon Monoxide detection, where required on the contract drawings shall be a single or multi-channel, dual-level detectors, using solid-state sensors with 3-year minimum life, maximum 15-minute sensor replacement, suitable over a temperature range of 23°F to 130°F, calibrated for 50 and 100 ppm, with maximum 120-second response time to 100-ppm carbon monoxide.
4. Carbon Dioxide Sensor and Transmitter: Single detectors using solid-state infrared sensors; suitable over a temperature range of 23°F to 130°F (-5°C to 55° C) and calibrated for 0% to 2% of full range, with continuous or averaged reading, 4- to 20-mA output for wall mounting.
5. Occupancy Sensor: Passive infrared, with time delay, daylight sensor lockout, sensitivity control, and 180-degree field of view with vertical sensing adjustment; for flush mounting.
6. Oxygen Sensor and Transmitter: Single detectors using solid-state zircon cell sensing; suitable over a temperature range of -32°F to 1100°F (0°C to 593°C) and calibrated for 0% to 5%, with continuous or averaged reading, 4- to 20-mA output; for wall mounting.

2.14 SWITCHING SENSORS/THERMOSTATS

A. Temperature Thermostats

1. Provide one (1) Low Limit thermostat for each 20 sq/ft of coil face. Low limit thermostat shall be of the vapor pressure remote element, manual reset type with adjustable set point. The device shall respond to the lowest temperature to which any 1 foot of the element is exposed. Capillary sensing tubing serpentine vertically across the discharge face of the coil, and be supported firmly by mechanical clips.
 - a. Low Limit thermostats shall be DPDT with a minimum of one (1) NO contact and one (1) NC contact

2. High limit thermostat shall be manual reset type. Sensing element shall be bimetal.
3. Capillary Type Thermostats shall have liquid or vapor-filled thermal system consisting of stainless steel or copper sensing element, connected to a fully compensating capillary tube, and operating bellows or spiral.
4. Surface Mounted Thermostats shall be line voltage on-off type suitable for strapped mounting to pipe.
5. Wall Mounted Thermostats shall be line voltage on-off type suitable for wall mounting.

2.15 AUTOMATIC CONTROL VALVES

A. General Requirements

1. Valves shall be provided with metallic linkage.
2. Unless otherwise indicated, all valves shall have a minimum range-ability of 50:1. All valves shall be guaranteed to have not more than 1% leakage of design flow rate at the pump shut-off pressure
3. Globe valves shall have replaceable seats.
4. Valves shall be quiet in operation.
5. Unless otherwise indicated, minimum body rating for any valve is 125 psi and maximum fluid temperature of 177°C (350°F).
6. Valves shall have stainless-steel stems and stuffing boxes with extended necks to clear the piping insulation.
7. Valve bodies shall meet or exceed pressure and temperature class rating based upon design operating temperature and 150% design operating pressure.
8. Unless otherwise indicated two and three-way Automatic Control Valves shall be globe-style bodies and comply with the following selection criteria:
 - a. Globe-style valve minimum body rating for any valve is 125 psi and maximum fluid temperature of 120°C (250°F).
 - b. Bodies for valves 2" and smaller shall be brass or bronze with NPT threaded connections, and shall be rated for ANSI Class 250 working pressure. Spring-loaded packing shall be required to protect against leakage at the stem.
 - c. Bodies for valves 2½" to 3" shall be brass, bronze or iron with flanged connections and shall be rated for ANSI Class 125 working pressure. Packing shall protect against leakage at the stem.
 - d. Bodies for valves 3" to 6" shall be iron, cast iron or cast steel with flanged connections and shall be rated for ANSI Class 125 working pressure. Packing shall protect against leakage at the stem.
 - e. For modulating applications, valve Cv (Kv) shall be within 100% to 125% of the design Cv (Kv)

- f. For two-position applications, valve Cv (Kv) shall be the largest available for the valve size
 - g. Valve and actuator combination shall be Normally-Open (NO) or Normally-Closed (NC) as shown
9. Where specified ball-style body Automatic Control Valves shall adhere to the following:
- a. Ball-style valve minimum body rating for any valve is 125 psi and maximum fluid temperature of 100°C (212°F).
 - b. Bodies for valves 2" and smaller shall be forged brass body with nickel plating, NPT threaded connections
 - c. All control ball valves shall be furnished with chrome plated bronze ball and stainless steel stem and fiberglass reinforced Teflon® seats and seals. The valves shall have a blow out proof stem design.
 - d. The stem packing shall be 2 O-rings designed for modulating service and requiring no maintenance.
 - e. All control ball valves shall feature characterized flow guides when used for modulating applications
10. Where specified butterfly-style body Automatic Control Valves shall adhere to the following:
- a. Unless otherwise indicated, butterfly valves shall have a minimum range ability of 10:1. All valves shall be guaranteed to have not more than 1% leakage of design flow rate at the pump shut-off pressure
 - b. Butterfly-style valve minimum body rating for any valve is 125 psi and maximum fluid temperature of 120°C (250°F).
 - c. Bodies for valves 3" to 12" shall be fully-lugged cast iron body
 - d. Flanges shall meet all ANSI 125 and ANSI 150 standards.
 - e. The stem shall be one piece stainless.
 - f. The 416 stainless shaft shall be supported at three locations with PTFE bushings for positive shaft alignment.
 - g. The seat shall be EPDM; Phenolic backed, non-collapsible, and easy to replace.
 - h. The disc shall be aluminum bronze to provide bubble-tight close off in either direction.
 - i. Valve shall have a long stem design to accommodate 2 inches insulation.
11. Valves for Chilled Water (CHW) and Glycol (GCHW) service shall adhere to the following:
- a. All internal trim regardless of body type shall be Type 316 Stainless Steel. Valves 3" and larger shall be butterfly valves.
12. Valves for Heating Hot Water (HHW) service shall adhere to the following:

- a. Valves for HHW service between 210°F (99°C) and 250°F (120°C) shall have all internal trim (including seats, rings, modulating plugs and springs) of Type 316 Stainless Steel
- b. Valves for HHW service below 210°F (99°C) shall have all internal trim (including seats, rings, modulating plugs and springs) of Brass, Bronze or Type 316 Stainless Steel
- c. Nonmetallic valve components shall be suitable for a minimum continuous operating temperature of 250°F (120°C) and/or 50°F (10°C) above the system design temperature, whichever is higher

2.16 VALVE ACTUATORS

- A. Actuators used in wet conditions and/or in or near outdoor air streams shall have NEMA 2 housings.
- B. Valve Actuators shall be modulating, with feedback signal, two-position and spring return fail safe as called out in the control sequence of operation or indicated on the drawings. All modulating valves shall be positive positioning, and respond to a 0-10VDC or 2-10 VDC with the exception that terminal unit zone valves may use an actuator that responds to a floating or tri-state with feedback signal.
- C. All control valves shall have a visual position indicator.
- D. All non-spring return actuators shall have an external clutch/manual gear release to allow manual positioning of the valve when the actuator is not powered. Spring return actuators with more than 60-in-LB torque capacity shall have a manual crank for this purpose. In lieu of a manual positioning device, it will be acceptable for the contractor to provide a full line size bypass around the control valve. Three bypass shut off valves shall be provided to allow the control valve to be isolated while the open stop valve in the bypass allows flow around the control valve.
- E. All modulating actuators shall have an external, built-in switch to allow the reversing of direction of rotation.
- F. Any mechanical equipment with direct introduction of outside air shall require fail-safe spring return valve actuators. Terminal equipment (VAV ATU, &c.) without direct introduction of outside air are permitted to have actuators that maintain their last commanded position when power is lost to the actuator. Equipment isolation and differential or temperature pressure bypass valves shall not be required to be provided with a spring return actuator provided that a failure of the valve to return to its “fail-safe” position will not incur damage to property or the system it serves.

2.17 AUTOMATIC CONTROL DAMPERS

- A. All Automatic Control Dampers provided as a part of this Specification shall bear the AMCA Seal as an indication that they comply with all requirements of the AMCA Certified Ratings Programs.

- B. A single damper section shall have blades that do not exceed 48" in length and shall be no higher than 72". Damper blades shall not exceed 8" in width. Applications requiring larger dampers shall be achieved by combining single damper sections.
- C. Frame construction shall be a minimum of #14 gauge galvanized steel formed into channels and welded, 14 gauge galvanized roll-formed steel or extruded aluminum at a minimum 4½" by 1' by 0.125" thick.
- D. Blades and baffles shall be fabricated of minimum 16 gauge steel with corrosion resistant galvanized finish or extruded aluminum 6" by 0.08".
- E. All dampers shall be provided with nylon, cyclopy or oilite bearings, stainless steel or elastomeric side seals, and zinc plated hardware as standard.
- F. Axles shall be a minimum of ½" diameter and be locked to blade with rivets or welded.
- G. Dampers shall be made up of 6" or 8" blades or combination of the two. Dampers shall have a minimum of four blades running the entire length. Silicone or polyurethane blade edging shall be furnished on all dampers.
- H. Maximum leakage rate through any 48 inches by 48 inches closed damper in any application shall not exceed 10.0 cfm per sq. ft. of damper face area at 4 inches of water pressure differential and a maximum closing torque of 4 inch-lbs/sq. ft. of damper face area. Damper leakage ratings shall be certified in accordance with AMCA Standard 500-D.
- I. Blades mounted vertically shall be supported by thrust bearings
- J. All Automatic Control Dampers in modulating applications shall be sized so as to achieve linear airflow characteristics
- K. Flow Control Application Dampers (Opposed Blade Operational Style)
 - 1. Opposed Blade Automatic Flow Control Dampers shall be required as indicated on the drawings for:
 - a. All mixing, volume throttling, airflow control, &c. applications installed in Outdoor, Relief, Exhaust, and/or Supply airstreams.
 - b. Any application upstream of critical components
 - c. Ducted Outlets
 - d. Automatic Flow Control Dampers specifically indicated to be provided by Mechanical Equipment manufacturer and/or as a component of packaged equipment shall not be provided by the Contractor.
 - 2. To minimize leakage, blade edges shall be interlocked and blade seals shall be compressible at all contact points. Channel frames shall also be provided with jamb seals.
 - 3. All Outdoor Air Damper components shall be suitable for applications operating in the temperature range of -40°F (-4°C) to 167°F (75°C)
 - 4. Damper shall be rated for a minimum velocity of 2000 ft/min
- L. Mechanical Ventilation, Miscellaneous Utility Dampers (Parallel Blade Operational Style)

1. Parallel Blade Automatic Flow Control Dampers shall be permitted as indicated on the drawings for applications not requiring Opposed Blade operation pursuant with that specification section and for:
 - a. Two-position (fully-open or fully-closed) applications
 - b. Applications where the damper constitutes the primary source of total system pressure loss
 - c. Applications where greater control is required at the upper end of airstream volume operating range
 - d. Mechanical Space ventilation and exhaust, combustion intake & exhaust, &c.
2. Shall comply with AMCA 500-D Class 4 and shall not leak in excess of 80cfm per sq/ft at 4inwc static pressure when closed.
3. Damper shall be rated for a minimum velocity of 1500 ft/min

M. Operating Linkages and Damper Accessories

1. All operating linkages and/or damper accessories required for installation and application in accordance with specification design intent and manufacturer's installation procedures shall be provided
2. Operating linkages provided external to dampers (crank arms, connecting rods, shaft extensions, &c.) for transmitting motion from the actuator/operator to dampers shall be designed as to functionally operate a load equal to or in excess of 300% of the maximum required operating force for the damper.
3. Crank arms and connecting rods shall be adjustable. Linkages shall be brass, bronze, zinc-coated steel, or stainless steel.
4. Adjustments of Crank Arms shall control the position of the damper
5. Use of Operating Linkages external to damper drive shaft shall neither delay nor impede operation of the damper in a manner of performance less than a direct-coupled damper actuator. Operating linkages shall not under any circumstances be permitted to flex, warp, shift &c. under normal operation of connected damper sections.

2.18 AUTOMATIC CONTROL DAMPER ACTUATORS

- A. Control damper actuators shall be electronic direct-coupled type. Actuators shall have a means for reversing drive direction and a manual override accessible at the front cover.
- B. Single bolt or setscrew type fasteners are not acceptable.
- C. The actuator shall have electronic overload or digital rotation sensing circuitry. Mechanical end switches or magnetic clutch to deactivate the actuator at the end of rotation are not acceptable.
- D. For spring return fail-safe applications, an internal mechanical spring return mechanism shall be built into the actuator housing. Non-mechanical forms of fail-safe operation are not acceptable.

- E. All non-spring return actuators shall have an external manual clutch/gear release to allow manual positioning of the damper when the actuator is not powered. Spring return actuators with more than 60 in-LB torque capacity shall have a manual crank for this purpose.

PART 3 – EXECUTION

3.1 GENERAL

- A. BAS component locations are the responsibility of the System Contractor. All control system components shall be installed in locations as required to properly sense the controlled medium.
- B. BAS Installation shall be performed by professionals in a workmanlike manner and in compliance with the Contract Documents, Division 26 Project Electrical System Specifications, the National Electric Code (NEC), and any/all applicable local codes and/or Authorities Having Jurisdiction (AHJ) and the following:
 - 1. Complete BAS installation including all DDC Devices, Enclosures, wiring, equipment, control devices and sensors shall be installed in accordance with the manufacturers' recommended installation procedures and as specified.
 - 2. All control devices are to be provided and installed with all required gaskets, seals, flanges, connection enclosures, thermal compounds, insulation, piping, fittings and valves as required for design operation, isolation, equalization, purging and calibration.
 - 3. Strap-on control devices shall not be permitted except as explicitly called out
 - 4. All control devices mounted outdoors shall be protected by a weather-shield, integral outdoor enclosure, &c. from ambient elements in such a manner as to not impede design functionality and/or sensing
 - 5. BAS installation shall be such that it provides sufficient clearance for system maintenance by maintaining sufficient access for equipment, device and/or component service, calibration, removal, repair or replacement.
 - 6. BAS installation shall not interfere with required clearance for mechanical and/or electrical equipment maintenance.
 - 7. Penetrations through and mounting holes in the building exterior associated with the BAS installation shall be sealed and made water-tight
 - 8. Dielectric isolation shall be provided where dissimilar metals are used in installation for connection and support
 - 9. Installation, wiring and material shall be protected from damage by and during BAS installation by BAS Contractor,
- C. The Contractor shall be responsible for his/her work and equipment until finally inspected, tested and accepted. The Contractor shall protect his/her work against theft or damage, and shall carefully store material and equipment received on site that is not immediately installed.
- D. After completion of installation, calibrate and commission all components provided as part of the Control System and demonstrate proper sequence of operation in compliance with the specifications. BAS components not operating correctly shall be field corrected or replaced.

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3.2 DIRECT AND WEB-ENABLED BAS APPLICATION SOFTWARE

- A. At time of acceptance all operating system, Third party and Control System Application software shall be at least the latest official release version available.
- B. Software programs are described to their general intent. It is recognized that Networked System manufacturer's software differ; however, the Application software provided shall incorporate the features described fully implemented and optimized to provide the sequences described, minimize energy consumption and prolong equipment life.
- C. The following standard naming convention shall be utilized for the naming of BACnet Devices on the BACnet internetwork.
 - 1. The convention for object names must adhere to the standards set by **UTHealth** Energy Management Environmental Controls System (EMECS) office.
- D. When programming the system BACnet addressing rules will be strictly adhered to. All addressing strategies will have to be approved by **UTHealth** EMECS office prior to configuring any LAN types.
- E. All analog and binary values shall be programmed with appropriate alarms.
- F. Except as specified otherwise, throttling ranges, proportional bands, and switching differentials shall be centered on the associated set point.
- G. All set points unless otherwise indicated are adjustable and shall be programmable for all control loops.
- H. Each control loop and/or interlock(s) for all mechanical system including terminal unit systems shall be programmed with a control loop specific graphical trend to trend all values associated with each specific control loop or system interlock.
- I. Where any sequence or occupancy schedule calls for more than one motorized unit to start simultaneously, the system start commands shall be staggered by 60-second (adj.) intervals to minimize inrush current.
- J. Scheduling shall be developed for each mechanical system. Final schedules shall be coordinated with **UTHealth** EMECS office prior to system commissioning. Until indicated otherwise the following schedule shall be used:
 - 1. Occupied: Monday – Friday/07:00 – 20:00
 - 2. Unoccupied: All other times and all statutory holidays.
- K. Optimal start/stop programs shall be applied to all regularly scheduled mechanical and electrical systems.
- L. At a minimum, trend log/historical data shall be implemented for every hardware point on the system. Additionally all software (virtual) points used as setpoints shall be trended. Point trends shall be grouped into logically interrelated points for individual mechanical and building systems. Initial set-up shall be to log values once every 5 minutes. Refer to points list on electrical and mechanical drawings for components requirements.
- M. B-OWS Graphical User Interface (GUI) must be approved by **UTHealth** EMECS office and shall incorporate at a minimum the following:

1. At a minimum, all physical hardware, sensors, control devices and set points shall be visible on a B-OWS in graphical form.
 2. All mechanical systems shall have a programmed real time color graphic for primary graphical user interface
 3. Individual floor plan graphics will be programmed for each floor or area of the building. All space sensors will be visible on floor plan graphics and system graphic.
- N. The system shall observe the following command priorities (from highest to lowest):
1. Smoke Control and Life Safety (BACnet Object Priority Array Level 1 & 2)
 2. Manual Operator Command (BACnet Object Priority Array Level 8)
 3. Energy Management (BACnet Object Priority Array Level 9)
 4. Normal Automatic Control (BACnet Object Priority Array Level 10)

3.3 DIRECT AND WEB-ENABLED SERVER, (B-OWS) HARDWARE

- A. Provide as specified for each PC-Based B-OWS
- B. Assemble server components in a configuration that allows easy operator access to all necessary components from one position. Locate components as required by the **UTHealth** EMECS office.
- C. Connect to LAN as required. If LAN/WAN is not dedicated to the BACnet network then Contractor shall develop a LAN/WAN System Architecture diagram denoting server B-OWS relative to other nodes on its segment of the LAN/WAN. This diagram shall be submitted at a minimum as a part of the As-Built and O&M Documentation.
- D. Provide sufficient permanent and removable storage drives for 25% free memory after provision for all operating system, Third party and Control System Application software, all fully configured point databases, storage/back-up of all B-BC, B-AAC and B-ASC application programming, all graphic files, all user-defined reports and a three year archive of all trend and historical data described in this specification.
- E. Provide sufficient RAM to meet system performance requirements.

3.4 LOCAL AREA NETWORKS (LAN)

- A. The control system shall be configured so that any individual network shall not exceed 80% of its total design network capacity. The system shall have a reserve of 20% network capacity.
- B. Where possible all Hubs, Switches, Half and Full Routers will be from the same manufacturer. Switches will be all "Store and Forward" type and will be installed in accordance with manufacturer specifications.
- C. Inverted Networks will not be allowed. Networks with minimum packet sizes smaller than those it connects to will not interconnect networks with larger minimum packet sizes. If three or more networks are interconnected the network with the highest speed and minimum packet size will be utilized to interconnect the slower networks.

- D. Where BACnet/IP LAN type is used, non-TCP/IP devices shall not be used. Where BACnet/IP is provided it shall comply with all Addendum to ANSI/ASHRAE 135-1995 BACnet/IP.

3.5 BACnet PROTOCOL VERIFICATION SOFTWARE

- A. Demonstrate exclusive communication utilizing the BACnet Protocol on all segments of the BACnet network.

3.6 BUILDING CONTROLLER (B-BC)

- A. Provide as required to meet performance requirements of the system with a 20% increase in connected B-AAC and B-ASC on any individual network. Provide a dedicated B-BC for all project specific equipment requiring this controller type.
- B. Locate strategically such that B-BC locations are as equally distributed throughout the project as possible.

3.7 ADVANCED APPLICATION CONTROLLERS (B-AAC)

- A. Provide a dedicated B-AAC for each medium-sized mechanical system.
- B. All points used for a single mechanical system shall be connected to the same B-AAC. Points used for control loop reset based on outside air, or space/zone temperature, or extremely remote differential pressure sensors on slow acting control loops are exempt from this requirement.
- C. Provide spare additional I/O such that future use of spare capacity shall require providing only the field device, field wiring, point database definition and operational sequence programming changes as required. Additional point modules may be required to implement use of these spare points.
 - 1. Provide at least one (1) spare universal input and one (1) spare universal output or 15% spare I/O of the total capacity of each B-AAC whichever is greater.
 - 2. If B-AAC I/O is not universal then provide at least one (1) spare analog input, one (1) spare digital input, one (1) spare analog output and one (1) spare digital output or 15% spare I/O of the total capacity for each point type of each B-AAC whichever is greater.

3.8 APPLICATION SPECIFIC CONTROLLERS (B-ASC)

- A. Provide a dedicated B-ASC for each Terminal Unit Mechanical Device on the project, including VAV and Fan Powered Terminal Units, Unit Heaters, and Individual Fans. Terminal Units specifically called out in the sequence of operation, as “Non-DDC” shall be excluded from this requirement.
- B. All points used for a single Terminal Unit Mechanical Device shall be connected to a dedicated B-ASC. Points used for control loop reset based on outside air, or space/zone temperature, or extremely remote differential pressure sensors on slow acting control loops are exempt from this requirement.
- C. VAV ATU and FP-VAV ATU Controllers
 - 1. Provide networked B-ASC for each VAV ATU and FP-VAV ATU consisting of a controller, damper actuator, and velocity transducer.

2. The ATU manufacturer shall provide a transformer, and factory wire the B-ASC and other unit mounted control devices such as actuators.
3. The ATU shall be provided with multi-point averaging type flow sensor factory piped to the velocity transducer.
4. Provide a networked communicating room sensor for each terminal unit that shall be field mounted and wired. Networked communicating room sensors shall be capable of performing airflow calibration and TAB functions without additional hardware or software.
5. Where indicated on the drawings and/or in one (1) location per floor, wing, building or section (whichever is more frequent), install networked communicating room sensor enabled to provide BACnet network connection to Service Tool and/or Portable B-OWS.

3.9 LOCAL SYSTEM NETWORK INTERFACE

- A. At a minimum the Portable B-OWS shall be able to connect to the BACnet Internetwork within each mechanical equipment space within the project. For manufacturers systems that do not allow direct portable B-OWS connections to B-AAC and B-ASC this may require that a higher level LAN be routed to each mechanical equipment space with a jack.

3.10 TEMPERATURE CONTROL PANELS (TCP), ENCLOSURES & SUB-PANELS

- A. All system components not designed for or required to be field installed shall be mounted in a control enclosure. Those components shall be sub panel mounted except components that are mounted on the panel face. Provide on/off power switch with over-current protection for control power sources in each local enclosure.
- B. All control enclosures shall be located as shown on the drawings and wherever possible (or where not indicated on the drawings) so that visual observation and adjustment can be accomplished while standing flatfooted on the floor in a convenient location adjacent to the equipment served. Install all equipment in readily accessible location as defined by Chapter 1 Article 100 Part A of the NEC.
- C. Label all control system components.
- D. A copy of the "As-built" application engineering for the system served shall be laminated in clear plastic, shall be legible and suspended within enclosure.
- E. All B-BC shall be mounted in an enclosure.

3.11 INTERCONNECTING WIRING AND CABLING

- A. General
 1. It shall be the System Contractor's responsibility to provide all wiring required for a complete Control System.
 2. Control system wiring and cabling installed for this project shall be performed by professionals in a workmanlike manner and in accordance with the Contract Documents, Division 16 Project Electrical System Specifications, the National Electric Code (NEC), and any/all applicable local codes and/or Authorities Having Jurisdiction (AHJ) and shall include but may not be limited to the following:

- a. All power wiring required not indicated on the electrical plans and specifications.
 - b. Power to all actuators and sensors.
 - c. Provide all wiring and cabling for network communications except for owner provided LAN's/WAN's.
 - d. All sensor and control device input and output wiring.
 - e. All interconnecting cabling between and amongst network devices, PCs printers, modems, etc.
 - f. Interlock wiring between devices, and between motor starters.
 - g. All other necessary wiring for fully complete and functional system as specified.
 - h. Install piping, wiring/cabling routed parallel to or at right angles with the structure, properly supported every six (6) feet at a minimum and installed in a workmanlike manner.
3. Maximum allowable voltage for control wiring shall be 120-volts.
 4. All wiring shall be installed as continuous links. Any required splices shall be made only within an approved junction box or other approved protective device with a maximum fill of 50%.
 - a. BACnet network cabling shall not be field spliced
 5. Verify integrity of all wiring to ensure continuity and freedom from shorts and grounds.
 6. This Contractor shall terminate all control and/or interlock wiring and shall maintain updated (as-built) wiring diagrams with terminations identified at the job site.
- B. Power Wiring and Cabling
1. Where required, power wiring for the control system shall be from circuits on emergency power panels. At a minimum; B-BC's, the B-OWS and any other DDC devices and control devices connected to and/or responsible for system critical equipment shall be powered from circuits on emergency power panels.
 2. Power wiring for all enclosures and equipment, including branch circuit wiring from circuit breaker panels shall be the responsibility of the System Contractor unless specifically shown on the Plans or Specifications to be provided under Division 26. Dedicated branch circuits shall be provided under Division 26.
 3. All B-OWS equipment shall be served from isolated ground receptacles via UPS by dedicated branch circuits.
 4. All other enclosures, sensor and control devices shall be fed from separate circuits in the electrical distribution panels and shall not be served from the typical floor receptacle or lighting circuits.
- C. Network Wiring and Cabling
1. Network installation shall strictly adhere to the manufacturer's networking installation instructions and procedures

2. All communications wire shall be externally identified as “Building Energy Management System Network” at least once every five feet.
3. Network installation shall conform to standards for the LAN types and cabling types selected. Specific network rules inherent to the ANSI/AHRAE Standard 135-1995, BACnet will be followed. Those include but are not limited to:
 - a. Only one path can exist from any BACnet device to another
 - b. Each BACnet device connected to an internetwork LAN must have a unique device instance (0 - 4,194,303).
 - c. Each internetwork LAN must have a unique Network Number (1 - 65,545).
 - d. Wire type used for MSTP, RS-485 twisted pair communications must be balanced twisted pair with 100 to 120 Ohms Characteristic Impedance. The wire shall be less than 30 pF per foot, and preferred 22AWG or lower. A shield wire shall be included for ground connection.
4. Primary LAN Network wire and cable shall be run separately from all other wiring.
5. Other LAN Network wire and cabling shall be installed separate from any wiring over thirty (30) volts.
6. All communications shielding shall be grounded as per Networked System manufacturer’s recommendations.

D. Installation

1. Except in mechanical and electrical spaces where other conduits or piping is exposed, conceal wiring and cabling as much as possible and install and comply with the requirements of the Contract Documents, Division 26 Project Electrical System Specifications, the National Electric Code (NEC), and any/all applicable local codes and/or Authorities Having Jurisdiction (AHJ)
2. All wiring and cabling installed in and/or routed through TCP, Enclosures and Sub-Panels shall regardless of voltage and/or service be fastened securely using cable ties, non-metallic wiring duct and/or other standard industry wiring management means and methods in a workmanlike manner parallel and/or perpendicular with enclosure.
3. All TCP, Enclosures, Sub-Panels, Junction Boxes, Pull Boxes, Troughs, Trays, Raceways, Conduits, &c. shall not exceed 70% maximum conductor fill. Blue conduit for control wire.
4. Each Input/Output device shall be controlled from a dedicated 2-pair conductor
5. Each Input/Output device requiring power shall have a dedicated power wire run to the control enclosure and shall be terminated to a dedicated terminal strip
6. All wire with controls enclosure shall be neat and suitably bundled and contained in Panduit wire duct or equivalent
7. All wiring will be suitably identified by thermal print heat shrink tubing at controller and Input/Output device.

3.12 ANALOG SENSORS

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A. Temperature

1. All wires attached to sensors shall be air sealed in their conduits or in the wall to stop air transmitted from other areas affecting sensor readings.
2. Install and properly support all enclosures and sensing elements as much as possible in the center of duct cross section and in straight duct runs. In condensing environments use stainless steel flanges to support sensing elements.
3. Sensors mounted on air ducts having exterior insulation shall be provided with handy-box mounting with insulating material firmly fitted around handy-box.
4. Sensors for mixed air and outdoor air streams greater than 6 square feet or 24" in either direction shall be averaging type. Provide a minimum of 1 linear foot of sensor per 4 square feet of duct area or equal to duct width where installed, whichever is longer. Averaging sensing tubing shall serpentine vertically across airstream and be supported firmly by mechanical clips.
5. Temperature sensors installed in piping or tanks shall be in separable thermowells. Sensors shall be inserted into thermowells with conductive paste. Assembly shall allow removal of sensor without loss of fluid.
6. At a minimum one outside air temperature sensor shall be installed. It shall be mounted outside on a northern exposure as high as serviceable on the building. The sensor shall be mounted within a ventilated enclosure to shield the sensor from the effects of the sun. The sensor location shall be selected such that it may not be affected by artificial and/or mechanical airstreams (i.e., building exhaust, building relief, &c.).
7. Terminal Unit Sensors shall be provided one per terminal unit device with the exception of large non-partitioned areas served by multiple terminal units.
 - a. They shall be wall mounted in the space served 60" above finished floor and located as shown on drawings.
 - b. Provide a minimum of 16' of coiled temperature sensor control wiring for equipment with space sensor not located on the Drawings.
 - c. In all areas where terminal unit sensor locations are not known at the time of building startup, sensors shall be hung approximately 24 inches from the ceiling in the area of the controlled zone and connected. Control wiring shall be neatly coiled and attached to ceiling grid. Sensors located in service corridors where subject to regular damage shall be mounted 84" above finished floor.
8. Zone temperature sensors shall not be located on perimeter walls. Where explicitly indicated on drawings to do so and/or in locations near exterior walls and/or subject to drafts sensors shall have insulated mounting bases to prevent false room temperature readings.
9. Where wall sensors are mounted in an area subject to damage provide suitable protective guard.
10. Where wall sensors are mounted in public spaces with adjustable set points provide suitable security guard.

11. Provide matched temperature sensors for differential temperature measurement. Differential accuracy shall be within 0.1°C (0.2°F).

B. Wet Bulb

1. For outside air mount same as outside air temperature sensor.
2. For duct mounting execute same as duct mounted temperature sensor.

C. Pressure

1. Orient static pressure sensing taps faced directly down-stream in the airflow so as to eliminate velocity pressure effects. Locate pressure transducers within 50' of sensing point and use tubing sized such as to prevent signal phase lag.
 - a. Final location of static/differential pressure sensing taps shall be pursuant with Contract Documents and as indicated on drawings. Where not explicitly indicated on drawings, pressure sensing taps shall be located as follows:
 - 1) Duct static pressure control sensor tap shall be located 2/3 distance from the Air Handling Unit of the total duct length in a straight section of ductwork with a minimum of four (4) duct diameters in both directions
 - 2) Positive static high-pressure safety cut-outs shall be located at Air Handling Unit immediately downstream of fan section
 - 3) Mixed-Air static and/or differential sensor tap shall be located in mixing box section
 - 4) Negative static pressure safety cut-outs shall be located immediately upstream of fan section
 - 5) Filter differential pressure taps shall be installed on both filter inlet and outlet
 - b. Mount air differential pressure taps so that true differential is sensed
2. Water gauge taps shall include snubbers and isolation valves
3. Water differential pressure sensors shall be piped through a five-valve bypass assembly with snubbers

D. Position

1. Mount damper position indicator onto damper blade and out of air stream as much as possible.

E. Flow

1. Mount airflow measuring station differential pressure sensor outside of fan casing.

3.13 SWITCHING SENSORS

A. Temperature

1. Wherever mixed or entering air temperatures are below 35°F (1.4°C), the sensing tube shall be installed across the leaving face of the first coil in the airstream. The low-temperature thermostat shall be arranged to stop the units supply fan and its associated

return air fan should the temperature at any point along the sensing element fall below 35°F (1.4°C). Provide a minimum of one foot of sensing element for each square foot of coil face area. In condensing environments use stainless steel sensing element and capillary mounting clips.

B. Differential Pressure

1. Differential pressure type switches shall be installed as per differential pressure sensors and shall provide a maximum switching differential of 10% of the sensed operating range for the application at minimum and maximum designed flow rates. Set point shall be selected to operate at midpoint of span.
2. Paddle type water flow switch shall be used to verify flow through chillers, other applications for operational, safety or other critical control interlock, on-off flow status monitoring, and at locations as indicated on the Drawings. Provide with NEMA 4 enclosure when installed in a condensing environment.
3. Differential pressure type water flow switch shall be used for on-off flow status monitoring of equipment and to position secondary chilled water loop return control valves. The sensing tubes shall be installed between the equipment and the nearest service valves.

C. Position

1. Mount damper blade end switch in such a manner that it is located out of the airstream as much as possible. End switch as installed shall be repeatable to within a range of 5 degrees. Under no circumstances shall mercury-style end switches be permitted.

D. Direct drive motors are permitted to utilize a current switch without an adjustable set point.

3.14 AUTOMATIC CONTROL VALVES

A. Flow characteristics shall be as follows:

1. Flow type for 2-way valves shall be equal percentage, except for terminal unit zone valves, and differential pressure control applications.
2. Flow type for 3-way valves shall be linear, except for terminal unit zone and ball valves.
3. Terminal unit zone, differential pressure applications shall be linear flow characteristic.

B. Two-way, control valves shall be provided for all convectors, fin radiation, horizontal unit heaters, unit ventilators, and all steam applications.

C. Two-way control valves shall be provided for all cabinet unit heaters, duct coils, and any other locations noted on drawings.

D. Two-way valves shall not be placed on branch or main hydronic circuits where these valves will cause a "dead-head" pumping condition. Three-way valves shall be used to avoid this condition.

E. Valve actuator and trim shall be furnished to provide the following minimum close-off pressure ratings:

1. Two-Way liquid valves shall be 150% of total system (pump) head.

2. Three-Way liquid valves shall be 300% of pressure differential between ports A and B at design flow or 100% of total system (pump) head, whichever is greater.

F. Water Sizing Criteria at full flow:

1. Two-position service shall be line size.
2. Two-way or three-way modulating service shall have a maximum pressure drop not to exceed 4 PSI.
3. Differential pressure modulating service shall have a maximum pressure drop not to exceed 12 PSI.

3.15 VALVE ACTUATORS

- A. When an air handling unit or major piece of mechanical equipment is not in operation, control devices shall remain in their “off” positions. Fail-safe positions shall be the same and defined as follows:

<u>DEVICES</u>	<u>OFF/FAIL-SAFE POSITION</u>
1. HHW Coil Valves:	As-is position to Coil/Equipment
2. CHW Coil Valves:	As-is position to Coil/Equipment

3.16 DAMPER ACTUATORS

- A. Check operation of damper/actuator combination to confirm that actuator modulates damper smoothly throughout stroke to both open and closed positions.
- B. Spring return actuators shall be provided except as follows.
1. Terminal or unitary equipment without direct introduction of outside air are permitted to have actuators that maintain their last commanded position when power is lost.
 2. Damper actuator shall not be required to be provided with spring return provided that it is not directly connected to Outdoor Air and a failure of the damper to return to its “normal” position will not incur damage to the system/space it serves.
- C. Modulating actuators shall be provided for terminal unit mechanical devices may use an actuator that responds to a floating or tri-state signal.
- D. Minimum torque and power output requirements of actuators shall not be less than 1.2 times required design load.
- E. When an air handling unit or major piece of mechanical equipment is not in operation, control damper shall remain in their “off” positions. Fail-safe positions shall be the same and defined as follows

<u>DEVICES</u>	<u>OFF/FAIL-SAFE POSITION</u>
1. Outdoor Air Dampers:	Closed
2. Return Air Dampers:	Open
3. Exhaust/Relief Air Dampers:	Closed

END OF SECTION

SECTION 23 06 20.13
HYDRONIC SPECIALTIES

PART 1 GENERAL

1.00 The following sections are to be included as if written herein:

- A. Section 23 00 00 – Basic Mechanical Requirements
- B. Section 23 05 29 – Sleeves, Flashings, Supports and Anchors
- C. Section 23 05 53 – Mechanical Identification

1.01 WORK INCLUDED

- A. Expansion Tanks
- B. Automatic Air Vents
- C. Air Separators
- D. Strainers
- E. Gauges and Gauge Connections
- F. Thermometer and Thermometer Wells
- G. Pump Suction Fittings
- H. Water Relief Valves
- I. Water Flow Measuring and Balancing System
- J. Chilled Water and Steam Integrating Meters

1.02 RELATED WORK

- A. Section 22 13 16 - Plumbing Piping
- B. Section 23 21 00 - Hydronic Piping
- C. Section [_____ - _____:] Pipe cleaning

1.03 REFERENCES

A. ANSI/ASME - Boilers and Pressure Vessels Code

1.04 REGULATORY REQUIREMENTS

A. Conform to ANSI/ASME Boilers and Pressure Vessels Code Section 8D for manufacture of tanks.

1.05 QUALITY ASSURANCE

A. Manufacturer: For each product specified, provide components by same manufacturer throughout.

1.06 SUBMITTALS

A. Submit shop drawings and product data under provisions of Section 23 00 00.

B. Submit shop drawings and product data for manufactured products and assemblies required for this project.

C. Include component sizes, rough in requirements, service sizes, and finishes. Include product description, model number and dimensions.

D. Submit inspection certificates for pressure vessels from [_____].]

E. Submit manufacturer's installation instructions under provisions of Section 23 00 00.

1.07 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data under provisions of Section 23 00 00.

B. Include installation instruction, assembly views, lubrication instructions, and replacement parts list.

1.08 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to site under provisions of Section 23 00 00.

B. Store and protect products under provisions of Section 23 00 00.

PART 2 PRODUCTS

2.01 EXPANSION TANKS

A. Construction: Closed, welded steel, tested and stamped in accordance with Section 8D of ANSI/ASME Code; 125 psi rating; cleaned, prime coated, and supplied with steel support saddles; with tappings for installation of accessories.

- B. Gauge Glass Set: Brass compression stops, guard, and 3/4 inch red line glass, maximum 24 inches length, long enough to cover tank for 2 inches above bottom to 2 inches below top.
- C. Quick Connect Air Inlet: Automotive tire valve type, manual air vent, tank drain, and pressure relief valve.
- D. Automatic Cold Water Fill Assembly: Pressure reducing valve, reduced pressure double check back flow preventer, test cocks, strainer, vacuum breaker, and valved bypass.
- E. Hot Water Heating System: Set expansion tank pressure relief valve at 125 psi maximum and pressure reducing valve at 100 psi.
- F. Chilled Water System: Set expansion tank pressure relief valve at 125 psi maximum and pressure reducing valve at 100 psi.
- G. Size: [] diameter, [] overall length, [] capacity.

2.02 AUTOMATIC AIR VENTS

- A. Provide at the highest points of the chilled water system and on the chilled water coils as shown on the Drawings, an automatic air vent, Armstrong No. 21AR or approved equal, with a pressure rating of 250 psig. Provide shut-off valve to facilitate maintenance of air vent. Locate all air vents and their discharge lines in accessible locations, preferably clustered.

2.03 AIR SEPARATORS

- A. Dip Tube Fitting: For 125 psig operating pressure; to prevent free air collected in boiler from rising into system.
- B. In-line Air Separators: Cast iron for sizes 1-1/2 inches and smaller, or steel for sizes 2 inches and larger; tested and stamped in accordance with Section 8D of ANSI/ASME Code; for 125 psig operating pressure.
- C. Air Elimination Valve: Bronze, float operated, for 125 psig operating pressure.
- D. Combination Air Separators/Strainers: Steel, tested and stamped in accordance with Section 8D of ANSI/ASME Code, for 125 psig operating pressure, with galvanized steel integral strainer with 3/16 inch perforations, tangential inlet and outlet connections, and internal stainless steel air collector tube.

2.04 STRAINERS

- A. Each control valve for chilled water and heating water, and each pressure reducing valve assembly regardless of its size shall be preceded by a sediment strainer. The arrangement of these sediment strainers shall be such that the screens may be removed for cleaning with ease through a gasketed plug. Monel or stainless steel shall be used to fabricate the noncollapsible lapped screens, which shall contain no soldered joints.
- B. Sediment strainers shall be placed in piping systems wherever shown on the Drawings and at such other points as may be required for the removal of foreign material from the piping systems.
- C. Strainers for water piping 2-1/2" and larger shall be Crane No. 989-1/2 Sediment Separators or approved equal. In piping two inches (2") and smaller, they shall be Crane No. 988-1/2, or approved equal.
- D. Strainers, 2" and smaller, bronze body, screwed ends, No. 10 mesh strainer, screwed cap with bronze blow off valve (size to be determined by standard tap size in cap). Cast iron body, 2 1/2" and larger, isolating type flanged ends where installed in copper lines, No. 7 perforated monel strainer, flanged cap with bronze ball blow off valve (size of blow off valve shall be determined by standard tap size in cap). Special Note: All strainers 6" and larger shall have studs mounted in the body flange in lieu of bolts for removal of cap. Baskets for strainers 6" and larger shall have stainless steel reinforcing bands at ends to prevent collapsing.
- E. Full sized blow off valves shall be installed on all strainers in steam, condensate, chilled and hot water lines and a drain shall be installed from each valve to the nearest floor drain.

2.05 GAUGES AND GAUGE CONNECTIONS

- A. Furnish and install Ashcroft No. 1279A Duragauges on both suction and discharge sides of pumps, complete with Ashcroft No. 1095 lever handle shut-off cocks, and Ashcroft No. 1106B pulsation piston type dampeners, or approved equal. Porous type will not be accepted. See pump Specifications. Gauges shall have stainless steel movement and 1/2 of 1% accuracy. Gauges shall have back connection when used on a panel; otherwise they shall have bottom connections. The graduation of the dials and the arrangement of the mechanisms shall conform to the pressure range details shown on the Drawings.
- B. Combination pressure or vacuum gauges shall be Ashcroft Duragauges Number 1279AC, or approved equal. The accessories for these gauges shall conform to those prescribed for pressure gauges.

- C. Furnish and install, where noted or indicated on the accompanying Drawings or called for elsewhere in these Specifications, gauge connections complete with Ashcroft No. 1095 lever handle union shutoff cocks, or approved equal. All gauge connections shall be made up with brass pipe, nipples and brass screw fittings.

NOTE TO SPECIFICATION WRITER: Item D is for Austin campus only. Delete item D for all other campuses.

- D. Provide pressure gauges before and after air handler control valves, located between the isolation valves and valve inlet/outlet. Provide stainless steel nipples with isolation valves for gauge taps.

2.06 THERMOMETER AND THERMOMETER WELLS

- A. Furnish and install thermometers of not less than 9" scale complete with brass separable sockets with extension neck to allow for insulation of piping. These thermometers shall be mercury red reading type in one piece glass tubes extending from top of scale to sensor, and shall be located so that they may be easily read. Field adjustable angle thermometers are acceptable. Thermometers shall in all cases be installed upright or at the proper angle to be read while standing on the floor. The wells for thermometers shall be located in vertical pipes where possible and when necessary in horizontal pipes they shall be installed in the side and not on the top of the pipe. They shall be Weksler Industrial Thermometers, or approved equal, with range of 0 to 100 degrees F. for chilled water, and 0 to 220 degrees F for hot water.
- B. Thermometer wells and thermometers shall be located where noted on the accompanying Drawings and where called for in other sections of the Specifications. Thermometer test wells only shall be installed in a vertical position in horizontal lines and at 45 degrees, in vertical lines to hold a fluid in the well.
- C. Thermometer test wells shall be 3/4" Weksler Thermal Wells, brass with stem of minimum length to extend beyond the mid-diameter of the pipe, 2-1/2" extension neck, and brass screw plug. Wells shall be suitable for use of industrial type thermometers.
- D. Indicating thermometers shall be placed in lines wherever shown on the Drawings. These thermometers shall be Weksler Industrial Thermometers having stainless steel separable sockets and scales of the range shown on the Drawings.
- E. Provide thermometer and thermowell assemblies, as described above, with one assembly each for the chilled water supply and return main pipes. Install the assemblies in close proximity to the RTDs that are provided for the chilled water BTU meter.

2.07 PUMP SUCTION FITTINGS

- A. Fitting: Angle pattern, cast iron body, threaded for 2 inch and smaller, flanged for 2-1/2 inch and larger, rated for 175 psig working pressure, with inlet vanes, cylinder strainer with 3/16 inch diameter openings, disposable fine mesh strainer to fit over cylinder strainer, and permanent magnet located in flow stream and removable for cleaning.
- B. Suction diffusers shall be Paco or approved equal, cast iron body and cover, steel diffuser, and stainless steel strainer, 125 pound ASA (flat face) flange for a working pressure of 175 psi and temperature of 300°F.
- C. Accessories: Adjustable foot support, blow down tapping in bottom, gauge tapping in side.

2.08 WATER RELIEF VALVES

- A. The pressure relief valves installed for the protection of the water circulating circuits shall be McAlear No. 307 single seated diaphragm and spring type valves with screwed connections or approved equal. They shall be 3/4" size of bronze construction with bronze seat, composition shut-off disc and rubber diaphragm.

NOTE TO SPECIFICATION WRITER: For Austin Campus, delete this Part 2.09.

2.09 CHILLED [AND HOT] WATER [AND STEAM CONDENSATE] FLOW MEASURING AND BALANCING SYSTEM (SUB-METERING)

- A. Furnish and install complete transit time Balance Master Metering systems manufactured by NuSonic. Flow element shall be installed in a straight run of pipe in accordance to manufacturer's guidance for the specific installation in order to maintain rated accuracy.
- B. This shall be a coordinated system, including flow stations to work with a Portable Master Meter. Each flow station shall be complete with quick mount sensor carriers mounted in the 'transverse' arrangement, laminated or metal identification tag on chain giving pipe size, meter series, and station identification. Flow stations shall be of steel construction, welded in place.
- C. Furnish to the Owner a Master Meter mounted in a portable carrying case, complete with 2 (two) 6' (six foot) lengths of meter cable and attached meter sensors, and installation and operating instructions. Meter shall operate on both 115 VAC and self-contained battery pack (field selectable). Meter display shall be backlit LCD, indicating instantaneous flow rate in GPM. Meter full scale accuracy shall be 2% or better with a fluid operating range of 1-15 ft/sec. Meter shall have built-in automatic pipe size compensation. Meter shall have positive zero flow indication.

- D. Unit shall accommodate the following fluid operating ranges:
Temperature: 36° to 250° F.
Pressure: 0 to 150 psi.

2.10 BUILDING MAIN CHILLED [AND HOT] WATER [AND STEAM CONDENSATE]
INTEGRATING METERS:

NOTE TO SPECIFICATION WRITER: For Austin campus, delete items A-D, and replace with "Refer to DDC Controls Specification 23 09 25a for flow meter information."

NOTE TO SPECIFICATION WRITER: Except for Austin campus projects, the specification for the following BTU meter must not be deleted from the project specification, as it is referenced in the special conditions of the contract documents.

- A. Furnish and install complete transit time Controlotron Metering systems. Flow element shall be installed in a straight run of pipe in accordance to manufacturer's guidance for the specific installation in order to maintain rated accuracy.
- B. Each flow station shall consist of dual flow sensor and carriers mounted in the 'transverse' arrangement with laminated or metal identification tag on chain giving pipe size, meter series, and station identification. Flow stations shall be of steel construction, welded in place.
- C. Wall mounted meter shall be complete with adequate lengths of flow cables attached sensors, and installation and operating instructions. Meter shall operate on 115 VAC. Meter shall be backlit LCD, dual channel (one for chilled water, the other for [hot water] [steam condensate]). Each channel shall indicate:
- 1 Instantaneous flow rate in GPM, and total gallons
 2. Each channel shall have dual outputs for each of the displayed values. Out puts shall be 4-20 mA and TTL pulse rate, each proportional to display values, compatible with building EMS.
 3. Meter shall have positive zero flow indication.
- D. Unit shall accommodate the following fluid operating ranges:
Temperature: 36° to 250° F.
Pressure: 0 to 150 psi.

NOTE TO SPECIFICATION WRITER: In case orifice is provided with CDAS, provide steam flow meter manufacturer with orifice data. Steam flow meter manufacturer needs to know orifice differential requirements for proper range selection. Steam flow meter manufacturer will need to know if he is to provide orifice and orifice flanges.

2.11 STEAM INTEGRATING METERS

NOTE TO SPECIFICATION WRITER: For Austin campus, delete this part 2.11.

NOTE TO SPECIFICATION WRITER: Except for Austin campus projects, the specification for the following BTU meter must not be deleted from the project specification, as it is referenced in the special conditions of the contract documents.

- A. Furnish and install as per details on drawings in the condensate return system a Daniels Industries, Inc., Model CR turbine meter. Meter shall be constructed of stainless steel with stainless steel internal parts and tungsten carbide bearings. (Turbine meter to be installed to read GPM from all pumps.)

Maximum Operating Range: 210 degrees F

Pressure Range: 0 to 100 Psig

Maximum Pressure Drop: 4 Psig.

System Flow Rate: Engineer shall complete GPM discharge rate of one condensate pump.

Output: 12 VDC

Maximum Accuracy: $\pm 0.05\%$ over linear flow range

Power Available: 12 VDC

1. Meter shall be mounted in a horizontal position at the pump discharge with required upstream and downstream straight runs of pipe.
2. Furnish and install a line size spool piece in the main until all piping has been cleaned and flushed.

NOTE TO SPECIFICATION WRITER: In case orifice is provided with CDAS, provide steam flow meter manufacturer with orifice data. Steam flow meter manufacturer needs to know orifice differential requirements for proper range selection. Steam flow meter manufacturer will need to know if he is to provide orifice and orifice flanges.

PART 3 EXECUTION

3.01 INSTALLATION AND APPLICATION

- A. Install specialties in accordance with manufacturer's instructions to permit intended performance.
- B. Support tanks inside building from building structure in accordance with manufacturer's instructions.
- C. Provide manual air vents at system high points and as indicated.

- D. Provide manual air vents at entrance to all heating hot water coils, with a "cane" shaped discharge tube, positioned to permit draining to a portable receptacle.
- E. For automatic air vents in ceiling spaces or other concealed locations, extend vent tubing to nearest drain.
- F. Provide air separator on suction side of system circulation pump and connect to expansion tank.
- G. Provide valved drain and hose connection on strainer blow down connection.
- H. Provide pump suction fitting on suction side of base mounted centrifugal pumps. Remove temporary strainers after cleaning systems. Clean all permanent strainers after circulating systems for a minimum of 48 hours at full capacity.
- I. Support pump fittings with floor mounted pipe and flange supports.
- J. Provide relief valves on pressure tanks, low pressure side of reducing valves, heat exchangers, and expansion tanks.
- K. Select system relief valve capacity so that it is greater than make-up pressure reducing valve capacity. Select equipment relief valve capacity to exceed rating of connected equipment.
- L. Pipe relief valve outlet to nearest floor drain.
- M. Where one line vents several relief valves, make cross sectional area equal to sum of individual vent areas.

NOTE TO SPECIFICATION WRITER: Item N is for Austin campus only. Delete item N for all other campuses.

- N. Provide pipe unions and gate type isolation valves, or two-piece ball valves in pipe, on both sides of air handler control valves to facilitate change out of valve.

3.02 EXPANSION TANK SCHEDULE

<u>Drawing Code</u>	<u>XTK-1</u>	<u>XTK-2</u>	<u>XTK-3</u>	<u>XTK-4</u>
Location				
Service				
Capacity				
Diameter				
Length				

END OF SECTION

SECTION 23 07 13
DUCTWORK INSULATION

PART 1 GENERAL

1.00 The following sections are to be included as if written herein:

- A. Section 23 00 00 – Basic Mechanical Requirements
- B. Section 23 05 29 – Sleeves, Flashings, Supports and Anchors
- C. Section 23 05 53 – Mechanical Identification

1.01 SECTION INCLUDES

- A. Ductwork insulation
- B. Insulation jackets

1.02 RELATED SECTIONS

- A. Section 09 91 00 - Painting: Painting insulation jackets
- B. Section 23 31 00 - Ductwork: Duct liner
- C. Section 23 33 00 - Ductwork Accessories: Duct liner

1.03 REFERENCES

- A. ASTM B209 - Aluminum and Aluminum-Alloy Sheet and Plate
- B. ASTM C518 - Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus
- C. ASTM C553 - Mineral Fiber Blanket and Felt Insulation
- D. ASTM C612 - Mineral Fiber Block and Board Thermal Insulation
- E. ASTM E84 - Surface Burning Characteristics of Building Materials
- F. ASTM E96 - Water Vapor Transmission of Materials
- G. NFPA 255 - Surface Burning Characteristics of Building Materials
- H. SMACNA - HVAC Duct Construction Standards - Metal and Flexible

I. UL 723 - Surface Burning Characteristics of Building Materials

1.04 SUBMITTALS

- A. Submit under provisions of Section 23 00 00.
- B. Product Data: Provide product description, list of materials and thickness for each service, and locations.
- C. Samples: Submit two samples of any representative size illustrating each insulation type.
- D. Manufacturer's Installation Instructions: Indicate procedures which ensure acceptable workmanship and installation standards will be achieved.

1.05 QUALITY ASSURANCE

- A. Materials: Flame spread/smoke developed rating of 25/50 in accordance with NFPA 255.

1.06 QUALIFICATIONS

- A. Applicator: Company specializing in performing the work of this section with minimum three years experience.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Deliver, store, protect and handle products to site under provisions of Section 23 00 00.
- B. Deliver materials to site in original factory packaging, labeled with manufacturer's density and thickness.
- C. Store insulation in original wrapping and protect from weather and construction traffic.
- D. Protect insulation against dirt, water, chemical, and mechanical damage.

1.08 ENVIRONMENTAL REQUIREMENTS

- A. Maintain ambient temperatures and conditions required by manufacturers of adhesives, mastics, and insulation cements.
- B. Maintain temperature during and after installation for minimum period of 24 hours.

PART 2 PRODUCTS

2.01 Insulation A:

- A. Three pound per cubic foot minimum density glass fiber semi-rigid board insulation with fiber perpendicular to the surface and with factory applied white foil reinforced vapor barrier jacket (ASJ). Insulation shall be equal to E.O. Woods Company "Rigid-Wrap".
- B. The insulation shall be secured to the ducts with mechanical fasteners; "Stick-clips", Graham Pins or Speed Clips, and shall be spaced approximately 12" on center on bottom of duct and where required elsewhere to hold insulation securely against the duct as noted in the published recommendations of the Insulation Manufacturer.
- C. After insulation is in place, all joints and seams shall be sealed with Foster 30-35 white vapor barrier emulsion applied over a 3" wide strip of Duramesh Glass Fabric. All protrusions through the vapor barrier shall be thoroughly sealed.
- D. On ducts that are reinforced with standing seams or angle iron stiffeners 1" and over in height, the Contractor shall apply a strip of fiberglass board 1" thick by 6" wide, sealing same to the other insulation with mastic.
- E. Vapor sealing of joints and seams is not required on hot duct application where concealed.

2.02 Insulation B:

- A. Three pound per cubic foot minimum density glass fiber rigid board insulation with factory applied white foil reinforced All Service Jacket (ASJ).
- B. Insulation B shall be applied as specified for Insulation A.
- C. Contractor at his option may substitute Insulation A where Insulation B is called for.

2.03 Insulation C:

- A. Blanket insulation with a thermal conductivity (K) of 0.27 or less similar in construction to Owens-Corning Fiberglass Series one pound per cubic foot minimum density with foil reinforced Kraft (FRK) vapor barrier facing. Insulation shall be wrapped tightly on the ductwork with all circumferential joints butted and longitudinal joints overlapped a minimum of 2". Adhere insulation to metal with 4" strips of insulation bonding adhesive at 8" on center. On circumferential and longitudinal joints, the 2" flange of the facing shall be secured using 9/16" flare door staples applied 6" on

center and taped with 4" wide fiberglass tape embedded in Foster 30-35 white vapor barrier Emulsion and covered with Foster 30-35 white vapor barrier Emulsion until the tape is completely covered. All pin penetrations or punctures in facing shall also be taped. Vapor sealing of joints is not required on hot duct application where concealed.

- 2.04 All ductwork in the building and in the crawl spaces except toilet exhaust and fume hood exhaust ducts shall be insulated externally unless specifically excluded. Only sound attenuated return ducting may be insulated internally, if specifically designated as such.
- 2.05 Where ducts are lined internally, (see Drawings for Scope) no exterior insulation will be required, except where specifically stated otherwise. Where internal and external insulation join, they shall lap at least 24 inches.
- 2.06 Low pressure supply duct taps to ceiling diffusers shall be externally insulated including top of ceiling diffuser with 2" Insulation C.
- 2.07 Flexible round ducts are specified in Section 23 31 00.UT as factory insulated.
- 2.08 All kitchen hood exhaust ductwork connected to both inlet and discharge sides of Fans shall be insulated. Insulation shall be 1" insulation A or B.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that ductwork has been tested before applying insulation materials.
- B. Verify that surfaces are clean, foreign material removed, and dry.

3.02 INSTALLATION

- A. Install materials in accordance with manufacturer's instructions.
- B. Insulated ductwork conveying air below ambient temperature:
 - 1. Provide insulation with vapor barrier jackets.
 - 2. Finish with tape and vapor barrier jacket.
 - 3. Continue insulation through walls, sleeves, hangers, and other duct penetrations.
 - 4. Insulate entire system including fittings, joints, flanges, fire dampers, flexible connections, and expansion joints.

- C. Insulated ductwork conveying air above ambient temperature:
 - 1. Provide with or without standard vapor barrier jacket.
 - 2. Insulate fittings and joints. Where service access is required, bevel and seal ends of insulation.
- D. For ductwork exposed in mechanical equipment rooms or in finished spaces, finish with aluminum jacket.
- E. For exterior applications, provide insulation with vapor barrier jacket. Cover with caulked aluminum jacket with seams located on bottom side of horizontal duct section.
- F. External Duct Insulation Application:
 - 1. Secure insulation with vapor barrier with wires and seal jacket joints with vapor barrier adhesive to match jacket.
 - 2. Secure insulation without vapor barrier with staples, tape, or wires.
 - 3. Install without sag on underside of ductwork. Use adhesive or mechanical fasteners where necessary to prevent sagging. Lift ductwork off trapeze hangers and insert spacers.
 - 4. Seal vapor barrier penetrations by mechanical fasteners with vapor barrier adhesive.
 - 5. Stop and point insulation around access doors and damper operators to allow operation without disturbing wrapping.
- G. Duct and Plenum Liner Application:
 - 1. Adhere insulation with adhesive for 100 percent coverage.
 - 2. Secure insulation with mechanical liner fasteners. Refer to SMACNA Standards for spacing.
 - 3. Seal and smooth joints.
 - 4. Seal liner surface penetrations with adhesive.
 - 5. Duct dimensions indicated are net inside dimensions required for air flow. Increase duct size to allow for insulation thickness.

- 3.03 All piping, equipment, ductwork, all plenums including metal and masonry construction, fans, etc., shall be insulated as indicated on the Drawings, as specified herein, and as required for a complete system. In each case, the insulation shall be equal to that specified and materials applied and finished as described in these Specifications.
- 3.04 All insulation shall be applied by mechanics skilled in this particular work and regularly engaged in such occupation. All insulation shall be applied in strict accordance with these Specifications and with factory printed recommendations on items not herein mentioned. Unsightly, inadequate, or sloppy work will not be acceptable, and all such work shall be removed and replaced as many times as necessary to achieve an acceptable installation.
- 3.05 All insulation, jacket, adhesives, mastics, sealers, etc., utilized in the fabrication of these systems shall meet NFPA for fire resistant ratings (maximum of 25 flame spread and 50 smoke developed ratings) and shall be approved by the insulation manufacturer for guaranteed performances when incorporated into their insulation system, unless a specific product is specified for a specific application, and is stated as an exception to this requirement. Certificates to this effect shall be submitted along with Contractor's submittal data for this section of the Specifications. No material may be used that, when tested by the ASTM E84-89 test method, is found to melt, drip or delaminate to such a degree that the continuity of the flame front is destroyed, thereby resulting in an artificially low flame spread rating.
- 3.06 All surfaces to be insulated shall be clean and dry before applying the insulation. All sections of molded pipe covering shall be firmly butted together. Where an insulation covering is applied, it shall lap the adjoining section of insulation by at least three inches (3"). Where insulation terminates, it shall be neatly beveled and finished. No insulation shall be applied until the pipe, duct, etc., have been pressure tested and found tight. Piping, flexible connections, flanges, valves, strainers, and unions shall be covered unless specifically noted otherwise. Flexible connections on duct shall not be covered. All materials used shall be fire retardant or nonflammable. Refer to Section 15A.
- 3.07 Where vapor barriers are required, the vapor barrier shall be on the outside. Extreme care shall be taken that the vapor barrier is unbroken. Joints, etc., shall all be sealed. Where insulation with a vapor barrier terminates, it shall be sealed off with the vapor barrier being continuous to the surface being insulated. Ends shall not be left raw.
- 3.08 Extreme care shall be taken in covering high and medium pressure (high and medium pressure ductwork shall be all ductwork between the fan discharge and all mixing boxes) ductwork to insure the duct is not pierced with sheet metal screws or other fasteners. All high and medium pressure ducts in these specifications are classified as high velocity ductwork.

- 3.09 Where specified, aluminum bands shall be used on piping insulation. The bands shall be applied three (3) to a section of pipe. Fittings, valves, etc., shall have bands on each side.
- 3.10 Where canvas finish is specified, use Arabol lagging adhesive to prevent mildew in securing canvas. Do not use wheat paste. In addition, cover all canvas insulation with a fire retardant coating.
- 3.11 For purpose of definition in this Specification: "concealed" areas are those areas which cannot be seen by the building occupants, and "exposed" areas are all areas which are exposed to view by the building occupants, including under counter and inside cabinet areas, plus all mechanical rooms.
- 3.12 The handling and installation of all insulation materials shall be performed in strict accordance with the manufacturer's recommendations.
- 3.13 TOLERANCE
- A. Substituted insulation materials shall provide thermal resistance within 10 percent at normal conditions, as materials indicated.
- 3.14 DUCT INSULATION SCHEDULE:

<u>Duct Type</u>	<u>Insulation Type</u>
Cold Supply Round	1 1/2" Insulation A
Hot Supply Round	1" Insulation A
Cold Supply Flat Oval	1 1/2" Insulation A
Hot Supply Flat Oval	1" Insulation A
Cold/Hot/or Combination Rectangular	1 1/2" Insulation B
Hot and Cold Combination Supply Round	2" Insulation C
Outside Air	1" Insulation B

END OF SECTION

SECTION 23 07 16
EQUIPMENT INSULATION

PART 1 GENERAL

1.00 The following sections are to be included as if written herein:

- A. Section 23 00 00 – Basic Mechanical Requirements
- B. Section 23 05 29 – Sleeves, Flashings, Supports and Anchors
- C. Section 23 05 53 – Mechanical Identification

1.01 SECTION INCLUDES

- A. Equipment insulation
- B. Covering
- C. Breaching insulation

1.02 RELATED SECTIONS

- A. Section 09 91 00 - Painting: Painting insulation covering

1.03 REFERENCES

- A. ASTM B209 - Aluminum and Aluminum-Alloy Sheet and Plate
- B. ASTM C177 - Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded- Hot-Plate Apparatus
- C. ASTM C195 - Mineral Fiber Thermal Insulation Cement
- D. ASTM C335 - Steady-State Heat Transfer Properties of Horizontal Pipe Insulation
- E. ASTM C449 - Mineral Fiber Hydraulic-setting Thermal Insulating and Finishing Cement
- F. ASTM C518 - Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus
- G. ASTM C533 - Calcium Silicate Block and Pipe Thermal Insulation

- H. ASTM C534 - Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form
- I. ASTM C552 - Cellular Glass Block and Pipe Thermal Insulation
- J. ASTM C553 - Mineral Fiber Blanket and Felt Insulation
- K. ASTM C612 - Mineral Fiber Block and Board Thermal Insulation
- L. ASTM C640 - Corkboard and Cork Pipe Thermal Insulation
- M. ASTM C921 - Properties of Jacketing Materials for Thermal Insulation
- N. ASTM D1056 - Flexible Cellular Materials - Sponge or Expanded Rubber
- O. ASTM E84 - Surface Burning Characteristics of Building Materials
- P. ASTM E96 - Water Vapor Transmission of Materials
- Q. NFPA 255 - Surface Burning Characteristics of Building Materials
- R. UL 723 - Surface Burning Characteristics of Building Materials

1.04 SUBMITTALS

- A. Submit under provisions of Section 23 00 00.
- B. Product Data: Provide product description, list of materials and thickness for equipment scheduled.
- C. Samples: Submit two samples of any representative size illustrating each insulation type.
- D. Manufacturer's Installation Instructions: Indicate procedures which ensure acceptable workmanship and installation standards will be achieved.

1.05 QUALITY ASSURANCE

- A. Materials: Flame spread/smoke developed rating of 25/50 in accordance with NFPA 255.

1.06 QUALIFICATIONS

- A. Applicator: Company specializing in performing the work of this section with minimum three years experience.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Deliver, store, protect and handle products to site under provisions of Section 23 00 00.
- B. Deliver materials to site in original factory packaging, labeled with manufacturer's density and thickness.
- C. Store insulation in original wrapping and protect from weather and construction traffic.
- D. Protect insulation against dirt, water, chemical, and mechanical damage.

1.08 ENVIRONMENTAL REQUIREMENTS

- A. Maintain ambient temperatures and conditions required by manufacturers of adhesives, mastics, and insulation cements.
- B. Maintain temperature during and after installation for minimum period of 24 hours.

PART 2 PRODUCTS

2.01 EMERGENCY GENERATOR EXHAUST PIPING AND MUFFLER:

- A. Emergency generator exhaust piping and muffler shall be insulated. Insulation shall be Owens-Corning Fiberglass "Kaylo", applied in two one inch (1") layers with staggered seams and joints, and finished with a .016" thick aluminum jacket, banded with 3/4" wide aluminum banding (.020" thick) using three (3) bands per three foot (3') section of covering. Thickness of insulation shall be sufficient to reduce the surface temperature to the maximum permitted by OSHA and other governing criteria, but in no case more than 150 degrees F. Insulation shall be rated for 1200 degrees F. service.

2.02 HEAT EXCHANGERS AND HOT WATER GENERATORS:

- A. The domestic hot water generator(s) and steam heating hot water converter(s) shall be insulated as hereinafter specified.
- B. Contractor shall install dimensional standard cellular glass insulation, Pittsburgh Corning "FOAMGLAS". The "FOAMGLAS" "StrataFab System" may also be installed as appropriate. "FOAMGLAS" for higher than ambient temperature service shall be manufactured using Pittsburgh Corning Hydrocal B-11 as the joint adhesive between layers of material. Prior to application of any insulation, all metal surfaces

shall be thoroughly cleaned. Regular "FOAMGLAS" insulation shall be applied to the piping with butt joints staggered and all joints tightly butted. The insulation shall be held in place using stainless steel bands. The bands shall be spaced at 12 inches on center. A jacket of aluminum or stainless steel shall be applied to the completed installation. The Longitudinal joint of the jacketing shall be placed with overlap directed to bottom of pipe. The jacketing shall be overlapped a minimum of 3 inches, and it shall be held in place using 3/4 inch bands applied at 12 inches on center. Note that the use of asphaltic compounds in higher-than-ambient temperature service is prohibited.

- C. Fitting insulation shall be applied in same manner as pipe application. Refer to piping insulation specification for proper guidance.
- D. The insulation thickness shall be as follows:

Temperature	<u>Thickness</u>
75°F to 150°F	2"
151°F to 300°F	2 1/2"
above 300°F	3"

- E. Securing of the jacket shall be made by the use of 1/2" x 0.016" aluminum or stainless steel bands and seals. The shields at support points shall be secured with 1/2" x 0.020" stainless steel bands and seals. Ferrous metal surfaces shall be primed with a red lead oxide primer. The metal jacketing and fitting covers shall be fabricated of 0.016" aluminum or stainless steel with a smooth finish.

2.03 PUMPS:

- A. Each water pump shall not be insulated but the insulation of the connecting piping shall be continued up to the face of the flanges on the piping connection to the pump and any bare metal that projects over the bed plate of the pump and from which condensation might drip onto the floor.
- B. The heating hot water pump and the condensate return pump shall not be insulated but the insulation of the connecting piping shall be beveled to the face of the pipe flange connection to the pump flange.

2.04 BUILT UP AIR CONDITIONING CASINGS AND DRAIN PANS:

- A. All walls and ceilings in the built up system plenums shall be lined with Mico Aire M/F Fiberglass ductboard Type 475, 1" thick. Liner shall be applied to the ceilings and walls with quick tacking rubber base adhesive. Liner shall be additionally secured to

surfaces with stick clips and washers spaced 16" on centers. Provide No. 6 mountings, ASTM-C-60T sound absorption test method.

- B. Floors of built up system plenums shall be insulated externally (beneath the floor surface) with 2 inch thick Insulation A, or its equivalent (including vapor barrier protection) integrated into the architectural/structural construction, in all instances where plenums may act as drain pans or otherwise collect moisture, or where personnel access is possible. In all other plenums, floors shall be lined as hereinbefore specified for walls and ceilings.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that equipment has been tested before applying insulation materials.
- B. Verify that surfaces are clean, foreign material removed, and dry.

3.02 INSTALLATION

- A. Install materials in accordance with manufacturer's instructions.
- B. Do not insulate factory insulated equipment.
- C. On exposed equipment, locate insulation and cover seams in least visible locations.
- D. Apply insulation close to equipment by grooving, scoring, and beveling insulation. Secure insulation to equipment with studs, pins, clips, adhesive, wires, or bands.
- E. Fill joints, cracks, seams, and depressions with bedding compound to form smooth surface. On cold equipment, use vapor barrier cement.
- F. Insulated dual temperature equipment or cold equipment containing fluids below ambient temperature:
 - 1. Provide vapor barrier jackets, factory applied or field applied.
 - 2. Finish with glass cloth and vapor barrier adhesive.
 - 3. Insulate entire system.
- G. For insulated equipment containing fluids above ambient temperature:

1. Provide standard jackets, with or without vapor barrier, factory applied or field applied.
 2. Finish with glass cloth and adhesive.
 3. For hot equipment containing fluids 140 degrees F or less, do not insulate flanges and unions, but bevel and seal ends of insulation.
 4. For hot piping conveying fluids over 140 degrees F, insulate flanges and unions, including those at equipment, but label the insulation to indicate a concealed flange or union.
- H. Inserts and Shields:
1. Application: Equipment 2 inches diameter or larger.
 2. Shields: Galvanized steel between hangers and inserts.
 3. Insert location: Between support shield and equipment and under the finish jacket.
 4. Insert configuration: Minimum 6 inches (150 mm) long, of same thickness and contour as adjoining insulation; may be factory fabricated.
 5. Insert material: Heavy density insulating material suitable for the planned temperature range.
- I. Finish insulation at supports, protrusions, and interruptions.
- J. For equipment in mechanical equipment rooms or in finished spaces, finish with aluminum jacket.
- K. For exterior applications, provide vapor barrier jacket or finish with glass mesh reinforced vapor barrier cement. Cover with aluminum jacket with seams located on bottom side of horizontal equipment.
- L. Cover cellular glass and cellular foam insulation with aluminum jacket.
- M. Do not insulate over any nameplate or ASME stamps. Bevel and seal insulation around such.
- N. Install insulation for equipment requiring access for maintenance, repair, or cleaning, in such a manner that it can be easily removed and replaced without damage.

- O. All piping, equipment, ductwork, all plenums including metal and masonry construction, fans, etc., shall be insulated as indicated on the Drawings, as specified herein, and as required for a complete system. In each case, the insulation shall be equal to that specified and materials applied and finished as described in these Specifications.
- P. All insulation shall be applied by mechanics skilled in this particular work and regularly engaged in such occupation. All insulation shall be applied in strict accordance with these Specifications and with factory printed recommendations on items not herein mentioned. Unsightly, inadequate, or sloppy work will not be acceptable, and all such work shall be removed and replaced as many times as necessary to achieve an acceptable installation.
- Q. All insulation, jacket, adhesives, mastics, sealers, etc., utilized in the fabrication of these systems shall meet NFPA for fire resistant ratings (maximum of 25 flame spread and 50 smoke developed ratings) and shall be approved by the insulation manufacturer for guaranteed performances when incorporated into their insulation system, unless a specific product is specified for a specific application, and is stated as an exception to this requirement. Certificates to this effect shall be submitted along with Contractor's submittal data for this section of the Specifications. No material may be used that, when tested by the ASTM E84-89 test method, is found to melt, drip or delaminate to such a degree that the continuity of the flame front is destroyed, thereby resulting in an artificially low flame spread rating.
- R. All surfaces to be insulated shall be clean and dry before applying the insulation. All sections of molded pipe covering shall be firmly butted together. Where an insulation covering is applied, it shall lap the adjoining section of insulation by at least three inches (3"). Where insulation terminates, it shall be neatly beveled and finished. No insulation shall be applied until the pipe, duct, etc., have been pressure tested and found tight. Piping, flexible connections, flanges, valves, strainers, and unions shall be covered unless specifically noted otherwise. Flexible connections on duct shall not be covered. All materials used shall be fire retardant or nonflammable. Refer to Section 15A.
- S. Where vapor barriers are required, the vapor barrier shall be on the outside. Extreme care shall be taken that the vapor barrier is unbroken. Joints, etc., shall all be sealed. Where insulation with a vapor barrier terminates, it shall be sealed off with the vapor barrier being continuous to the surface being insulated. Ends shall not be left raw.
- T. Extreme care shall be taken in covering high and medium pressure (high and medium pressure ductwork shall be all ductwork between the fan discharge and all mixing boxes) ductwork to insure the duct is not pierced with sheet metal screws or other

fasteners. All high and medium pressure ducts in these specifications are classified as high velocity ductwork.

- U. Where specified, aluminum bands shall be used on piping insulation. The bands shall be applied three (3) to a section of pipe. Fittings, valves, etc., shall have bands on each side.
- V. Where canvas finish is specified, use Arabol lagging adhesive to prevent mildew in securing canvas. Do not use wheat paste. In addition, cover all canvas insulation with a fire retardant coating.
- W. For purpose of definition in this Specification: "concealed" areas are those areas which cannot be seen by the building occupants, and "exposed" areas are all areas which are exposed to view by the building occupants, including under counter and inside cabinet areas, plus all mechanical rooms.
- X. The handling and installation of all insulation materials shall be performed in strict accordance with the manufacturer's recommendations.

END OF SECTION

**SECTION 23 07 19
PIPING INSULATION**

PART 1 GENERAL

1.00. The following sections are to be included as if written herein:

- A. 23 00 00 -- Basic Mechanical Requirements
- B. 23 05 29 -- Sleeves, Flashings, Supports and Anchors
- C. 23 05 53 -- Mechanical Identification

1.01. SECTION INCLUDES

- A. Piping insulation
- B. Jackets and accessories

1.02. PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION

- A. Section 21 13 13 - Fire Protection Piping: Placement of hangers and hanger inserts.
- B. Section 22 13 16 - Plumbing Piping: Placement of hangers and hanger inserts.
- C. Section 23 21 00 - Hydronic Piping: Placement of hangers and hanger inserts.
- D. Section 23 22 00 - Steam Piping: Placement of hangers and hanger inserts.

1.03. RELATED SECTIONS

- A. Section 09 91 00 - Painting: Painting Insulation Jacket.

1.04. REFERENCES

- A. ASTM B209 - Aluminum and Aluminum-Alloy Sheet and Plate.
- B. ASTM C177 - Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded- Hot-Plate Apparatus.
- C. ASTM C195 - Mineral Fiber Thermal Insulation Cement.
- D. ASTM C335 - Steady-State Heat Transfer Properties of Horizontal Pipe Insulation.
- E. ASTM C449 - Mineral Fiber Hydraulic-setting Thermal

- F. ASTM C518 - Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus.
- G. ASTM C533 - Calcium Silicate Block and Pipe Thermal Insulation.
- H. ASTM C534 - Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form.
- I. ASTM C547 - Mineral Fiber Preformed Pipe Insulation.
- J. ASTM C552 - Cellular Glass Block and Pipe Thermal Insulation.
- K. ASTM C578 - Preformed, Block Type Cellular Polystyrene Thermal Insulation.
- L. ASTM C585 - Inner and Outer Diameters of Rigid Thermal Insulation for Nominal Sizes of Pipe and Tubing (NPS System).
- M. ASTM C591 - Rigid Preformed Cellular Urethane Thermal Insulation.
- N. ASTM C610 - Expanded Perlite Block and Pipe Thermal Insulation.
- O. ASTM C640 - Corkboard and Cork Pipe Thermal Insulation.
- P. ASTM C921 - Properties of Jacketing Materials for Thermal Insulation.
- Q. ASTM D1056 - Flexible Cellular Materials - Sponge or Expanded Rubber.
- R. ASTM D1667 - Flexible Cellular Materials - Vinyl Chloride Polymers and Copolymers (Closed Cell Foam).
- S. ASTM D2842 - Water Absorption of Rigid Cellular Plastics.
- T. ASTM E84 - Surface Burning Characteristics of Building Materials.
- U. ASTM E96 - Water Vapor Transmission of Materials.
- V. NFPA 255 - Surface Burning Characteristics of Building Materials.
- W. UL 723 - Surface Burning Characteristics of Building Materials.

1.05. SUBMITTALS

- A. Submit under provisions of Section 23 00 00.

- B. Product Data: Provide product description, list of materials 'k' value, 'R' value, mean temperature rating, and thickness for each service, and locations.
- C. Samples: When requested, submit two samples of any representative size illustrating each insulation type.
- D. Manufacturer's Installation Instructions: Indicate procedures which ensure acceptable workmanship and installation standards will be achieved.

1.06. QUALITY ASSURANCE

- A. All insulation, jacket, adhesives, mastics, sealers, etc., utilized in the fabrication of these systems shall meet NFPA for fire resistant ratings (maximum of 25 flame spread and 50 smoke developed ratings) and shall be approved by the insulation manufacturer for guaranteed performances when incorporated into their insulation system, unless a specific product is specified for a specific application, and is stated as an exception to this requirement. Certificates to this effect shall be submitted along with Contractor's submittal data for this section of the Specifications. No material may be used that, when tested by the ASTM E84-89 test method, is found to melt, drip or delaminate to such a degree that the continuity of the flame front is destroyed, thereby resulting in an artificially low flame spread rating.
- B. All surfaces to be insulated shall be clean and dry before applying the insulation. All sections of molded pipe covering shall be firmly butted together. Where an insulation covering is applied, it shall lap the adjoining section of insulation by at least three inches (3"). Where insulation terminates, it shall be neatly beveled and finished. No insulation shall be applied until the pipe, duct, etc., have been pressure tested and found tight. Piping, flexible connections, flanges, valves, strainers, and unions shall be covered unless specifically noted otherwise. Flexible connections on duct shall not be covered. All materials used shall be fire retardant or nonflammable. Refer to Section 23 00 00.
- C. All piping, equipment, ductwork, all plenums including metal and masonry construction, fans, etc., shall be insulated as indicated on the Drawings, as specified herein, and as required for a complete system. In each case, the insulation shall be equal to that specified and materials applied and finished as described in these Specifications.
- D. To be considered, alternate materials shall have equivalent thermal and moisture resistance of the specified materials.

1.07. QUALIFICATIONS

- A. All insulation shall be applied by mechanics skilled in this particular work and regularly engaged in such occupation.
- B. All insulation shall be applied in strict accordance with these Specifications and with factory printed recommendations on items not herein mentioned. Unsightly, inadequate, or sloppy work will not be acceptable, and all such work shall be removed and replaced as many times as necessary to achieve an acceptable installation. The company performing the work of this section shall have a minimum of three years experience specializing in the trade.

1.08. DELIVERY, STORAGE, AND HANDLING

- A. Deliver, store, protect, and handle products to site under provisions of Section 23 00 00.
- B. Deliver materials to site in original factory packaging, labeled with manufacturer's identification, including product thermal ratings and thickness.
- C. Store insulation in original wrapping and protect from weather and construction traffic. Protect insulation against dirt, water, chemical, and mechanical damage.

1.09. ENVIRONMENTAL REQUIREMENTS

- A. Maintain ambient temperatures and conditions required by manufacturers of adhesives, mastics, and insulation cements.
- B. Maintain temperature during and after installation for minimum period of 24 hours.
- C. All insulation materials to be asbestos free.

PART 2 PRODUCTS

2.01. DOMESTIC HOT AND COLD WATER

- A. All domestic hot and cold water lines in buildings, including valves, strainers, unions, flanges, etc., except where specifically noted to the contrary, shall be insulated.
- B. All domestic cold water lines shall be insulated as scheduled with preformed fiberglass insulation with a factory applied All Service Jacket, vapor sealing all joints, and factory performed fittings with vapor seal, or a flexible, "25-50" rated, closed cell elastomeric thermal insulation such as "Self Seal Armaflex 2000".

Elastomeric products shall be supplied in a pre-slit tubular form with a pressure sensitive adhesive system for closure and vapor sealing of the longitudinal joint. All elastomeric insulating products shall be guaranteed not to react with copper piping. Valves shall be insulated with mitered pipe covering with voids filled with glass fiber blanket insulation. Valves and fittings shall be vapor sealed with a water base asphaltic emulsion. Fittings on concealed insulation shall be built up to the thickness of adjacent insulation with glass fiber fitting wrap and shall be finished with Glasfab tape embedded in vapor barrier emulsion. Exposed fitting insulation shall be built up to same thickness as adjoining pipe insulation with one coat cement and after drying shall be finished with a white vapor seal and canvas jacket secured with "Arabol" adhesive and be suitable for painting. Seams in jacket shall be placed in the least noticeable locations. Where seams, joint or fittings are rough they shall be covered with an application of insulating cement troweled on smoothly before the canvas is applied with Arabol adhesive. The canvas must be free of wrinkles and have a smooth, neat appearance.

- C. All domestic hot water piping systems shall be insulated as specified above for cold water except the vapor barrier may be deleted and the lap and butt joints secured with staples and a field applied adhesive (self sealing lap and butt joints alone are not acceptable). The insulation thickness shall be as scheduled. Where service temperature exceeds 250°F, insulation shall contain high temp binders.
- D. The only domestic hot and cold water piping that will not require insulation are the exposed runouts under non-handicap plumbing fixtures. Where pipe chases are tight, adequate provision shall be made at the rough in stage utilizing offset fittings or other means (except springing the pipe) to insure that insulation can be applied throughout the length of the pipe.

2.02. ROOF DRAIN PIPING

- A. All horizontal runs of roof drain piping in the building, and the bottom of all roof drains shall be insulated and sealed to the roof. Insulation shall be as specified for domestic cold water. Vertical roof drain piping inside the building shall not be insulated.

2.03. FIRE PROTECTION PIPING

- A. Fire protection piping, exposed or concealed, subject to freezing temperatures, shall be insulated with fiberglass UL rated noncombustible pipe insulating system using sectional pipe covering, jacketed with a factory applied vapor barrier laminate of aluminum foil and glass cloth. Exposed piping shall be sized for painting. Thickness shall be as scheduled for Hot (2) systems.
- B. Refer to details on the Drawings. The phrase "subject to freezing temperatures" shall be interpreted to mean all areas not within the confines of heated building spaces.

2.04. STEAM AND CONDENSATE PIPING - TUNNELS & BUILDINGS

- A. Steam and condensate piping in the main tunnel system and up to and including PRV's in the building shall be insulated with Manville's Thermo-12 or Owens/Corning "Kaylo" calcium silicate insulation with a factory applied aluminum cover .016" thick (Metal-On). Joints shall be sealed with aluminum snap straps provided, fastened in place with 3/4" wide x .020" stainless steel bands. Fittings and valves shall be insulated with the same thickness as that applied to the adjacent pipe and shall have an outer removable covering of aluminum as manufactured by Premetco.
- B. Consideration will be given to the use of Manville's Thermo-12 or Owens/Corning "Kaylo" with an outer covering of Premetco smooth finish, pre-cut, pre-rolled, Kraft paper lined aluminum Jacketing with zee type closure and 1-3/4" wide snap strap with permanent sealant in lieu of "Metal-On". Thickness of this jacketing shall be .016" on pipe sizes 8" and smaller and .020" on 10" pipe and larger.
- C. If Premetco jacketing is used, it shall be aluminum banding (.020N thick) using three section of covering
- D. Pipe insulation shall be firmly wired In place by the use of no less than six (6) loops of No. 16 annealed copper clad iron wire per three foot section of insulation. These sections shall be staggered. The ends of these loops shall be twisted together tightly and bent over and hammered into the insulation so as to leave no projection. Bands shall be .020" thick, 3/4" wide, 3 bands per section of insulation. Fittings, valves, etc., shall have bands on each side.
- E. All fittings on pipe 4" and larger shall be covered with the same material as the pipe, mitered and smoothed, and securely wired to the pipe.
- F. Fittings and valves for pipe smaller than 4" shall be insulated with Manville's No. 301 hydraulic setting cement and each application shall be in layers not thicker than 1/2". Each layer shall be allowed to dry before the next layer is applied.
- G. All cracks and voids in this insulation shall be filled carefully with Manville's Cement No. 301 so that the resulting surface is smooth and continuous.
- H. At all pipe flanges, the insulation shall be beveled in such a manner that access may be had to the bolt studs and nuts without injuring the insulation where removable covers have been specified.
- I. A layer of 40 pound rosin-size paper or 3/4 pound deadening felt shall be wrapped around the insulation before an 8 ounce canvas jacket is pasted in place. This canvas jacket shall be pasted onto the covered pipe valves and fittings (where insulated) in a neat and workmanlike fashion, using Arabol adhesive.

- J. All flanges, valves, pressure regulating valves, strainers, and any other hot surfaces shall be covered with a built-up removable covering made of Thermo-12 or “Kaylo” Pipe Covering with a finishing coat of Ryder hydraulic setting cement. This removable covering shall be banded on the valve or joint in such a fashion that it can readily be removed and replaced; it shall be of the same thickness as the insulation on the adjoining pipe.
- K. Piping insulated with calcium silicate pipe insulation and finished with canvas outer jacket shall be painted in accordance with campus paint scheme.
- L. Refer to Section 23 00 00 and 09 91 00 for painting requirements.

2.05. CHILLED and HOT WATER (200 deg and above) WATER PIPING - TUNNELS AND BUILDINGS

- A. Chilled and Hot Water Piping - “FOAMGLAS” as manufactured by the Pittsburgh Corning Corporation or “INSUL-PHEN” as manufactured by Resolco, Inc. and shall be installed on chilled water lines in tunnels and in buildings up to the building circulating pump. The “FOAMGLAS” “StrataFab System” may also be installed on larger pipe sizes as appropriate. Prior to application of any insulation, all metal surfaces shall be thoroughly cleaned. The metal shall then be primed with an asphaltic primer consisting of one (1) coat of Foster No. 60-26 Primer or Pittcote 300 Primer. Cleaning and priming specified in this paragraph is not included in requirements for “Cleaning and Painting” specified in other sections of the Specifications. Regular “FOAMGLAS” insulation shall be applied to the piping with butt joints staggered and all joints tightly butted and sealed with a ¼” bead of joint sealer ½” from outside edge. Hold in place with 14 gauge copper clad wire 9” o.c. After insulation has been wired in place, a 1/16” minimum thick, 3” wide band of asphaltic vapor seal mastic shall be brushed or troweled on the outside of the “FOAMGLAS” insulation at the approximate location of the aluminum bands. (Note that the asphaltic material specified in this paragraph is intended to be an exception to the flame spread and smoke generation limitations found elsewhere in this specification.) An aluminum jacketing 0.016” thickness equal to Premetco precast, pre rolled Z-lock Kraft paper lined pipe covering with zee type closure and ¾” wide snap straps with permanent sealant shall then be fitted to O.D. of insulation and applied over the insulated pipe with 3” end and side caps secured with aluminum bands on 12” centers. Longitudinal joint of aluminum jacketing shall be placed with overlap directed to bottom of pipe. Any voids in “the completed installation of the insulation shall not be filled with vapor seal coating but shall be eliminated by refitting or replacing insulation.
- B. “FOAMGLAS” or “INSUL-PHEN” insulation on flanges, valves and other fitting shall consist of prefabricated fitting covers of the same thickness as specified for adjoining pipe insulation.

- C. Fitting covers shall be applied in same manner as pipe application except that 16 gauge aluminum wire may be used to secure screwed fitting covers. Protruding metal parts (such as valve stems) shall be completely sealed off. Fitting cover jacketing shall be equal to Gasco, Papco or RPR Metals prefabricated fitting covers of 0.016" paper coated aluminum, secured as recommended by the manufacturer.
- D. The insulation thickness shall be as scheduled.
- E. "FOAMGLAS" or "INSUL-PHEN" installed inside the building downstream of the blending station shall be insulation with factory applied Class I, Fire Rated, Kraft-Aluminum, vapor barrier jacketing as manufactured by Pittsburgh Corning. It shall be applied in strict accordance with the manufacturer's recommendations after the pipe has been primed with one (1) coat of Foster No. 60-26 Primer or Pittcoat 300 Primer. (Note that the asphaltic material specified in this paragraph is intended to be an exception to the flame spread and smoke generation limitations found elsewhere in this specification.) It will be necessary to include expansion joints at regular intervals on dual temperature service. Thickness shall be as scheduled.
- F. Fitting covers shall be built up of shaped segments of "FOAMGLAS" or "INSUL-PHEN." These fitting covers shall be adhered in place using "Foster No. 30-35 80" water based vapor seals, then smoothly covered by a one-quarter inch (1/4") thick application of one coat white insulating cement. All this piping and fittings shall be finished with an eight ounce canvas jacket neatly applied using Arabol adhesive.
- G. Valves, fittings, etc., in congested areas around coil and heat exchanger equipment, etc., shall be insulated by building up fitting segments and pre-molded sections, plus white vapor seal mastic, plus Manville No. 301 finishing cement to smooth surfaces, plus canvas applied and sized for painting with fire resistant adhesive. In addition, all manufactured vapor barrier jacketing in mechanical rooms and finished spaces shall be finished with canvas applied and sized for painting with fire resistant adhesive.
- H. No chilled water pipe supporting structures shall pierce the insulation except as anchor points as shown on the Drawings. At these points, the anchor member shall occur on the bottom of the piping to allow condensation to drain.
- I. The application of the protective shields at rack and guide points in tunnels and in central chilling stations shall be as detailed on the accompanying Drawings.
- J. All insulation joints (longitudinal and butt) shall be buttered with vapor sealant mastic then pressed firmly together.

2.06. Not Used

2.07 PREINSULATED TUNNEL PIPING

- A. In lieu of the above, the following system will be allowed for tunnel piping.
- B. Factory preinsulated pipe may be used for chilled water, hot water, steam (limited to 365F) and condensate piping installed in tunnels. .Factory preinsulated pipe shall consist of standard straight sections and fitting kits. Materials specified in this paragraph is intended to be an exception to the flame spread and smoke generation limitations found elsewhere in this specification.
- C. Pipe insulation shall be seamless, 90-95% spray applied, or injected, close cell polyurethane foam having the following properties:
 - 1. Thermal Conductivity (k-value) - 0.15 BTU-in./hr.-ft ²-°F minimum at 73° per ASTM C 518. ‘R’ value per Section 23 07 19 -3.13B.
 - 2. Density - 2.5 lb./cu. ft. (Minimum) per ASTM D 1622.
 - 3. Compressive Strength - 22 psi minimum per ASTM D 1621.
 - 4. Flexural Strength - 25 psi minimum per ASTM D 790.

Each pipe unit shall be inspected at the factory to ensure that there are no voids in the insulation.

- A. Jackets for preinsulated piping shall be white in color, minimum of 0.06” thickness, seamless PVC, HDPE, or, fiberglass reinforced polyester resin (FRP) and provide a vapor barrier and protection from mechanical abuse.
- B. Connections of factory preinsulated pipe and fittings shall be field insulated by pour foaming insitu, using materials furnished by the system including PVC jacketing and fitting covers. Transitions to factory insulated pipe at field joints shall be sealed with white PVC tape.
- C. No pipe supporting structures shall pierce the insulation except as anchor points as shown on the Drawings. Protective shields at rack and guide points in tunnels shall be as described in Part 3.03.

2.08. CONDENSATE DRAIN AND WATER RECOVERY (Fin Water) PIPING

- A. Condensate drain piping from fan and coil units, coil banks, drinking fountain refrigeration units, and other items of piping or equipment subject to condensation forming on the surface shall be insulated with a “25-50” rated, closed cell elastomeric thermal insulation. Elastomeric products shall be supplied in a pre-slit tubular form with a pressure sensitive adhesive system for closure and vapor sealing of the longitudinal joint. All elastomeric insulating products shall be guaranteed not to react with copper piping.
- B. Drain piping from mechanical rooms, and other areas potentially receiving chilled water or condensate from air handlers, shall be similarly insulated for a minimum of 15 feet from the floor drains receiving the cold fluid.

2.09. PROTECTIVE JACKETING

- A. Provide protective jacketing as described elsewhere.
- B. Jacketing and fitting covers shall be .016 aluminum smooth as manufactured by Premetco or Childers. The jacket shall be pre-cut, pre-rolled, and lapped a minimum of two inches (2") in all directions to shed water. The metal shall be secured at each joint with a minimum of one each (1 ea.) $\frac{3}{4}$ " wide .020 aluminum or stainless steel band and seal. The metal jacketing and fitting covers shall be fabricated of 0.016" aluminum or stainless steel with a smooth finish.
- C. In indoor applications, Proto Corp. LoSmoke PVC jacketing and fitting covers may be used. Material shall have 25/50 rating and shall be limited to piping systems operating at 140 degrees or below.

2.10. EXPANSION JOINTS

- A. Where expansion bends occur in the lines, a two foot (2') double layer contraction joint shall be provided in the main line starting two feet from the end of the main line on both sides of the expansion loop. Contraction joints shall consist of two 1-1/2" thick x 24" long pipe covering cuts into 17-1/4" and 6" lengths to provide a $\frac{3}{4}$ " space by 10-1/4". A slip joint mastic (Pittseal III) shall be placed between layers from the $\frac{3}{4}$ " space provided on the inside layer to the $\frac{3}{4}$ " space on the outside layer.
- B. The $\frac{3}{4}$ " space on inside layer shall be filled with mineral wool loose fill and the $\frac{3}{4}$ " space on the outer layer shall also be filled with same loose fill and joint sealer pressed $\frac{1}{2}$ " deep into space for sealing (Pittseal III). Around the outside layer at the $\frac{3}{4}$ " space, there shall be wrapped a 4" wide piece of glass fabric and sealed down with vapor seal mastic. On pipe sizes smaller than aforementioned, the same contraction joint shall be provided using one inch (1") thick "FOAMGLAS" or "INSUL-PHEN" pipe covering for the inner layer. On two inch (2") IPS, both inner and outer layer shall be 1" thick "FOAMGLAS" or "INSUL-PHEN".
- C. The joint and vapor seal mastic shall be Pittsburgh Corning Corporation Pittcote 300. (Note that the asphaltic material specified in this paragraph is intended to be an exception to the flame spread and smoke generation limitations found elsewhere in this specification.
- D. The slip joint sealer shall be Pittsburgh Corning Corporation's Pittseal III.

2.11. PUMPS

- A. The chilled water pump and hot water pumps shall not be insulated but the insulation of the connecting piping shall be continued up to the face of the flanges on

the piping connection to the pump and any bare metal that projects over the bed plate of the pump and from which condensation might drip onto the floor.

- B. Receivers of the steam condensate pumps shall be insulated with 6 lb. (minimum) density fiberglass board or rigid wrap insulation with a factory applied All Service Jacket. All joints shall be filled with insulating cement and covered with All Service Jacket material stapled in place and sealed with adhesive. Thickness shall be as scheduled. [OMIT FOR AUSTIN CAMPUS]

2.12. INSULATED UNDERGROUND PIPING

See Section 23 20 00.A.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that piping has been tested before applying insulation materials.
- B. Verify that surfaces are clean, foreign material removed, and dry.

3.02 INSTALLATION

- A. Install materials in accordance with manufacturer's instructions in the absence of specific instruction herein.
- B. On exposed piping, locate insulation and cover seams in least visible locations, but not higher than at the side of the pipe at the "90°" position, with the seam lapped such that the lap is directed down.
- C. Insulated dual temperature pipes or cold pipes conveying fluids below ambient temperature: Vapor barriers are required. The vapor barrier shall be on the outside. Extreme care shall be taken that the vapor barrier is unbroken. Joints, etc., shall be sealed. Where insulation with a vapor barrier terminates, it shall be sealed off with the vapor barrier being continuous to the surface being insulated. Ends shall not be left raw.
 - 1. Provide vapor barrier jackets, factory applied or field applied.
 - 2. Insulate fittings, joints, and valves with molded insulation of like material and thickness as adjacent pipe.
 - 3. Finish with glass cloth and vapor barrier adhesive.
- D. Continue insulation through walls, sleeves, pipe hangers, and other pipe penetrations.

- E. For insulated pipes conveying fluids above ambient temperature:
 - 1. Provide standard jackets, with or without vapor barrier, factory applied or field applied.
 - 2. Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe.
- F. If PVC fitting covers are used they shall have 25/50 rating.
- G. For hot piping conveying fluids 140°F or less, do not insulate flanges and unions at equipment, but bevel and seal ends of insulation.
- H. For hot piping conveying fluids over 140°F, insulate flanges and unions, including those at equipment, but label the insulation to indicate a concealed flange or union. See 2.04K.

3.03 INSERTS, SUPPORTS and SHIELDS

- A. Application: Piping 3/4 inch diameter or larger for all systems except direct buried.
- B. Shields: Install between pipe hangers or pipe hanger rolls and inserts. Hangers shall be on the outside of the insulation and shall not be in contact with the pipe. Curved metal shields shall be used between the hangers or support points and the bottom of the insulated pipe for insulated pipes 3/4" and larger. Curved metal shields shall be designed to limit the bearing stress on the insulation to 35 psi and shall be curved to fit up to mid-perimeter of the insulated pipe. Shields shall be made of galvanized iron, or black iron painted on both sides with two coats of aluminum paint. Required metal shield sizes are as follows:

Nominal IPS	Metal Thickness	Lengths of Shield
up thru 2"	14 gauge	12"
thru 6"	12 gauge	16"
and above	10 gauge	20"

- C. Insert Location: Between support shield and piping and under the finish jacket.
- D. Insert Configuration: Minimum 2" inches longer than length of shield, of same thickness and contour as adjoining insulation; may be factory fabricated.
- E. Insert Material: Heavy density insulating material suitable for the planned temperature range, and the weight of the pipe.
- F. The shields at support points shall be secured with 1/2" x 0.016" stainless steel bands and seals.

- G. Finish insulation at supports, protrusions, and interruptions.
- H. The application of the protective shields at rack and guide points in tunnels and in central chilling stations shall be as detailed on the accompanying Drawings.
- I. In lieu of the above the following system of support may be used:
 - 1. At the pipe support positions, the insulation and vapor barrier shall be continuous and shall not be punctured by the support. The insulation at the support shall be the full circumference of 5lbs/ft³ INSUL-PHEN Foam material to withstand the bearing loads transmitted from the pipe to the support, it shall extend for at least 1" on either side of the support to allow sealing of the joints with the pipe insulation jacket.
 - 2. The load bearing insulation at the support shall be capable of withstanding the maximum static compressive loads generated by pipe supported at the centers shown in Table 1.

Variations: Pipe loads greater than those generated at the support centers shown in Table 1 shall be referred to the manufacturer to establish the length and density of the insulated support block. The support centers are based on the weight of Sch 80 pipe filled with water and covered with 1" thickness of 2.2 lbs/ft³ standard insulation including FSK/ASJ vapor barrier.

Table 1 K Block Support Centers

Nominal Pipe Size	3/4	1	1 1/4	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24
Max support centers (feet)																
Sch 80 pipe filled with water covered with 1" of Standard Insulation	6.5	6.5	6.5	10	10	10	10	10	14	14	14	20	20	20	20	20
Metal Saddle Gauge (Galvanized Steel)	22	22	22	20	20	20	16	14	14	14	14	14	14	14	14	14
Length of K Block (inches)	6	6	6	6	6	6	6	9	9	9	9	9	9	12	12	12

1. The Insulation at supports shall be a Kooltherm K Block. K Blocks shall be faced with factory applied FSK/ASJ vapor barrier and fitted with a galvanized steel 180° saddle bonded to the bottom section of the K Block, for all pipe sizes 1 1/2" and larger.
2. The vapor barrier shall be completed by the use of a FSK/ASJ overlap and factory applied self-seal lap tape and sealed with vapor barrier adhesive.
3. At all support positions, other than those where the insulated pipe support block is surrounded by a clip or saddle in direct contact with the block, a block designed to accept the loads generated by the pipe shall be presented to the engineer for approval. e.g. Of the type Kooltherm products K Block. Ref:- Kooltherm sketch 106/2c for use with Roller or flat beam support.
4. In all cases where roller supports are used the length of the insulation and the wearing plate where fitted shall extend beyond the limits of the pipe movement.

3.04 For heat traced piping, insulate fittings, joints, and valves with insulation of like material, thickness, and finish as adjoining pipe. Size large enough to enclose pipe and heat tracer. Cover with aluminum jacket with seams located on bottom side of horizontal piping.

3.05 Where canvas finish is specified, use Arabol lagging adhesive to prevent mildew in securing canvas. Do not use wheat paste. In addition, cover all canvas insulation with a fire retardant coating.

3.06 For purpose of definition in this Specification: "concealed" areas are those areas which cannot be seen by the building occupants, and "exposed" areas are all areas

which are exposed to view by the building occupants, including under counter and inside cabinet areas, plus all mechanical rooms.

- 3.07 Self Sealing Lap and butt joints will not be acceptable as the only seal on piping insulation joints. Self Sealing Lap and butt joints may be utilized only if the joints are additionally secured with field applied vapor barrier adhesive (on piping Systems requiring vapor barriers) or staples and field applied adhesive (on piping system which do not require a vapor barrier jacket). Mechanical fasteners shall be used whenever possible to assure permanent installation.
- 3.08 Insulation minimum thickness shall be as scheduled; however, additional thickness shall be provided to prevent condensation on the cold surfaces and to provide a maximum exterior insulation surface of 140°F on the hot surfaces.
- 3.09 Special Protection: All insulated piping in the mechanical rooms within 8'-0" of the floor shall be encased in a protective jacket, and where applicable, finish at top with nickel-plated brass flange plate with set screws or end joint sealing butt strips.
- 3.10 All exposed outdoor piping shall have metal jacket.
- 3.11 Fitting insulation shall be applied in same manner as pipe application. Protruding metal parts (such as valve stems) shall be completely sealed off. Fitting cover jacketing shall be equal to Gasco, Pabco or RPR Metals prefabricated fitting covers of 0.016" paper coated aluminum, secured as recommended by the manufacturer.
- 3.12 Valves, fittings, etc., in congested areas around coil and heat exchanger equipment, etc., shall be insulated by building up fitting segments and pre-molded sections as necessary.
- 3.13 No pipe supporting device (other than guides or anchors attached directly to the pipe) shall penetrate the insulation.
- 3.14 PAINTING
 - A. All exposed insulation shall be prepared to receive painting specified under Section 09 91 00.
 - B. The pipe primer shall be Pittsburgh Corning Corporation Pittcote 300.

Insulation 'R' Value Schedule (R = thickness / k)

Service	Oper Temp °F	'k' @ Mean Temp °F	Min. R value for each Pipe Size				
			1" & less	1-1/4" to 2"	2-1/2" to 4"	5" & 6"	8" & over
Hot (1)	350+	.33 @ 250	7.5	7.5	10.0	12.0	13.0
Hot (2)	251-350	.30 @ 200	6.5	8.5	8.5	11.5	12.5
Hot (3)	201-250	.29 @ 150	5.2	5.2	6.9	6.9	12.1
Hot (4)	141-200	.27 @ 125	5.6	5.6	5.6	5.6	5.6
Hot (5)	105-140	.26 @ 100	3.8	3.8	5.8	5.8	5.8
Cold (6)	40-55	.25 @ 75	2.0	3.0	4.0	4.0	4.0
Cold (7)	below 40	.25 @ 75	4.0	6.0	6.0	6.0	6.0

- (1) HTHW; Steam @ over 120#
- (2) HTHW; Steam @ 16# to 120#; med & hp condensate; water and fire line freeze protection
- (3) HTHW; Steam @ 0# to 15#; LP Condensate
- (4) HW
- (5) HW
- (6) Ch. Wtr; Dom. cold wtr; Storm; Cold condensate
- (7) Ch. Wtr; Brine; Refrig lines

Minimum 'R' does not consider water vapor transmission and condensation. Additional insulation and/or vapor retarders may be required to limit water vapor transmission and condensation under extreme conditions.

A minus 15 percent tolerance, on the insulation performance listed shall be permitted for manufacturers' standard insulation systems.

In non-conditioned mechanical rooms and all crawl spaces, insulation shall prevent formation of surface condensation under conditions of 95°F, 95%RH, and zero wind speed. Provide manufacturer's certification of this performance on submittal data.

END OF SECTION

SECTION 23 09 23
DIRECT DIGITAL CONTROL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Quality Assurance.
 - 2. System Architecture.
 - 3. Distributed Processing Units/Quantity and Location.
 - 4. Sequence of Work.
 - 5. Devices and Equipment.
- B. Contractor shall furnish and install a direct digital control and building automation system (BAS). The new BAS shall utilize electronic sensing, microprocessor-based digital control, and electronic actuation of dampers and valves (except where noted otherwise) to perform control sequences and functions specified. The BAS for this Project will generally consist of monitoring and control of systems described herein. Reference shall also be made to control Drawings, Sequence of Operation, and points lists.
- C. This Section defines the manner and method by which these controls function as well as the materials to be used.
- D. Provide the following electrical work as work of this Section, complying with requirements of Division 26 Sections.
 - 1. Control wiring between field-installed controls, indicating devices, and unit control panels.
 - 2. Interlock wiring between electrically interlocked devices, sensors, and between a hand or auto position of motor starters as indicated for all mechanical and controls.
 - 3. Wiring associated with annunciator and alarm panels (remote alarm panels) and connections to their associated field devices.
 - 4. All other necessary wiring for fully complete and functional control system as specified.

1.3 REFERENCE STANDARDS

- A. The latest published edition of a reference (prior to the date of contract) shall be applicable to this Project unless identified by a specific edition date.
- B. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.

- C. All materials, installation and workmanship shall comply with the applicable requirements and standards addressed within the following references:
1. American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE).
 2. ASHRAE 135: BACnet - A Data Communication Protocol for Building Automation and Control Networks, latest edition. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. and all current addenda and annexes.
 3. NFPA 70 - NEC
 4. Telecommunications Industry Standards:
 - a. CEA-709.1-A: Control Network Protocol Specification.
 - b. CEA-709.3: Free-Topology Twisted-Pair Channel Specification. TIA-232: Interface between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange.
 - c. TIA-485: Standard for Electrical Characteristics of Generator and Receivers for use in Balanced Digital Multipoint Systems.
 5. Underwriters Laboratories:
 - a. UL 916: Energy Management Systems.
 - b. UL 508a: Industrial Control Panels.
 6. NEMA Compliance:
 - a. NEMA 250: Enclosure for Electrical Equipment.
 - b. NEMA ICS 1: General Standards for Industrial Controls.
 7. Institute of Electrical and Electronics Engineers (IEEE)
 - a. IEEE 142: Recommended Practice for Grounding of Industrial and Commercial Power Systems.
 - b. IEEE 802.3: CSMA/CD (Ethernet – Based) LAN.
 - c. IEEE 802.4: Token Bus Working Group (ARCNET – Based) LAN.
 - d. IEEE 519: Recommended Practices and Requirements for Harmonic Control in Electric Power Systems.

1.4 DEFINITIONS

- A. Advanced Application Controller (AAC): A device with limited resources relative to the Building Controller (BC). It may support a level of programming and may also be intended for application specific applications.
- B. Application Protocol Data Unit (APDU): A unit of data specified in an application protocol and consisting of application protocol control information and possible application user data (ISO 9545).
- C. Application Specific Controller (ASC): A device with limited resources relative to the Advanced Application Controller (AAC). It may support a level of programming and may also be intended for application-specific applications.
- D. BACnet/BACnet Standard: BACnet communication requirements as defined by ASHRAE/ANSI 135 and all current addenda and annexes.

- E. BACnet Interoperability Building Blocks (BIBB): BIBB defines a small portion of BACnet functionality that is needed to perform a particular task. BIBBS are combined to build the BACnet functional requirements for a device in a Specification.
- F. Binding: In the general sense, binding refers to the associations or mappings of the sources network variable and their intended or required destinations.
- G. Building Automation System (BAS): The entire integrated management, monitoring, and control system.
- H. Building Controller (BC): A fully programmable device capable of carrying out a number of tasks including control and monitoring via direct digital control (DDC) of specific systems, acting as a communications router between the LAN backbone and sub-LANs, and data storage for trend information, time schedules, and alarm data.
- I. Change of Value (COV): An event that occurs when a measured or calculated analog value changes by a predefined amount (ASHRAE/ANSI 135).
- J. Client: A device that is the requestor of services from a server. A client device makes requests of and receives responses from a server device.
- K. Continuous Monitoring: A sampling and recording of a variable based on time or change of state (e.g. trending an analog value, monitoring a binary change of state).
- L. Controller or Control Unit (CU): Intelligent stand-alone control panel. Controller is a generic reference and shall include BCs, AACs, and ASCs as appropriate.
- M. Control Systems Server (CSS): This shall be a computer (or computers) that maintains the systems configuration and programming database. This may double as an operator workstation.
- N. Direct Digital Control (DDC): Microprocessor-based control including Analog/Digital conversion and program logic.
- O. Functional Profile: A collection of variables required to define key parameters for a standard application. For the HVAC industry, this would include applications like VAV terminal units, fan coil units, etc.
- P. Gateway (GTWY): A device, which contains two or more dissimilar networks/protocols, permitting information exchange between them (ASHRAE/ANSI 135-2001).
- Q. Hand Held Device (HHD): Manufacturer's microprocessor based device for direct connection to a Controller.
- R. IT LAN: Reference to the facility's Information Technology network, used for normal business-related e-mail and Internet communication.
- S. LAN Interface Device (LANID): Device or function used to facilitate communication and sharing of data throughout the BAS.
- T. Local Area Network (LAN): General term for a network segment within the architecture. Various types and functions of LANs are defined herein.

- U. Local Supervisory LAN: Ethernet-based LAN connecting Primary Controller LANs with each other and OWSs and CSSs and the LAN to which the GEMnet will be interfaced. See System Architecture herein.
- V. Master-Slave/Token Passing (MS/TP): Data link protocol as defined by the BACnet standard (ASHRAE/ANSI 135).
- W. Owner WAN: Internet-based network connecting multiple facilities with a central data warehouse and server, accessible via standard web-browser.
- X. Native BACnet: A building automation or monitoring device that does not require any additional module, gateway, or driver to communicate to other devices with BACnet communication protocol. The ability to communicate via BACnet is built-in and the device should be able to communicate immediately when connected to a network with other BACnet devices.
- Y. Open Database Connectivity (ODBC): An open standard application-programming interface (API) for accessing a database developed. ODBC compliant systems make it possible to access any data from any application, regardless of which database management system (DBMS) is handling the data.
- Z. Operator Interface (OI): A device used by the operator to manage the BAS including OWSs, POTs, and HHDs.
- AA. Operator Workstation (OWS): The user's interface with the BAS system. As the BAS network devices are stand-alone, the OWS is not required for communications to occur.
- BB. Point-to-Point (PTP): Serial communication as defined in the BACnet standard.
- CC. Portable Operators Terminal (POT): Laptop PC used both for direct connection to a controller and for remote dial up connection.
- DD. Protocol Implementation Conformance Statement (PICS): A written document, created by the manufacturer of a device, which identifies the particular options specified by BACnet that are implemented in the device (ASHRAE/ANSI 135).
- EE. Primary Controlling LAN: High speed, peer-to-peer controller LAN connecting BCs and optionally AACs and ASCs. Refer to System Architecture herein.
- FF. Router: A device that connects two or more networks at the network layer.
- GG. Secondary Controlling LAN: LAN connecting AACs and ASCs, generally lower speed and less reliable than the Primary Controlling LAN. Refer to System Architecture herein.
- HH. Server: A device that is a provider of services to a client. A client device makes requests of and receives responses from a server device.
- II. SQL: Standardized Query Language, a standardized means for requesting information from a database.
- JJ. Smart Device: A control I/O device such as a sensor or actuator that can directly communicate with the controller network to which it is connected. This differs from an ASC in that it typically deals only with one variable.

KK. XML (Extensible Markup Language): A specification developed by the World Wide Web Consortium. XML is a pared-down version of SGML, designed especially for Web documents. It allows designers to create their own customized tags, enabling the definition, transmission, validation, and interpretation of data between applications and between organizations.

1.5 QUALITY ASSURANCE

- A. Product Line Demonstrated History: The product line being proposed for the Project must have an installed history of demonstrated satisfactory operation for a length of one (1) year since date of final completion in at least ten (10) installations of comparative size and complexity. Submittals shall document this requirement with references.
- B. Installer's Qualifications: Firms specializing and experienced in control system installations for not less than 5 years. Firms with experience in DDC installation projects with point counts equal to this Project and systems of the same character as this Project. If installer is a Value Added Reseller (VAR) of a manufacturer's product, installer must demonstrate at least three years prior experience with that manufacturer's products. Experience starts with awarded Final Completion of previous projects. Submittals must document this experience with references.
- C. Installer's Experience with Proposed Product Line: Firms shall have specialized in and be experienced with the installation of the proposed product line for not less than one year from date of final completion on at least three (3) projects of similar size and complexity. Submittals shall document this experience with references.
- D. Installer's Field Coordinator and Sequence Programmer Qualifications: Individual(s) shall specialize in and be experienced with control system installation for not less than five (5) years. Proposed field coordinator shall have experience with the installation of the proposed product line for not less than two (2) projects of similar size and complexity. Installer shall submit the names of the proposed individual and at least one alternate for each duty. Submittals shall document this experience with references. Proposed individuals must show proof of the following training:
- E. Product Line Training: Individuals overseeing the installation and configuration of the proposed product line must provide evidence of the most advanced training offered by the manufacturer on that product line for installation and configuration.
- F. Programming Training: Individuals involved with programming the Site-specific sequences shall provide evidence of the most advanced programming training offered by the vendor of the programming application offered by the manufacturer.
- G. Installer's Service Qualifications: The installer must be experienced in control system operation, maintenance and service. Installer must document a minimum five (5) year history of servicing installations of similar size and complexity. Installer must also document at least a one year history of servicing the proposed product line.
- H. Installer's Response Time and Proximity:

1. Installer must maintain a fully capable service facility within a 60 mile radius of the Project Site. Service facility shall manage emergency service dispatches and maintain inventory of spare parts.
 2. Emergency response times are listed below in this Section. Installer must demonstrate ability to meet response times.
- I. The BAS and components shall be listed by Underwriters Laboratories (UL 916 and 508a) as an Energy Management System.
 - J. All controllers installed shall be BTL listed for no less than one year and be Native BACnet controllers.

1.6 SUBMITTALS

- A. During bid, contractor shall submit the expected number of IT data drops to allow for review of the proposed system architecture (all IP based or a combination of IP and other communication wiring).
- B. Within 90 days of notice to proceed, contractor shall submit drawings showing required IT data drops on architectural backgrounds (height above finished floor and quantity). Drawings shall include any spare drops.
- C. All approved complete submittals shall be provided as a hard copy for the owner at the completion of the project. Digital copies shall be provided during the construction phase.
- D. Functional Intent: Throughout the Contract Documents, detailed requirements are specified, some of which indicate a means, method or configuration acceptable to meet that requirement. Contractor may submit products that utilize alternate means, methods, and configurations that meet the functional intent. However, these will only be allowed with prior approval.
- E. Electronic Submittals: While all requirements for hard copy submittal apply, control submittals and operation and maintenance (O&M) information shall also be provided in electronic format as follows:
 1. Drawings and Diagrams: Shop Drawings shall be provided on electronic media as an AutoCAD drawing per Owner's CAD standards. All 'x reference' and font files must be provided with AutoCAD files.
 2. Other Submittals: All other submittals shall be provided in PDF format.
- F. Qualifications: Manufacturer, Installer, and Key personnel qualifications as indicated for the appropriate items.
- G. Product Data: Submit manufacturer's technical product data for each control device, panel, and accessory furnished, indicating dimensions, capacities, performance and electrical characteristics, and material finishes. Also include installation and start-up instructions.
 1. Shop Drawings: Submit Shop Drawings electronically on AutoCAD software for each control system, including a complete drawing for each air handling unit, system, pump, device, etc. with all point descriptors, addresses and point names indicated. Shop Drawings shall contain the following information:
 - a. System Architecture and System Layout:

- 1) One-line diagram indicating schematic locations of all control units, workstations, LAN interface devices, gateways, etc. Indicate network number, device ID, address, device instance, MAC address, drawing reference number, and controller type for each control unit. Indicate media, protocol, baud rate, and type of each LAN. All optical isolators, repeaters, end-of-line resistors, junctions, ground locations etc. shall be located on the diagram.
 - 2) Provide floor plans locating all control units, workstations, servers, LAN interface devices, gateways, etc. Include all WAN and LAN communication wiring routing, power wiring, power originating sources, and low voltage power wiring. Indicate network number, device ID, address, device instance, MAC address, drawing reference number, and controller type for each control unit. Indicate media, protocol, baud rate, and type of each LAN. All optical isolators, repeaters, end-of-line resistors, junctions, ground locations etc. shall be located on the floor plans. Wiring routing conditions shall be maintained accurately throughout the construction period and the Record Drawings shall be updated to accurately reflect accurate, actual installed conditions.
- b. Schematic flow diagram of each air and water system showing fans, coils, dampers, valves, pumps, heat exchange equipment and control devices. Include written description of sequence of operation.
 - c. All physical points on the schematic flow diagram shall be indicated with names, descriptors, and point addresses identified as listed in the point summary table.
 - d. Label each control device with setting or adjustable range of control.
 - e. Label each input and output with the appropriate range.
 - f. Provide a Bill of Materials with each schematic. Indicate device identification to match schematic and actual field labeling, quantity, actual product ordering number, manufacturer, description, size, voltage range, pressure range, temperature range, etc. as applicable.
 - g. Indicate all required electrical wiring. Electrical wiring diagrams shall include both ladder logic type diagram for motor starter, control, and safety circuits and detailed digital interface panel point termination diagrams with all wire numbers and terminal block numbers identified. Provide panel termination Drawings on separate Drawings. Ladder diagrams shall appear on system schematic. Clearly differentiate between portions of wiring that is existing, factory-installed and portions to be field-installed.
 - h. Details of control panels, including controls, instruments, and labeling shown in plan or elevation indicating the installed locations.
 - i. Sheets shall be consecutively numbered.
 - j. Each sheet shall have a title indicating the type of information included and the HVAC system controlled.
 - k. Table of Contents listing sheet titles and sheet numbers.
 - l. User Interface Graphic Screens.
 - m. Trends.

- n. Alarms.
 - o. Legend and list of abbreviations.
 - p. Submit along with Shop Drawings but under separate cover calculated and guaranteed system response times of the most heavily loaded LAN in the system.
2. BACnet Protocol Information:
 - a. Submit the following:
 - 1) BACnet object description, object ID, and device ID, for each I/O point. (required for integration into the existing system).
 - 2) Documentation for any non-standard BACnet objects, properties, or enumerations used detailing their structure, data types, and any associated lists of enumerated values.
 - 3) Submit PICS indicating the BACnet functionality and configuration of each controller.
- H. Record Documents:
1. Record copies of product data and control Shop Drawings updated to reflect the final installed condition.
 2. Record copies of approved control logic programming and database on paper and on CD's. Accurately record actual setpoints and settings of controls, final sequence of operation, including changes to programs made after submission and approval of Shop Drawings and including changes to programs made during specified testing.
 3. Record copies of approved Project specific graphic software digitally.
 4. Provide network architecture Record Drawings showing all nodes including a description field with specific controller identification, description and location information.
 5. Record copies shall include individual floor plans with controller locations with all interconnecting wiring routing including space sensors, LAN wiring, power wiring, low voltage power wiring. Indicate device instance, MAC address and drawing reference number.
 6. Provide record riser diagram showing the location of all controllers.
 7. Maintain Project record documents throughout the Warranty Period and submit final documents at the end of the Warranty Period.
- I. Operation and Maintenance Data:
1. Submit maintenance instructions and spare parts lists for each type of control device, control unit, and accessory.
 2. Submit BAS User's Guides (Operating Manuals) for each controller type and for all workstation hardware and software and workstation peripherals.
 3. Submit BAS advanced Programming Manuals for each controller type and for all workstation software.
 4. Include all submittals (product data, Shop Drawings, control logic documentation, hardware manuals, software manuals, installation guides or manuals, maintenance instructions and spare parts lists) in maintenance manual; in accordance with requirements of Division 01.

- a. Contractor shall provide Owner with all product line technical manuals and technical bulletins, to include new and upgraded products, by the same distribution channel as to dealers or branches. This service will be provided for five (5) years as part of the Contract price, and will be offered to Owner thereafter for the same price as to a dealer or branch.
- b. Manufacturer's Certificates: For all listed and/or labeled products, provide certificate of conformance.
- c. Product Warranty Certificates: Submit manufacturers product warranty certificates covering the hardware provided.

1.7 SYSTEM ARCHITECTURE

- A. The system provided shall incorporate hardware resources sufficient to meet the functional requirements of these Specifications. Contractor shall include all items not specifically itemized in these Specifications that are necessary to implement, maintain, and operate the system in compliance with the functional intent of these Specifications.
- B. Intent is that major equipment and floor level controller(s) will have BacNet IP connection via dedicated BAS network. Smaller equipment such as terminal units and fan coil units will be connected via non-IP based daisy-chained communication protocols (BacNet MS/TP) to floor level controls (multiple as required to meet the performance requirements).
- C. The system shall be configured as a distributed processing network(s) capable of expansion as specified below.
 1. Coordinate all requirements of the BAS WAN / Primary LAN with the owner IT department.
 2. All BAS IT network specified by Division 23 specifications or by the project construction documents shall be compliant with the owner's current IT network standards. Reference and compliance with Division 27 Communication specifications. The owner's IT department solely manages and governs the IT infrastructure.
 3. Division 23 shall submit for approval all permanent devices or network cables within/inside the IT network infrastructure. The BAS shall connect via multiple BacNet IP connections to the owners Gateways/Routers.
 4. The IT department shall grant approval to utilize the owner's IT network and provide Ethernet IP address after all their requirements are satisfied. Upon approval an Ethernet drops will be provided with a jackplate, IP address, and computer name specified by the owner for utilization by Division 23.
- D. Dynamic Data Access: Any data throughout any level of the network shall be available to and accessible by all other devices, Controllers and OWS, whether directly connected or connected remotely.
- E. Remote Data Access: The system shall support the following methods of remote access to the building data. All remote access shall be approved by Information Security department prior to installation.

1. Connection will allow secure access to all control system facilities and graphics with appropriate password. The Owner will provide and pay for the internet connection to support this remote connection.
 2. Browser-based access: A remote user using a standard browser will be able access all control system facilities and graphics with proper password. Owner will secure and pay for the continuous Internet connection. The following paradigms are acceptable for browser-based access:
 - a. Native Internet-based user interfaces (HTML, Java, XML, etc.) that do not require a plug-in.
 - b. User interfaces that via a standard browser use a freely distributed and automatically downloaded and installed plug-in or 'thick' client that presents the user interface across the web.
- F. The communication speed between the controllers, LAN interface devices, CSS, and operator interface devices shall be sufficient to ensure fast system response time under any loading condition. Contractor shall submit guaranteed response times with Shop Drawings including calculations to support the guarantee.
- G. Control Systems Server (CSS): This shall be a computer (or computers) that maintain the systems configuration and programming database. It shall hold the backup files of the information downloaded into the individual controllers and as such support uploading and downloading that information directly to/from the controllers. It shall also act as a control information server to non-control system-based programs. It shall allow secure multiple-access to the control information. New server shall not be used for graphics, long term data storage, trending, or reporting. All graphics, long term data storage, trending, and reporting shall be fully integrated into the owner existing JCI system. Integration via a link to a separate server is not acceptable. All licenses, software, subscriptions required for this server shall be included in the contractors bid.
- H. The Operator Interface shall provide for overall system supervision, graphical user interface, management report generation, alarm annunciation, and remote monitoring.
- I. Interruptions or fault at any point on any Primary Controller LAN shall not interrupt communications between other BAS nodes on the network. If a LAN is severed, two (2) separate networks shall be formed and communications within each network shall continue uninterrupted.
- J. All line drivers, signal boosters, and signal conditioners etc. shall be submitted to and approved by the owners IT department as necessary for proper data communication.
- K. Anytime any controller's database or program is changed in the field, the controller shall be capable of automatically uploading the new data to the CSS.
- L. BAS shall be capable of and include a low level alarm when an overridden value is maintained for 48 hours or longer. This shall alarm every 48 hours for overridden values until the values are returned to an "auto" state.

1.8 DELIVERY, STORAGE AND HANDLING

- A. Provide factory-shipping cartons for each piece of equipment and control device. Maintain cartons during shipping, storage and handling as required to prevent equipment damage, and to eliminate dirt and moisture from equipment. Store equipment and materials inside and protect from weather.

1.9 WARRANTY

- A. Contractor shall warrant all products and labor for a period of 1 year after Substantial Completion. Controllers shall be provided with a 5-year parts/labor warranty.
- B. The Owner reserves the right to make changes to the BAS during the Warranty Period. Such changes do not constitute a waiver of warranty. Contractor shall warrant parts and installation work regardless of any such changes made by Owner, unless the Contractor provides clear and convincing evidence that a specific problem is the result of such changes to the BAS. Any disagreement between Owner and Contractor on such matters shall be subject to resolution through the Contract 'Disputes' clause.
- C. At no cost to the Owner, during the Warranty Period, Contractor shall provide maintenance services for software, firmware and hardware components as specified below:
 - 1. Maintenance services shall be provided for all devices and hardware specified in the Contract Documents. Service all equipment per the manufacturer's recommendations. This includes monthly system health reports to identify points that are not in auto (or overridden), devices that are offline, and communication issues. On a quarterly basis controls shall include any loop tuning required for stable operation.
 - 2. Emergency Service: Any malfunction, failure, or defect in any hardware component or failure of any control programming that would result in property damage or loss of comfort control shall be corrected and repaired following telephonic notification by the Owner to the Contractor. Emergency service shall be provided 24 hours per day, 7 days per week, and 365 days per year with no exceptions and at no cost to the Owner.
 - 3. Normal Service: Any malfunction, failure, or defect in any hardware component or failure of any control programming that would not result in property damage or loss of comfort control shall be corrected and repaired following telephonic notification by the Owner to the Contractor.
 - 4. At any time during the Warranty Period that Contractor is on Site for maintenance, emergency, or normal service, Contractor shall notify Owner and the local building operating personnel. Contractor shall notify said personnel of all work anticipated being involved for the service work.
 - 5. Contractor shall specify a maximum of three telephone numbers for Owner to call in the event of a need for service. At least one of the lines shall be attended at any given time, at all times. Alternatively, pagers or phone numbers can be used for technicians trained in system to be serviced. One of the three notified technicians shall respond to every call within 30 minutes.

6. Technical Support: Contractor shall provide technical support by telephone throughout the Warranty Period.
7. Preventive maintenance shall be provided throughout the Warranty Period in accordance with the hardware component manufacturer's requirements.
8. In the last month of the Warranty Period, all System software and controller firmware, software, drivers, etc. will be upgraded to the latest release (version) in effect at the end of the Warranty Period.

1.10 WORK BY OTHERS

- A. Control Valves furnished under this Section shall be installed under the applicable piping Section under the direction of the BAS Provider who will be fully responsible for the proper operation of the valve.
- B. Control Dampers furnished under this Section shall be installed under the applicable air distribution or air handling equipment Section under the direction of the BAS Provider who will be fully responsible for the proper operation of the damper.
- C. Water Pressure Taps, Thermal Wells, Flow Switches, Flow Meters, etc. that will have wet surfaces, shall be installed under the applicable piping Section under the direction of the BAS Provider who will be fully responsible for the proper installation and application.
- D. Variable Frequency Drives furnished under section 23 05 13 shall be provided with serial communication protocol information specific to the selected BAS Provider. BAS Provider shall be fully responsible to interface and make available VFD information in the building automation system as monitor only information.
- E. Controlled Equipment Power Wiring shall be furnished and installed under Division 26. Where control involves 120 volt (V) control devices controlling 120V equipment, Division 26 Contractor shall extend power wiring to the equipment. BAS Provider shall extend it from the equipment to the control device.

PART 2 - PRODUCTS

2.1 GENERAL

- A. All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction. The new BAS Database shall be prepared and individual points shall be enabled to be broadcast via BACnet/IP. Full read/write access to monitor, command, and reset setpoints shall be enabled through the JCI front end. A JCI Network Integration Engine will be required to integrate into the existing front end.
- B. Provide electronic control products in sizes and capacities indicated, consisting of valves, dampers, controllers, sensors, and other components as required for complete installation. Except as otherwise indicated, provide manufacturer's standard materials and components as published in their product information; designed and constructed as recommended by manufacturer, and as required for application indicated.

- C. Contractor shall be responsible for all integration tasks to fully integrate with the owners existing front end. No downtime to the existing front end is acceptable. Coordinate on the existing front end with the owner.

2.2 MANUFACTURERS – BAS/DDC SYSTEM

- A. The BAS and digital control and communications components installed as work of this Contract shall be an integrated distributed processing system using BTL listed open/native BACnet protocol. Manufacturers shall be capable of integrating with owners existing Johnson Controls front end system. Acceptable manufacturers include:
 - 1. Base Bid – No Controls
 - 2. Alternate Bid No. 1 - Siemens Building Technologies
 - 3. Alternate Bid No. 2 - Delta
 - 4.
 - 5. Johnson Controls

2.3 ATTIC STOCK

- A. Provide two addition controllers of each type utilized on the project for owner's attic stock.

2.4 UNIFORMITY

- A. To the extent practical, all equipment of the same type serving the same function shall be identical and from the same manufacturer.

2.5 MATERIALS AND EQUIPMENT

- A. Instrument Pipe and Tube:
 - 1. Hydronic and Instruments:
 - a. Connection To Main Piping: Provide ½ inch minimum size threadolet, ½ inch x 2 inch brass nipple, and ½ inch ball valve for connection to welded steel piping. Provide tee fitting for other types of piping.
 - b. Remote Instruments: Adapt from ball valve to specified tubing and extend to remote instruments. Provide a union or otherwise removable fitting at ball valve so that connection to main can be cleaned with straight rod. Where manifolds with test ports are not provided for instrument, provide tees with ¼ inch FPT branch with plug for use as test port. Adapt from tubing size to instrument connection.
 - c. Line Mounted Instruments: Extend rigid piping from ball valve to instrument. Do not use close or running thread nipples. Adapt from ball valve outlet to instrument connection size. Provide a plugged tee if pipe makes 90 degree bend at outlet of valve to allow cleaning of connection to main with straight rod without removing instrument.

- d. Instrument Tubing: Seamless copper tubing, Type K or L, ASTM B 88; with cast-bronze solder joint fittings, ANSI B1.18; or wrought-copper solder-joint fittings, ANSI B16.22; or brass compression-type fittings. Solder shall be 95/5 tin antimony, or other suitable lead free composition solder. Tubing outside diameter size shall be not less than the larger of ¼ inch or the instrument connection size.
- e. Rigid Piping for Line Mounted Instruments: Schedule 40 threaded brass, with threaded brass fittings.
- 2. Low Pressure Air Instrument Sensing Lines
 - a. Connections: Use suitable bulkhead type fitting and static sensing tip for static pressure connections. Adapt tubing to instrument connection.
 - b. Tubing: Virgin polyethylene non-metallic tubing type FR, ASTM D 2737, with flame-retardant harness for multiple tubing. Use compression or push-on brass fittings.
- B. Secondary LAN Communication Wiring and BAS low voltage wiring/cables: All wiring shall be in accordance with the latest edition of the National Electrical Code and Division 26.
 - 1. Contractor shall supply all communication wiring between Building Controllers, AAC's, ASC's and local and remote peripherals outside the IT infrastructure.
 - 2. Local Supervisory LAN: For any portions of this network required under this Section of the Specification, Contractor shall comply with Division 27 Communication specifications. Network shall be run with no splices and separate from any wiring over thirty (30) volts.
 - 3. Secondary Controller LANs: Communication wiring shall be individually 100 percent shielded pairs per manufacturer's recommendations for distances installed, with overall PVC cover, Class 2, plenum-rated run with no splices and separate from any wiring over thirty (30) volts. Shield shall be terminated, and wiring shall be grounded as recommended by building controller manufacturer.
 - a. Wet / Damp Locations – Wiring in underground raceways or raceways which are subject to moderate degrees of moisture shall be listed for installation in wet locations. Direct burial wiring without a raceway is prohibited.
 - 4. BAS low voltage wiring/cables: All cables shall have legible printed sleeve identification labels at each device and the panel termination. Each label shall be identified with the entire BAS point name.
- C. Signal Wiring: Contractor shall run all signal wiring in accordance with the latest edition of the National Electrical Code and Division 26.
 - 1. Signal wiring to all field devices, including, but not limited to, all sensors, transducers, transmitters, switches, etc. shall be twisted, 100 percent shielded pair, minimum 18-gage wire, with PVC cover. Signal wiring shall be run with no splices and separate from any wiring above thirty (30) volts.
 - a. Wet / Damp Locations – Wiring in underground raceways or raceways which are subject to moderate degrees of moisture shall be listed for installation in wet locations. Direct burial wiring without a raceway is prohibited.
 - 2. Signal wiring shield shall be grounded at controller end only unless otherwise recommended by the controller manufacturer.

- D. Low Voltage Analog Output Wiring: Contractor shall run all low voltage control wiring in accordance with the latest edition of the National Electrical Code and Division 26.
1. Low voltage control wiring shall be minimum 18-gage, twisted pair, 100 percent shielded, with PVC cover, Class 2 plenum-rated. Low voltage control wiring shall be run with no splices separate from any wiring above thirty (30) volts.
 - a. Wet / Damp Locations – Wiring in underground raceways or raceways which are subject to moderate degrees of moisture shall be listed for installation in wet locations. Direct burial wiring without a raceway is prohibited.
- E. Control Panels: Provide control panels with suitable brackets for wall mounting, unless noted otherwise, for each control system. Locate panel adjacent to systems served. Mount center of control panels [60 inches – confirm with Owner] above finished floor or roof.
1. Interior: Fabricate panels of 16-gage furniture-grade steel, totally enclosed on four sides, with removable perforated backplane, hinged door and keyed lock, with manufacturer's standard shop-painted finish and color. Panel / enclosure shall be sized to provide adequate mounting space for all components plus a minimum of 25% spare backplane capacity. All components shall have a minimum of 2 inch clearance from the four sides of the panel unless factory wired and designed otherwise.
 2. Exterior: 16-gage 304 or 316 stainless steel NEMA 4X enclosure. Panel shall have hinged door, keyed lock, and integral, thermostatically controlled heater. Provide hinged deadfront inside panel when flush-mounted control and/or indicating devices are included in panel. Fiberglass or aluminum, as applicable, to be used when gases that are being used in the panel area are corrosive to stainless steel.
 3. Provide UL-listed cabinets for use with line voltage devices.
 4. Control panel shall be completely factory wired and piped, and all electrical connections made to a terminal strip. Wire nuts are not acceptable in exposed area of panel. High and low voltage cables shall be isolated from each other.
 5. All gauges and control components shall be identified by means of nameplates or Owner approved equivalent.
 6. All control tubing and wiring shall be run neatly and orderly in open slot wiring duct with cover.
 7. Provide a 6 inch x 6 inch minimum wireway (metal wiring/tubing) trough across the entire width of the panel mounted to the top of the panel with close nipples of sufficient size for additional 50 percent wiring and tubing capacity. Wireways shall not be less than 24 inches in length. Control panel wiring shall be installed and distributed in the wireway to minimize routing of wiring and tubing within the control panel. Wireway construction to be the same as the associated control panel.

2.6 STANDARD SERVICE CONTROL VALVES

- A. Control Valve Sizing
1. The Contractor is responsible for sizing of control valves. Coordinate final equipment water flow rates with approved equipment submittals. Controls contractor to review all valve size sizes and reselect where appropriate.

2. Valves for terminal units, fan coil units and air handling units shall be sized for a maximum pressure drop of 5 psig.
3. Campus butterfly valves shall be sized for a maximum of 2 psig and shall be normally open.

B. General:

1. Provide factory fabricated control valves of type, body material and pressure class indicated.
2. Where type or body material is not indicated, provide selection as determined by manufacturer for installation requirements and pressure class, based on maximum pressure and temperature in piping system.
3. Provide valve size in accordance with scheduled or specified maximum pressure drop across control valve.
4. Control valves shall be equipped with actuators, and with proper close-off rating for each individual application.
5. Minimum close-off rating shall be as scheduled and adequate for each application, and shall generally be considered at dead head rating of the pump.

C. Butterfly Type:

1. Body: Extended neck epoxy coated cast or ductile iron with full lug pattern, ANSI Class 125 or 250 bolt pattern to match specified flanges.
2. Seat: Full replaceable EPDM or Buna N.
3. Disc: Bronze, elastomer coated ductile iron, or stainless steel, pinned or mechanically locked to shaft.
4. Bearings: Bronze or stainless steel.
5. Shaft: Stainless steel.
6. Cold Service Pressure: 175 psi.
7. Close Off: Bubble-tight shutoff to 150 psi.
8. Sizing: 1-psig maximum pressure drop at design flow rate.
9. Operation: Valve and actuator operation shall be smooth both seating and unseating. Should more than 2 psi deadband be required to seat/unseat the valve, valve shall be replaced at no cost to the Owner.
10. Acceptable Manufacturers: Subject to compliance with requirements, approved manufacturers are as follows:
 - a. Keystone.
 - b. Jamesbury.
 - c. Bray Series.
 - d. Dezurik.
 - e. Bray Sales

D. Segmented or Characterized Ball Type:

1. Body: Forged brass/bronze with union and threaded ends.
2. Seat: Reinforced teflon (PTFE).
3. Ball: Stainless steel ASTM A351.
4. Port: Segmented design with equal-percentage characteristic.
5. Stem: Stainless steel (extended as required for insulation thickness).
6. Cold Service Pressure: 200 psi WOG.

7. Sizing: 5-psig maximum pressure drop at design flow rate, to close against pump shutoff head. Select control valves for a minimum Cv of 1.0 to reduce the risk of system dirt accumulating in small orifices in characterizing-discs.
8. Acceptable Manufacturers: Subject to compliance with requirements, approved manufacturers are as follows:
 - a. Fisher.
 - b. Belimo.
 - c. Siemens
 - d. Johnson Controls
 - e. Bray Sales

2.7 CONTROL DAMPERS

- A. General: Provide factory fabricated automatic control dampers of sizes, velocity and pressure classes as required for smooth, stable, and controllable airflow. Provide parallel blade dampers for open/close applications and opposed blade dampers for modulating applications. For dampers located near fan outlets, provide dampers rated for fan outlet velocity and close-off pressure, and recommended by damper manufacturer for fan discharge damper service. Control dampers used for smoke dampers shall comply with UL 555S. Control Dampers used for fire dampers shall comply with UL 555.
- B. For general isolation and modulating control service in rectangular ducts at velocities not greater than 1500 fpm (7.62 m/s), differential pressure not greater than 2.5 inches w.c. (622 Pa):
 1. Performance: Test in accordance with AMCA 500.
 2. Frames: Galvanized steel, 16-gage minimum thickness, welded or riveted with corner reinforcement.
 3. Blades: Stainless steel or aluminum in stainless steel ductwork, maximum blade size 8 inches (200 mm) wide by 48 inches (1219 mm) long, attached to minimum 1/2 inch (12.7 mm) shafts with set screws, 16 gage minimum thickness.
 4. Blade Seals: Synthetic elastomer, mechanically attached, field replaceable.
 5. Jamb Seals: Flexible metal compressible type.
 6. Shaft Bearings: Oil impregnated sintered bronze, graphite impregnated nylon sleeve or other molded synthetic sleeve, with thrust washers at bearings.
 7. Linkage: Concealed in frame.
 8. Linkage Bearings: Oil impregnated sintered bronze or graphite impregnated nylon.
 9. Leakage: Pressure class 1. Maximum of 4 cfm/sqft at 1" w.g.
 10. Maximum Pressure Differential: 2.5 inches wg. (622 Pa).
 11. Temperature Limits: -40 to 200 degrees F (-40 to 93 degrees C).
 12. Where opening size is larger than 48 inches (1219 mm) wide or 72 inches (1829 mm) high, provide dampers in multiple sections. Provide each damper section with an actuator.
- C. For general isolation and modulating control service in rectangular ducts at velocities not greater than 4000 fpm (20.3 m/s), differential pressure not greater than 12 inches w.c. (2986 Pa):
 1. Performance: Test in accordance with AMCA 500.

2. Frames: 6063T5 extruded aluminum hat channel with 0.081" minimum wall thickness and mounting flanges.
 3. Blades: Extruded heavy gauge 6063T5 aluminum hollow airfoil shape, maximum blade size 8 inches (200 mm) wide by 48 inches (1219 mm) long, attached to minimum 1/2 inch (12.7 mm) shafts.
 4. Blade Seals: Synthetic elastomeric, mechanically attached, field replaceable.
 5. Jamb Seals: Flexible metal compressible type.
 6. Shaft Bearings: Oil impregnated sintered bronze sleeve, graphite impregnated nylon sleeve, molded synthetic sleeve, or stainless steel sleeve, with thrust washers at bearings.
 7. Linkage: Concealed in frame.
 8. Linkage Bearings: Oil impregnated sintered bronze or graphite impregnated nylon or molded synthetic.
 9. Leakage: Pressure class 1. Maximum of 4 cfm/sqft at 1" w.g.
 10. Maximum Pressure Differential: 6 inches wg. (622 Pa).
 11. Temperature Limits: -40 to 200 degrees F (-40 to 93 degrees C).
 12. Where opening size is larger than the maximum damper size at the required maximum pressure rating of the ductwork provide dampers in multiple sections. Provide each damper section with an actuator.
 13. Pressure drop: 24"x24" damper shall not exceed 0.08" w.g. at 2,000 fpm.
- D. For general isolation and modulating control service in rectangular ducts serving outside air or where called out on documents intake:
1. Performance: Test in accordance with AMCA 500.
 2. Frames: Coated steel, 12-gage minimum thickness, welded or riveted with corner reinforcement.
 3. Jamb seals: Stainless steel.
 4. Blades: Stainless steel or aluminum airfoil shape, maximum blade size 8 inches (200 mm) wide by 48 inches (1219 mm) long, attached to minimum 3/4 inch (19 mm) shafts with set screws. EPDM blade seals.
 5. Shaft Bearings: Oil impregnated stainless steel, externally bolted to frame.
 6. Linkage: Heavy duty, concealed outside of airstream.
 7. Linkage Bearings: External bolt-on ball bearings with seal.
 8. Leakage: Pressure class 1. Maximum 4 cfm/sqft at 1" w.g.
 9. Maximum Pressure Differential: 19 inches wg.
 10. Temperature Limits: -40 to 250 degrees F.
 11. Where opening size is larger than 48 inches (1219 mm) wide or 72 inches (1829 mm) high, provide dampers in multiple sections, with intermediate frames and jackshafts appropriate for the installation.
- E. For general isolation and modulating control service in round ducts up to 40 inches in size at velocities not greater than 2500 fpm (12.7 m/s), differential pressure not greater than 4 inches w.c. (994 Pa):
1. Performance: Test in accordance with AMCA 500.
 2. Frames: Minimum rolled 12 gage steel strip for sizes 6 inch and smaller, minimum rolled 14 gage steel channel for larger sizes, galvanized or aluminum finish.

3. Blades: Steel construction, 12 gage minimum thickness for dampers less than 18 inches (457 mm) in size, 10 gage minimum thickness for larger dampers.
4. Blade Seals: Full circumference neoprene.
5. Shaft: ½ inch (12.7 mm) diameter zinc or cadmium plated steel.
6. Shaft Bearings: Oil impregnated sintered bronze or stainless steel, pressed into frame, with thrust washers at bearings.
7. Leakage: Pressure class 1. Maximum of 4 cfm/sqft at 1” w.g.
8. Maximum Pressure Differential: 4 inches wg. (994 Pa).
9. Temperature Limits: -40 to 300 degrees F (-40 to 149 degrees C).

2.8 ACTUATORS

- A. General: Size actuators and linkages to operate their appropriate dampers or valves with sufficient reserve torque or force to provide smooth modulating action as specified. Select spring-return actuators with manual override to provide positive shut-off of devices as they are applied.
- B. Actuators:
 1. Ambient Operating Temperature Limits: -10 to 150 degrees F (-12.2 to 66 degrees C).
 2. Electronic Actuators: Provide modulating actuators with spring return for 0-5 Vdc, 0-10 Vdc, 2-10Vdc, 4-20 mA, as required. Spring return actuators are not required for terminal boxes or their reheat valves unless otherwise indicated. Terminal boxes shall fail in place unless otherwise noted. Actuators shall travel full stroke in less than 90 seconds. Actuators shall be designed for a minimum of 60,000 full cycles at full torque and be UL 873 listed. Provide stroke indicator. Actuators shall have positive positioning circuit. Each damper or valve shall receive and actuator. Actuators shall have current limiting motor protection. Actuators shall have manual override where indicated. Modulating actuators for valves shall have minimum rangeability of 40 to 1. Actuators shall have position feedback for all dampers and water control valves 2” and larger. Position feedback shall be interfaced into the BAS.
 - a. Close-Off Pressure: Provide the minimum torque required, and spring return for fail positioning (unless otherwise specifically indicated) sized for required close-off pressure. Required close-off pressure for two-way water valve applications shall be the shutoff head of associated pump. Required close-off rating of steam valve applications shall be design inlet steam pressure plus 50 percent for low pressure steam, and 10 percent for high pressure steam. Required close-off rating of air damper applications shall be shutoff pressure of associated fan, plus 10 percent.
 - b. Subject to compliance with requirements, approved manufacturers are as follows:
 - 1) Siemens.
 - 2) Belimo.
 - 3) Johnson Controls.
- C. Quarter-Turn Actuators (for Ball Valves):

1. Electric:
 - a. Motor: Suitable for 120 or 240 volt single-phase power supply. Insulation shall be NEMA Class F or better. Motor shall be rated for 100 percent duty cycle. Motors shall have inherent overload protection.
 - b. Gear Train: Motor output shall be directed to a self-locking gear drive mechanism. Gears shall be rated for torque input exceeding motor locked rotor torque.
 - c. Wiring: Power and control wiring shall be wired to a terminal strip in the actuator enclosure
 - d. Failsafe Positioning: Actuators shall be spring return type for failsafe positioning.
 - e. Enclosure: Actuator enclosure shall be a NEMA 4 epoxy coated metal enclosure, and shall have a minimum of two threaded conduit entries.
 - f. Limit Switches: Travel limit switches shall be UL approved. Switches shall limit actuator in both open and closed positions.
 - g. Mechanical Travel Stops: The actuator shall include mechanical travel stops of stainless steel construction to limit actuator to specific degrees of rotation.
 - h. Manual Override: Actuators shall have manual actuator override to allow operation of the valve when power is off. For valves 4 inches and smaller the override may be a removable wrench or lever or geared handwheel type. For larger valves, the override shall be a fixed geared handwheel type. An automatic power cut-off switch shall be provided to disconnect power from the motor when the handwheel is engaged for manual operation.
 - i. Valve Position Indicator: A valve position indicator with arrow and open and closed position marks shall be provided to indicate valve position.
 - j. Torque Limit Switches: Provide torque limit switches to interrupt motor power when torque limit is exceeded in either direction of rotation.
 - k. Position Controller: For valves used for modulating control, provide an electronic positioner capable of accepting 4-20 mA, 0-10 Vdc, 2-10 Vdc, and 135 Ohm potentiometer.
 - l. Ambient Conditions: Actuator shall be designed for operation from -40 to 150 degrees F ambient with 0 to 100 percent relative humidity.

2.9 GENERAL FIELD DEVICES

- A. Provide field devices for input and output of digital (binary) and analog signals into controllers (BCs, AACs, ASCs). Provide signal conditioning for all field devices as recommended by field device manufacturers and as required for proper operation in the system.
- B. It shall be the Contractor's responsibility to assure that all field devices are compatible with controller hardware and software.

- C. Field devices specified herein are generally 'two-wire' type transmitters, with power for the device to be supplied from the respective controller. If the controller provided is not equipped to provide this power, is not designed to work with 'two-wire' type transmitters, if field device is to serve as input to more than one controller, or where the length of wire to the controller will unacceptably affect the accuracy, the Contractor shall provide 'four-wire' type equal transmitter and necessary regulated DC power supply or 120 VAC power supply, as required.
- D. For field devices specified hereinafter that require signal conditioners, signal boosters, signal repeaters, or other devices for proper interface to controllers, Contractor shall furnish and install proper device, including 120V power as required. Such devices shall have accuracy and repeatability equal to, or better than, the accuracy and repeatability listed for respective field devices.
- E. Accuracy: As stated in this Section, accuracy shall include combined effects of nonlinearity, non-repeatability and hysteresis.

2.10 VFD SERIAL COMMUNICATION

- A. VFD Serial communications or BACnet shall include, but not be limited to monitor the following feedback signals:
 - 1. Process variable.
 - 2. Output speed/frequency.
 - 3. Current
 - 4. Torque
 - 5. Power (kW)
 - 6. Operating hours
 - 7. Kilowatt hours (kWh)
 - 8. Relay outputs
 - 9. Diagnostic warning and fault information

2.11 TEMPERATURE SENSORS (TS)

- A. Sensor range: When matched with A/D converter of BC, AAC/ASC, or SD, sensor range shall provide a resolution of no worse than 0.2 degrees F (unless noted otherwise). Where thermistors are used, the stability shall be better than 0.25 degrees F over five (5) years.
 - 1. Provide setpoint adjustment where indicated. The setpoint adjustment shall be a warmer/cooler indication that shall be scalable via the BAS.
 - 2. Provide an occupancy override button on the room sensor enclosure where indicated. This shall be a momentary contact closure.
 - 3. , unless otherwise noted we do not use displays in office area.
- B. Critical Room Temperature Sensor: Shall be an element contained within a ventilated cover, suitable for wall mounting. Provide insulated base. Following sensing elements are acceptable:
 - 1. Sensing element shall be platinum RTD, +/- 0.1 degrees C measured at 0 degrees C.

2. Provide setpoint adjustment where indicated. The setpoint adjustment shall be a warmer/cooler indication that shall be scalable via the BAS.
 3. Provide an occupancy override button on the room sensor enclosure where indicated. This shall be a momentary contact closure
 4. Provide current temperature indication via an LCD or LED readout, where noted.
- C. Single-Point Duct Temperature Sensor: Shall consist of sensing element, junction box for wiring connections and gasket to prevent air leakage or vibration noise. Temperature range as required for resolution indicated. Sensor probe shall be 316 stainless steel.
1. Sensing element shall be platinum RTD, thermistor, or integrated circuit, +/- 0.3 degrees F accuracy at calibration point
- D. Averaging Duct Temperature Sensor: Shall consist of an averaging element, junction box for wiring connections and gasket to prevent air leakage. Provide sensor lengths and quantities to result in one lineal foot of sensing element for each three square feet of cooling coil/duct face area. Provide the minimum number of sensors for the installed coil/duct face area per the manufacturer's instructions. Temperature range as required for resolution indicated.
1. Sensing element shall be platinum RTD, or thermistor, +/- 0.3 degrees F accuracy at calibration point.
- E. Liquid immersion temperature sensor shall include brass thermowell, sensor and connection head for wiring connections. Temperature range shall be as required for resolution of 0.15 degrees F.
1. Sensing element (chilled water/glycol systems) shall be platinum RTD +/- 0.2 degrees C measured at 0 degrees C.
- F. Pipe Surface-Mount Temperature Sensor (Only where indicated or by written approval by owner): Shall include metal junction box and clamps and shall be suitable for sensing pipe surface temperature and installation under insulation. Provide thermally conductive paste at pipe contact point. Temperature range shall be as require for resolution indicated in this Section.
1. Sensing element shall be platinum RTD, thermistor, or integrated circuit, +/- 0.4 degrees F accuracy at calibration point.
- G. Outside air sensors shall consist of a sensor, sun shield, utility box, and watertight gasket to prevent water seepage. Temperature range shall be as require for resolution indicated in this Section.
1. +/- 0.2 degrees C measured at 0 degrees C.

2.12 HUMIDITY TRANSMITTERS

- A. Units shall be suitable for duct, wall (room) or outdoor mounting. Unit shall be two-wire transmitter utilizing bulk polymer resistance change or thin film capacitance change humidity sensor. Unit shall produce linear continuous output of 4-20 mA for percent relative humidity (% RH). A combination temperature and humidity sensor may be used for zone level monitoring. Sensors shall have the following minimum performance and application criteria:
1. Input Range: 0 to 100% RH.

2. Accuracy (% RH): +/- 2 percent between 20-90% RH at 77 degrees F, including hysteresis, linearity, and repeatability.
3. Sensor Operating Range: As required by application.
4. Long Term Stability: Less than 1 percent drift per year.

B. Acceptable Manufacturers: Units shall be Vaisala HM Series, Kele, Siemens, Johnson Controls.

2.13 DIFFERENTIAL PRESSURE TRANSMITTERS (DP)

A. General Purpose Low Pressure Air: Generally for each measurement of duct pressure, filter differential pressure, etc.

1. General: Loop powered two-wire differential capacitance cell-type transmitter.
2. Output: Two wire 4-20 mA output with zero adjustment.
3. Overall Accuracy: Plus or minus 1 percent.
4. Minimum Range: 0.1 inches w.c.
5. Maximum Range: 10 inches w.c.
6. Housing: Polymer housing suitable for surface mounting.
7. Acceptable Manufacturers: Units shall be Setra, Modus T30, Veris PX Series, or Dwyer Series 616.
8. Static Sensing Element: Pitot-type static pressure sensing tips similar to Dwyer model A-301 and connecting tubing.
9. Range: Select for specified setpoint to be between 25 percent and 75 percent full-scale.
10. Magnehelic Gauges: Provide Dwyer Series 2000 Magnehelic Differential Pressure Gauge (or equal) for each DP transmitter. Provide gauge, mounting bracket, ¼ inch aluminum tubing, static pressure tips, and molded plastic vent valves for each gauge connection. Select range for specified recommended filter loading pressure drop to be 75 percent full-scale. For other DP transmitters select range for specified setpoint to be between 25 percent and 75 percent full-scale.

2.14 AIRFLOW MEASURING STATIONS (AFMS)

A. Fan Inlet Probe: Shall consist of vortex shedding multi-sensor probes which are installed in the inlet of the fan. Individual sensors on the probe provide direct proportional and linear signals to airflow velocity.

1. Sensor Accuracy: +/- 2.0 percent.
2. Interchangeability: +/- 0.5 percent.
3. Velocity Range: 750 to 9000 fpm.
4. Electronics Accuracy: +/- 0.05 percent.
5. Temperature Limits: -20 degrees F to 140 degrees F.
6. Enclosure for Electronics: NEMA 1.
7. Material: Aluminum.
8. Operating Range: Select minimum range to accommodate the expected flow range of the equipment.
9. Acceptable Manufacturers: Tek-Air Systems Inc. 'Vortek' Model VT8000, or approved equal.

- B. Duct Mounted (applications other than outside air):
 - 1. Industrial Thermal Dispersion Technology Type, Similar to Ebtron, Inc. Model GT. Each measuring device shall consist of one or more multi-point measuring probes and a single microprocessor-based transmitter.
 - 2. Each unit shall operate on 24 VAC.
 - 3. Each sensing point shall independently determine the airflow rate and temperature, and shall equally weight and average by the transmitter prior to output. Pitot tube arrays are not acceptable.
 - 4. A single manufacturer shall provide probe and transmitter.
 - 5. The operating range shall be from 0 - 5000 fpm with accuracy of $\pm 2\%$ over the entire operating airflow range and be verified against standards that are traceable to NIST.
 - 6. The transmitter shall be capable of communicating with the host controls using 0-10VDC and 4-20ma, RS-485 and BACnet.
 - 7. Sensors shall be UL listed.
 - 8. Manufacturer shall have review and approve placement in field, and provide written report to engineer indicating airflow measuring stations are installed in accordance with manufacturer's installation requirements.

- C. Outside Airflow Monitoring (untreated outside air only):
 - 1. Vortex Shedding Technology Type, Similar to Accutrol Model VDT. Each measuring device shall consist of sensing ports that convert low pressure vortices into a digital signal via a trapezoidal shedder.
 - 2. Each unit shall operate on 24 VAC.
 - 3. A single manufacturer shall provide probe and transmitter.
 - 4. The operating range shall be from 0 - 3000 fpm with accuracy of $\pm 2\%$ over the entire operating airflow range and be verified against standards that are traceable to NIST.
 - 5. The transmitter shall be capable of communicating with the host controls using 0-10VDC and 4-20ma, BACnet.
 - 6. Sensors shall be UL listed.
 - 7. Manufacturer shall have review and approve placement in field, and provide written report to engineer indicating airflow measuring stations are installed in accordance with manufacturer's installation requirements.

2.15 VALVE BYPASS FOR DIFFERENTIAL PRESSURE SENSORS

- A. Provide a five valve bypass kit for protection of DP sensors where the static on the pipe can cause an over pressure when connected to one port with the other at atmospheric pressure. Kit shall include high and low pressure isolation valves, high and low pressure vent valves, calibration taps, and a bypass valve contained in a NEMA 1 enclosure.

2.16 DIFFERENTIAL PRESSURE SWITCHES (DPS)

- A. General Service Auto Reset - Air: Diaphragm with adjustable setpoint and differential and snap acting form C contacts rated for the application. Provide manufacturer's recommended static pressure sensing tips and connecting tubing. Acceptable Manufacturer - Dwyer Series 1900 or approved equal.
- B. General Service Manual Reset - Air: Diaphragm with adjustable setpoint and differential and snap acting form C contacts rated for the application. Manual reset shall be readily accessible in reach of personnel installed at height not to exceed 5 feet above finished floor. Provide manufacturer's recommended static pressure sensing tips and connecting tubing. Acceptable Manufacturer - Dwyer Series 1900 or approved equal. The High Static Pressure Safety Switch shall alarm to the Building Automation System upon activation.
- C. General Service - Water: Diaphragm with adjustable setpoint, 2 psig or adjustable differential and snap-acting Form C contacts rated for the application. 60 psid minimum pressure differential range and 0 degrees F to 160 degrees F operating temperature range.

2.17 PRESSURE SWITCHES (PS)

- A. Diaphragm or bourdon tube with adjustable setpoint and differential and snap-acting Form C contacts rated for the application. Pressure switches shall be capable of withstanding 150 percent of rated pressure.
- B. Acceptable Manufacturers: Square D, ITT Neo-Dyn, ASCO, Penn, Honeywell, and Johnson Controls.

2.18 CURRENT SWITCHES (CS)

- A. Provide a high performance miniature split-core current status switch with adjustable set point (where indicated). The current status switch shall have an operating range of between 2.5 – 135 amps and be able to detect belt loss and mechanical failure. Shall be Veris Hawkeye H908 or equal.
- B. Variable Speed Status: Where current switches are used to sense the status for variable speed devices, the CT shall include on-board VA/Hz memory to allow distinction between a belt break and subsequent ramp up to 60 Hz, versus operation at low speed. The belt break scenario shall be indicated as a loss of status and the operation at low speed shall indicate normal status.

2.19 CURRENT TRANSDUCER (CT)

- A. Clamp-On Design Current Transducer (for Motor Current Sensing):
 1. Range: 1-10 amps minimum, 20-200 amps maximum.
 2. Trip Point: Adjustable.
 3. Output: 0-5 VDC.
 4. Accuracy: +/- 0.2 percent from 20 to 100 Hz.
 5. Acceptable Manufacturers: KELE SA100.

2.20 OUTDOOR AIR STATIC PRESSURE SENSING TIP

- A. Pressure Sensor: Pressure sensing tip shall be designed to minimize the effects of wind and resulting velocity pressure up to 80 mph. Acceptable manufacturers shall be Dwyer A-306.
- B. Low Air Pressure Surge Dampener: 30-second time constant. Acceptable manufacturer shall be Modus SD030.

2.21 MAGNETIC FLOW METER FOR WATER SERVICE

- A. General Requirements:
 - 1. Water Flow Sensors: Water flow sensors shall be furnished by BAS, Magnetic flowmeter flow tubes. Each sensor shall be sized specifically for the pipe in which it is to be installed. Sensor shall have $\pm 0.5\%$ accuracy from 1 to 30 feet/second, with Class 150 carbon steel flanges, exterior painted with polyurethane, grounding electrode, Teflon (PTFE) lining, and Type 316L stainless steel electrodes. Contractor shall furnish remote mounted magnetic flowmeter transmitters, with 115Vac/1ph/60hz power supply, NEMA 4X enclosure, 4 – 20 ma output, battery-backup totalizer, and local operator interface.
- B. Calibration: The sensor must be calibrated on an internationally accredited (i.e. NAMAS) flow rig with accuracy better than 0.1 percent. Calibration shall be traceable to National Institute of Standard and Technology.
- C. Electronics:
 - 1. Flow Transmitters: Flow transmitters shall provide a 4-20 mA DC signal output proportional to flow. Accuracy of $\pm 0.25\%$ of calibrated span. Temperature Limits: -40°F to $+220^{\circ}\text{F}$. Stability of $\pm 0.25\%$ of upper range limit for 6 months. Range of transmitter shall match flow conditions.
 - 2. As standard, the electronics must be installable directly on the sensor or capable of remote installation. For meters not within 7 feet of floor install electronics with display on wall not more than 6 feet above floor.
 - 3. The electronics must have an internal totalizer for summation of flow.
- D. Error Detection:
 - 1. The electronics must be able to detect the flowing error conditions:
 - a. Signal connection between electronics and sensor interrupted.
 - b. Loss of current to the coil circuit.
 - c. Load on the current output.
 - d. Defective electronics.
 - e. Defective sensor.
 - f. Empty pipe.
 - 2. The electronics must have an Error Log where all error conditions occurring within a period of 180 days are stored.
- E. Electronic Replacement Programming:
 - 1. The electronics must be immediately replaceable without the need of cable disconnection or renewed configuration programming.

2. When the supply voltage is applied, the electronics must self configure and display flow without keyboard contact (no programming required).
3. The electronics must be provided with an automatic zero flow setting.
4. The electronics shall be programmable with respect to:
 - a. User display options and menu
 - b. Setting data
 - c. Configuration of outputs
 - d. Zero 'cut-off' from 0 percent to 9.9 percent of maximum flow.
5. For ease of programming, the electronics shall be programmable away from the meter using the meter Sensor-Prom and a 9 V battery.

F. Acceptable Manufacturers:

1. Engineering Measurements Co./Spirax Sarco
2. Rosemont.

2.22 CO2 SENSORS/TRANSMITTERS (CO2)

- A. General: CO2 sensors shall use silicon based, diffusion aspirated, infrared single beam, dual-wavelength sensor.
- B. Accuracy: +/- 90ppm at 75 degrees F.
- C. Stability: 5 percent over 5 years.
- D. Output: 4-20 mA, 0-10 Vdc or relay.
- E. Mounting: Duct or Wall as indicated.
- F. Acceptable Manufacturer: Vaisala, Inc. GMD20 (duct) or GMW20 (wall) or similar.

2.23 ELECTRIC CONTROL COMPONENTS

- A. Limit Switches (LS): Limit switches shall be UL listed, SPDT or DPDT type, with adjustable trim arm. Limit switches shall be as manufactured by Square D, Allen Bradley.
- B. Low Temperature Detector ('Freezestat') (FZ): Low temperature detector shall consist of a 'cold spot' element which responds only to the lowest temperature along any one foot of entire element, minimum bulb size of 1/8 inches x 20 feet (3.2mm x 6.1m), junction box for wiring connections and gasket to prevent air leakage or vibration noise, DPDT (4 wire, 2 circuit) with manual reset. Manual reset shall be readily accessible in reach of personnel installed at height not to exceed 5 feet above finished floor. Temperature range 15 to 55 degrees F (-9.4 to 12.8 degrees C), factory set at 38 degrees F. Provide sensor lengths and quantities to result in one lineal foot of sensing element for each five square feet of cooling coil/duct face area. The Low Temperature Detector shall alarm to the Building Automation System upon activation.
- C. Surface-Mounted Thermostat: Surface-mounted thermostat shall consist of SPDT contacts, operating temperature range of 50 to 150 degrees F (10 to 65 degrees C), and a minimum 10 degrees F fixed setpoint differential.

- D. Low Voltage Wall Thermostat: Wall-mounted thermostat shall consist of SPDT sealed contacts, operating temperature range of 50 to 90 degrees F (10 to 32 degrees C), switch rating of 24 Vac (30 Vac maximum), and both manual and automatic fan operation in both the heat and cool modes.
- E. Control Relays: All control relays shall be UL listed, with contacts rated for the application, and mounted in minimum NEMA 1 enclosure for indoor locations, NEMA 4 for outdoor locations.
1. Control relays for use on electrical systems of 120 volts or less shall have, as a minimum, the following:
 - a. AC coil pull-in voltage range of +10 percent, -15 percent or nominal voltage.
 - b. Coil sealed volt-amperes (VA) not greater than four (4) VA.
 - c. Silver cadmium Form C (SPDT) contacts in a dustproof enclosure, with 8 or 11 pin type plug.
 - d. Pilot light indication of power-to-coil. Pilot light shall be visible from a standing position of 5 feet AFF
 - e. Coil rated for 50 and 60 Hz service.
 - f. Relays shall be labeled in a professional manner to identify the function or purpose. Coordinate with owner for approved verbiage of labels
 - g. Acceptable Manufacturers: Relays shall be Functional Devices (RIB), Potter Brumfield, Model KRPA or approved equal.
 2. Relays used for across-the-line control (start/stop) of 120V motors, 1/4 horsepower, and 1/3 horsepower, shall be rated to break minimum 10 Amps inductive load. Relays shall be IDEC or approved equal.
 3. Relays used for stop/start control shall have low voltage coils (30 VAC or less) and shall be provided with transient and surge suppression devices at the controller interface.
 4. All safety circuits shall be installed to operate individual interposing relays located in the associated equipment control panel. Each safety device (i.e. Freezestat, DP safety, smoke detector, firestat, etc.) wiring circuit shall be installed with individual homeruns back to the associated control panel. See control drawings for details.
- F. General Purpose Power Contactors: NEMA ICS 2, AC general-purpose magnetic contactor. ANSI/NEMA ICS 6, NEMA 1 enclosure. Manufacturer shall be Square 'D', Cutler-Hammer or Westinghouse.
- G. Control Transformers: Furnish and install control transformers as required. Control transformers shall be machine tool type, and shall be US and CSA listed. Primary and secondary sides shall have replaceable fuses in accordance with the NEC. Transformer shall be properly sized for application, and mounted in minimum NEMA 1 air vented enclosure. Multiple transformers in a single enclosure shall have fan aided ventilation whenever ambient temperature exceeds 140 Deg F.
1. Transformers shall be manufactured by Westinghouse, Square 'D', or Jefferson.
- H. Time Delay Relays (TDR): TDRs shall be capable of on or off delayed functions, with adjustable timing periods, and cycle timing light. Contacts shall be rated for the application with a minimum of two (2) sets of Form C contacts, enclosed in a NEMA 1 enclosure.

1. TDRs shall have silver cadmium contacts with a minimum life span rating of one million operations. TDRs shall have solid state, plug-in type coils with transient suppression devices.
 2. TDRs shall be UL and CSA listed, Crouzet type.
- I. Electric Push Button Switch: Switch shall be momentary contact, oil tight, push button, with I number of N.O. and/or N.C. contacts as required. Contacts shall be snap-action type, and rated for minimum 120 Vac operation. Switch shall be 800T type, as manufactured by Allen Bradley or approved equal.
 - J. Pilot Light: Panel-mounted pilot light shall be NEMA ICS 2 oil tight, transformer type, with screw terminals, push-to-test unit, LED type, rated for 120 VAC. Unit shall be 800T type, as manufactured by Allen-Bradley or approved equal.
 - K. Alarm Horn: Panel-mounted audible alarm horn shall be continuous tone, 120 Vac Sonalert solid-state electronic signal, as manufactured by Mallory or approved equal.
 - L. Electric Selector Switch (SS): Switch shall be maintained contact, NEMA ICS 2, oil-tight selector switch with contact arrangement, as required. Contacts shall be rated for minimum 120 Vac operation. Switch shall be 800T type, as manufactured by Allen-Bradley or approved equal.

2.24 CARBON MONOXIDE DETECTION SYSTEMS

- A. Carbon Monoxide Monitor and Sensor
- B. Provide a pre-programmed carbon monoxide sensor compliance with Texas Boiler Administration Rules 65.100(C) 2015. The sensor shall have UL 2075 approval.
- C. The sensor shall be audible alarm capable of at least 85 dB at 10 ft.
- D. The sensor shall have 7500 square feet or 50ft radius of coverage.
- E. Accuracy shall be +/- 5 ppm.
- F. The sensor shall be equipped with a 0-10 VDC control signal as well as a relay.
- G. The sensor shall have two alarm settings. A low-level alarm of 50 ppm and high level alarm of 100 ppm.

2.25 NAMEPLATES

- A. Provide engraved phenolic or micarta nameplates for all equipment, components, and field devices furnished. Nameplates shall be 1/8 inch thick, black, with white center core, and shall be minimum 1 inch x 3 inch, with minimum 1/4 inch high block lettering. Nameplates for devices smaller than 1 inch x 3 inch shall be attached to adjacent surface.
- B. Each nameplate shall identify the function for each device.

2.26 TESTING EQUIPMENT

- A. Contractor shall test and calibrate all signaling circuits of all field devices to ascertain that required digital and accurate analog signals are transmitted, received, and displayed at system operator terminals, and make all repairs and recalibrations required to complete test. Contractor shall be responsible for test equipment required to perform these tests and calibrations. Test equipment used for testing and calibration of field devices shall be at least twice as accurate as respective field device (e.g., if field device is +/- 0.5 percent accurate, test equipment shall be +/- 0.25 percent accurate over same range).

PART 3 - EXECUTION

3.1 PREPARATION

- A. Examine areas and conditions under which control systems are to be installed. Do not proceed with Work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 INSTALLATION

- A. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.
- B. All installation shall be in accordance with manufacturer's published recommendations.
- C. Fasteners requiring explosive powder (shooting) or pneumatic-driven actuation will not be acceptable under any circumstances.
- D. General: Install systems and materials in accordance with manufacturer's instructions, roughing-in drawings and details shown on drawings. Install electrical components and use electrical products complying with requirements of the latest edition of the National Electrical Code and all local codes.
- E. Control Wiring: The term "control wiring" is defined to include providing of wire, conduit and miscellaneous materials as required for mounting and connection of electric control devices.
 - 1. Wiring System: Install complete wiring system for electric control systems. Conceal wiring exposed in mechanical rooms and areas where other conduit and piping are exposed. Installation of wiring shall generally follow building lines. Install in accordance with the latest edition of the National Electrical Code and Division 26. Fasten flexible conductors bridging cabinets and doors, neatly along hinge side, and protect against abrasion. Tie and support conductors neatly.
 - 2. Control Wiring Conductors: Install control wiring conductors, without splices between terminal points, color-coded. Install in neat workmanlike manner, securely fastened. Install in accordance with the latest edition of the National Electrical Code and Division 26.

3. Communication wiring, signal wiring and low voltage control wiring shall be installed separate from any wiring over thirty (30) volts. Signal wiring shield shall be grounded at controller end only, unless otherwise recommended by the controller manufacturer.
 4. All WAN and LAN patch cords shall be approved and installed as directed by owner and shall be Cat 6A.
 5. BAS low voltage wiring/cables: All cables shall have legible printed sleeve identification labels at each device and the panel termination.
 - a. Labels shall be Brady PermaSleeve TM, part number - "BPSPT-187-175-WT" or approved equal.
 - b. Each label shall be identified with the entire BAS point name.
 6. Terminate all control wiring internal to panels to screw terminals connections or owner approved wire connection equivalent. Wire nuts and/or splices are not allowed in panels. When terminating a wire cable, the cable jacket, cable shielding wire, and cable shielding material shall be finished in a neat consistent workmanlike manner.
 7. Install all control wiring external to panels in electric metallic tubing or raceway. Installation of wiring shall generally follow building lines. Provide compression type connectors. Install wiring in galvanized rigid steel conduit at all exterior locations and where subjected to moisture. Install in PVC Schedule 40 conduit if encased in concrete. All conduits penetrating partitions, walls or floors shall be sealed with a submitted and approved fire/smoke sealant material to prevent migration of air through the conduit system.
 8. Secondary LAN Communication cabling shall be provided in an Owner approved color dedicated to the BAS.
 9. Number-code or color-code conductors appropriately for future identification and servicing of control system. Code shall be as indicated on approved installation drawings.
- F. Control Valves: Install so that actuators, wiring, and tubing connections are accessible for maintenance. Where possible, install with valve stem axis vertical, with operator side up. Where vertical stem position is not possible or would result in poor access, valves may be installed with stem horizontal. Do not install valves with stem below horizontal, or down.
- G. Averaging Temperature Sensors: Cover no more than two square feet per linear foot of sensor length except where indicated. Generally, where flow is sufficiently homogeneous/adequately mixed at sensing location, consult Engineer for requirements.
- H. Airflow Measuring Stations: Install per manufacturer's recommendations in an unobstructed straight length of duct (except those installations specifically designed for installation in fan inlet). For installations in fan inlets, provide on both inlets of double inlet fans and provide inlet cone adapter as recommended by AFM station manufacturer.
- I. Fluid Flow Sensors: Install per manufacturer's recommendations in an unobstructed straight length of pipe.

- J. Relative Humidity Sensors: Provide element guard as recommended by manufacturer for high velocity installations. For high limit sensors, position remote enough to allow full moisture absorption into the air stream before reaching the sensor.
- K. Water Differential Pressure Transmitters: Provide valve bypass arrangement to protect against over pressure damaging the transmitter.
- L. Pipe Surface Mount Temperature Sensors (Shall only be used where indicated on drawings or by written approval by owner): Install with thermally conductive paste at pipe contact point. Where sensor is to be installed on an insulated pipe Contractor shall neatly cut insulation install sensor, repair or replace insulation and vapor barrier and adequately seal vapor barrier.
- M. Flow Switches: Where possible, install in a straight run of pipe at least 15 diameters in length to minimize false indications.
- N. Current Switches for Motor Status Monitoring: Adjust so that setpoint is below minimum operating current and above motor no load current.
- O. Supply Duct Pressure Transmitters:
 - 1. General: Install pressure tips with at least four (4) 'round equivalent' duct diameters of straight duct with no takeoffs upstream. Install static pressure tips securely fastened with tip facing upstream in accordance with manufacturer's installation instructions. Locate the transmitter at an accessible location to facilitate calibration.
 - 2. VAV System 'Down-Duct' Transmitters: Locate pressure tips as required by current energy code and as shown on drawings.
- P. Cutting and Patching Insulation: Repair insulation to maintain integrity of insulation and vapor barrier jacket. Use hydraulic insulating cement to fill voids and finish with material matching or compatible with adjacent jacket material.

3.3 DIGITAL CONTROL STATIONS, CONTROLLER QUANTITY AND LOCATION

- A. Individual Digital Control Stations (DCS) are referenced to indicate allocation of points to each DCS and DCS location. Digital control stations shall consist of one or multiple controllers to meet requirements of this Specification.
- B. Where a DCS is referenced, Contractor shall provide at least one (1) controller, and additional controllers as required, in sufficient quantity to meet the requirements of this Specification. Contractor shall extend power to the DCS from an acceptable power panel. If the BAS provider wishes to further distribute panels to other locations, Contractor is responsible for extending power to that location also. Furthermore, Contractor is responsible for ensuring adequate locations for the panels that do not interfere with other requirements of the Project and maintain adequate clearance for maintenance access.
- C. Contractor shall locate DCS's as referenced. It is the Contractor's responsibility to provide enough controllers to ensure a completely functioning system, according to the point list and sequence of operations.
- D. Contractor shall provide a minimum of the following:

1. One DCS (including at least one controller) in each chilled water/hot water plant mechanical room
2. One DCS (including at least one controller) for each air handler located in applicable mechanical room
3. One DCS (including at least one controller) for each critical fan system
4. One DCS (including at least one controller) for each pumping system
5. One controller for each piece of terminal equipment located at the equipment.

3.4 SURGE PROTECTION

- A. Contractor shall furnish and install any power supply surge protection, filters, etc. as necessary for proper operation and protection of all BCs, AAC/ASCS operator interfaces, printers, routers, gateways and other hardware and interface devices. All equipment shall be capable of handling voltage variations 10 percent above or below measured nominal value, with no effect on hardware, software, communications, and data storage.

3.5 CONTROL POWER SOURCE AND SUPPLY

- A. BAS Provider shall extend all power source wiring required for operation of all equipment and devices provided under Division 23 and the Drawings.
- B. General requirements for obtaining power include the following:
 1. In the case where additional power is required, obtain power from a source that feeds the equipment being controlled such that both the control component and the equipment are powered from the same panel. Where equipment is powered from a 460V source, obtain power from the electrically most proximate 120v source fed from a common origin.
 2. Where control equipment is located inside a new equipment enclosure, coordinate with the equipment manufacturer and feed the control with the same source as the equipment. If the equipment's control transformer is large enough and is the correct voltage to supply the controls, it may be used. If the equipment's control transformer is not large enough or of the correct voltage to supply the controls, provide separate transformer
 3. Where a controller controls multiple systems on varying levels of power reliability (normal, emergency, and/or interruptible), the controller shall be powered by the highest level of reliability served. Furthermore, the controller in that condition shall monitor each power type served to determine so logic can assess whether a failure is due to a power loss and respond appropriately. A three-phase monitor into a digital input shall suffice as power monitoring.
 4. Provide an uninterruptible power supply (UPS) system battery backup for each controller or DCS. All panels shall be provided with full UPS power. UPS shall protect against blackouts, brownouts, surges and noise.
 - a. UPS shall include LAN port and modem line surge protection.
 - b. UPS shall be sized for a 7-minute full load runtime, 23-minute 1/2 load runtime, with a typical runtime of up to 60 minutes. Transfer time shall be 2-4 milliseconds.

- c. UPS shall provide a 480-joule suppression rating and current suppression protection for 36,000 amps and provide 90 percent recharge capability in 2-4 hours. Suppression response time shall be instantaneous. UPS low voltage switching shall occur when supply voltage is less than 94 volts.

3.6 BAS START-UP

- A. No mechanical, electrical, or plumbing equipment shall be energized prior to controls being completely installed and functional.

3.7 OWNER TRAINING

- A. Provide a minimum 40 hours of owner training. Owner training shall at a minimum include information on:
 - 1. Each controller type
 - 2. Graphics
 - 3. Each equipment type
 - 4. System architecture
 - 5. Modifications to graphics and backgrounds
 - 6. Alarms
 - 7. Sequences

END OF SECTION

**SECTION 23 09 43
PNEUMATIC CONTROL SYSTEMS**

NOTE: THIS SPECIFICATION IS UNTOUCHED FROM THE SPECIFICATION SUGGESTED BY CSI. IT IS INCLUDED FOR REFERENCE ONLY, AND WILL REQUIRE SIGNIFICANT EDITING TO BECOME APPROPRIATE FOR USE.

PART 1 GENERAL

1.00 The following sections are to be included as if written herein:

- A. Section 23 00 00 – Basic Mechanical Requirements
- B. Section 23 05 29 – Sleeves, Flashings, Supports and Anchors
- C. Section 23 05 53 – Mechanical Identification

1.01 SECTION INCLUDES

- A. Air compressor and receiver
- B. Compressed Air Piping
- C. Refrigerated Air Dryer
- D. Thermostats
- E. Humidistats
- F. Control Valves
- G. Automatic Dampers
- H. Damper Operators
- I. Highest/Lowest/Averaging Signal Selector
- J. Multi-purpose Positioning Relays
- K. Time Clocks
- L. Transmitters
- M. Receiver Controller

- N. Miscellaneous Accessories
 - O. Control Panel
 - P. Alarm System
- 1.02 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION
- A. Section 23 21 00 - Hydronic Piping: Installation of control valves, flow switches, temperature sensor sockets, gauge taps
 - B. Section 23 22 00 - Steam and Steam Condensate Piping: Installation of control valves, flow switches, temperature sensor sockets, gauge taps
 - C. Section 23 33 00 - Ductwork Accessories: Installation of automatic dampers
- 1.03 PRODUCTS INSTALLED BUT NOT FURNISHED UNDER THIS SECTION
- A. Section 23 61 16 - Reciprocating Refrigerant Compressors: Connection of cylinder unloaders
 - B. Section [_____ - _____]: Connect control components factory supplied as part of equipment controlled, unless specified otherwise
- 1.04 RELATED SECTIONS
- A. Section 23 05 48 - Vibration Isolation
 - B. Section 23 09 23 - Direct Digital Control Systems
 - C. Section 23 09 00 -Instrumentation: Thermometer sockets, gauge taps
 - D. Section 23 09 93 - Sequence of Operation
 - E. Section 26 27 26 - Wiring Devices: Elevation of exposed components
 - F. Section 26 05 00 - Equipment Wiring Systems
- 1.05 REFERENCES
- A. AMCA 500 - Test Methods for Louvers, Dampers and Shutters

- B. ANSI/ASME B16.22 - Wrought Copper and Copper Alloy Solder Joint Pressure fittings
- C. ANSI/ASTM B32 - Solder Metal
- D. ANSI/NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum)
- E. ANSI/NFPA 90A - Installation of Air Conditioning and Ventilation Systems
- F. ASTM B280 - Seamless Copper Tube for Air Conditioning and Refrigeration Field Service
- G. ASTM D1693 - Environmental Stress - Cracking of Ethylene Plastics
- H. FS-GG-G-76 - Gages, Pressure and Vacuum, Dial Indicating (for Air, Steam, Oil, Water, Ammonia, Chloro- Fluorohydrocarbon Gases, and Compressed Gases)
- I. FS-QQ-S-571 - Solder, Tin Alloy; Tin-Lead Alloy; and Lead Alloy
- J. MIL-F-18280 - Fittings, Flareless Tube, Fluid Connection
- K. MIL-S-29175 - Switch, Thermostatic, Low Voltage, Non- (Setback/Setup) and Setback/Setup, Limiting: Heating, Cooling and Heating-Cooling
- L. NEMA DC 3 - Low-Voltage Room Thermostats

1.06 SYSTEM DESCRIPTION

- A. Provide control systems consisting of thermostats, control valves, dampers and operators, indicating devices, interface equipment and other apparatus and accessories required to operate mechanical systems, and to perform functions specified.
- B. Provide pneumatic automatic temperature control systems with electric accessories.

1.07 SUBMITTALS

- A. Submit under provisions of Section [01 33 00.] [01 33 23.]
- B. Shop Drawings: Indicate complete operating data, system drawings, wiring diagrams, and written detailed operational description of sequences. For automatic dampers indicate arrangement, velocities, and static pressure drops for each system.
- C. Product Data: Include description and engineering data for each control system component. Include sizing as requested.

- D. Samples: Submit [two] [_____] of [each type of room thermostat and cover.] [thermostat guard.] [each exposed control component.]
- E. Design Data: Submit design data indicating [sizing and selection of compressor.] [sizing of air tubing.] [_____].]
- F. Submit manufacturer's certificate under provisions of Section [00 65 13] [00 65 19] that [products] [_____] meet or exceed [specified requirements.] [_____].]
- G. Submittals of automatic control systems components which are not the product of the control system manufacturer shall bear evidence of his approval.
- H. Submit manufacturer's installation instructions under provisions of Section [01 33 00.] [01 33 23.]
- I. Submit manufacturer's field reports under provisions of Section [01 33 19.] [01405.]
- J. Submit field reports indicating operating conditions after detailed check out of systems at Date of Substantial Completion.

1.08 PROJECT RECORD DOCUMENTS

- A. Submit record documents under provisions of Section [01 77 00.] [01 78 39.]
- B. Accurately record actual location of control components, including panels, thermostats, and sensors.
- C. Revise shop drawings to reflect actual installation and operating sequences.

1.09 OPERATION AND MAINTENANCE DATA

- A. Submit operation and maintenance data under provisions of Section [01 77 00.] [01 78 23.13.]
- B. Include systems descriptions, set points, and controls settings and adjustments.
- C. Include inspection period, cleaning methods, recommended cleaning materials, and calibration tolerances.

1.10 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing the products specified in this Section with minimum [three] [_____] years [documented] experience.
- B. Installer: Company specializing in installing the work of this Section [with minimum [_____] years [documented experience.] [and approved by manufacturer.]
- C. Design system under direct supervision of a Professional Engineer experienced in design of this work and licensed [at the place where project is located.] [in the State of [_____].]

1.11 SEQUENCING AND SCHEDULING

- A. Sequence work under the provisions of Section [01 12 16] [_____].
- B. Schedule work under the provisions of Section [01 32 13.] [_____].
- C. Sequence work to ensure installation of components is complementary to installation of similar components in other systems.
- D. Coordinate work under provisions of Section [01 32 13.] [01 31 13] [01 14 16], and ensure system is completed and commissioned by Date of Substantial Completion.
- E. Coordinate installation of system components with installation of mechanical systems equipment such as air handling units and air terminal units.

1.12 WARRANTY

- A. Provide [five] [_____] year warranty under provisions of Section [01 77 00.] [01740.]
- B. Warranty: Include coverage for [control air compressors.] [_____].

1.13 MAINTENANCE SERVICE

- A. Furnish service and maintenance of automatic controls system for [one] [_____] year from Date of Substantial Completion.
- B. Provide [two] [four] [_____] complete inspections, to inspect, calibrate, and adjust controls as required, and submit written reports.
- B. ***** [OR] ***** Provide complete service of controls systems, including call backs. Make minimum of [_____] complete normal inspections of approximately [_____] hours duration in addition to normal service calls to inspect, calibrate, and adjust controls, and submit written reports.

1.14 EXTRA MATERIALS

- A. Submit maintenance materials under provisions of Section [01 77 00] [01 78 46.]
- B. Provide [two] [_____] of each type thermostat [,] [and] [_____] under provisions of Section [01 77 00.] [01 78 46.]

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. [_____] Product [_____.]
- B. [_____] Product [_____.]
- C. [_____] Product [_____.]
- D. Substitutions: Under provisions of Section [0026 00.] [01 25 00.]

2.02 AIR SUPPLY

- A. Air Supply and Receiver: [Simplex] [Duplex] belt driven air compressor and tank unit with belt guard, silencers, flexible connections, air filter, automatic and manual drain assemblies, oil and particle filter for minimum 0.5 micron particles, pressure reducing valves, and pressure relief valves. Size [each] compressor and storage tank to limit compressor starts to maximum [10] [_____] per hour and [50] [30] percent running time.
- B. Pressure Control: Zinc or aluminum castings, rated for service with elastomeric diaphragm, adjustable electric contacts, set to start and stop compressor at [50 and 65 psig (340 and 445 kPa)] [60 and 80 psig (410 and 550 kPa)] [70 and 90 psig (480 and 620 kPa)] [100 and 125 psig (690 and 865 kPa)].[,] [and second compressor at [50 and 65 psig (340 and 445 kPa)] [60 and 80 psig (410 and 550 kPa)] [70 and 90 psig (480 and 620 kPa)].]
- C. Electrical Alternation Set: With motor starters to operate compressors [alternately.] [on time schedule.]
- D. Pressure Regulators: Zinc or aluminum castings, rated for service with elastomeric diaphragm, balanced construction to automatically prevent pressure buildup, and producing flat, reduced pressure curve for system capacity demand.
- E. Particle Filters: Zinc or aluminum castings, rated for service with threaded connections, quick-disconnect service devices, aluminum bowl or plastic bowl with metal guard equipped with manual draincock, to separate liquid and solid particles.

- F. Combination Filter/Regulators: Zinc or aluminum castings, rated for service with elastomeric diaphragm, balanced construction to automatically prevent pressure buildup, and producing flat, reduced pressure curve for system capacity demand; with threaded pipe connections, quick-disconnect service devices, aluminum bowl or plastic bowl with metal guard equipped with manual draincock to separate liquid and solid particles.
- G. Airborne Oil Filter: Rated for service with filtration efficiencies of 99.9 percent for particles of 0.025 micron or larger particles of airborne lubricating oil.
- H. Pressure Relief Valves: ASME Code Rated and labeled for high pressure side and sized for installed capacity of pressure regulators at low pressure. Set at maximum 20 percent above low pressure.

2.03 CONTROL AND INSTRUMENTATION TUBING

- A. Copper Tubing: ASTM B280, Type K, seamless, hard drawn or annealed.
 - 1. Fittings: ANSI/ASME B16.22, wrought copper.
 - 2. Joints: ANSI/ASTM B32 [or FS QQ-S-571 alloy 58-5] [95-5] [60-4] tin antimony.
- B. Copper Tubing: ASTM B280, Type K, seamless, hard drawn or annealed.
 - 1. Fittings: UL approved [to MIL-F-18280] rod or forged brass rated to 200 psig at 100 degrees F (1380 kPa at 38 degrees C).
 - 2. Joints: Ball Sleeve compression type.
- C. Polyethylene Tubing: Black, flame retardant, virgin polyethylene, conforming to modified ASTM D1693 test.
 - 1. Fittings: UL approved [to MIL-F-18280] rod or forged brass rated to 200 psig at 100 degrees F (1380 kPa at 38 degrees C).
 - 2. Joints: Compression or barbed type.

2.04 REFRIGERATED AIR DRYER

- A. General Assembly: Self-contained, commercial quality, refrigerated, compressed air dryer complete with heat exchangers, moisture separator, and internal wiring and piping. Provide air inlet and outlet connections connected through manual by-pass valve.

- B. Heat Exchangers: Air to refrigerant coils. Provide centrifugal type moisture separator located at discharge of compressed air complete with automatic trap assembly. Provide automatic control system to bypass refrigeration system on low or no load conditions.
- C. Refrigeration Unit: Hermetically sealed, operating to maintain dew point of [5] [13] degrees F ([-15] [-10.5] degrees C) at 20 psig (138 kPa). House in steel cabinet with access door and panel.
- D. Accessories: Air inlet temperature gauge, air inlet pressure gauge, on/off switch, high temperature light, power on light, refrigerant gauge on back, air outlet temperature gauge, air outlet pressure gauge.

2.05 THERMOSTATS

- A. Pneumatic Room Thermostats: Adjustable proportioning type, [single] [dual] setpoint, containing [single bimetallic element for heating or cooling only] [dual bimetallic elements for] [heating and cooling] [day or night], minimum 10 degrees F (6 degrees C) set point adjustment[.] [and] adjustable dead band.] Provide locking covers with [set point adjustment,] [setpoint indication,] [concealed setpoint,] [with thermometer.] [without thermometer.]
- B. Electric Room Thermostats: [NEMA DC 3] Low voltage type [with setback/setup temperature control] for [cooling only.] [heating only.] [cooling and heating.] [Conform to MIL-S-29175.]
- C. Line Voltage Thermostats: Integral manual On/Off/Auto selector switch, maximum dead band of 2 degrees F (one degree C) concealed temperature adjustment, and locking cover, rated for [motor] load, single or two pole as required.
- D. Room Thermostat Accessories:
 1. Thermostat Covers: [Brushed aluminum.] [_____.]
 2. Insulating Bases: For thermostats located on exterior walls.
 3. Thermostat Guards: [Metal] [Locking transparent plastic] [_____] mounted on separate base.
 4. Adjusting Key: As required for device.
- E. Outdoor Reset Thermostat: Remote bulb or bimetal rod and tube type, for proportioning action with adjustable throttling range; scale range of [-10 to 70 degrees F (2 to 35 degrees C)] [_____] with adjustable setpoint.

- F. Immersion Thermostat: Remote bulb or bimetallic rod and tube type, for proportional action with adjustable setpoint and adjustable throttling range.
- G. Airstream Thermostats: Remote bulb or bimetallic rod and tube type, for proportional action with adjustable setpoint in middle of range and adjustable throttling range. For averaging service provide remote bulb element [7.5 feet (2.3 m).] [20 feet (6 m).]
- H. Electric Low Limit Duct Thermostat: Snap acting, single pole, single throw, manual reset switch which trips if temperature sensed across any 12 inches (300 mm) of bulb length is equal to or below setpoint, requiring minimum [20] [_____] feet ([6] [_____] m) length of bulb. Provide one thermostat for every 20 sq ft (1.86 sq m) of coil surface.
- I. Electric High Limit Duct Thermostat: Snap acting, single pole, single throw, manual reset switch which trips if temperature sensed across any 12 inches (300 mm) of bulb length, is equal to or above setpoint, requiring minimum 20 feet (6 m) length of bulb. Provide one thermostat for every 20 sq ft (1.86 sq m) of coil surface.
- J. Fire Thermostats: UL approved and listed, factory set in accordance with ANSI/NFPA 90A with normally closed contacts, manual reset.
- K. Heating/Cooling Valve Top Thermostats: Proportional acting for proportional flow, molded rubber diaphragm, [remote bulb] liquid filled element, direct and reverse acting at differential pressures to 25 psig (172 kPa), cast housing with position indicator and adjusting knob.

2.06 HUMIDISTATS

- A. Room Humidistats: Wall mounted, proportioning type, with adjustable [2] [5] percent relative humidity throttling range, operating range from [30 to 80] [_____] percent at temperatures up to [110] [_____] degrees F ([43] [_____] degrees C), cover with [set point indication.] [concealed setpoint.]
- B. Duct Humidistats: Insertion type, proportioning type, with adjustable 2 percent relative humidity throttling range, operating range from 20 to 80 percent at temperatures up to 150 degrees F (65 degrees C).
- C. High Limit Duct Humidistat: Insertion type, reverse acting, two position type, with differential maximum 2 percent relative humidity.

2.07 CONTROL VALVES

- A. Globe Pattern:

1. Up to 2 inches (50 mm): Bronze body, bronze trim, rising stem, renewable composition disc, screwed ends[,] [with backseating capacity repackable under pressure.]
 2. Over 2 inches (50 mm): Iron body, bronze trim, rising stem, plug-type disc, flanged ends, renewable seat and disc.
- B. Butterfly Pattern: Iron body, [bronze] [aluminum bronze] [stainless steel] disc, resilient replaceable seat for service to [180 degrees F (82 degrees C)] [250 degrees F (121 degrees C)] wafer or long ends, extended neck.
- C. Operators:
1. Rolling diaphragm, spring loaded, piston type with spring range [2 to 5 psig (15 to 35 kPa).] [3 to 10 psig (20 to 70 kPa).] [8 to 11 psig (55 to 75 kPa).] [as scheduled.]
 2. Valves shall spring return to normal position as indicated on freeze, fire, or temperature protection.
- D. Hydronic Systems:
1. Rate for service pressure of 125 psig at 250 degrees F (860 kPa at 121 degrees C).
 2. Replaceable plugs and seats of [stainless steel.] [brass.]
 3. Size for [3] [_____] psig ([20] [_____] kPa) maximum pressure drop at design flow rate.
 4. Two way valves shall have equal percentage characteristics, three way valves linear characteristics. Size two way valve operators to close valves against pump shut off head.
- E. Steam Systems:
1. Rate for service pressure of 125 psig at 250 degrees F (860 kPa at 121 degrees C).
 2. Replaceable plugs and seats of stainless steel. Pressure drop across any steam valve at maximum flow shall be as shown on the Drawings.
 3. Size for 10 psig (70 kPa) inlet pressure and 5 psig (35 kPa) pressure drop.

4. Valves shall have modified linear characteristics.

2.08 DAMPERS

- A. Performance: Test in accordance with AMCA 500.
- B. Frames: [Galvanized steel] [Extruded aluminum] [Rolled carbon steel] [Stainless steel], welded or riveted with corner reinforcement.
- C. Blades: [Galvanized steel] [Extruded aluminum] [Rolled carbon steel] [Stainless steel], maximum blade size [8] [] inches ([200] [] mm) wide, 48 inches (1 200 mm) long, attached to minimum 1/2 inch (13 mm) shafts with set screws.
- D. Blade Seals: [Synthetic elastomeric] [Neoprene] [inflatable] mechanically attached, field replaceable.
- E. Jamb Seals: Stainless steel.
- F. Shaft Bearings: [Oil impregnated sintered bronze or graphite impregnated nylon sleeve, with thrust washers at bearings.] [Lubricant free, stainless steel, single row, unground, flanged, radial, antifriction type with extended inner race.]
- G. Linkage Bearings: Oil impregnated sintered bronze or graphite impregnated nylon.
- H. Leakage: Less than [one] [1/2] percent based on approach velocity of 2000 ft/min (10 m/sec) and 4 inches wg (1.0 kPa).
- I. Maximum Pressure Differential: 6 inches wg (1.5 kPa).
- J. Temperature Limits: -40 to 200 degrees F (-40 to 93 degrees C).

2.09 DAMPER OPERATORS

- A. General: Provide smooth proportional control with sufficient power for air velocities 20 percent greater than maximum design velocity and to provide tight seal against maximum system pressures. Provide spring return for two position control and for fail safe operation.
- B. Pneumatic Operators: Rolling diaphragm piston type[.] [with adjustable stops.]
- C. Pilot Positioners: Starting point adjustable from 2 to 12 psig (15 to 83 kPa) and operating span adjustable from 5 to 13 psig (35 to 90 kPa).
- D. Electric Operators: Split phase type with oil immersed gear train.

- E. Number: Sufficient to achieve unrestricted movement throughout damper range.
[Provide one damper operator for maximum 36 sq ft (3.34 sq m) damper section.]
- F. Inlet Vane Operators: High pressure with pilot positioners and sufficient force to move vanes when fan is started with vanes in closed position. Return vane operator to closed position on fan shutdown.

2.10 TIME CLOCKS

- A. Seven day programming switch timer with synchronous timing motor and seven day dial, continuously charged Ni-cad battery driven power failure 8 hour carry over and multiple switch trippers to control systems for minimum of two and maximum of eight signals per day with two normally open and two normally closed output switches.
- B. Solid state programmable time control with [_____] separate programs, 24 hour battery carry over[,][.] [duty cycling] [individual on/off/auto switches for each program] [7 day programming] [365 day calendar with 20 programmable holidays] [choice of fail safe operation for each program] [system fault alarm].

2.11 WATER TEMPERATURE CONTROLLERS

- A. Operate on adjustable differential over adjustable temperature range and suitable for operating control valve provided.

2.12 TRANSMITTERS

- A. Building Static Pressure Transmitter: One pipe, [direct acting, double bell,] differential type with temperature compensation, scale range 0.01 to 6.0 inch wg (2.5 to 1500 kPa) positive or negative, and sensitivity of 0.0005 inch wg (0.125 kPa). Transmit [electronic] [pneumatic] signal to receiver with matched scale range.
- B. Pressure Transmitters: One pipe direct acting [indicating type] for gas, liquid, or steam service, range suitable for system, proportional [electronic] [pneumatic] output.
- C. Temperature Transmitters: One pipe, directly proportional output signal to measured variable, linearity within plus or minus 1/2 percent of range for 200 degree F (93 degree C) span and plus or minus one percent for 50 degree F (10 degree C) span, with 50, 100, or 200 degree F (10, 38, 93 degree C) temperature range, compensated bulb, averaging capillary, or rod and tube operating on 20 psig (138 kPa) input pressure and 3 to 15 psig (20 to 100 kPa) output.

- D. Humidity Transmitters: One pipe, directly proportioned output signal to measured variable, linearity within plus or minus one percent for 70 percent relative humidity span, capable of withstanding 95 percent relative humidity without loss of calibration.

2.13 RECEIVER CONTROLLERS

- A. Single or dual input models [with control point adjustment] direct or reverse acting with mechanical set point adjustment [with locking device], proportional band adjustment, and authority adjustment. Provide [proportional] [proportional plus integral] control mode.
- B. Remote control point adjustment shall be plus or minus [20] [____] percent of sensor span, input signal [3 to 13 psig (20 to 90 kPa).] [1 to 20 psig (7 to 140 kPa).]
- C. Proportional band shall extend from 2-1/2 to 40 percent of primary sensor span, authority from 10 to 200 percent of primary sensor span[.] [and integral time 0.5 to 20 min.]
- D. Suitable for supply air pressure of [18 psig (125 kPa)] [20 psig (140 kPa)] with input signals of [3 to 15 psig (20 to 100 kPa)] [1 to 20 psig (7 to 140 kPa)] and output signal 0 to [15 psig (100 kPa).] [20 psig (140 kPa).]

2.14 PNEUMATIC SYSTEMS ACCESSORIES

- A. Pressure Gages: Manufacturer's standard [to FS-GG-G-76], black letters on white background, [3-1/2 inch (90 mm)] [2-1/2 inch (65 mm)] [2 inch (50 mm)] diameter, flush or surface mounted, with [front calibration screw,] suitable dial range calibrated to match sensor, in appropriate units.
- B. Instrument Pressure Gages: Manufacturer's standard [to FS-GG-G-76], black letters on white background, [2 inch (50 mm)] [1-1/2 inch (40 mm)] diameter, stem mounted with suitable dial range.
- C. Diaphragm Control and Instrument Valves: 1/4 and 3/8 inch (6 and 10 mm) forged brass body with reinforced Teflon diaphragm, stainless steel spring, and color coded phenolic handle.
- D. Gage Cocks: Tee or lever handle, bronze, rated for 125 psig (860 kPa).
- E. Relays: For summing, reversing, amplifying, highest or lowest pressure selection, with fixed 1:1 [or adjustable] input/output ratio.
- F. Switches: With indicating plates, accessible adjustment, calibrated and marked.

2.15 CONTROL PANELS

- A. Unitized cabinet type for each system under automatic control with relays and controls mounted in cabinet and temperature indicators, pressure gauges, pilot lights, pushbuttons and switches flush on cabinet panel face.
- B. ANSI/NEMA 250, general purpose utility enclosures with enameled finished face panel.

2.16 ALARM SYSTEM

- A. Provide alarm panel with individual indication, horn, silenced acknowledge switch, and test switch.
- B. At any alarm condition indication light will flash and alarm will sound. Stop horn by depressing acknowledge switch and indicate alarm conditions by a continuous light until trouble condition has cleared. Sound alarm again should second alarm occur before first one has cleared.
- C. Provide remote panels where indicated with indication horn, activated by any alarm. Provide alarm silence/acknowledge switch such that alarm can be acknowledged from master and remote panel.
- D. Provide panels in locations described to serve duplicate functions of primary panel. Provide alarm silence/acknowledge switch such that alarm can be acknowledged from any panel.
- E. Provide dry contacts at main alarm panel for use by independent alarm monitoring company to indicate [each] alarm condition.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that systems are ready to receive work.
- B. Beginning of installation means installer accepts existing conditions.

3.02 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Mount compressor and tank unit on vibration isolation[.] [consisting of springs, with minimum [one inch (25 mm)] [2 inches (50 mm)] static deflection and one inch (25 mm) clearance to floor.] [Refer to Section 21 05 48.] Isolate air supply with wire-braid reinforced rubber hose[.] [or polyethylene tubing.]

- C. Supply instrument air from compressor units through filter, pressure-reducing valve, pressure relief valve, with pressure gauges, and shutoff and bypass valves.
- D. Install pressure-reducing stations consisting of pressure reducing valve, particle filter, valved bypass, pressure gauge on inlet and outlet, and pressure relief valve.
- E. Locate refrigerated air dryer in discharge air line from tank. Mount dryer on wall on rubber in shear mounts. Install pressure regulator downstream of dryer. Pipe automatic drain to nearest floor drain.
- F. Use copper tubing in mechanical rooms, where subject to damage or temperatures in excess of 200 degrees F (93 degrees C), where adjacent to heating pipes passing through common sleeve, and where not readily accessible. In mechanical rooms bundled plastic tubing with suitable junction boxes or single plastic tubing with tray or raceway may be used.
- G. Conceal tubing. Run exposed only in mechanical rooms, storage rooms and like, in neat manner and properly supported. [Refer to Section 23 05 29.]
- H. Mechanically attach tubing to supporting surfaces. Sleeve through concrete surfaces in minimum one inch (25 mm) sleeves, extended 6 inches (150 mm) above floors and one inch (25 mm) below bottom surface of slabs.
- I. Purge tubing with dry, oil-free compressed air before connecting control instruments.
- J. Provide instrument air tubing with check and hand valves to expansion tanks with Schraeder fittings and hose.
- K. Install [pressure gauges] [test plugs] on branch lines at each receiver controller and signal lines at each transmitter excepting individual room controllers.
- L. Check and verify location of thermostats[,] [humidistats,] and other exposed control sensors with plans and room details before installation. Locate room thermostats [60 inches (1 500 mm)] [48 inches (1 200 mm)] [42 inches (1 050 mm)] above floor. Align with lighting switches[,] [and humidistats].
- M. Mount freeze protection thermostats using flanges and element holders.
- N. Mount outdoor reset thermostats and outdoor sensors indoors, with sensing elements outdoors[,] [with sun shield.]
- O. Provide separable sockets for liquids and flanges for air bulb elements.

- P. Provide thermostats in aspirating boxes in front entrances[,] [handball courts,] [gymnasiums,] [high security areas] [and] [_____].] [and where indicated.]
- Q. Provide guards on thermostats in entrance hallways [and other public areas.] [and where indicated.]
- R. Provide valves with position indicators and with pilot positioners where sequenced with other controls.
- S. Provide separate steam valve for each bank of coils. Provide two valves in parallel where steam load exceeds 1500 lb/hr (0.10 kg/sec). Capacities for two valves in parallel shall have 1/3 - 2/3 load capacities sequenced with smaller valve opening first.
- T. Provide mixing dampers of [opposed] [or] [parallel] blade construction arranged to mix streams. Provide pilot positioners on mixed air damper motors. [Provide separate minimum outside air damper section adjacent to return air dampers with separate damper motor.]
- U. Provide pilot positioners on damper operators sequenced with other controls.
- V. Test multizone dampers for temperature pickup due to leakage when hot deck is closed and cold deck is open. Adjust for maximum temperature rise of 2 degrees F (one degree C) when the temperature difference between the hot and cold decks is 20 degrees F (11 degrees C).
- W. Mount control panels adjacent to associated equipment on vibration free walls or free standing angle iron supports. One cabinet may accommodate more than one system in same equipment room. Provide engraved plastic nameplates for instruments and controls inside cabinet and engraved lamicoïd nameplates on cabinet face.
- X. Install "hand/off/auto" selector switches to over-ride automatic interlock controls when switch is in "hand" position.
- Y. Provide conduit and electrical wiring where required. Refer to Section 26 05 00.
- Z. After completion of installation, test and adjust control equipment. Submit data showing set points and final adjustments of controls.
- AA. Test pneumatic systems to system pressure maximum of 30 psig (200 kPa). Check calibration of instruments. Recalibrate or replace.

3.03 MANUFACTURER'S FIELD SERVICES

- A. Prepare and start systems under provisions of Section [01 43 33.] [01 45 16.]

3.04 DEMONSTRATION

- A. Provide systems demonstration under provisions of Section [01 79 00.] [_____.]
- B. Demonstrate complete operation of systems, including sequence of operation after Date of Substantial Completion.

3.05 CONTROL VALVE SCHEDULE

<u>Drawing Code</u>	<u>CV-1</u>	<u>CV-2</u>	<u>CV-3</u>	<u>CV-4</u>
Location				
Service				
Manufacturer				
Model Number				
Valve Size				
Valve CV				
Operator Spring Range				
Normal Position				

3.06 CONTROL DAMPER SCHEDULE

<u>Drawing Code</u>	<u>CD-1</u>	<u>CD-2</u>	<u>CD-3</u>	<u>CD-4</u>
Location				
Service				
Manufacturer				
Model Number				
Height				
Width				
Air Flow				
Air Pressure Drop				

END OF SECTION

SECTION 23 11 13
FUEL OIL PIPING SYSTEM

PART 1 GENERAL

1.00 The following sections are to be included as if written herein:

- A. Section 23 00 00 – Basic Mechanical Requirements
- B. Section 23 05 29 – Sleeves, Flashings, Supports and Anchors
- C. Section 23 05 53 – Mechanical Identification

1.01 SECTION INCLUDES

- A. Pipe and Pipe Fittings
- B. Valves
- C. Fuel Oil Storage Tanks
- D. Accessories

1.02 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION

- A. Section [____ - _____]: Placement of pipe sleeves.

1.03 RELATED SECTIONS

- A. Section 31 23 16 - Excavating
- B. Section 31 23 23.13 - Backfilling
- C. Section 31 23 16.13 - Trenching
- D. Section 09 91 00 - Painting
- E. Section 23 05 16.UT - Expansion Compensation

1.04 REFERENCES

- A. ACT 100 - Fabrication of FRP Clad/Composite Underground Storage Tanks
- B. ANSI B31.1 - Power Piping

- C. ANSI B31.4 - Liquid Petroleum Transportation Piping Systems
- D. ANSI B31.9 - Building Service Piping
- E. API Spec 12P - Fiberglass Reinforced Plastic Tanks
- F. API 650 - Welded Steel Tanks for Oil Storage
- G. API 1615 - Installation of Underground Petroleum Storage Systems
- H. API 1632 - Cathodic Protection of Underground Petroleum Storage Tanks and Piping Systems
- I. API 2000 - Venting Atmospheric and Low Pressure Storage Tanks
- J. ASME - Boiler and Pressure Vessel Code
- K. ASME Sec. 9 - Welding and Brazing Qualifications
- L. ASME B16.3 - Malleable Iron Threaded Fittings
- M. ASME B16.18 - Cast Bronze Solder-Joint Pressure Fittings
- N. ASME B16.22 - Wrought Copper and Bronze Solder-Joint Pressure Fittings
- O. ASME B16.26 - Cast Bronze Fittings for Flared Copper Tubes
- P. ASME B36.10 - Welded and Seamless Wrought Steel Pipe
- Q. ASTM A53 - Pipe, Steel, Black and Hot-Dipped Zinc Coated, Welded and Seamless
- R. ASTM A120 - Pipe, Steel, Black and Hot-Dipped Zinc Coated (Galvanized), Welded and Seamless, for Ordinary Uses
- S. ASTM A234 - Pipe Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and Elevated Temperatures
- T. ASTM B88 - Seamless Copper Water Tube
- U. ASTM D2310 - Machine-Made Reinforced Thermosetting Resin Pipe
- V. ASTM D2996 - Filament-Wound Reinforced Thermosetting Resin Pipe

- W. ASTM D4021 - Glass-Fiber-Reinforced Polyester Underground Petroleum Storage Tanks
- X. AWS A5.8 - Brazing Filler Metal
- Y. AWWA C105 - Polyethylene Encasement for Ductile Iron Piping for Water and Other Liquids
- Z. NACE RP-01-69 - Control of External Corrosion on Underground or Submerged Piping Systems
- AA. NACE RP-02-85 - Control of External Corrosion on Metallic Buried, Partially Buried or Submerged Liquid Storage Systems
- BB. NFPA 30 - Flammable and Combustible Liquids Code
- CC. NFPA 31 - Installation of Oil Burning Equipment
- DD. STI sti-P3 - Cathodically Protected Steel Underground Storage Tanks
- EE. UL 58 - Steel Underground Tanks for Flammable and Combustible Liquids
- FF. UL 80 - Steel Inside Tanks Oil-Burner Fuel
- GG. UL 142 - Steel Aboveground Tanks for Flammable and Combustible Liquids
- HH. UL 1316 - Glass-Fiber-Reinforced Plastic Underground Tanks for Petroleum Products

1.05 SUBMITTALS

- A. Submit under provisions of Section 23 00 00.
- B. Shop Drawings: Indicate tanks, system layout, pipe sizes, location, and elevations. For fuel oil tanks, indicate dimensions and accessories including manholes and hold down straps.
- C. Product Data: Provide data on pipe materials, pipe fittings, valves and accessories. Provide manufacturers catalog information. Indicate valve data and ratings.

1.06 PROJECT RECORD DOCUMENTS

- A. Submit under provisions of Section 23 00 00.

- B. Record actual location of piping system, storage tanks, and system components.
- 1.07 OPERATION AND MAINTENANCE DATA
- A. Submit under provisions of Section 23 00 00.
 - B. Maintenance Data: Include installation instructions, spare parts lists [, exploded assembly views].
- 1.08 QUALITY ASSURANCE
- A. Valves: Manufacturer's name and pressure rating marked on valve body.
 - B. Welding Materials and Procedures: Conform to ASME Code [and applicable state labor regulations.]
 - C. Welders Certification: In accordance with ASME Sec 9.
 - D. Maintain one copy of each document on site.
- 1.09 QUALIFICATIONS
- A. Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience.
 - B. Installer: Company specializing in performing the work of this section with minimum three years documented experience.
- 1.10 REGULATORY REQUIREMENTS
- A. Conform to applicable EPA, State of Texas, and Local Regulations for installation of fuel oil systems.
 - B. Provide certificate of compliance from [_____] indicating approval of installation of fuel oil system.
- 1.11 DELIVERY, STORAGE, AND HANDLING
- A. Deliver, store, protect and handle products to site under provisions of Section 23 00 00.
 - B. Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.
- 1.12 EXTRA MATERIALS

A. Furnish under provisions of Section 23 00 00.

B. Provide two repacking kits for each size valve.

PART 2 PRODUCTS

2.01 FUEL OIL [AND TANK VENT] PIPING, BURIED

A. Copper Tubing: ASTM B88, Type [K,] [L,] [M,] [hard drawn.] [annealed.]

1. Fittings: ASME B16.18, cast bronze or ASTM B16.22 wrought copper or bronze.

2. Joints: AWS A5.8, BCuP silver braze.

B. Copper Tubing: ASTM B88, Type [K,] [L,] annealed.

1. Fittings: ASME B16.26, cast bronze.

2. Joints: Flared.

C. Steel Pipe: ASTM A53 or A120, Schedule 40 black.

1. Fittings: ASTM A234, forged steel welding type.

2. Joints: [ANSI B31.1] [ANSI B31.4] [ANSI B31.9] welded.

3. Jacket: AWWA C105 polyethylene or double layer, half-lapped 10 mil (0.25 mm) polyethylene tape.

D. FRP: ASTM D2310 and ASTM D2996, UL listed filament wound fiberglass reinforced epoxy pipe with integral epoxy liner and exterior coating.

1. Fittings: Compression molded, filament wound fiberglass reinforced epoxy.

2. Joints: Tapered bell and spigot adhesive bonded.

2.02 FUEL OIL [AND TANK VENT] PIPING, ABOVE GROUND

A. Copper Tubing: ASTM B88, Type [K,] [L,] [M,] hard drawn.

1. Fittings: ASME B16.18, cast bronze or ASTM B16.22 wrought copper and bronze.

2. Joints: NFPA 30; AWS A5.8, BCuP silver braze.
- B. Copper Tubing: ASTM B88, Type [K,] [L,] annealed.
1. Fittings: ASME B16.26, cast bronze.
 2. Joints: Flared.
- C. Steel Pipe: ASTM A53 or A120, or ASME B36.10, Schedule 40 black.
1. Fittings: ASTM B16.3, malleable iron, or ASTM A234, forged steel welding type.
 2. Joints: NFPA 30, threaded or welded to [ANSI B31.1] [ANSI B31.4] [ANSI B31.9].
- D. FRP: ASTM D2310 and ASTM D2996, UL listed filament wound fiberglass reinforced epoxy pipe with integral epoxy liner and exterior coating.
1. Fittings: Compression molded, filament wound fiberglass reinforced epoxy.
 2. Joints: Tapered bell and spigot adhesive bonded.

2.03 FLANGES, UNIONS, AND COUPLINGS

- A. Pipe Size 2 Inches (50 mm) and Under:
1. Ferrous pipe: 150 psig (1 034 kPa) malleable iron threaded unions.
 2. Copper tube: 150 psig (1 034 kPa) bronze unions with brazed joints.
- B. Pipe Size Over 2 Inches (50 mm):
1. Ferrous pipe: 150 psig (1 034 kPa) forged steel slip-on flanges; 1/16 inch (1.6 mm) thick preformed neoprene gaskets.
 2. Copper tube: 150 psig (1 034 kPa) slip-on bronze flanges; 1/16 inch (1.6 mm) thick preformed neoprene gaskets.
- C. Dielectric Connections: Union with galvanized or plated steel threaded end, copper solder end, water impervious isolation barrier.

2.04 GATE VALVES

A. Manufacturers:

1. [] Model [].
2. Other acceptable manufacturers offering equivalent products.
 - a. [] Model [].
 - b. [] Model [].
 - c. [] Model [].

B. Bronze body, bronze trim, [non-rising] [rising] stem, handwheel, inside screw, single wedge or disc, [solder] [or] [threaded] ends.

2.05 GLOBE VALVES

A. Manufacturers:

1. [] Model [].
2. Other acceptable manufacturers offering equivalent products.
 - a. [] Model [].
 - b. [] Model [].
 - c. [] Model [].

B. Bronze body, bronze trim, rising stem, handwheel, inside screw, renewable composition disc, [solder] [or] [threaded] ends, with backseating capacity (repackable under pressure).

2.06 BALL VALVES

A. Manufacturers:

1. [] Model [].
2. Other acceptable manufacturers offering equivalent products.
 - a. [] Model [].

b. [] Model [].

c. [] Model [].

B. [Bronze] [Stainless steel] [one] [two] piece body, [stainless] [chrome plated] steel ball, Teflon seats and stuffing box ring, lever handle [and balancing stops], [solder] [or] [threaded] ends [with union.]

2.07 SWING CHECK VALVES

A. Manufacturers:

1. [] Model [].

2. Other acceptable manufacturers offering equivalent products.

a. [] Model [].

b. [] Model [].

c. [] Model [].

B. Bronze body, bronze swing disc, [solder] [or] [threaded] ends.

2.08 RELIEF VALVES

A. Manufacturers:

1. [] Model [].

2. Other acceptable manufacturers offering equivalent products.

a. [] Model [].

b. [] Model [].

c. [] Model [].

B. Bronze body, Teflon seat, steel stem and springs, automatic, direct pressure actuated at maximum 60 psi (400 kPa), UL listed for fuel oil, capacities ASME certified and labeled.

2.09 STRAINERS

A. Manufacturers:

1. [_____] Model [_____].
2. Other acceptable manufacturers offering equivalent products.
 - a. [_____] Model [_____].
 - b. [_____] Model [_____].
 - c. [_____] Model [_____].

B. Threaded brass or iron body for 175 psig (1200 kPa) working pressure, Y pattern with 1/32 inch (0.8 mm) stainless steel perforated screen.

2.10 FLEXIBLE CONNECTORS

A. Manufacturers:

1. [_____] Model [_____].
2. Other acceptable manufacturers offering equivalent products.
 - a. [_____] Model [_____].
 - b. [_____] Model [_____].
 - c. [_____] Model [_____].

B. Bronze inner hose and braided exterior sleeve, suitable for minimum 200 psi (1380 kPa) WOG and 250 degrees F (121 degrees C).

2.11 UNDERGROUND FUEL STORAGE TANKS

A. Manufacturers:

1. [_____] Model [_____].
2. Other acceptable manufacturers offering equivalent products.
 - a. [_____] Model [_____].
 - b. [_____] Model [_____].

c. [] Model [].

B. Capacity:

1. Volume: [] gallons ([] liters).
2. Diameter: [] inches ([] mm).
3. Overall Length: [] inches ([] mm).

C. Tank: [ACT 100] [API Spec 12P] [ASTM D4021] [UL 1316], UL listed and labeled, closed [single] [double] wall type, reinforced glass fiber polyester, capable of liquid storage with specific gravity of [1:1] [] and temperatures up to 150 degrees F (65 degrees C,) anchor straps and attachments, fittings, lifting lugs, and tapings for accessories.

C. ***** [OR] ***** Tank: [API 650] [UL 58] [UL 142], UL listed and labeled, closed [single] [double] wall type, heavy gauge welded steel, cleaned and coated with [corrosion-resistant asphalt base paint] [hot applied bitumen] [epoxy] [coal tar epoxy], anchor straps and attachments, fittings, lifting lugs, and tapings for accessories.

D. Tank Fittings:

1. Fill: [] inch ([] mm).
2. Vent: [] inch ([] mm), galvanized, including "T" and elbow assembly with 1/4 inch (6 mm) square mesh screen over inlet.
3. Suction: [] inch ([] mm) anti-siphon connection to tank bottom with foot valve.
4. Return: [] inch ([] mm).
5. Gauge Fitting: [] inch ([] mm).
6. Connections: UL 567, dielectric bushings.

E. Filler Cap: 3 inch (75 mm) watertight brass with lock [, recessed box and cover].

F. Manhole: [18] [22] [] inch ([450] [550] [] mm) diameter manhole at top of tank with cover and gasket, and extension sleeve and cover.

- G. Gauge: Remote reading, electronic, for two wire, 24-volt power, with wall mounted direct reading gauge.
- H. Cathodic Protection: [API 1632,] Galvanic type with sacrificial magnesium anodes wired to tank [, to NACE RP- 02-85] [, to sti-P3].
- I. Leak Detector System: Model [_____] manufactured by [_____].

2.12 FUEL STORAGE DAY TANKS

- A. Manufacturers:
 - 1. [_____] Model [_____].
 - 2. Other acceptable manufacturers offering equivalent products.
 - a. [_____] Model [_____].
 - b. [_____] Model [_____].
 - c. [_____] Model [_____].
- B. Capacity: [_____] gallons ([_____] Liters).
- C. Tank: UL 80, welded steel, oval with steel support saddles, tappings for accessories, threaded connections.
- D. Accessories: Tank fill, gauge, vent, and outlet connections.
- E. Gauge: Remote reading, electronic, for two wire, 24-volt power, with wall mounted direct reading gauge.

2.13 FUEL OIL PUMPS

- A. Manufacturers:
 - 1. [_____] Model [_____].
 - 2. Other acceptable manufacturers offering equivalent products.
 - a. [_____] Model [_____].
 - b. [_____] Model [_____].

c. [] Model [].

B. Performance:

1. Flow: [] gal/min ([] L/sec), at [] feet ([] kPa) head.
2. Motor: [] HP ([] KW), [] volt, [single] [three] phase, 60 Hz.

C. Casing: Bronze, rated for 125 psig (860 kPa) working pressure with integral pressure relief valve.

D. Impeller: Bronze gears, positive displacement.

E. Drive: Direct connected with flexible coupling.

2.14 TRANSFER SYSTEM

A. System: Float valves and relays to automatically energize transfer pumps to fill day tank from main storage tank.

1. Low level: Energize pumps when tank level drops below [50] [33] [] percent of full volume.
2. Full level: De-energize pumps when full.
3. Alarm: Sound audible alarm when fuel overflows into return line.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify excavations under provisions of Section [01039.] [].
- B. Verify that excavations are to required grade, dry, and not over excavated.

3.02 PREPARATION

- A. Ream pipe and tube ends. Remove burrs. [Bevel plain end ferrous pipe.]
- B. Remove scale and dirt, on inside and outside, before assembly.
- C. Prepare piping connections to equipment with flanges or unions.

- D. Excavate in accordance with Sections [02222] [_____] and [02225] and [_____] for work of this Section.
- E. Backfill in accordance with Sections [02223] [_____] and [02225] [_____] for work of this Section.

3.03 PIPING INSTALLATION

- A. Install in accordance with manufacturer's instructions [and API 1615].
- B. Provide non-conducting dielectric connections wherever jointing dissimilar metals. Install to NACE RP-01-69.
- C. Route piping in orderly manner and maintain gradient.
- D. Install piping to conserve building space and not interfere with use of space.
- E. Group piping whenever practical at common elevations.
- F. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.
- G. Provide clearance for installation of insulation and access to valves and fittings.
- H. Provide access where valves and fittings are not exposed. [Coordinate size and location of access doors with Section 08305.]
- I. Establish elevations of buried piping outside the building to ensure not less than [_____] ft ([_____] m) of cover.
- J. Where pipe support members are welded to structural building framing, scrape, brush clean, weld, and apply one coat of zinc rich primer.
- K. Prepare pipe, fittings, supports, and accessories not pre-finished, ready for finish painting. Refer to Section 09 91 00.
- L. Identify piping systems including underground piping. Refer to Section 23 05 53.
- M. Install valves with stems upright or horizontal, not inverted.
- N. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed system.

3.04 FUEL TANK INSTALLATION

- A. Install tanks in accordance with manufacturer's instructions [and API 1615].
- B. Clean and flush [underground] [aboveground] tanks [prior to delivery to site.] [after installation.] Seal until pipe connections are made.
- C. Install underground tanks on concrete ballast pad with mass equal to tank capacity, and secure with hold down straps and turnbuckles.
- D. Install underground tanks with minimum [24] [] inch ([600] [] mm) cover.
- E. Install single wall underground tanks in concrete vault or provide impermeable liner in excavation around tank.
- F. Backfill steel tanks in accordance with NFPA 30 and 31.
- G. Backfill glass fiber tanks with [sand] [washed pea gravel.] [granular fill specified in Section 02223.] Do not bed on timbers, beams, or cradles.
- H. Provide piping connections to tanks with unions and swing joints. Provide venting to API 2000.
- I. Extend fill line and cover to grade and provide minimum 24 x 24 x 6 inch (600 x 600 x 150 mm) concrete pad.
- J. Mount aboveground tanks on steel support saddles and stands as indicated.
- K. Clean and flush day tank [prior to delivery to site.] [after installation.] Seal until pipe connections are made.
- L. Fill tanks at project turn over with appropriate fuel.

3.05 TANK SCHEDULE

<u>Drawing Code</u>	<u>TK-1</u>	<u>TK-2</u>	<u>TK-3</u>	<u>TK-4</u>
Location				
Service				
Capacity				
Diameter				
Length				
Fitting Sizes				
Inlet				
Outlet				

Vent
Gauge
Fill
Auxiliary
Manhole Size

3.06 PUMP SCHEDULE

<u>Drawing Code</u>	<u>TK-1</u>	<u>TK-2</u>	<u>TK-3</u>	<u>TK-4</u>
---------------------	-------------	-------------	-------------	-------------

Manufacturer				
Model				
Flow Capacity				
Head Pressure				
Motor Size				

END OF SECTION

SECTION 23 20 00
HVAC PUMPS

PART 1 GENERAL

1.00 The following sections are to be included as if written herein:

- A. Section 23 00 00 – Basic Mechanical Requirements
- B. Section 23 05 29 – Sleeves, Flashings, Supports and Anchors
- C. Section 23 05 53 – Mechanical Identification

1.01 **WORK INCLUDED**

- A. Base mounted pumps

1.02 **RELATED WORK**

- A. Section 23 05 13 - Motors
- B. Section 21 05 48 - Vibration Isolation
- C. Section 23 07 19 - Piping Insulation
- D. Section 23 07 16 - Equipment Insulation
- E. Section 23 21 00 - Hydronic Piping
- F. Section 23 06 20.13 - Hydronic Specialties
- G. Section 26 29 23 – Variable Speed Drives

1.03 **REFERENCES**

- A. ANSI/UL 778 - Motor Operated Water Pumps

1.04 **QUALITY ASSURANCE**

- A. Manufacturer: Company specializing in manufacture, assembly, and field performance of pumps with minimum three years experience.
- B. Alignment: Base mounted pumps shall be aligned by qualified millwright and alignment certified.

1.05 SUBMITTALS

- A. Submit shop drawings and product data under provisions of Section 23 00 00.
- B. Submit certified pump curves showing performance characteristics with pump and system operating point plotted. Include NPSH curve when applicable.
- C. Submit manufacturer's installation instructions under provisions of Section 23 00 00

1.06 OPERATION AND MAINTENANCE DATA

- A. Submit operation and maintenance data under provisions of Section 23 00 00.
- B. Include installation instructions, assembly views, lubrication instructions, and replacement parts list.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Deliver products to site under provisions of Section 23 00 00.
- B. Store and protect products under provisions of Section 23 00 00.

1.08 EXTRA PARTS

- A. Provide one extra set of mechanical seals for pumps under provisions of Section 23 00 00.

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. ITT Allis-Chalmers
- B. ITT Bell & Gossett
- C. Buffalo Forge
- D. Aurora
- E. Taco
- F. Paco
- G. Substitutions: Under provisions of Section 23 00 00

2.02 HIGH TEMPERATURE PUMPS (EL PASO CAMPUS ONLY):

NOTE TO UTEP REVIEWER: PLEASE SUBMIT PREFERRED SPECIFICATION FOR CLOSE COUPLED PUMP FOR REPLACEMENT OF THE TEXT BELOW.

- A. Furnish and install a high temperature hot water pump with performance characteristics as scheduled on the Drawings. The pump shall be designed for a maximum working temperature of 500 degrees F. when the suction pressure plus differential pressure is 420 psi or less and shall have the following construction: casing - ductile iron, impeller - ductile iron, gland - ductile iron, channel rings - cast iron, shaft - AISI-C-1045 steel, and shaft sleeve - 400c hardened stainless steel.
- B. The pump shall be equipped with vacuum degassed ball bearings. The outboard thrust bearing shall be a double row deep groove angular bearing. The inboard is a single row deep groove bearing. The bearing shall be designed to give less than .001" (one thousandth inch) end play and a maximum of .002" (two thousandths inch) deflection at the mechanical seal faces. The bearing shall be oil lubricated and be equipped with constant level oiler with a clear Plexiglass oil reservoir to indicate oil reserve.
- C. The mechanical seal shall be Chesterton 123 with 18-8 stainless steel spring and metal parts, ethylene propylene elastomer bellows and solid tungsten carbide sealing face. The seal shall have a minimum life of 8000 hours when the pump is operating at 150 psig suction and 300 degrees F.
- D. The pump shall be equipped with water cooled stuffing box. The water cooled stuffing box shall be so constructed that it can be supplied with low pressure cooling water which shall circulate around seal housing and then to drain.
- E. The pump shall be mounted on a rigid cast iron base which is equipped with a tapered drip basin with 1" (one inch) pipe tap. The pump shall be connected to the motor with a Woods spacer coupling and coupling shafts shall be protected with a coupling guard. The pump shall have a centerline mounted casing to insure proper alignment and allows for expansion all directions from the horizontal centerline of the shaft.
- F. The pump shall be an Aurora Pump Company Series 154 "Apco Chem" peripheral turbine pump or approved equal.

2.03 DOUBLE SUCTION PUMPS:

- A. Furnish and install chilled water pumps of the capacities and efficiencies shown on the Drawings. These pumps shall be selected to be nonoverloading over the entire pump curve range, and shall be further selected such that the selected impeller size does not exceed 90% of the maximum impeller diameter catalogued.

- B. The pump casings shall be cast iron members. They shall be split at the horizontal centerline of the shaft in each case. The flanges of the upper and lower sections of the casing shall be arranged so that they may be held together rigidly with the use of appropriate bolts. The pump suction and discharge nozzles shall be located in the lower section of the casings. The design shall be such that the rotors of the pumps may be exposed for inspection or for removal by resorting to the expediency of removing the top section of the casing, but without disconnecting any part of the main interconnecting pipe systems.
- C. Both suction and discharge nozzles shall be provided with appropriate flanges by means of which the proper piping systems may be attached to the pumps. These flanges shall be dimensioned, faced, drilled and spot faced to conform to the latest American Flange Standard.
- D. The impellers of these pumps shall be arranged for single stage, double suction service. These enclosed impellers shall be made of bronze. They shall be machined carefully and balanced. Their arrangement shall be such as to minimize end thrust.
- E. The pump shafts shall be stainless steel members of liberal proportions. These shafts shall be machined with care, ground to gauge and heat treated.
- F. The pump rotors shall be supported in the case of each pump upon two ball type bearings. One ball bearing shall be located on each side of the pump impeller and each shall be in split bearing housings. The design of the split bearing housings shall be such as to make them dust-tight, grease-tight, water-tight with integral bearing arms cast to the main pump frame.
- G. The shaft sleeves provided for each pump shall be bronze and shall extend from the hub to the impellers out beyond the stuffing boxes. The sleeves shall be held rigidly to the rotating elements and they shall protect the steel shafts from the corrosive action of the water.
- H. Leakage from the discharge side of the pumps to the suction sides shall be prevented by the provision of the cast bronze case wearing rings. The design of these members shall be such that they may be removed and replaced with facility. All water pumps shall also have impeller wearing rings.
- I. Pump shaft seal: Seals shall be mechanical. Mechanical seals shall be John Crane Type "L" or approved equal. A bypass shall be provided from the pump casing to the seal chamber for seal flushing.
- J. Each pump shall be provided with a Thomas Flexible coupling Type DBZ of the proper size and with coupling guard.

- K. Each pump shall be mounted upon a fabricated steel or cast iron bed plate. The proportions of these bed plates shall be such as to accommodate not only the pump in each case but the pump driving member as well. These bed plates shall be provided with continuous drip canal around three (3) sides. Each bed plate shall, moreover, be provided with grout holes and leveling pads, with bolts. Each bed plate shall be arranged with a threaded drainage opening. Bed plates on chilled water pumps shall be extended sufficiently wide to assure that any dripping from pumps, pump nozzles and companion flanges will fall on the base 3" (three inches) beyond pipe companion flange). See Drawings for construction details of pump base.
- L. Provide and deliver to the Owner three complete sets of assembly drawings and repair parts lists for each device, i.e., for the pumps and the motors. The Drawings and literature provided shall relate to the actual units involved. They shall not be of such a general nature as to include details which are not incorporated in the devices. They shall, on the other hand, be so complete that no part or parts are omitted. Three manuals of instructions for the proper care, operation and maintenance of these devices shall be provided, likewise.
- M. After the pumps have been built and assembled, they shall be factory tested using shop turbine per Hydraulic Institute Standards and a complete set of test curves shall be obtained. These curves shall be certified by affidavit and delivered in triplicate to Owner.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install pumps in accordance with manufacturer's instructions.
- B. Provide access space around pumps for service. Provide no less than a minimum of three feet, not including piping and piping appurtenances.
- C. Ensure pumps operate at specified system fluid temperatures without vapor binding and cavitation, are non-overloading in parallel or individual operation, and operate within 15 percent of midpoint of published maximum efficiency curve.
- D. Decrease from line size with long radius reducing elbows or reducers. Support piping adjacent to pump such that no weight is carried on pump casings. For close coupled or base mounted pumps, provide supports under elbows on pump suction and discharge line sizes 4 inches and over. Refer to Section 23 05 48.
- E. Provide line sized shut-off valve (ball or butterfly) and strainer on pump suction, and line sized soft seat check valve and balancing (ball or butterfly with memory stop) valve on pump discharge.

- F. Provide air cock and drain connection on horizontal pump casings.
- G. Provide drains for bases and seals, piped to and discharging into floor drains.
- H. Lubricate pumps before start-up.
- I. Alignment: A qualified millwright shall check, align and certify pumps. A reverse alignment procedure utilizing laser instruments shall be used. Alignment shall be performed in both hot and cold operating extremes. The maximum parallel and angular misalignment shall not exceed .002 inch. Record and deliver copies of the alignment report to the Owner's RCM and include copy of the report in the O&M Manual.
- J. Vibration Testing: Vibration velocity readings shall be taken at all bearing locations of all pumps. Pumps driven by variable speed drives shall be tested throughout their range of speeds. Vibration shall not exceed 0.15 inch/second (peak). Record and deliver copies of the test report to Owner's RCM and include report in the O&M Manual.

NOTE TO SPECIFICATION WRITER: THE FOLLOWING SCHEDULES ARE INCLUDED FOR INFORMATION. JOB SCHEDULES ARE TO APPEAR ON THE DRAWINGS RATHER THAN IN THE SPECIFICATIONS.

3.02 PUMP SCHEDULE

<u>Drawing Code</u>	<u>P-1</u>	<u>P-2</u>	<u>P-3</u>	<u>P-4</u>
Manufacturer				
Model No.				
Location				
Service				
Capacity				
Head				
Minimum Efficiency				
Motor Size				
Seal Type				

END OF SECTION

SECTION 23 20 00.A
PIPING, VALVES AND FITTINGS

PART 1 GENERAL

1.00 The following sections are to be included as if written herein:

- A. Section 23 00 00 – Basic Mechanical Requirements
- B. Section 23 05 29 – Sleeves, Flashings, Supports and Anchors
- C. Section 23 05 53 – Mechanical Identification

1.01 SECTION INCLUDES

- A. Pipe and Pipe Fittings
- B. Valves

1.02 RELATED SECTIONS

- A. Section 02222 - Excavating
- B. Section 31 23 23.13 - Backfilling
- C. Section 31 23 16.13 - Trenching
- D. Section 33 13 00 - Disinfection of Water Distribution System
- E. Section 08 31 13 - Access Doors and Frames
- F. Section 09 91 00 - Painting
- G. Section 23 05 16 - Expansion Compensation
- H. Section 23 05 48 - Vibration Isolation
- I. Section 23 07 19 - Piping Insulation
- J. Section 22 13 16.A - Plumbing Specialties
- K. Section 22 40 00 - Plumbing Fixtures
- L. Section 22 11 23 - Plumbing Equipment

1.03 REFERENCES

- A. AGA - American Gas Association
- B. ANSI B31.1 - Power Piping
- C. ANSI B31.2 - Fuel Gas Piping
- D. ANSI B31.4 - Liquid Petroleum Transportation Piping Systems
- E. ANSI B31.9 - Building Service Piping
- F. ASME - Boiler and Pressure Vessel Code
- G. ASME Sec. 9 - Welding and Brazing Qualifications
- H. ASME B16.1 - Cast Iron Pipe Flanges and Flanged Fittings Class 25, 125, 250 and 800
- I. ASME B16.3 - Malleable Iron Threaded Fittings
- J. ASME B16.4 - Cast Iron Threaded Fittings Class 125 and 250
- K. ASME B16.18 - Cast Bronze Solder-Joint Pressure Fittings
- L. ASME B16.22 - Wrought Copper and Bronze Solder-Joint Pressure Fittings
- M. ASME B16.23 - Cast Copper Alloy Solder-Joint Drainage Fittings - DWV
- N. ASME B16.26 - Cast Bronze Fittings for Flared Copper Tubes
- O. ASME B16.29 - Wrought Copper and Wrought Copper Alloy Solder Joint Drainage Fittings - DWV
- P. ASME B16.32 - Cast Copper Alloy Solder-Joint Fittings for Solvent Drainage Systems
- Q. ASTM A47 - Ferric Malleable Iron Castings
- R. ASTM A135 - Pipe, Steel, Black and Hot-Dipped Zinc Coated, Welded and Seamless
- S. ASTM A74 - Cast Iron Soil Pipe and Fittings

- T. Not Used
- U. ASTM A234 - Pipe Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and Elevated Temperatures
- V. ASTM B32 - Solder Metal
- W. ASTM B42 - Seamless Copper Pipe
- X. ASTM B43 - Seamless Red Brass Pipe
- Y. ASTM B75 - Seamless Copper Tube
- Z. ASTM B88 - Seamless Copper Water Tube
- AA. ASTM B251 - Wrought Seamless Copper and Copper-Alloy Tube
- BB. ASTM B302 - Threadless Copper Pipe (TP)
- CC. ASTM B306 - Copper Drainage Tube (DWV)
- DD. ASTM C14 - Concrete Sewer, Storm Drain, and Culvert Pipe
- EE. ASTM C425 - Compression Joints for Vitrified Clay Pipe and Fittings
- FF. ASTM C443 - Joints for Circular Concrete Sewer and Culvert Pipe, Using Rubber Gaskets
- GG. ASTM C564 - Rubber Gaskets for Cast Iron Soil Pipe and Fittings
- HH. ASTM C700 - Vitrified Clay Pipe, Extra Strength, Standard Strength, and Perforated
- II. ASTM D1785 - Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120
- JJ. ASTM D2235 - Solvent Cement for Acrylonitrile - Butadiene - Styrene (ABS) Plastic Pipe and Fittings
- KK. ASTM D2241 - Poly (Vinyl Chloride) (PVC) Plastic Pipe (SDR-PR)
- LL. ASTM D2466 - Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40

- MM. ASTM D2513 - Thermoplastic Gas Pressure Pipe, Tubing and Fittings
- NN. ASTM D2564 - Solvent Cements for Poly (Vinyl Chloride) (PVC) Plastic Pipe and Fittings
- OO. ASTM D2680 - Acrylonitrile-Butadiene-Styrene (ABS) Composite-Sewer Piping
- PP. ASTM D2683 - Socket-Type Polyethylene Fillings for Outside Diameter - Controlled Polyethylene Pipe
- QQ. ASTM D2729 - Poly (Vinyl Chloride) (PVC) Sewer Pipe and Fittings
- RR. ASTM D2751 - Acrylonitrile-Butadiene-Styrene (ABS) Sewer Pipe and Fittings
- SS. ASTM D2846 - Chlorinated Polyvinyl Chloride (CPVC) Pipe, Fittings, Solvent Cements and Adhesives for Potable Hot Water Systems
- TT. ASTM D2855 - Making Solvent-Cemented Joints with Poly Vinyl Chloride (PVC) Pipe and Fittings
- UU. ASTM D3033 - Type PSP Poly Vinyl Chloride (PVC) Sewer Pipe and Fittings
- VV. ASTM D3034 - Type PSM Poly Vinyl Chloride (PVC) Sewer Pipe and Fittings
- WW. ASTM D3309 - Polybutylene (PB) Plastic Hot Water Distribution System
- XX. ASTM F477 - Elastomeric Seals (Gaskets) for Joining Plastic Pipe
- YY. ASTM F493 - Solvent Cements for Chlorinated Poly Vinyl Chloride (CPVC) Plastic Pipe and Fittings
- ZZ. ASTM F845 - Plastic Insert Fittings for Polybutylene (PB) Pipe
- AAA. AWS A5.8 - Brazing Filler Metal. BA. AWWA C105 - Polyethylene Encasement for Ductile Iron Piping for Water and Other Liquids
- BBB. AWWA C110 - Ductile - Iron and Gray - Iron Fittings 3 in. through 48 in., for Water and Other Liquids
- CCC. AWWA C111 - Rubber-Gasket Joints for Ductile Iron and Gray-Iron Pressure Pipe and Fittings

DDD.AWWA C151 - Ductile-Iron Pipe, Centrifugally Cast in Metal Molds or Sand-Lined Molds, for Water or Other Liquids

EEE.AWWA C651 - Disinfecting Water Mains

FFF.CISPI 301 - Cast Iron Soil Pipe and Fittings for Hubless Cast Iron Sanitary Systems

GGG.CISPI 310 - Joints for Hubless Cast Iron Sanitary Systems

HHH.CAN-3 B281 - Aluminum Drain, Waste, and Vent Pipe and Components

III. NCPWB - Procedure Specifications for Pipe Welding

JJJ. NFPA 54 - National Fuel Gas Code

KKK.NFPA 58 - Storage and Handling of Liquefied Petroleum Gases

LLL.TDH - Texas Department of Health, Water System Regulations

1.04 SUBMITTALS

- A. Submit under provisions of Section 23 00 00.
- B. Product Data: Provide data on pipe materials, pipe fittings, valves, and accessories. Provide manufacturers catalog information. Indicate valve data and ratings.

1.05 PROJECT RECORD DOCUMENTS

- A. Submit under provisions of Section 23 00 00.
- B. Record actual locations of valves, etc. and prepare valve charts.

1.06 OPERATION AND MAINTENANCE DATA

- A. Submit under provisions of Section 23 00 00.
- B. Maintenance Data: Include installation instructions, spare parts lists, exploded assembly views.

1.07 QUALITY ASSURANCE

- A. Valves: Manufacturer's name and pressure rating marked on valve body.

- B. Welding Materials and Procedures: Conform to ASME Code and applicable state labor regulations.
- C. Welder's Certification: In accordance with ASME Sec. 9. Submit welder's certifications prior to any shop or field fabrication. Welder's certifications shall be current within six months of submission.
- D. Maintain one copy of each document on site.

1.08 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum three years' documented experience.
- B. Installer: Company specializing in performing the work of this section with minimum of three years' documented experience.

1.09 DELIVERY, STORAGE, AND HANDLING

- A. Deliver, store, protect and handle products to site under provisions of Section 23 00 00.
- B. Accept valves on site in shipping containers with labeling in place. Inspect for damage.
- C. Provide temporary protective coating on cast iron and steel valves.
- D. Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.
- E. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed system.

1.10 ENVIRONMENTAL REQUIREMENTS

- A. Do not install underground piping when bedding is wet or frozen.

1.11 EXTRA MATERIALS

- A. Furnish under provisions of Section 23 00 00.
- B. Provide two repacking kits for each size valve.

PART 2 PRODUCTS

2.01 STEEL PIPING:

- A. Scope: This section applies to all piping systems providing for welded piping, fittings, and other appurtenances. Specific systems requiring welded piping include, but are not limited to: chilled water, hot water, steam, steam condensate, and fire protection systems.

- B. Pipe: Unless otherwise indicated, chiller and boiler plants piping shall be Schedule 40, and underground and building piping shall be Standard weight, Grade A or B, seamless black steel pipe conforming in all details to Standard ASTM Designation A135, A106, and A53, latest revisions. Steam condensate shall be Schedule 80.

- C. Fittings:
 - 1. All weld fittings shall be domestic made wrought carbon steel butt-welding fittings conforming to ASTM A234 and ASME/ANSI B16.9, latest edition, as made by Weld Bend, Tube Turn, Hackney, or Ladish Company. Attach to only pipe with a hole for the entire length. Each fitting shall be stamped as specified by ASME/ANSI B16.9 and, in addition, shall have the laboratory control number metal stenciled on each fitting for ready reference as to physical properties required for any fittings selected at random. Fittings which have been machined, remarked, printed, or otherwise produced domestically from non-domestic forgings or materials will not be acceptable. Each fitting is to be marked in accordance with MSS SP-25. Markings shall be placed on the fittings at the farthest point from the edge to be welded to prevent disfiguring from the welding process. Submittal data for these fittings shall include a letter signed by an official of the manufacturing firm certifying compliance with these specifications.

 - 2. All screwed pattern fittings specifically called for shall be Class 150 malleable iron fittings of Grinnell Company, Crane Company or Walworth Company manufacture (300 lb. for unions).

D. FABRICATION:

- 1. Welded piping and fittings in chiller and boiler plants shall be fabricated in accordance with ASME/ANSI the latest editions of Standards B31.1 and B31.3 for Steam and Condensate systems, from the Code for Pressure Piping. Standard B31.9 –Building Services Piping may be used within

buildings. Machine beveling in shop is preferred. Field beveling may be done by flame cutting to recognized standards.

2. Ensure complete penetration of deposited metal with base metal. Contractor shall provide filler metal suitable for use with base metal. Contractor shall keep inside of fittings free from globules of weld metal. All welded pipe joints shall be made by the fusion welding process, employing a metallic arc or gas welding process. All pipe shall have the ends beveled 37-1/2 degrees and all joints shall be aligned true before welding. Except as specified otherwise, all changes in direction, intersection of lines, reduction in pipe size and the like shall be made with factory-fabricated welding fittings. Mitering of pipe to form elbows, notching of straight runs to form tees, or any similar construction will not be permitted.
3. Align piping and equipment so that no part is offset more than 1/16 inch. Set all fittings and joints square and true, and preserve alignment during welding operation. Use of alignment rods inside pipe is prohibited.
4. Do not permit any weld to project within the pipe so as to restrict it. Tack welds, if used, must be of the same material and made by the same procedure as the completed weld. Otherwise, remove tack welds during welding operation.
5. Do not split, bend, flatten or otherwise damage piping before, during or after installation.
6. Remove dirt, scale and other foreign matter from the inside of piping, by swabbing or flushing, prior to the connection of other piping sections, fittings, valves or equipment.
7. In no cases shall Schedule 40 pipe be welded with less than three passes including one stringer/root, one filler and one lacer. Schedule 80 pipe shall be welded with not less than four passes including one stringer/root, two filler and one lacer. In all cases, however, the weld must be filled before the cap weld is added.
8. Procedure of Assembling Screw Pipe Fittings: All screw joints shall be made with taper threads properly cut. Joints shall be made tight with Teflon applied to the pipe threads only and not to fittings. When threads are cut on pipes, the ends shall be carefully reamed to remove any burrs. Before installing pipe that has been cut and threaded, the lengths of pipe shall be upended and hammered to remove all shavings and foreign material.

E. WELD TESTING:

1. All welds are subject to inspection, visual and/or X-ray, for compliance with specifications. The owner will, at the owner's option, provide employees or employ a testing laboratory for the purposes of performing said inspections and/or X-ray testing. Initial visual and X-ray inspections will be provided by the owner. The contractor shall be responsible for all labor, material and travel expenses involved in the re-inspection and re-testing of any welds found to be unacceptable. In addition, the contractor shall be responsible for the costs involved in any and all additional testing required or recommended by ASME/ANSI Standards B31.1, B31.9, and B31.3 due to the discovery of poor, unacceptable, or rejected welds.
2. Welds lacking penetration, containing excessive porosity or cracks, or are found to be unacceptable for any reason, must be removed and replaced with an original quality weld as specified herein. All qualifying tests, welding and stress relieving procedures shall, moreover, be in accord with Standard Qualification for Welding Procedures, Welders and Welding Operators, Appendix A, Section 6 of the Code, current edition.

2.02 CAST IRON PIPING:

A. PIPE & FITTINGS:

1. Service weight cast iron soil pipe conforming to ASTM Specification A-74 and CISPI Standard 301, hub and spigot for pipe ten inch (10") and larger and hubless for eight inch (8") and smaller. Each piece of pipe and each fitting shall be coated at the factory with asphaltum or coal tar pitch and with the manufacturer's mark or name cast on it.
2. All joints in hub and spigot cast iron pipe shall be made water and gas tight with Tyseal neoprene gaskets. Lead and Oakum may be used only under special conditions, with prior written permission from the Resident Construction Manager. Joints in hubless cast iron soil pipe and fittings shall be made by the use of a neoprene sleeve and 24-gauge, Type 304 Stainless Steel shield made tight with a torque wrench and torqued to a minimum of 100 inch-pounds. Each clamp shall consist of a neoprene gasket with a stainless steel outer band which effectively captures the gasket material. Each clamp shall bear the FM and UPC stamp, shall be approved to Class I of Factory Mutual Standard #1680, and shall be Clamp-All or approved equal. All elbows and tees shall be braced against thrust loads which might result in joint separation due to static pressure or dynamic forces caused by sudden, heavy impulse loading (water hammer) conditions. Hubless piping systems shall not be used in a directly buried, underground application.

2.03 DUCTILE IRON PIPING

- A. Pipe: All pipe used for underground water piping mains shall be Class 52 centrifugally cast, close grained cast iron pipe or Class 50 DUCTILE iron pipe arranged with bell and spigot mechanical joints and shall conform in every detail to Federal Specifications WW-P-421, E-4, Type II for CAST IRON PIPE CENTRIFUGALLY CAST IN SAND LINED MOLDS. This pipe shall be provided in laying lengths of sixteen feet (16'). Each length of pipe shall be plainly marked in such a fashion as to indicate the name or trademark of the manufacturer and the year in which the pipe was cast. Exterior surfaces shall be completely coated with coal tar pitch varnish to which sufficient oil has been added to effect a smooth coating, tough and tenacious when cold, not "tacky" and not brittle.
- B. Fittings:
1. All fittings used for underground water piping mains shall be Class D bell and spigot mechanical joint fittings made in strict conformity with the Specifications of the American Water Works Association A.W.W.A.-C100-08. All dimensions and weights of such fittings shall conform to the dimensions and weights shown in tables included in the latest edition HANDBOOK OF CAST IRON PIPE published by Cast Iron Pipe Research Association. All fittings shall be coated outside with the same coal tar pitch varnish used on cast iron pipe.
 2. All mechanical joints shall be for cast iron pressure pipe made by pit cast or by centrifugal methods and cast iron pressure fittings. Mechanical joints shall be of the stuffing box type and shall consist of a bell cast integrally with the pipe or fitting and provided with an exterior flange having cored or drilled bolt holes and interior annular recesses for the sealing gasket and the spigot of the pipe or fitting; a pipe or fitting spigot; a sealing gasket; a separate cast iron follower gland having cored or drilled bolt holes. The joint shall be designed to permit normal expansion, contraction, and deflection of the pipe line.
 3. Bolts shall be high strength, heat treated cast iron tee-head bolts with hexagon nuts.
 4. Gaskets shall be made of a vulcanized crude rubber compound and, unless otherwise specified, the rubber shall be first grade plantation rubber. The joint, gaskets, bolts, and nuts shall meet the latest requirements of ANSI 21.11 for Mechanical Joints for Cast Pressure Pipe and Fittings.
 5. All underground cast iron or ductile iron pipe shall be encased in black 8-mil thick, polyethylene plastic sheet, per ANSI/AWWA, C105/A21.5-82, Method C.
 6. Tie rods and retaining bolts shall be all stainless steel construction.

- C. Valves: All valves used in underground water piping systems shall be A.W.W.A., iron body, mechanical joint, double hump, double disc, parallel seats, brass trimmed non-rising stem gate valves.

2.04 CONCRETE PIPING:

- A. Precast concrete sewer pipe conforming to ASTM Specification C-14 in sizes up to and including eight inches (8") and shall be precast reinforced concrete sewer pipe conforming to ASTM Specification C-76 in size twelve inches (12") and larger. Bell and spigot fittings with elastomeric seal joints.

2.05 GALVANIZED STEEL PIPE

- A. Pipe: Schedule 40 and shall conform in every detail to ASTM Standard Specifications for BLACK AND HOT-DIPPED ZINC-COATED GALVANIZED WELDED AND SEAMLESS STEEL PIPE ASTM Designation A-135, latest revision. This threaded pipe shall be supplied with thread protectors on each end. All steel water pipe shall be hot-dipped galvanized pipe zinc coated both inside and outside.
- B. Fittings: All fittings for six inch (6") and larger water lines shall be 125 lb., cast iron, flanged pattern fittings. These fittings shall be hot-dipped galvanized, after all machining operations have been completed. These fittings shall be of Crane Company, or approved equal, manufacture and their flanges shall be dimensioned, faced drilled and spot faced to conform to the Class 150 American Standard for Steel Pipe Flanges and Flanged Fittings.

2.06 COPPER PIPE

- A. Copper Pipe: Piping four inches (4") and smaller shall be fabricated of Type K, hard drawn, copper pipe made of deoxidized copper (99.9% pure). This Type K copper pipe shall conform in every detail to ASTM Standard Specifications for COPPER WATER TUBE, Serial Designation B-88-66, and it shall be provided in 20-foot straight lengths. Copper pipe 4" and smaller may only be joined using non-lead-bearing solder, such as 95-5 silver or antimony solder (95 percent tin, and 5 percent silver or antimony). Copper pipe 4" and larger may be joined using roll grooved fittings.

(Note: For UT Austin, substitute the following sentence for the previous two sentences: "Copper pipe may only be joined using "Silvabrite" solder. No other solders may be used.")

- B. Fittings: All fittings for four inch (4") and smaller water lines shall be Streamline Solder Fittings manufactured by Streamline Pipe and Fittings Division, Mueller Brass Company, or approved equal. These wrought copper fittings shall be rigid and strong with openings machined to accurate capillary fit for the pipe.

- C. Lead: It is forbidden that lead in any form be used in any water system other than waste. If lead is used in the fabrication or installation of any water system other than waste, then ALL of the installed equipment and material, which may have come in contact with the lead, shall be marked with bright red or orange spray paint, and shall be removed from the project site. The system(s) shall then be restored and reinstalled using ALL NEW MATERIALS.

2.07 PIPING - UNDERGROUND - Type 'A': (Small systems – 50’ or less)

- A. Underground water piping shall be Schedule 40 black steel and shall be fabricated and insulated Foamglas or Koophen ‘K’ as specified for the same water systems within the building.
- B. All piping shall be clean when it is installed. Before installation it shall be checked, upended, swabbed, if necessary, and all rust or dirt from storage or from lying on the ground shall be removed. The Contractor is cautioned to exercise rigid control of the interior cleanliness of the pipe as it will be impossible to flush clean after assembly.
- C. Piping shall be temporarily supported on blocks in the excavation to an adequate height to make all welds and apply insulation. Blocks shall be removed after insulation is applied and supported on shields resting on permanent blocks of an inert material such as concrete construction blocks. Temporary blocks shall have a dimensional height greater than the permanent blocks equal to the thickness of the insulation plus saddle. At the Contractor's option he may insulate the pipe prior to lowering into the excavation on a compacted sand fill bed set to line and grade, leaving bell holes for welding and completion of insulation at the joint.
- D. After the insulation has been applied on buried pipe and all joints and sealed as specified above the insulation shall be protected in lieu of metal jacketing with a heavy duty flexible jacket of 50 mil rubberized bitumen adhesive laminated to a 10 mil polyethylene film equal to Polyguard Products ‘Insulrap 50’ and installed in accordance with the manufacturer's directions.

2.08 PIPING UNDERGROUND TYPE 'B': (Water systems with temperatures not exceeding 210 deg F)

- A. Provide a factory pre-insulated underground piping system of straights and fittings, as described herein. Products deviating from any aspect of this specification must be submitted for approval ten (10) days prior to bid date. All pre-insulated pipe and fittings shall be factory fabricated to job dimensions and designed to minimize the number of field welds. Where possible, straight sections shall be supplied in 40-foot random lengths with piping exposed at each end for field joint construction. The system shall be computer analyzed by a PE registered engineer of the piping system manufacturer, having a minimum of five (5)

years experience, to determine stress on the carrier pipe and anticipated pipe thermal movement. The system design shall be in strict conformance with ANSI B31.1, latest edition.

- B. The manufacture shall furnish written installation procedures and provide on-site field technical assistance during the initial periods of installation. The representative shall submit a written report, through the Contractor to the Engineer and RCM, immediately after each visit reporting upon the progress of the work.
- C. Carrier pipe shall be standard weight, carbon steel, A106, ASTM A-53, Grade B, seamless. All joints shall be butt-welded for 2 1/2" and greater, and socket or butt-welded for 2" and below. Pipe fittings shall be forged, long radius bends, beveled for butt welding, having a wall thickness equal to the pipe.
- D. Insulation shall be 90-95% close cell polyurethane foam having the following properties:
 - 1. Thermal Conductivity (k-value) - 0.13 BTU-in./hr.-ft²-°F minimum at 73° per ASTM C 518. 'R' value shall be as defined in Section 23 07 19 -3.13
 - 2. Density - 1.7 to 2.5 lb./cu. ft. per ASTM D 1622.
 - 3. Compressive Strength - 17 psi minimum per ASTM D 1621.
 - 4. Flexural Strength - 25 psi minimum per ASTM D 790.
 - 5. Closed Cell Content - 90% minimum per ASTM D 2856.
 - 6. Water Absorption - 2% of volume maximum per ASTM D 2842.
 - 7. Water Permeability - 3 perm inches maximum per ASTM E 96.

To assure that there are no insulation voids, each factory pre-insulated pipe unit shall be infrared inspected at the factory, or, visually checked prior to application of the outer protective jacket. Minimum thickness shall be as specified in Section 23 07 19 for the medium carried in the pipe.

- E. Jackets for pre-insulated piping, including fittings, shall be seamless high-density urethane polymer (HDUP), HDPE, or, fiberglass reinforced polyester resin (FRP). Jackets that are mitered, taped or wrapped will not be allowed. Jackets shall have the following minimum properties:
 - 1. Tensile Yield Strength - 3,000 psi minimum per ASTM D 638
 - 2. Ultimate Tensile Strength - 3,600 psi minimum per ASTM D 638
 - 3. Elongation - 50% minimum per ASTM D 638
 - 4. Compressive Strength - 4,000 psi minimum per ASTM D 695
 - 5. Water Absorption (24 hr.) - 0.6% maximum per ASTM D 570
 - 6. Impact Strength (0.125") - Non-break per ASTM D 256 (Method A)
- F. For systems where the entire factory applied insulation surface on the carrier pipe can be visual inspected, jackets applied directly to insulation surfaces shall be a minimum thickness

of 80 mils for pipe sizes 6" and below, 100 mils for sizes 8"-12", 120 mils for 14"-20", and 150 mils 24" and larger. For systems requiring injection of urethane foam into the annulus between the carrier pipe and jacket, the jacket thickness shall be 50% thicker than the above minimums.

- G. Pre-insulated pipe and fittings shall be provided with factory End Seals. End Seals may be constructed of the same material as the jacket, or, cross-linked polyolefin heat shrink seals, bonded to the jacket and the core pipe protecting and sealing the insulation.
- H. Carrier pipe shall be hydrostatically tested to 150 psig, or 1½ times the operating pressure, whichever is greater. After testing of the carrier pipe, all field joints shall be insulated, with kits provided by the pre-insulated pipe manufacturer. Field insulation of fittings shall not be acceptable. Field joint insulation shall be applied only in straight sections by pour foam *in situ*, using molds furnished by the system manufacturer. Field joint insulation surface shall be sealed with a heat shrinkable sleeve.
- I. Underground piping shall be bedded in compacted clean sand, in 6" layers, or fine gravel 8" under, around and 6" over pipe. Cover with densely compacted select stabilized backfill. Piping trenches within 8'-0" from building shall not have pea gravel or sand but shall be selected backfill densely compacted and stabilized as specified elsewhere.
- J. See Section 23 07 19 for insulation performance.

2.09 PIPING UNDERGROUND TYPE 'C': (Steam, condensate, and water systems with temperatures exceeding 210 deg F)

- A. General: The insulated pipe conduit systems where noted on the Drawings shall be a heavy steel mechanically sealed, testable, prefabricated, insulated piping system. The system shall include the inner pipe and fittings, outer steel casing, insulation materials, pipe supports, anchor, end seals, expansion loops and bends, and corrosion protective coating. The system when installed shall have a continuous drainage and venting system through its entire length.
- B. Conduit: Conduit shall be 10-gauge smooth wall hot dipped galvanized steel having all outside surfaces of the conduit (except for overhead lines) machine-coated with high melting point VOC free, urethane elastomer, to a minimum thickness of 50 mils, structurally reinforced with an interposed layer of fiberglass mesh applied spirally under tension or a high solids epoxy, reinforced with a fiberglass membrane, applied to a 50 mil thickness. All coatings shall be holiday tested at factory to 6,000 volts before shipping. Conduit closures shall be furnished with the conduit at a ratio of one closure for each fabricated item or length. Closures shall consist of 10 gauge steel suitable rust-proofed and in cylindrical form with a single horizontal split and shall be field welded over adjacent units. After test, as soon thereafter as possible, all field welds on closures shall

be cleaned of all welding slag, burned coating, mud, etc. by wire brushing and grinding of weld high points. Closure shall then be covered with shrink-wrap in accordance with the system manufacture's approved instructions, using materials supplied. Finished closure shall then be holiday tested to 6000 volts. All materials and insulation required for complete field closure shall be furnished with the conduit.

- C. Pipe and Pipe Support Guides: All piping in conduit shall be as hereinbefore specified in this section for the service required, except that condensate piping shall be Schedule 80. All ferrous pipe field joints shall be welded by competent mechanics and tested under hydrostatic pressure per 23 00 00. Concealed pipe welds in prefabricated conduit fittings shall be factory tested the same as specified for field welds prior to assembly. Piping shall be suitably spaced and supported in conduit by specially designed full round insulating support-guides and shall permit the pipe to expand and/or contract freely without stress or wear on the pipe or insulation as well as provide for drainage and free air circulation.
- D. Expansion Loops, Ells, and Tees: Prefabricated ells, loops, and tees shall be furnished and installed where shown on Drawings and shall consist of pipe, insulation, and conduit conforming to the same specification as hereinbefore specified for straight runs. Expansion loops shall be of proper design in accordance with stress limits indicated by ASME Code for Pressure Piping, District Heating Section. Loop piping shall be installed in conduit suitably sized to handle indicated pipe movement. All inner pipe loops and expansion bends shall be cold sprung 50% in the field by the Contractor. Submit details and calculations to Engineer and Owner's RCM prior to fabrication.
- E. End Seals and Glands: Terminal ends of conduits inside manholes, pits, or building walls shall be equipped with end seals consisting of a steel bulk head plate welded to the pipe and conduit. Where there is no anchor within five feet of a terminal end, conduits shall be equipped with gland seals consisting of a packed stuffing box and gland follower mounted on a steel plate welded to end of conduit. Ends seals or gland seals shall be equipped with drain and vent openings located diametrically opposite on the vertical center line of the mounting plate and shall be shipped to the job site with plugs in place. Terminate all conduits 2" beyond the inside face of manhole or building walls to protect any exposed piping insulation from damp-wall condensation.
- F. Leakplates: To provide an effective moisture barrier, conduits shall be equipped with leakplates in building or manhole walls, but only when there is an anchor plate within five feet outside the wall. Leakplates shall consist of a steel plate flange 4" larger in outside diameter than the conduit, welded to the conduit only and located in the wall approximately 6" from the end of the conduit.
- G. Anchors: Prefabricated plate anchors shall be furnished and installed where shown on Drawings and shall consist of a steel plate welded to pipe and conduit. The steel plate shall be 3/8" thick for 6-5/8" to 10-3/4" conduit, 1/2" thick for 12" to 22" conduit and

3/4" thick for conduit over 22". A concrete block shall be cast over the plate and conduit shall be large enough for firm anchorage into undisturbed trench sidewalls and/or bottom. The concrete block to be at least 30" in length and extend a minimum of 9" beyond the top and bottom of anchor plate.

- H. Conduit Air Test: All field welds at conduit closures shall be tested for leaks before applying shrink-wrap. -During testing all field welds shall be checked with soapsuds, and re-welded if necessary until air tight at 15 lbs. pressure. The Contractor shall furnish all necessary equipment and labor to perform the air test, including air compressor, gauges, conduit caps, temporary pipe and connections, etc., and complete the test to the satisfaction of the Architect and/or Engineer.
- I. Pipe Insulation: All pipe or pipes in conduit, shall be insulated as specified in Section 23 07 19 for the medium carried in the pipe.
- J. Manufacturer's Field Service Instructor: Who is technically qualified to determine whether or not the installation is being made in accordance with the manufacturer's recommendations shall be present during critical periods of installation, including cold springing, and test of the system. On completion of the installation, the Contractor shall deliver to the Owner a certificate from the manufacturer stating that the installation has been made in accordance with the manufacturer's recommendations.
- K. Provide a sacrificial anode system designed for a minimum life of 20 years. The design to be based on soil resistivity measurements and a complete soil analysis. The system shall be given a complete check for proper potential readings immediately after the installation and again after the system has been in operation for six months, at which time any modifications or adjustment are to be made. Provide dielectric flanged connection where the insulated pipe conduit system terminates.
- L. Provide a control box to maintain a constant per-set pressure on the conduit. System will alarm to any time the conduit system has required additional air to maintain the pre-set pressure. Use the control air compressor and extend an air line to the nearest air in the building.
- M. Prior to backfilling, all surfaces of the conduit system, including field closures, shall be Holiday Tested to 6,000 volts. Repair all holidays in accordance with manufacturer's recommendations. A 4-inch layer of sand or fine gravel shall be placed and tamped in the trench to provide a uniform bedding for the conduit. The entire trench shall be evenly backfilled with a similar material as the bedding in 6 inch compacted layers to a minimum height of 6 inches above the top of the insulated piping system. The remaining trench shall be evenly and continuously backfilled in uniform layers with suitable excavated soil.

2.09 PVC PIPING

2.10 PVDF PIPING

2.11 GLASS PIPING

2.10 VALVES:

- A. All valves shall be located such that the removal of their bonnets is possible. All flanged valves shown in horizontal lines with the valve stem in a horizontal position shall be positioned so that the valve stem is inclined one bolt hole above the horizontal position. Screw pattern valves placed in horizontal lines shall be installed with their valve stems inclined at an angle of a minimum of 30 degrees above the horizontal position. All valves must be true and straight at the time the system is tested and inspected for final acceptance. Valves shall be installed as nearly as possible to the locations indicated in the Construction Drawings. Any change in valve location must be so indicated on the Record Drawings. All valves must be of threaded or flanged type. No solder connected or grooved fitting valves shall be used on this project. All bronze and iron body gate and globe valves shall be the product of one manufacture for each project. Manufacturers of other types may not be mixed on the same project; i.e., all butterfly valves shall be of the same manufacture, all ball valves shall be of the same manufacture, etc.
- B. All valves used in circulating systems, plumbing and steam systems (low and medium pressure) shall be Class 150 SWP. Class 300 valves shall be constructed of all ASTM B-61 composition. All gate, globe and angle valves shall be union bonnet design. Metal used in the stems of all bronze gate, globe and angle valves shall conform to ASTM B371 Alloy 694, ASTM B99 Alloy 651, or other corrosion resistant equivalents. Written approvals must be secured for the use of alternative materials. Alloys used in all bronze ball, gate, globe, check, or angle valves shall contain no more than 15% zinc. No yellow brass valves will be allowed.
- C. All iron body valves shall have the pressure containing parts constructed of ASTM designated of 126 class B iron. Stem material shall meet ASTM B16 Alloy 360 or ASTM 371 Alloy 876 silicon bronze or its equivalent. Gates and globes shall be bolted bonnet with OS&Y (outside screw and yoke) and rising stem design. A lubrication fitting is preferred on yoke cap for maintenance lubrication of the yoke bushing.
- D. All cast steel body valves shall have the pressure containing parts constructed of ASTM designation A-216-GR-WCB carbon steel. Gate and globe valves shall be bolted bonnet outside and screw and yoke design with pressure-temperature rating conforming to ANSI B16-34-1977. Stems shall meet ASTM designation A-186-F6 chromium stainless steel. Wedge (gate valves) may be solid or flexible type and shall meet ASTM A-182-F6 chromium stainless steel on valves from 2" to 6". Sizes 8" and larger may be A-216-WCB with forged rings or overlay equal to 182-F6. Seat ring shall be hard faced carbon steel or 13% chromium A-182-F6 stainless. Handwheels shall be A47 Grade 35018 malleable iron or Ductile Iron ASTM A536.

- E. All forged steel body valves shall have the pressure containing parts constructed of ASTM 105, Grade 2 forged carbon steel. Seat and wedges shall meet ASTM A-182-F6 chromium stainless steel. Seat rings shall be hard faced. Valves shall conform to ANSI B16-34 pressure-temperature rating.
- F. All valves shall be repackable, under pressure, with the valve in the full open position. All gate valves, globe valves, angle valves and shutoff valves of every character shall have malleable iron hand wheels, except iron body valves 2-1/2" and larger which may have either malleable iron or ASTM A-126 Class B, gray iron hand wheels.
- G. Packing for all valves shall be free of asbestos fibers and selected for the pressure-temperature service of the valve. It is incumbent upon the manufacturer to select the best quality, standard packing for the intended valve service. At the end of one year, period spot checks will be made, and should the packing show signs of hardening or causing stem corrosion then all valves supplied by the manufacturer shall be repacked by the Contractor, at no expense to the Owner, with a packing material selected by the Owner.
- H. Valves 12" and larger located with stem in horizontal position shall be drilled and tapped in accordance with MSS-SP-45 to accommodate a drain valve and equalizing by-pass valve assembly.
- I. Balancing and/or Shutoff Valves for Hot Water Systems: Two inches and smaller, three piece full port bronze body ball valve, stainless steel ball and stem. Teflon seats, packing and gasket, bronze gland follower, adjustable stuffing box, steel lever type handle, with plastic sheathed operating handle, adjustable memory stops, and shall be class 150 SWP/600 WOG, screwed pattern. Manufacturer shall certify ball valves for use in throttling service. Stem extensions shall be furnished for use in insulated lines. Cold water service valves shall be as above, except two piece construction. All valves 2 1/2" and larger shall be tapped full lug butterfly valves with aluminum bronze discs of ASTM B148 Alloy C955 and 316, 416, or 420 stainless steel shafts. Design must incorporate bushing between shafts and body of material suitable to provide a bearing surface to eliminate seizing or galling. Valve must be capable of providing a bubble tight seal at 200 psi for valves up to 12" (150 psi for larger valves) when used for end of line service without requiring the installation of a blind flange on the downstream side. Liners shall be resilient material suitable for 225 °F temperature and bodies of ductile iron. Butterfly valves 8" and larger and butterfly valves used for balancing service, regardless of size, shall have heavy duty weather proof encased gear operators, with malleable iron handwheel or crank. Valves 2 1/2" through 6" shall have lever handles which can be set in interim positions between full open and full closed. All butterfly valves shall be absolutely tight against a pressure differential of 150 psi.
- J. Check Valves for Water Systems: Bronze body, 2" and smaller, bronze body regrinding disc and seat with screw-in cap. Iron body, 2 1/2" and larger, bronze disc and seat or non

slam wafer type with stainless pins and springs, and bronze plate. Forged steel lift check valves, 2" and smaller shall be bolted cap and body, screwed end connections and conform to ANSI B16.34 and pressure temperature rating.

- K. Valves for Fire Protection Service: 2" and smaller, bronze body ball valve as above, Underwriters' Laboratories Listed and Factory Mutual Approved, screw pattern 2 1/2" and larger, Underwriters Laboratories Listed and Factory Mutual Approved butterfly valves with tapped full lug body and gear operated with malleable iron hand-wheel and position indicator. All valves to be furnished with two factory mounted internal supervisory switches.

Gate valves 2 1/2" and larger shall have approved rating of 175 psi WWP or greater, iron body with resilient rubber encapsulated wedge, epoxy-coated interior, and pre-grooved stem for supervisory switch.

- L. Check Valves Fire Protection System: Iron body, swing-check, bronze disc, seat ring and hinge pin, 300 psi rated working pressure, Underwriters' Laboratories and Factory Mutual approved. Complete with ball drip assembly.

M. Standards of Quality for Valves:

NOTE TO SPECIFICATION WRITER: DELETE ANY INAPPLICABLE VALVES IN THE FOLLOWING TABULATION AND ADD ANY APPLICABLE TYPES NOT ALREADY INCLUDED.

Standard of Quality for Valves:

			Class	Milwaukee	Nibco	Stockham or as noted
2" & smaller Austin Campus Only	Gate Valve	L.P. Steam	150	1151	T-134	B-105
			300	1186	T-174SS	B-145
2-1/2" & larger Austin Campus Only	Gate Valve	L.P. Steam	125	F-2885	F-617-0	G-623
			150	--	F-637-33	
*2" & smaller	Ball Valve for shut-off	Domestic Cold Water Plumbing Systems Re-circulating Chilled Water	150 --		T-585-70	Apollo 77-100

Requires extended stems in insulated lines with adjustable memory stop.

*2" & Smaller	Ball Valve	Domestic Hot Water Plumbing Systems & Re-circulating Hot Water	150	--	Nibco T-585-Y-66	Apollo 77-140
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Requires extended stems in insulated lines with adjustable memory stop.

2" & smaller	Globe, Angle & Balancing Valve	Chilled Water, L.P. Steam	150	590T	T-235	B-22
2-1/2" & larger	Globe, Angle & Balancing Valve	Plumbing, Chilled Water, L.P. Steam	125	F-2981	F-718-B	G-514-T
2-1/2" & larger	Butterfly Valve for Shutoff	Domestic Hot & Cold Water Plumbing Systems Re-circulating Chilled and Heating Water	150	NE-C,NF	LD2000	DeZurik 632,L,D, RS66,6

Valves 8" and larger, and valves used for balancing service regardless of size, shall have heavy-duty weatherproof encased gear operator.

2" & smaller	Ball Valve (UL,FM)	Fire Protection	300	BB-SC	T-505-4	--
2-1/2" & larger	Butterfly Valve	Fire Protection	175	--	LD3510-8	LG72UF
2-1/2" & larger	Gate Valve OS&Y	Fire Protection	175	--	F-607-RW	G-610
2-1/2" & larger	Check Valve	**Fire Protection	175	--	F-908-W	G-940
2" & smaller	Check Valve	All Water Systems	150	510	T-433	B-345

2-1/2" & larger	Check Valve	All Water Systems	150	1400 Series	W-920-W	Stockham 'Duo-Check'
2" & smaller	Globe Valve	Primary Hot Water	300	1186	T-276-AP	B-74
2-1/2" & larger	Globe Valve	Primary Hot Water	300	F-2983-M	F-768-B	--
1-1/2" & smaller	Gate Valve	High Pressure Steam	300	--	--	--
2" & larger	Gate Valve	High Pressure Steam	300	--	--	Stockham 30-OF
2" to 12"	Hub End (below ground)	(AWWA)	150	--	--	Mueller 2380-5
1-1/2" & smaller	Lubricated Gas Cock	Medical, Lab Gases & Natural Gas	150	BB2-100		Rockwell 1796 & 142 With Wrench
2" & larger	Lubricated Gas Cock	Medical, Lab Gases & Natural Gas	150	--		Rockwell 143 & 1797 With Wrench
2" & smaller	Isolation Ball Valve	Medical, Lab Gases & Natural Gas	150			Spirax Sarco Model 60

Valves 8" and larger, and valves used for balancing service regardless of size, shall have heavy-duty weatherproof encased gear operators.

* Requires extended stem in insulated lines.

** Requires ball drip assembly.

2.13 UNIONS:

- A. Provide and install unions at proper points to permit removal of pipe and various equipment and machinery items without injury to other parts of the system. No unions will be required in welded lines or lines assembled with solder joint fittings except at

equipment items, machinery items and other special pieces of apparatus. Unions in 2" and smaller in ferrous lines shall be Class 300 AAR malleable iron unions with iron to brass seats, and 2 1/2" and larger shall be ground flange unions. Unions in copper lines shall be Class 125 ground joint brass unions or Class 150 brass flanges if required by the mating item of equipment. Companion flanges on lines at various items of equipment, machines and pieces of apparatus shall serve as unions to permit removal of the particular items. See particular Specifications for special fittings and pressure.

- B. Unions connecting ferrous pipe to copper or brass pipe shall be dielectric type equal to EpcO.
- C. In all water lines where the material of the pipe is changed from ferrous to copper or brass, a dielectric coupling shall be used at the transition.

2.14 FLANGES:

- A. All 150 lb. and 300 lb. ANSI flanges shall be weld neck and shall be domestically manufactured, forged carbon steel, conforming to ANSI B16.5 and ASTM A-181 Grade I or II or A-105-71 as made by Tube Turn, Hackney or Ladish Company. Slip on flanges shall not be used. Each fitting shall be stamped as specified by ANSI B16.9 and, in addition, shall have the laboratory control number stenciled on each fitting for ready reference as to physical properties and chemical composition of the material. Complete test reports may be required for any fitting selected at random. Flanges which have been machined, remarked, painted or otherwise produced domestically from imported forges will not be acceptable. Flanges shall have the manufacturer's trademark permanently identified in accordance with MSS SP-25. Contractor shall submit data for firm certifying compliance with these Specifications. Bolts used shall be carbon steel bolts with semi-finished hexagon nuts of American Standard Heavy dimensions. Allthread rods will not be an acceptable for flange bolts. Steam system flange bolts shall have a tensile strength of 105,000 psi and an elastic limit of 81,000 psi and rated at least ANSI Grade V. Other bolts shall have a tensile strength of 80,000 psi and an elastic limit of 36,000 psi and rated at least ANSI Grade I.
- B. Flat faced flanges shall be furnished to match 125 lb cast iron flanges on pumps, check valves, strainers, etc. with full flange gaskets. Bolting of raised face flanges to flat faced flanges is not allowed.

C. FLANGE GASKETS

1. Gaskets shall be placed between the flanges of all flanged joints.
2. Gaskets for steam piping - All steam flange joints shall use Flexitallic Class 150 spiral wound for low pressure applications and Flexitallic Class 300 spiral wound

gaskets for medium or high pressure applications. Raised and flat face flange gaskets shall be Flexitallic compression gauge (CG) style. External ring shall be Type 304 stainless steel and color coded yellow. Filler material shall be Flexite Super and color coded with pink stripe. Equivalents may be submitted with all design data so that an evaluation of the gasket can be made.

3. Gaskets for all other applications: Gaskets shall be ring form gaskets fitting within the bolt circle of their respective flanges. Gaskets shall be 1/16" thick asbestos free material recommended for service by Anchor, Garlock, or John Crane. The inside diameter of such gaskets shall conform to the nominal pipe size and the outside diameter shall be such that the gasket extends outward to the studs or bolts employed in the flanged joint.
4. Spares - Contractor shall provide ten spares for every flange size and rating.

D. Flange Bolt Installation:

1. Bolt Lubrication: Bolts shall be well lubricated with a heavy graphite and oil mixture.
2. Torque Requirements - Bolts shall be stressed to 45,000 psi.

Nominal Bolt Dia. (Inch)	Torque (Ft-Lbs)
.25	6
.3125	12
.375	18
.4375	30
.5	45
.5625	68
.625	90
.75	150
.875	240
1.0	368
1.125	533
1.25	750
1.375	1020
1.5	1200

3. Torque shall be checked with a calibrated breaking action torque wrench on the final torque round. Bolts shall be cold and hot torqued.
4. Torque Pattern - Shall be a cross or star pattern with at least four passes. Limit each pass to 30% of full torque increases.

5. Hot Torque - Re-torque the flange bolts with system at normal operating pressure and temperature for at least four hours.
6. Inspection - Owner shall verify hot torquing of all medium and high pressure steam flange bolts.

PART 3 EXECUTION

Refer to other Sections for service specific requirements.

3.01 EXAMINATION

- A. Verify excavations under provisions of Section 23 00 00.
- B. Verify that excavations are to required grade, dry, and not over-excavated.

3.02 PREPARATION

- A. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.
- B. Remove scale and dirt, on inside and outside, before assembly.
- C. Prepare piping connections to equipment with flanges or unions.

3.03 INSTALLATION

- A. Provide non-conducting dielectric connections wherever jointing dissimilar metals.
- B. Route piping in orderly manner and maintain gradient.
- C. Install piping to conserve building space and not interfere with use of space.
- D. Group piping whenever practical at common elevations.
- E. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.
- F. Provide clearance for installation of insulation and access to valves and fittings.
- G. Provide access where valves and fittings are not exposed. Coordinate access door location with architectural features.

- H. Establish elevations of buried piping outside the building to ensure a minimum of cover. Refer to Section 23 00 00.
- I. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welding.
- J. Provide support for utility meters in accordance with requirements of utility companies.
- K. Prepare pipe, fittings, supports, and accessories not pre-finished, ready for finish painting. Refer to Division 09.
- L. Excavate in accordance with Section 23 00 00 for work of this Section.
- M. Backfill in accordance with Section 23 00 00 for work of this Section.
- N. Install bell and spigot pipe with bell end upstream.
- O. Install valves with stems upright or horizontal, not inverted.

3.04 ERECTION TOLERANCES

- A. Establish invert elevations, slopes for drainage to 1/8 inch per foot (one percent) minimum. Maintain gradients through each joint of pipe and throughout system.
- B. Slope water piping and arrange to drain at low points.

END OF SECTION

**SECTION 23 21 00
HYDRONIC PIPING**

PART 1 GENERAL

1.00 The following sections are to be included as if written herein:

- A. Section 23 00 00 – Basic Mechanical Requirements
- B. Section 23 05 29 – Sleeves, Flashings, Supports and Anchors
- C. Section 23 05 53 – Mechanical Identification

1.01 WORK INCLUDED

- A. Pipe and Pipe Fittings
- B. Valves
- C. Heating Water Piping System
- D. Glycol Water Piping System
- E. Chilled Water Piping System
- F. Condenser Water Piping System

1.02 SCOPE OF WORK: Furnish and install all labor, materials, equipment, tools and services and perform all operations required in connection with, or properly incidental to, the construction of complete HVAC piping and accessories systems as indicated on the Drawings, reasonably implied therefrom, or as specified herein unless specifically excluded.

1.03 RELATED WORK

- A. Section 08 31 13 - Access Doors

- B. Section 09 91 00 - Painting
- C. Section 23 20 00.A.UT - Piping, Valves and Fittings
- D. Section 23 05 16.UT - Expansion Compensation
- E. Section 21 05 48.UT - Vibration Isolation
- F. Section [_____ - _____:] Mechanical Seismic Control
- G. Section 23 07 19.UT - Piping Insulation
- H. Section 23 06 20.13.UT - Hydronic Specialties

1.04 REFERENCES

- A. ANSI/ASME - Boiler and Pressure Vessel Code
- B. ANSI/ASME Sec 9 - Welding and Brazing Qualifications
- C. ANSI/ASME B16.3 - Malleable Iron Threaded Fittings Class 150 and 300
- D. ANSI/ASME B16.23 - Cast Copper Alloy Solder Joint Drainage Fittings - DWV
- E. ANSI/ASME B16.29 - Wrought Copper and Wrought Copper Alloy Solder Joint Drainage Fittings - DWV
- F. ANSI/ASME B31.9 - Building Services Piping
- G. ANSI/ASTM D2466 - Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40
- H. ANSI/AWS A5.8 - Brazing Filler Metal

- I. ANSI/AWS D1.1 - Structural Welding Code
- J. ANSI/AWWA C105 - Polyethylene Encasement for Ductile Iron Piping for Water and Other Liquids
- K. ANSI/AWWA C110 - Ductile - Iron and Gray - Iron Fittings 3 in. through 48 in., for Water and Other Liquids
- L. ANSI/AWWA C111 - Rubber-Gasket Joints for Ductile Iron and Gray-Iron Pressure Pipe and Fittings
- M. ANSI/AWWA C151 - Ductile-Iron Pipe, Centrifugally Cast in Metal Molds or Sand-Lined Molds, for Water or Other Liquids

- N. ASTM A135 - Pipe, Steel, Black and Hot-Dipped Zinc Coated, Welded and Seamless
- O. ASTM A234 - Pipe Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and Elevated Temperatures
- P. ASTM B32 - Solder Metal
- Q. ASTM B88 - Seamless Copper Water Tube
- R. ASTM D1785 - Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120
- S. ASTM D2235 - Solvent Cement for Acrylonitrile-Butadiene-Styrene (ABS) Plastic Pipe and Fittings
- T. ASTM D2241 - Poly (Vinyl Chloride) (PVC) Plastic Pipe (SDR-PR)
- U. ASTM D2310 - Machine-Made Reinforced Thermosetting Resin Pipe
- V. ASTM D2466 - Socket-Type PVC Plastic Type Fittings, Schedule 40
- W. ASTM D2467 - Socket-Type PVC Plastic Type Fittings, Schedule 80
- X. ASTM D2680 - Acrylonitrile-Butadiene-Styrene (ABS) Composite-Sewer Piping
- Y. ASTM D2683 - Socket-Type Polyethylene Fittings for Outside Diameter-Controlled Polyethylene Pipe and Tubing
- Z. ASTM D2751 - Acrylonitrile-Butadiene-Styrene (ABS) Sewer Pipe and Fittings
- AA. ASTM D2855 - Making Solvent-Cemented Joints with PVC Pipe and Fittings
- BB. ASTM F477 - Elastomeric Seals (Gaskets) for Joining Plastic Pipe

1.05 REGULATORY REQUIREMENTS

- A. Conform to ANSI/ASME B31.9

1.06 QUALITY ASSURANCE

- A. Valves: Manufacturer's name and pressure rating marked on valve body.
- B. Welding Materials and Procedures: Conform to ANSI/ASME SEC. 9, and applicable state labor regulations.
- C. Welders Certification: In accordance with ANSI/AWS D1.1.

1.07 SUBMITTALS

- A. Submit product data under provisions of Section 23 00 00.

- B. Include data on pipe materials, pipe fittings, valves, and accessories.
- C. Include welder's certification of compliance with ANSI/AWS D1.1.

1.08 DELIVERY, STORAGE, AND HANDLING

- A. Deliver products to site under provisions of Section 23 00 00.
- B. Store and protect products under provisions of Section 23 00 00.
- C. Deliver and store valves in shipping containers with labeling in place.

PART 2 PRODUCTS

2.01 WALL, FLOOR AND CEILING PLATES:

- A. See Section 23 05 29.

2.02 SLEEVES, INSERTS, AND FASTENINGS:

- A. See Section 23 05 29.

2.03 HIGH TEMPERATURE HOT WATER (HTHW) SYSTEM: (*UT Brownsville, UT Tyler & UT El Paso Campuses Only*)

A. Piping shall be Schedule 80 black steel pipe, Grade A or Grade B, and to ANSI B36.10 dimensional standards. Installation shall be all welded construction.

B. Weld fittings shall be 300 PSIG rated conforming to ASTM Specification A234 and ANSI Standard B16.9-1964 as manufactured by Grinnell, Ladish or Tube-Turn.

C. Flanges shall be forged steel weldneck welding flange conforming to ASTM A-181 Grade I or II, 300 PSIG rating and ANSI Standard B16.5 as manufactured by Grinnell, Ladish or Tube-Turn.

D. Gate valves 2" and smaller shall be Jenkins Figure 8830 or approved equal with flanged ends, O.S. & Y., wedge disc, forged steel body, class 300.

E. Globe valves 2" and smaller shall be Jenkins Figure 8G83 or approved equal with flanged ends, O.S. & Y., bolted bonnet, forged steel body, class 300.

F. Check valves 2" and smaller shall be Jenkins Figure 8C80W or approved equal, socket weld, bolted cover, lift check, forged steel body, class 800.

G. Check valves 2-1/2" and larger shall be Jenkins Figure 1026 or approved equal, with flanged ends, bolted cover, swing check, cast steel body, class 300.

H. Strainers shall be Mueller No. 762 or approved equal, Y pattern, with flanged ends, bolted cover, perforated stainless steel screen for water service, blow off tapping, cast steel body, class 300.

I. All components used in the HTHW Piping System shall be rated for operation at the campus system conditions of 175 PSI and 450 degrees F.

2.04 UNDERGROUND PIPING (Including Chilled Water):

A. See Section 23 20 00.A.

1. Piping: Type ['A'] ['B'] ['C'] Underground Piping.

2. Valves: Class 150.

3. Fittings: Class 150.

4. Strainers and suction diffusers: Class 150 - See Section 23 06 20.13.

5. Unions: Class 300.

6. Flanges: Weld neck Class 150.

2.05 CHILLED WATER PIPING - ABOVE GROUND:

NOTE TO SPECIFICATION WRITER: IF HEATING HOT WATER IS APPLICABLE, INCLUDE IT UNDER THIS HEADING.

A. See Section 23 20 00.A.UT and 23 06 20.13.

1. All piping shall be Standard Weight-black steel pipe.
2. All unions: Class 300.
3. Low Zone (0' to 150' elevation)
 - a. Fittings on piping 2-1/2" and larger shall be standard weight butt welding type. Flanges shall be 150# welding neck type. Standard weight Weld-O-Lets, Thread-O-Lets, and shaped nipples may be used only when take-off is 1/3 or less nominal size of main. Bushings shall not be used.
 - b. Fittings on piping 2" and smaller shall be Class 150 black malleable iron screw fittings. (Class 300 for unions.)
 - c. Valves and strainers: Class 150.
4. High Zone (150' + elevation)
 - a. All fittings to be Class 300, welded construction.
 - b. Valves and strainers: Class 300.

2.06 CONDENSING WATER:

- A. See Section 23 20 00.A.
 1. Piping: Schedule 40 black steel.
 2. Valves: Class 150.
 3. Fittings: Class 150.
 4. Strainers and suction diffusers: Class 150 - See Section 23 06 20.13.

5. Unions: Class 300.
6. Flanges: Weld neck Class 150.

2.07 HEATING HOT WATER - SECONDARY:

- A. See Section 23 20 00.A.
 1. Piping: Standard Weight black steel.
 2. Valves: Class 150.
 3. Fittings: Class 150.
 4. Strainers and suction diffusers: Class 150 - See Section 23 06 20.13.
 5. Unions: Class 300.
 6. Flanges: Weld neck Class 150.

2.08 EQUIPMENT DRAIN PIPING:

- A. All factory fabricated or field erected air conditioning units with drain pans, all centrifugal water pumps and all other items or equipment or apparatus that require drains shall be connected with drain line run with adequate slope to a floor drain or other point of discharge as shown on the Drawings. On A.C. units the drain line shall include a properly sized water-sealed trap.
- B. All drain piping shall be one inch (1") size minimum or larger as may be indicated on the Drawings. Such piping shall be Type L hard copper tube. The drain piping shall be assembled with adapter tees at each change in direction. Install screw plugs in unused openings for access to rod and clean.

PART 3 EXECUTION

3.01 PREPARATION

- A. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.
- B. Remove scale and dirt on inside and outside before assembly.

- C. Prepare piping connections to equipment with flanges or unions.
- D. After completion, fill, clean, and treat systems. Refer to Section 22 13 16.UT

3.02 INSTALLATION

- A. Route piping in orderly manner, plumb and parallel to building structure, and maintain gradient.
- B. Install piping to conserve building space, and not interfere with use of space and other work.
- C. Group piping whenever practical at common elevations.
- D. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment. Refer to Section 23 05 16.
- E. Provide clearance for installation of insulation, and access to valves and fittings.
- F. Provide access where valves and fittings are not exposed. Coordinate size and location of access doors with Section [08 31 13] [_____].
- G. Slope piping and arrange systems to drain at low points. Use eccentric reducers to maintain top of pipe level.
- H. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to weld area.
- I. Prepare pipe, fittings, supports, and accessories for finish painting. Refer to Section 09 91 00.
- J. Install valves with stems upright or horizontal, not inverted.

3.03 FABRICATION OF PIPE:

- A. All the various piping systems shall be made up straight and true and run at proper grades to permit proper flow of the contained material. Lines shall also be graded for proper drainage.

B. Piping shall follow as closely as possible the routes shown on Drawings which take into consideration conditions to be met at the site.

C. Should any unforeseen conditions arise, lines shall be changed or rerouted as required after proper approval has been obtained.

D. All piping shall be installed with due regard to expansion and contraction and so as to prevent excessive strain and stress in the piping, in connections, and in equipment to which the lines are connected.

E. All piping shall be clean when it is installed. Before installation it shall be checked, upended, swabbed, if necessary, and all rust or dirt from storage or from lying on the ground shall be removed.

F. Procedure of Assembling Screw Pipe Fittings: All screw joints shall be made with taper threads, properly cut. Joints shall be made tight with Teflon applied to the pipe threads only and not to fittings. When threads are cut on pipes, the ends shall be carefully reamed to remove any burrs. Before installing pipe that has been cut and threaded, the lengths of pipe shall be upended and hammered to remove all shavings and foreign material.

G. Procedure for Assembling Other Joints: Procedures for assembling joints in cast iron and copper lines have been set forth elsewhere in these Specifications. For any special materials, consult the manufacturers for the recommended procedures in assembling the joints.

3.04 APPLICATION

A. Grooved mechanical couplings and fasteners may be used only in accessible locations and for pump fit-up assemblies, when approved by Owner in writing.

B. Install unions downstream of valves and at equipment or apparatus connections.

C. Install brass male adapters each side of valves in copper piped system. Sweat solder adapters to pipe.

D. Install [ball] [butterfly] valves for shut-off and to isolate equipment, part of systems, or vertical risers.

E. Install [ball] [butterfly] valves for throttling, bypass, or manual flow control services.

F. Provide spring loaded check valves on discharge of condenser water pumps.

G. Use gas plug cocks for throttling service. Use non-lubricated plug cocks only when shut-off or isolating valves are also provided.

H. Use butterfly valves [in heating water systems] [in chilled and condenser water systems] [in heating, chilled and condenser water systems].

I. Use only butterfly valves in chilled and condenser water systems for throttling and isolation service.

J. Use lug end butterfly valves to isolate equipment.

K. Provide 3/4 inch (20 mm) ball drain valves at main shut-off valves, low points of piping, bases of vertical risers, and at equipment. [Pipe to nearest drain.]

3.05 PIPE PRESSURE TESTS:

A. See Section 23 00 00.

3.06 CLEANING AND FLUSHING OF WATER SYSTEMS

- A. Water circulating Systems shall be thoroughly cleaned before placing in operation to rid systems of rust, dirt, piping compound, mill scale, oil, grease, any and all other material foreign to water being circulated.
- B. Extreme care shall be exercised during construction to prevent dirt and other foreign matter from entering the pipe or other parts of systems. Pipe stored on the project shall have open ends capped and equipment shall have openings fully protected. Before erection, each piece of pipe, fitting, or valve shall be visually examined and dirt removed.
- C. At pipe end locations a temporary bypass will be installed. Bypass shall be *same* size as the supply and return pipe. Prior to flushing the distribution system, the Contractor shall install the temporary bypass and a temporary line size strainer between the supply and return pipes. Contractor shall verify that the isolation valves are open.
- D. After the temporary bypasses are installed, the Contractor shall provide and operate one pump which will cause a velocity of 10 feet per second in the main piping. Pump required will provide approximately XXX gpm at XXX' of head. This pump will be provided with a shot chemical feeder and a strainer assembly. Pump shall be connected to system at the point where piping goes into the building from the tunnel. If the pump is electric driven, rather than engine driven, the Contractor shall provide all temporary electrical disconnects, wiring, fuses, and other electrical devices that are required for safe operation.
- E. Circulation will be started using the temporary pump. A non-hazardous cleaning compound (Entec 324 or approved equal) shall be added using the shot feeder until the concentration level of 20 parts per million is reached. Once this 20 parts per million concentration is reached, circulation will be maintained for 48 hours. After this period of time, the cleaning water shall be dumped to the sanitary sewer.
- F. The distribution system will then be refilled with city water and circulated with continual bleed and make-up until the water is certified clean by the water treatment

consultant, and accepted by the Owner. At the completion of this step an inhibitor shall be introduced. All waste water shall be dumped into the sanitary sewer system.

- G. After the system is certified as clean, the Contractor shall close the valves. The bypass piping shall be removed as final connections to the building are accomplished.
- H. During the flushing procedure, strainers shall be cleaned as often as necessary to remove debris and, in any event, all strainers shall be cleaned by physically removing the strainer screen from the body of the strainer at the end of flushing. Replace strainer basket and gasket. Contractor shall not flush through control valves, coils, etc. Contractor shall provide temporary bypasses at coils and spool pieces at control valves. Flush the coils individually wasting water to sanitary sewer. Connect coils and install control valves after flushing.
- I. Test samples shall be taken at all bypass locations and all tests shall indicate that the entire system has reached a PH, conductivity, and chemical concentration level as approved by the Owner to match present systems. Contractor shall purchase needed chemicals from Owner's chemical treatment supplier.
- J. Contractor shall provide a smaller assembly to clean and flush any miscellaneous piping that can not be included in the initial system flush. All other criteria shall remain the same.
- K. Contractor shall add inhibitor to the cleaning and flushing chemicals if, once the system is approved as clean, there is any delay in connecting the new system to the existing system. This is to prevent any corrosion after the new pipe is clean.

END OF SECTION

**SECTION 23 22 00
STEAM AND STEAM CONDENSATE PIPING**

NOTE TO SPECIFICATION WRITER: MANY PROJECTS WILL USE STEAM ONLY AS A HEATING MEDIUM, WITH NO HEATING WATER SYSTEM AT ALL. THIS SECTION OF THE SPECIFICATIONS IS LARGELY (BUT NOT ENTIRELY) BASED ON THAT ASSUMPTION. WHERE THIS IS NOT THE CASE, AND WHERE HEATING WATER SYSTEMS ARE EMPLOYED ON THE PROJECT, REFERENCES TO THAT SYSTEM MUST BE ADDED WHEREVER APPROPRIATE, INCLUDING DESCRIPTIONS OF HOT WATER SPECIALTIES AS APPLICABLE. ALSO, WHERE HIGH PRESSURE AND/OR MEDIUM PRESSURE STEAM ARE NOT EMPLOYED ON THE PROJECT, REFERENCE TO SAME SHOULD BE DELETED; WHERE ALL STEAM IS LOW PRESSURE, ALL REFERENCES TO STEAM PRESSURE (AS RELATED TO PIPING SYSTEM MATERIALS) SHOULD BE DELETED.

PART 1 GENERAL

1.00 The following sections are to be included as if written herein:

- A. Section 23 00 00 – Basic Mechanical Requirements
- B. Section 23 05 29 – Sleeves, Flashings, Supports and Anchors
- C. Section 23 05 53 – Mechanical Identification

1.01 WORK INCLUDED

- A. Pipe and Pipe Fittings
- B. Valves
- C. Steam Piping System
- D. Steam Condensate Piping System

1.02 RELATED WORK

- A. Section 08 31 13 - Access Doors
- B. Section 09 91 00 - Painting
- C. Section 23 20 00.A - Piping, Valves and Fittings

- D. Section 23 05 16 - Expansion Compensation
- E. Section 23 05 48 - Vibration Isolation
- F. Section 23 07 19 - Piping Insulation
- G. Section 23 22 00.A - Steam and Steam Condensate Specialties

1.03 REFERENCES

- A. ANSI/ASME SEC 9 - Welding and Brazing Qualifications
- B. ANSI/ASME B16.3 - Malleable Iron Threaded Fittings Class 150 and 300
- C. ANSI/ASME B16.23 - Cast Copper Alloy Solder Joint Drainage Fittings - DWV
- D. ANSI/ASME B16.29 - Wrought Copper and Wrought Copper Alloy Solder Joint Drainage Fittings - DWV
- E. ANSI/ASME B31.1 - Code for Power Piping
- F. ANSI/ASME B31.9 - Building Services Piping
- G. ANSI/AWS A5.8 - Brazing Filler Metal
- H. ANSI/AWS D1.1 - Structural Welding Code
- I. ASTM A135 - Pipe, Steel, Black and Hot-Dipped Zinc Coated, Welded and Seamless
- J. ASTM A234 - Pipe Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and Elevated Temperatures
- K. ASTM B32 - Solder Metal
- L. ASTM B88 - Seamless Copper Water Tube

1.04 REGULATORY REQUIREMENTS

- A. Conform to ANSI/ASME B31.9, and ANSI/ASME B31.1.

1.05 QUALITY ASSURANCE

- A. Valves: Manufacturer's name and pressure rating marked on valve body.
- B. Welding Materials and Procedures: Conform to ANSI/ASME SEC 9, and applicable state labor regulations.
- C. Welders Certification: In accordance with ANSI/AWS D1.1.

1.06 SUBMITTALS

- A. Submit product data under provisions of Section 23 00 00.
- B. Include data on pipe materials, pipe fittings, valves and accessories.
- C. Include welder's certification of compliance with ANSI/AWS D1.1.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Deliver products to site under provisions of Section 23 00 00.
- B. Store and protect products under provisions of Section 23 00 00.
- C. Deliver and store valves in shipping containers with labeling in place.

PART 2 PRODUCTS

2.01 STEAM AND CONDENSATE PIPING - UNDERGROUND:

- A. General: The insulated pipe conduit systems where noted on the Drawings shall be Type '***'.
- B. See Section 23 20 00.A.

2.02 PIPING AND FITTINGS: (See also Section 23 20 00.A)

- A. Piping systems shall conform to the following requirements.
- B. Piping systems designed for steam pressure below 15 psig are low pressure steam systems. Piping systems designed for steam pressures from 15 psig up to and including 125 psig are medium pressure steam. Systems 126 psig and above are high pressure steam.
- C. High Pressure Steam Piping:

1. All piping shall be Schedule 80 black steel piping.
 2. Fittings shall be extra heavy butt welding type. Flanges shall be 300# welding neck type. Extra strong Weld-O-Lets, Thread-O-Lets, or shaped nipples may be used only when take-off is 1/3 or less nominal size of main. Screwed fittings around traps shall be 2,000 pound forged steel.
- D. Condensate Return and Pumped Condensate Return Piping:
1. All piping shall be Schedule 80 black steel piping.
 2. Fittings on piping 2-1/2" and larger shall be extra heavy butt welding type. Flanges shall be 150# welding neck type. Extra strong Weld-O-Lets, Thread-O-Lets, or shaped nipples may be used only when take-off is 1/3 or less nominal size of main.
 3. Screwed fittings around traps and for piping 2" and smaller shall be 125# black cast iron. (300# for unions). At contractor's option, socket weld fittings may be used.
- E. Low and Medium Pressure Steam Piping:
1. All piping shall be Schedule 40 black steel piping, except sizes 1" and smaller shall be Schedule 80.
 2. Fittings on piping 2-1/2" and larger shall be standard weight butt welding type. Flanges shall be 150# welding neck type. Standard weight Weld-O-Lets, Thread-O-Lets, and shaped nipples may be used only when take-off is 1/3 or less nominal size of main. Bushings shall not be used.
 3. Screwed fittings around traps and for piping 2" and smaller shall be 125 lb. black cast iron. (250 lb. for unions.) At contractor's option, socket weld fittings may be used.
- F. Weld Fittings, Flanges and Unions:
1. Refer to Section 23 20 00.A.
- I. Piping Materials:
1. Sizes shown on the Drawings are nominal pipe sizes unless otherwise indicated.

2.03 VALVES:

- A. See Section 23 20 00.A.

2.04 STRAINERS:

- A. See Section 23 06 20.13.

2.05 UNIONS:

- A. See Section 23 20 00.A.

PART 3 EXECUTION

3.01 PREPARATION

- A. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.
- B. Remove scale and dirt on inside and outside before assembly.
- C. Prepare piping connections to equipment with flanges or unions.
- D. After completion, fill, clean, and treat systems.

3.02 INSTALLATION

- A. Route piping in orderly manner, plumb and parallel to building structure, and maintain gradient.
- B. Install piping to conserve building space and not interfere with use of space, other work, or equipment.
- C. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment. Refer to Section 23 05 16.
- D. Provide clearance for installation of insulation and access to valves and fittings.
- E. Provide access where valves and fittings are not exposed. Coordinate size and location of access doors with Section [_____].
- F. Slope steam piping one inch in 40 feet (0.25 percent) in direction of flow. Use eccentric reducers to maintain bottom of pipe level.

- G. Slope steam condensate piping one inch in 40 feet (0.25 percent). Provide drip trap assembly at low points and before control valves. Run condensate lines from trap to nearest condensate receiver. Provide loop vents over trapped sections.
- H. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welding.
- I. Prepare pipe, fittings, supports, and accessories for finish painting. Refer to Section 09 91 00.
- J. Install valves with stems upright or horizontal, not inverted.

3.03 APPLICATION

- A. Install unions downstream of valves and at equipment or apparatus connections. Install dielectric unions where joining dissimilar materials.
- B. Install brass male adapters each side of valves in copper piped system. Sweat solder adapters to pipe.
- C. Install valves for shut-off and to isolate equipment, part of systems, or vertical risers.
- D. Install valves for throttling, bypass, or manual flow control services.
- E. All high pressure steam valves 12" and larger shall be piped with an equalizing bypass valve assembly.

3.04 CLEANING AND FLUSHING OF STEAM SYSTEMS:

- A. Steam and condensate systems shall be thoroughly cleaned before placing in operation to rid systems of rust, dirt, piping compound, mill scale, oil, grease, any and all other material foreign to water being circulated.
- B. Extreme care shall be exercised during construction to prevent dirt and other foreign matter from entering the pipe or other parts of systems. Pipe stored on the project shall have open ends capped and equipment shall have openings fully protected. Before erection, each piece of pipe, fitting, or valve shall be visually examined and dirt removed.
- C. Chemicals, feeding devices, and water technician services shall be furnished by a single reputable manufacturer who will be responsible for the complete cleaning and flushing of the systems.

1. Add a temporary line with drain and isolate the building steam and condensate piping from the campus distribution piping to allow for proper circulation and cleaning of the new piping in the new tunnel and/or in the new or modified building piping system(s).

- D. Systems shall be cleaned with a chemical compound specifically formulated for the purposes of removing the above listed foreign matter. These chemicals shall be injected to the systems, circulated and completely flushed out. Repeat the process if required. After each flushing, remove and thoroughly clean all strainers.

- E. Final connection is not to be made to the campus loop system until the Chemical Contractor has filed with the Owner's representatives, a report stating that the systems are clean.

3.05 PIPE PRESSURE TESTS:

- A. See Section 23 00 00.

END OF SECTION

SECTION 23 22 00.A
STEAM AND STEAM CONDENSATE SPECIALTIES

PART 1 GENERAL

1.00 The following sections are to be included as if written herein:

- A. Section 23 00 00 – Basic Mechanical Requirements
- B. Section 23 05 29 – Sleeves, Flashings, Supports and Anchors
- C. Section 23 05 53 – Mechanical Identification

1.01 **WORK INCLUDED**

- A. Steam Traps
- B. Flash Tanks
- C. Condensate Return Pumping Units
- D. Steam Pressure Reducing Valves
- E. Steam Relief Valves
- F. Steam Safety Valve Discharge Elbows
- G. Steam Muffler Attachments
- H. Steam Pipe Anchors
- I. Steam Pipe Guides
- J. Drip Traps
- K. Sediment Strainers
- L. Gauges and Gauge Connections
- M. Thermometer and Thermometer Wells
- N. Steam Integrating (Condensate) Meters

O. Boiler Feed System

1.02 RELATED WORK

- A. Section 23 05 16 - Expansion Compensation
- B. Section 23 05 13 - Motors
- C. Section 23 07 19 - Piping Insulation
- D. Section 23 07 16 - Equipment Insulation
- E. Section 23 06 20.13 - Hydronic Specialties
- F. Section 23 22 00 - Steam and Steam Condensate Piping

1.03 REFERENCES

- A. ANSI/ASTM - Boilers and Pressure Vessels Code
- B. ASTM A105 - Forgings, Carbon Steel, for Piping Components
- C. ASTM A126 - Gray Iron Castings for Valves, Flanges, and Pipe Fittings
- D. ASTM A216 - Steel Casings, Carbon, Suitable for Fusion Welding, for High Temperature Service
- E. ASTM A395 - Ferric Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures
- F. ASME B31.9 - Building Services Piping

1.04 REGULATORY REQUIREMENTS

- A. Conform to ASME B31.9 - Building Services Piping

1.05 QUALITY ASSURANCE

- A. Manufacturer: For each product specified, provide components by same manufacturer throughout.

1.06 SUBMITTALS

- A. Submit [shop drawings and] product data under provisions of Section [01 33 00.] [01 33 23.]
- B. Submit [shop drawings and] product data for manufactured products and assemblies required for this project.
- C. Include product description, model, dimensions, component sizes, rough-in requirements, service sizes, and finishes.
- D. Submit schedule indicating manufacturer, model number, size, location, rated capacity, and features for each specialty.
- E. Submit manufacturer's installation instructions under provisions of Section [01 33 00.] [01 33 23.]

1.07 OPERATION AND MAINTENANCE DATA

- A. Submit operation and maintenance data under provisions of Section [01 77 00.] [01 78 23.16.]

1.08 EXTRA STOCK

- A. Provide [two] [_____] service kits for each size and type of steam trap under provisions of Section [01 77 00.]

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS - STEAM TRAPS

- A. Armstrong
- B. Spirax/Sarco
- C. [_____.]
- D. Substitutions: Under provisions of Section 23 00 00.UT

2.02 INVERTED BUCKET TRAPS

- A. Cast iron or semi-steel body and bolted cover for 250 psig WSP; provide access to internal parts without disturbing piping; with top test plug and bottom drain plugs, brass or stainless steel bucket, stainless steel seats and plungers, and stainless steel lever mechanism with knife edge operating surfaces, integral inlet strainer of monel or stainless steel.

2.03 FLOAT AND THERMOSTATIC TRAPS

- A. ASTM A126, cast iron or semi-steel body and bolted cover for 250 psig WSP; provide access to internal parts without disturbing piping; with bottom drain plug, stainless steel or bronze bellows type air vent, stainless steel or copper float, stainless steel lever and valve assembly.

2.04 THERMOSTATIC TRAPS

- A. Pressure balanced type with ASTM A216 WCB cast steel body and bolted or screwed cover, and integral ball joint union, for 300 psig WSP; monel or stainless steel bellows, stainless steel valve and seat; integral stainless steel strainer.
- B. Freeze proof type with cast iron body for 300 psig WSP, bronze bellows, stainless steel valve and seat, external adjustment.
- C. Bi-metallic type with ASTM A105 forged steel body and cover, for 300 psig WSP, bi-metal element with stainless steel components, integral Type 304 stainless steel strainer screen, 1/4 inch blow down valve.

2.05 FLASH TANKS

- A. Closed type, welded steel construction, tested and stamped in accordance with Section 8D of ANSI/ASME Boilers and Pressure Vessels Code for 125 psig working pressure; cleaned, prime coated, and supplied with steel support legs. Construct with nozzles and tappings for installation of accessories and piping connections.

2.06 CONDENSATE PUMPING UNITS:

- A. Condensate pumping units shall be Duplex Horizontal Type manufactured by Skidmore, Aurora or approved equal. Unit shall be complete with 3/16" (three sixteenths inch) thick steel receiver galvanized inside and outside and shall have magnesium anode protection. Each motor shall be provided with a fused safety switch and a magnetic starter providing overload and undervoltage protection. These magnetic starters shall be provided with three pole overload protection. The pump shall be bronze fitted throughout. The bearings shall be such as to protect them from dust and corrosion. Each duplex pump shall be mounted on a heavy steel mounting plate. Each unit shall have fully automatic control by a float and float switch. An alternator switch shall, furthermore, be provided as a part of this pumping device which will automatically alternate the operation of the pumps of this unit at the end of each pump operation. All accessories and auxiliaries, such as pressure gauges, water gauge glasses, etc., shall be installed complete. The

electrical wiring required shall be so complete that no wiring beyond that required by the driving motor need be supplied in the field. Such units shall be tested at the factory and adjusted prior to shipment. Alternator preferably shall be mechanical type. If electrical alternator is used, it shall be Allen Bradley. Pumps shall be capable of pumping 212 degrees F. condensate at the controlled water level. Each pump shall have stainless steel shafts. Contractor shall furnish an extra set of Viton seals or provide the pump with Viton seals installed. No turbine pumps will be permitted: only centrifugal type pumps shall be provided.

- B. Capacities and electrical characteristics shall be as scheduled on Drawings.
- C. Provide high level alarm switch complete with transformer, bell and one set of 120 volt AC rated, normally open contacts for connection to Central Data Acquisitions System.
- D. Submit complete wiring diagram for this specific contract.

2.07 STEAM PRESSURE REDUCING VALVES:

- A. All pressure reducing valves shall be capable of maintaining the set pressure from zero to the maximum steam flow within reasonable limits when subjected to usual steam pressure fluctuations. They shall be single seated valves with stainless steel trim, with renewable valve, lugs and seats. Valve bodies shall be cast steel for high pressure service and cast iron for medium and low pressure service. These valves shall be self contained type with upstream and downstream pressure gauges and shall be installed as per manufacturer's recommendations. Valve capacities are scheduled on the drawings. Pressure reduction is one stage (125 to 25 psig). Station shall consist of two PRV's sized 1/3 and 2/3 capacity. Discharge pressure shall be adjustable to any value between 10 psig and 75% of the supply pressure.
- B. All pressure regulators 2-1/2" and larger shall have flanged connections and those 2" and smaller may have screwed connections. Unions shall be installed on each side of any screwed pattern regulators installed.
- C. Each reducing valve shall be preceded by a sediment strainer complete with a full-sized blow off valve with threaded end for hose connection.
- D. These valves shall be Leslie, Spence (delete Spence on Austin projects, list first on Galveston projects), Spirax Sarco, Fisher, Mason Neilan or approved equal, with suitable automatic controllers.

2.08 STEAM RELIEF VALVES:

- A. Relief valves 2" and smaller shall have brass bodies and arranged for screwed connections. Such relief valves shall be Crane No. 2501 or Spirax Sarco 6010 Brass Safety Valves for steam or approved equal. Bushings shall not be used.
- B. Relief valves 2-1/2" and larger shall in the case of all medium and low pressure steam piping systems be arranged for flanged inlet and screwed outlet connections. Such relief valves shall be Consolidated Type 1511 or Spirax Sarco 252, ASME Standard Cast Iron Safety Valves, or approved equal.
- C. The pressure at which each relief valve shall open is designated on the Drawings. When such valves are ordered by the Contractor, he shall definitely specify the pressure at which each relief valve is to be set. Each valve shall have a metal tag attached stamped with the valve identification plus the pressure setting.

2.09 STEAM SAFETY VALVE DISCHARGE ELBOWS:

- A. All vent lines from safety valves shall be provided with safety valve discharge elbows at the point at which such lines rise to an elevation higher than that of the safety valve. The nature and design of the piping systems involved shall be such as to drain effectively all condensate from the discharge side of all relief valves. These safety valve discharge elbows shall be Grinnell Company's Safety Valve Drip Pan Elbows Figure No. 1538F, Spirax Sarco No. 299, or approved equal. No force shall be exerted on the safety valve by the discharge piping.

2.10 STEAM MUFFLER ATTACHMENTS:

- A. At the point at which vent lines from safety valve discharge elbows terminate, a muffler attachment of the proper size shall be installed. These muffler attachments shall be screwed pattern members Consolidated Type 1441, or approved equal.

2.11 STEAM PIPE ANCHORS:

- A. All steam lines shall be securely anchored at points designated on the Drawings and/or at such points as may be needed to assure proper control of the expansion and contraction of such systems.
- B. See Section 23 05 29 for additional requirements.

2.12 STEAM PIPE GUIDES:

- A. All steam piping systems shall be properly guided as shown on the Drawings.

2.13 DRIP TRAPS:

- A. High pressure drip trap assemblies shall be provided wherever called for on the Drawings and where required to keep such piping systems completely drained of condensate. Traps used in assemblies shall be 3/4" traps unless specifically shown to the contrary, i.e., they shall have 3/4" inlet and outlet connections. They shall have semi-steel bodies and the internal operating mechanisms shall be made of heat treated chrome steel. The caps shall be bolted to the bodies by the use of alloy steel heat treated machine bolts. These No. 213 Armstrong Traps, manufactured by Armstrong Machine Works, or approved equal, shall have a capacity for discharging at least 3,500 pounds of condensate per hour when operating at a pressure of 250 pounds per square inch. Where drip traps are installed in conjunction with 3" and larger steam lines, a drip pocket of the nature detailed on the Drawings shall be provided where a natural pocket does not exist. The piping and valves in trap assemblies shall be arranged as detailed on the Drawings; extra strong pipes shall be used on both sides of the trap.
- B. All drip traps used in medium pressure steam piping systems where automatic steam control valves are not employed shall be arranged as shown on the Drawings. They shall be 3/4" Armstrong No. 811 Inverted Bucket Traps, or approved equal, with cast iron bodies, vacuum breakers and stainless steel trim. Each trap shall be provided with a valved test line and shall be preceded by a sediment strainer.
- C. Condensate from coils, converters, hot water generators, low pressure drips and from all other devices where modulating steam valves are employed shall be of the float and thermostatic type. These traps shall be sized to handle 200% of the load with an inlet pressure drop of 0.5 psig and shall be equal to Armstrong "A" or "B" series, with vacuum breaker suitable for the system pressures. Installed traps with less than 12" of height between equipment outlet and trap inlet shall be sized for not less than 300 percent of the load. Each trap shall be provided with a 1/2" valve test line and shall be preceded by a sediment strainer. Under no circumstances shall a float and thermostatic trap be installed in a manner to lift condensate up in a return line.
- D. Shop Drawing submittal of traps shall contain an itemized list with a tabulation of the load, trap type, and trap size.

2.14 SEDIMENT STRAINERS:

- A. Each drip trap assembly, each control valve, for steam and each pressure reducing valve assembly regardless of its size shall be preceded by a sediment strainer. The arrangement of these sediment strainers shall be such that the screens may be removed for cleaning with ease through a gasketed plug.

- B. Sediment strainers shall be placed in steam piping systems wherever shown on the Drawings and at such other points as may be required for the removal of foreign material from the piping systems.
- C. Strainers in high pressure steam piping shall be cast steel sediment strainers and shall be suitable for working steam pressures as high as 300 pounds per square inch and temperatures not in excess of 750 degrees F. These strainers shall be the size designated on the Drawings. In the case of pipe sizes 2-1/2" and larger, flanged pattern sediment strainers shall be used. In the case of pipe smaller than 2-1/2", screwed pattern shall be used. Such strainers shall be Yarway No. 821 or 822 strainers manufactured by Yarnall Waring Company, or approved equal. The flanges of flanged strainers shall be dimensioned, faced, drilled, and spot faced to conform to the 300 pound American Standard for Steel Pipe Flanges and Flanged Fittings (B16e-1939).
- D. Strainers in low and medium pressure steam piping systems 2-1/2" and larger shall be flanged iron body strainers having bolted covers. These strainers shall be suitable for operating pressures as high as 125 psig. They shall be Crane Company No. 989-1/2 Sediment Separators, or approved equal.
- E. Sediment strainers in low and medium pressure steam piping systems 2" and smaller shall be arranged for screwed pipe connections. They shall be Crane No. 988-1/2 Sediment Separators, or approved equal.
- F. Full sized blow off valves shall be installed on all strainers in steam, condensate, chilled and hot water lines and a drain shall be installed from each valve to the nearest floor drain.

2.15 GAUGES AND GAUGE CONNECTIONS:

- A. See Section 23 05 19.
- B. Furnish and install, where noted or indicated on the accompanying Drawings or called for elsewhere in these Specifications, gauge connections complete with Ashcroft No. 1095 lever handle union shutoff cocks, or approved equal. All gauge connections shall be made up with brass pipe, nipples and brass screw fittings.

2.16 THERMOMETER AND THERMOMETER WELLS:

- A. See Section 23 21 00.A.
- B. Thermometer wells and thermometers shall be located where noted on the accompanying Drawings and where called for in other sections of the Specifications.

Thermometer test wells only shall be installed in a vertical position in horizontal lines and at 45 degrees, in vertical lines to hold a fluid in the well.

2.17 STEAM INTEGRATING METERS:

- A. See Section 23 06 20.13.
- B. Furnish and install as per details on Drawings in the condensate return system.

2.18 BOILER FEED SYSTEM:

- A. Furnish and install a spray type, horizontal de-aerator as shown on the Drawings. The system shall be a single tank design and guarantee oxygen removal to not more than .03 cc/liter in the effluent throughout all load conditions.
- B. The primary vent condensing and input to the unit shall be through an internally pressurized copper manifold and fed through multiple spring loaded, stainless steel spray nozzles. Gravity returns and high pressure returns shall enter through submerged heater tubes. The de-aerator vent shall be unrestricted for free release of noncondensable gases.
- C. The steel interior of the de-aerator shall be protected with baked phenolic lining. The unit shall be fitted with a renewable magnesium anode to inhibit electrolytic corrosion. The unit shall be provided with a 16" (sixteen inch) manhole.
- D. The heating assembly shall be sized to raise the scheduled GPM to 212 degrees F. with the minimum scheduled steam supply pressure at the regulator. The pneumatic regulator shall have dead end shutoff capability, stainless trim and be responsive to 1/4 degrees F., temperature change. The injector type heater tube shall be fabricated from copper steel alloy.
- E. The makeup water assembly shall consist of a motorized modulating valve with oversized line strainer and a displacer-type level control. The assembly shall be provided with a water gauge set on the receiver, a 3" (three inch) dial stainless temperature gauge, an external mixing tee for blending of returns and a high and low level alarm.
- F. The boiler feed pumps shall be flexible coupled with mechanical seals rated for 250 degrees F. The pumps shall not cavitate nor overload beyond its rated HP nor demand more than 2 ft. NPSH at any head point between 50% and 125% of the specified total discharge head. A stainless steel non-slam check valve shall be mounted in each pump discharge. The pumps shall be mounted on channel iron bases predrilled for adequately sized foundation bolts. Each pump shall be

furnished with a 4-1/2" (four and one-half inch) dial certified pressure gauge, siphon pipe and tee cock.

- G. The system shall be furnished with a prewired power and control panel. The enclosure shall require only one power connection and be NEMA 1, Class "A" construction. The panel shall include fused disconnect switches, external operating handles, starters with 3-leg overloads, running lights and motor control switches. In addition, the panel shall include a control power transformer with switch, indicating lights, relays, alarms and other necessary controls.
- H. The entire system shall be prefabricated on a steel stand with all wiring and interconnecting piping completed and tested prior to shipment.

PART 3 EXECUTION

3.01 INSTALLATION AND APPLICATION

- A. Install specialties in accordance with manufacturer's instructions.
- B. Install thermostatic steam traps to drain condensate from steam radiation units, convectors, and other similar terminal heating units.
- C. Install float and thermostatic traps to drain condensate from unit heaters, converters, heating coils, steam separators, flash tanks, steam jacketed equipment, and direct steam injected equipment.
- D. Install inverted bucket steam traps to drain condensate from steam main headers and branch lines.
- E. Size steam traps to handle minimum of two times maximum condensate load of apparatus served.
- F. Traps used on steam mains and branches shall be minimum 3/4 inch (20 mm) size.
- G. Install steam traps with union or flanged connections at both ends.
- H. Provide gate valve and strainer at inlet, and gate valve [and check valve] at discharge of steam traps.
- I. Provide minimum 10 inch (250 mm) long dirt pocket of same pipe sizes as apparatus return connection between apparatus and steam trap.
- J. Remove thermostatic elements from steam traps during temporary and trial usage, and until system has been operated and dirt pockets cleaned of sediment and scale.

- K. Provide pressure-reducing stations with pressure reducing valve, valved bypass, strainer and pressure gauge on upstream side, relief valve and pressure gauge on downstream side of pressure reducing valve.
- L. Pressure reducing station shall be one or two stages as [required,] [indicated,] to produce flat reduced pressure curve over range of capacity.
- M. Rate relief valves for pressure upstream of pressure reducing station, for full operating capacity. Set relief at maximum 20 percent above reduced pressure.
- N. Terminate relief valves to outdoors. Provide drip pan elbow with drain connection to nearest floor drain.
- O. When several relief valve vents are connected to a common header, header cross section area shall equal sum of individual vent outlet areas.

3.02 STEAM TRAP SCHEDULE

Drawing Code T-1 T-2 T-3 T-4

Manufacturer
 Model No.
 Type
 Capacity

3.03 BOILER FEED UNITS SCHEDULE

Drawing Code BF-1 BF-2 BF-3 BF-4

Manufacturer
 Model No.
 Location
 Service
 Receiver Capacity
 Pump Capacity
 Pump Head
 Motor Size

3.04 CONDENSATE RETURN UNITS SCHEDULE

Drawing Code CR-1 CR-2 CR-3 CR-4

Manufacturer
Model No.
Location
Service
Receiver Capacity
Pump Capacity
Pump Head
Motor Size

3.05 RECEIVER SCHEDULE

Drawing Code P-1 P-2 P-3 P-4

Manufacturer
Model No.
Location
Service
Capacity
Diameter
Length

3.06 PUMP SCHEDULE

Drawing Code P-1 P-2 P-3 P-4

Manufacturer
Model No.
Location
Service
Capacity
Head
Minimum Efficiency
Motor Size

END OF SECTION

SECTION 23 29 23
VARIABLE FREQUENCY DRIVES

PART 1 GENERAL

1.00 The following sections are to be included as if written herein:

- A. Section 23 00 00 – Basic Mechanical Requirements
- B. Section 23 05 29 – Sleeves, Flashings, Supports and Anchors
- C. Section 23 05 53 – Mechanical Identification

1.01 SECTION INCLUDES

- A. Variable Frequency Drives

1.02 RELATED SECTIONS

- A. Section 23 05 13 - Motors
- B. Section 23 05 48 - Vibration Isolation
- C. Section 23 09 23 – Direct Digital Control Systems
- D. Section 23 09 93 – Sequence of Operation
- E. Section 23 34 16 - Centrifugal Fans
- F. Section 23 34 13- Axial Fans
- G. Section 23 73 00 – Air Handling Units (Up to 10,000 CFM)
- H. Section 23 73 23 – Air Handling Units
- I. Section 26 05 19 - Cable, Wire and Connectors, 600 Volt
- J. Section 26 27 26 - Wiring Devices and Floor Boxes

1.03 REFERENCES

- A. AFBMA 9 - Load Ratings and Fatigue Life for Ball Bearings

- B. AFBMA 11 - Load Ratings and Fatigue Life for Roller Bearings
- C. AMCA 99 - Standards Handbook
- D. AMCA 210 - Laboratory Methods of Testing Fans for Rating Purposes
- E. AMCA 300 - Test Code for Sound Rating Air Moving Devices
- F. AMCA 301 - Method of Publishing Sound Ratings for Air Moving Devices
- G. NEMA MG1 - Motors and Generators
- H. NFPA 70 - National Electrical Code
- I. IEEE - 112B, 587 and 519

1.04 SUBMITTALS

- A. Submit under provisions of Section 23 00 00.
- B. Shop Drawings: Indicate assembly, unit dimensions, weight loading, required clearances, construction details, field connection details, and electrical characteristics and connection requirements.
- C. Product Data:
 - 1. Provide literature that indicates dimensions, weights, capacities, ratings, performance, gages and finishes of materials, and electrical characteristics and connection requirements.
 - 2. Submit electrical requirements for power supply wiring including wiring diagrams for interlock and control wiring, clearly indicating factory-installed and field-installed wiring.
- D. Manufacturer's Installation Instructions.

1.05 OPERATION AND MAINTENANCE DATA

- A. Submit under provisions of Section 23 00 00.
- B. Maintenance Data: Include instructions for routine service, spare parts lists, and wiring diagrams.

1.06 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience, who issues complete catalog data on total product.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Deliver, store, protect and handle products to site under provisions of Section 23 00 00.
- B. Accept products on site in factory-fabricated protective containers, with factory-installed shipping skids and lifting lugs. Inspect for damage.
- C. Store in clean dry place and protect from weather and construction traffic. Handle carefully to avoid damage to components, enclosures, and finish.

1.08 SCHEDULES ON DRAWINGS:

- A. In general, all capacities of equipment and electrical characteristics are shown in schedules on the Drawings. Reference shall be made to the schedules for such information. The capacities shown are minimum capacities. Variations in the capacities of the scheduled equipment supplied under this contract will be permitted only with the written direction of the owner. All equipment shall be shipped to the job with not less than a prime coat of paint or as specified hereinafter. Where installation instructions are not included in these Specifications or on the Drawings, the manufacturer's instructions shall be followed.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. ABB
- B. Advanced Technology/Emerson
- C. Reliance
- D. Eaton Dynamic
- E. MagneTek
- F. Robicon
- G. Graham
- H. Siemens

- I. Square D
- J. Substitutions: Under provisions of Section 23 00 00. The equipment as supplied by any of the acceptable manufacturers or an approved equal shall comply with all of the provisions of this specification.

2.02 GENERAL

NOTE TO SPECIFICATION WRITER: CAREFULLY REVIEW JOB REQUIREMENTS TO DETERMINE CRITICALITY OF SPECIFIC OPERATIONS, WHICH MAY ALLOW MULTIPLE MOTORS TO SHARE VFD'S AND/OR ELIMINATE BYPASS REQUIREMENTS.

- A. Furnish and install complete Pulse Width Modulation (PWM) or 6-step variable voltage, variable frequency speed controllers, as specified herein. All of the variable speed controllers shall be supplied by one manufacturer for this project. Motors must have a "bypass" switch as specified herein, to allow them to run if the controller malfunctions. All safety devices shall be energized. If an equal is proposed and accepted, Contractor must include installation and start-up by manufacturer's authorized personnel.
- B. The Contractor shall furnish and install Variable Frequency Drive (VFD) motor controllers to vary the speed of the supply, return and relief air fans and pumps as shown in the fan and pump schedules on the Drawings. One controller shall control the speed of one motor only. See schedules and Drawings for quantity of controllers required.
- C. The Variable Frequency Drive shall produce an adjustable AC voltage and frequency output for complete motor control using solid-state technology. The VFD shall be automatically controlled by a grounded electronic (4-20 ma) control signal. The drive shall produce an output volts/Hertz pattern to produce adequate starting torque under all conditions and operate smoothly at all operating speeds on variable torque load. The VFD shall be self-contained totally enclosed in NEMA 1 ventilated cabinet and capable of operation between 0 degrees and 40 degrees Celsius.
- D. VFD's shall be ETL or UL listed. All components used on option units shall be ETL or UL listed. VFD's shall be designed to meet IEEE-587 and shall comply with all applicable provisions of the latest revision of the National Electric Code. The VFD shall comply with IEEE-519 with respect to the line noise generation.
- E. The controllers shall be suitable for use with both standard and high efficiency 3-phase, squirrel cage, induction motors.

- F. The service factor of the controller shall be equal to 0.95 with a power unit rating basis of 100 percent rated current continuous. Rated continuous current of the VFD shall be equal to 110% of driven motor's FLA rating.
- G. Each controller shall consist of a converter, D.C. link filter or supply power backfeed RF (radio frequency) filter, and an inverter section with each section modularized for ease of troubleshooting. PWM controllers shall also have output line filters for motor noise reduction. All components shall be factory mounted and wired on a dead-front, grounded, freestanding or wall mounted minimum NEMA 1 enclosure arranged for top or bottom conduit entry.
- H. The controller enclosure shall be provided with the manufacturer's illustrated operating instructions and parts list mounted inside the enclosure door, manual speed control potentiometer, three position mode selector switch ("manual - off -auto", or equivalent), "power on" light, auxiliary relays and contacts for interlock and control wiring.
- I. The 6-step VFD shall convert 460 volt, three-phase 60 Hertz utility power to variable voltage and frequency, three phase, AC power. Both 6-step and PWM shall be designed to provide stepless motor control from 20 percent to 100 percent of base speed.

2.03 FEATURES

The VFD shall incorporate the following minimum features:

- A. Input power: 460 V/3 phase/60 Hz.
- B. Input fused disconnect switch.
- C. Input line filter capable of protecting the electronics against transient voltage spikes or notches, as well as backfeed of RF (Radio Frequency) interference, into the incoming power supply.
- D. Fuseless electronic power protection for ground fault protection. Isolation transformers for ground fault protection are not acceptable. Ground fault shall not cause fuses to open.
- E. The following door mounted devices:
 - 1. "Power on" light
 - 2. Hand/off/auto (or equivalent) selector switch
 - 3. Manual speed potentiometer (1000 ohms) and ammeter

4. Digital display unit
 5. Status, frequency/percent speed and fault diagnostics
- F. Minimum/maximum adjustable speeds
 - G. Disconnect switch and thermal motor overloads
 - H. Manual speed control during manual control mode
 - I. A thermally protected transfer switch for manual bypass of the VFD
 - J. The VFD shall have auto-restart after power failure, power surge, undercurrent and overcurrent. Overcurrent restart shall be limited to a maximum of five attempts.
 - K. Electronic and control follower board
 - L. External signal shutdown feature (i.e. fire/smoke, freeze, operable and normal bypass mode)
 - M. Output terminal for remote frequency and current meters (4 to 20 ma)
 - N. Trip relay for remote fault indication
 - O. A door interlock, designed to cut power to the unit when the door is opened
 - P. Instantaneous overcurrent trip
 - Q. Unit over temperature protection
 - R. A bypass switch which shall simultaneously isolate the VFD from input and output power, and provide line power directly to the motor. The bypass switch shall also have the capability of starting and stopping the motor. The switch shall consist of an enclosure separate from the VFD. The following shall be mounted on the enclosure door:
 1. Door interlocked main input disconnect switch
 2. Power on light
 3. "Drive-off-bypass" manual mode selector switch
 4. A "normal operation-off-test" selector to facilitate static testing of the drive at startup or while the motor is operating in the bypass mode

5. Speed lockout circuitry to allow the lockout or bypass of at least three speed ranges within the full range of the controller

2.04 DISCONNECT AND INTERFACE

The following shall be mounted within the enclosure:

- A. Line, load and bypass contactors capable of interrupting the locked rotor rating of the driven motor. Bypass and load contactors must be mechanically interlocked to prevent simultaneous closure.
- B. Overload relay
- C. A dedicated terminal strip to allow the controller to be interconnected with external shutdown contacts from smoke detectors, fire detectors, damper interlocks, freeze-stats, time clocks, remote master on-off switch, energy management and control system (FCMS) and input signals. The system must be capable of shutdown whether in the drive or in the bypass mode by remote detectors.

2.05 FAULT DETECTION DEVICES

A diagnostic fault detection center shall be integral to each VFD, providing an indication of the following fault conditions:

- A. External fault
- B. Processor line fault
- C. Low AC line voltage
- D. High AC line voltage
- E. Current overload
- F. High DC buss voltage
- G. VFD output fault

2.06 CONTROL

- A. All control adjustments shall be made without the necessity of an extender board of specialized meters, but rather from front access adjustable potentiometers.
- B. Low voltage logic and 115 V control circuits shall be electrically isolated from the power circuits. Signal circuit common shall be grounded.
- C. The VFD shall include a power ride-through feature to allow continuous operation through up to a three **to five** cycle line loss.
- D. Electronic output overload protection shall be provided to eliminate the use of bimetallic overloads. The drive shall not be phase sequence sensitive.
- E. The VFD shall have independently adjustable acceleration and deceleration circuits of 5 to 120 seconds. Extended time periods are also acceptable.
- F. The VFD shall have full function output current limit adjustable from 10 to 100 percent.

2.07 SYSTEM OPERATION

- A. Selector switch in the "off" position - the controller run circuit shall be open and the system shall not operate.
- B. Selector switch in the "manual" position - the speeds of the motors shall be controlled by the manual speed potentiometer.
- C. Selector switch in the "auto" position - operation shall be via the input 0 to 10 VDC signal with the output speed proportional to the input signal. If required for incorporation into the controls scenario, the VFD manufacturer shall furnish a pressure transducer mounted in the drive enclosure to convert a 3 to 15 psi pressure signal to a 0 to 10 VDC signal.
- D. The bypass switch shall provide the ability to service the control in bypass operation while not de-energizing the motor. It shall also allow for start/stop functions for the motor.
- E. In case of an output ground fault or similar abnormal output condition, any VFD serving multiple units shall be able to automatically alternate its output to either the duty device or the standby device. The VFD shall be fully operational after an output ground fault condition.

PART 3 EXECUTION

- 3.01 As part of the purchase price and agreement, a full, unconditional, one (1) year warranty on all parts and labor shall be provided. The warranty shall include all parts, labor, shipping, field service or technician time, labor or travel expenses and verbal or written correspondence with the VFD manufacturer or his representatives, including that which might be incidental to the proper installation and operation of the equipment.
- 3.02 The manufacturer's representative shall provide a list of recommended spare parts.
- 3.03 The manufacturer's representative shall provide terminal block to terminal block wiring diagrams coordinated with the owner to provide a complete and functional operating system. Furnish detailed drawings showing construction, dimensions, wiring diagrams and installation procedures for engineer's approval.
- 3.04 The manufacturer shall provide a factory trained technician to start the VFD and place it into operation.
- 3.05 The successful vendor shall provide for and present to the owner, at no cost to the owner, a training and troubleshooting course at the owner's location. This course shall be comprised of a minimum of two (2) days of classroom instruction for a minimum of four (4) hours per day complete with visual aids, documentation, circuit diagrams and hands-on training for a group of approximately 6 people. This course is not to be construed as a sale meeting, but rather as a school to familiarize the owner with the care, troubleshooting and servicing of the VFD.
- 3.06 VFD's shall be wall hung units. Contractor shall provide unistrut mounting bracket for drives. Contractor shall reinforce the wall studs with bracing as required to adequately support the drive. Installation of the VFD shall allow for clearance in front of the drive as required by the latest revision of the National Electric Code for an electrical panel.
- 3.07 TESTING

VFD's shall be shipped to the air handling unit, pump or fan manufacturer for testing. The units shall be operated over the full speed range to certify vibration limits are met.

END OF SECTION

SECTION 23 29 23.A
VARIABLE FREQUENCY DRIVES

PART 1 GENERAL

1.00 The following sections are to be included as if written herein:

- A. Section 23 00 00 – Basic Mechanical Requirements
- B. Section 23 05 29 – Sleeves, Flashings, Supports and Anchors
- C. Section 23 05 53 – Mechanical Identification

1.01 RELATED SECTIONS

- A. Section 23 05 13 - Motors
- B. Section 23 05 48 - Vibration Isolation
- C. Section 23 09 23 – Direct Digital Control Systems
- D. Section 23 09 93 – Sequence of Operation
- E. Section 23 34 16 - Centrifugal Fans
- F. Section 23 34 13- Axial Fans
- G. Section 23 73 00 – Air Handling Units (Up to 10,000 CFM)
- H. Section 23 73 23 – Air Handling Units
- I. Section 26 05 19 - Cable, Wire and Connectors, 600 Volt
- J. Section 26 27 26 - Wiring Devices and Floor Boxes

1.02 REFERENCES

- A. AFBMA 9 - Load Ratings and Fatigue Life for Ball Bearings
- B. AFBMA 11 - Load Ratings and Fatigue Life for Roller Bearings
- C. AMCA 99 - Standards Handbook

- D. AMCA 210 - Laboratory Methods of Testing Fans for Rating Purposes
- E. AMCA 300 - Test Code for Sound Rating Air Moving Devices
- F. AMCA 301 - Method of Publishing Sound Ratings for Air Moving Devices
- G. NEMA MG1 - Motors and Generators
- H. NFPA 70 - National Electrical Code
- I. ANSI/NEMA ICS 6 – Enclosures for Industrial Controls and Systems
- J. NEMA ICS 2 – Industrial Control Devices, Controllers, and Assemblies
- K. IEEE std 519 – Guide for Harmonic Control and Reactive Compensation of Static Power Converters
- L. IEEE – std 112B and 587

1.03 SUBMITTALS

- A. Submit under provisions of Section 23 00 00.
- B. Shop Drawings:
 - 1. Indicate assembly, unit dimensions, weight loading, required clearances, construction details, field connection details, and electrical characteristics and connection requirements.
 - 2. Provide terminal block to terminal block wiring diagrams coordinated with the Owner to provide a complete and functional system.
 - 3. Provide circuit board wiring diagrams and passive part generic specifications suitable to allow for circuit board service and repair by the Owner.
 - 4. Provide detailed drawings showing construction, dimensions, wiring diagrams, and installation procedures for Engineer’s approval.
- C. Product Data:
 - 1. Provide product data on variable frequency drives, relays, pilot devices, and switching and over-current protective devices. Specifically indicate which options are included.

2. Provide literature that indicates dimensions, weights, capacities, ratings, performance, gauges and finishes of materials, and electrical characteristics and connection requirements.
 3. Submit electrical requirements for power supply wiring including wiring diagrams for interlock and control wiring, clearly indicating factory installed and field installed wiring.
- D. Manufacturer's Installation Instructions
- E. Where not otherwise specified, provide a minimum of 6 submittals, plus the number the contractor wants returned.

1.04 OPERATION AND MAINTENANCE DATA

- A. Submit under provisions of Section 23 00 00.
- B. Submit 4 sets of O&M manuals, bound in 3-ring binders and indexed and tabbed for ease of use, containing, as a minimum, operation and maintenance data, troubleshooting guide, and all approved submittal data, including wiring diagrams.
- C. Include instructions for routine service and recommended maintenance procedures and intervals.
- D. Include spare parts data listing, source, and current prices of replacement parts and supplies.

1.05 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience, who issues complete catalog data on total product.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Deliver, store, protect and handle products to site under provisions of Section 23 00 00.
- B. Packaging: The drive must be delivered as a fully assembled, single unit ready for installation. It must be packaged in a manner suitable for anticipated shipping and storage conditions.
- C. Accept products on site in factory fabricated protective containers, with factory installed shipping skids and lifting lugs. Inspect for damage.

- D. Storage and Handling: The manufacturer shall inform the Contractor and the Owner of any special storage or handling requirement that may be required. Storage shall be indoors, in a clean dry place and protected from weather and construction traffic. Units shall be wrapped at the factory for protection from dirt, water, construction debris, and traffic. Protective wrapping shall be removed from the unit prior to start-up and shall be replaced and sealed by the Contractor until which time the unit is put into regular service. Handle carefully to avoid damage to components, enclosures, and finish.

1.07 SERVICE AND SPARE PARTS

- A. The manufacturer's representative shall provide a list of recommended spare parts.
- B. Fuses: Furnish, to Owner, three sets of spare fuses of each type and rating installed.
- C. Drive parts and service shall be available on a local or regional (within 100 miles radius) basis to preclude lengthy periods of operation in the uneconomical bypass mode.

1.08 WARRANTY AND GUARANTEE

- A. Provide warranty under provision of Section 23 00 00.
- B. Warranty shall be 36 months (3 Years) from the date of project substantial completion. Include all parts, labor, shipping, field service or technician time, labor or travel expenses, and expenses. In no case shall a charge be made to the Owner for VFD failures, other than those caused by flagrant abuse or extraordinary circumstances, such as water damage due to flooding or pipe break. Provide documentation of verbal and written correspondence with the VFD manufacturer or his representatives, including that which might be incidental to the proper installation and operation of the equipment.
- C. The representative shall maintain local factory certified technicians for 24 hour, 7-day a week service. Throughout the warranty service period, response shall be within 24 hours of initial contact for service.
- D. The manufacturer shall guarantee spare parts availability to the Owner for a minimum of five (5) years from date of purchase. Price escalation for spare parts shall not exceed 10% per year over the five (5) year duration.

1.09 TRAINING

- A. The manufacturer shall provide and present to the Owner, at no additional cost to the Owner, a training and trouble-shooting course at the Owner's location. The trainer shall be certified and factory trained by the equipment manufacturer. The course shall be made available to the Owner's maintenance personnel within 30 days of start-up.

- B. The instruction shall be comprised of two, 4-hour classes, with each class covering the same material. At the Owner's option, the class shall be given on separate days. One hour of each class shall be a classroom review of project specific equipment and operational needs, one hour shall be a classroom review of troubleshooting techniques and two hours shall be hands-on, in the building, reviewing actual equipment operation and system troubleshooting techniques. Each class shall be for approximately four people.
- C. The trainer shall provide visual aids, documentation, and circuit diagrams for each attendee. Operation and maintenance manuals shall be in the Owner's possession two days prior to start of the class.
- D. This training is not to be construed as a sales pitch, but rather to familiarize the maintenance technicians with the care, troubleshooting, servicing, and operation of the equipment and systems installed.

1.10 TESTING

- A. To ensure quality and minimize infantile failures at the job site, the VFD shall be burned in by the manufacturer. The VFD shall operate a dynamometer at full load and the load and speed shall be cycled during the test.
- B. All optional and special features shall be functionally tested at the factory for proper operation.
- C. Records of this factory testing shall be provided with VFD shipment and included in the Operation and Maintenance manuals.
- D. VFD's shall be shipped to the air handling unit, pump, or fan manufacturer for testing. The units shall be operated over the full speed range to certify vibration limits are met.

1.11 START-UP

- A. Start-up shall be provided within two weeks of notification by the Contractor or the Owner.
- B. The VFD manufacturer shall provide a factory trained and certified technician to check the installation, start the VFDs and place them into operation.
- C. Provide a certified start-up report, listing the following:
 - 1. Drive and motor nameplate data
 - 2. Physically installed location of the drive, including building, room number, and room name
 - 3. Date of start-up
 - 4. Start-up data pertinent to specific drive operation

- 5. Signature and printed name of the certified technician performing the start-up
- D. A copy of the start-up report shall be included in the Operation and Maintenance manual.
- E. Include instructions for contacting the service organization with each set of start-up documents. Instructions shall include name of service organization, address and phone number, and instructions for how to contact the service provider.
- F. Any remedial action required for harmonic distortion and line notching shall be at the manufacturer's expense. Manufacturer shall assist Owner in determining the optimum capacitance for power factor correction and avoidance of potential resonance problems. If the harmonic study indicates that harmonic levels of the facility are within IEEE 519 limitations, then line reactors are not required.

1.12 SCHEDULES ON DRAWINGS:

- A. In general, all capacities of equipment and electrical characteristics are shown in schedules on the Drawings. Reference shall be made to the schedules for such information. The capacities shown are minimum capacities. Variations in the capacities of the scheduled equipment supplied under this contract will be permitted only with the written direction of the owner. Where installation instructions are not included in these Specifications or on the Drawings, the manufacturer's instructions shall be followed.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. ABB (model ACH 550)
- B. Danfoss (model VLT FC100)
- C. Substitutions: Use provisions of Section 23 00 00. The equipment as supplied by any of the acceptable manufacturers or an approved equal shall comply with all of the provisions of this specification. Any substitutions for manufacturers or model numbers must be approved by the campus maintenance group.

2.02 GENERAL

NOTE TO SPECIFICATION WRITER: CAREFULLY REVIEW JOB REQUIREMENTS TO DETERMINE CRITICALITY OF SPECIFIC OPERATIONS, WHICH MAY ELIMINATE BYPASS REQUIREMENTS.

- A. Furnish and install complete solid state variable frequency drive, with Pulse Width Modulation (PWM) output waveform, including a full wave rectifier to prevent input line notching, AC line reactor, input fuses, capacitors, and insulated bipolar gate transistors (IBGT) as the output switching device. SCR, GTO and Darlington transistors are not acceptable. Six step and current source are not acceptable. All standard and optional features shall be included within the VFD enclosure. VFD shall be approved by the equipment manufacturer for the particular product and application involved. All of the variable speed controllers shall be supplied by one manufacturer for this project. All safety devices shall be energized. If an equal is proposed and accepted, Contractor must include installation and start-up by manufacturer's authorized personnel.
- B. The Contractor shall furnish and install Variable Frequency Drive (VFD) motor controllers to vary the speed of the supply, return and relief air fans and pumps as shown in the fan and pump schedules on the drawings. One controller shall control the speed of one motor only. See schedules and drawings for quantity of controllers required.
- C. The Variable Frequency Drive shall produce an adjustable AC voltage and frequency output for complete motor control using solid-state technology. The VFD shall be automatically controlled by a grounded electronic (4-20 ma) control signal. The drive shall produce an output volts/Hertz pattern to produce adequate starting torque under all conditions and operate smoothly at all operating speeds on variable torque load. The VFD shall be self-contained totally enclosed in NEMA 1 ventilated cabinet and capable of operation between 0 degrees and 40 degrees Celsius.
- D. VFD's shall be ETL or UL listed. All components used on option units shall be ETL or UL listed. VFD's shall be designed to meet IEEE-587 and shall comply with all applicable provisions of the latest revision of the National Electrical Code. The VFD shall comply with IEEE-519 with respect to the line noise generation.
- E. The controllers shall be variable torque, variable voltage/frequency type for centrifugal fan and pump applications and suitable for use with both standard and high efficiency 3-phase, squirrel cage, induction motors.
- F. The service factor of the controller shall be equal to 0.95 with a power unit rating basis of 100 percent rated current continuous. Rated continuous current of the VFD shall be equal to 110% of driven motor's FLA rating.
- G. Each controller shall consist of a converter, D.C. link filter or supply power back-feed RF (radio frequency) filter, and an inverter section with each section modularized for ease of troubleshooting. The converter section shall convert fixed frequency and voltage AC utility power to a DC voltage. The inverter section shall invert the DC voltage into a quality output wave form, adjustable voltage and frequency output for stepless motor speed control. PWM controllers shall also have output line filters for

motor noise reduction. All components shall be factory mounted and wired on a dead-front, grounded, freestanding or wall mounted minimum NEMA 1 enclosure arranged for top or bottom conduit entry.

- H. The controller enclosure shall be provided with the manufacturer's illustrated operating instructions and parts list mounted inside the enclosure door, manual speed control potentiometer, three position mode selector switch ("hand- off -auto", or equivalent), "power on" light, auxiliary relays and contacts for interlock and control wiring.
- I. The VFD and options shall be tested to ANSI/UL standard 508. The complete system shall be listed by a nationally recognized testing agency such as UL, ETH CUC or CSA.
- J. Power line noise shall be limited to a voltage distortion factor and line notch depth as defined in IEEE 519-1992. Prior to installation, the VFD manufacturer shall provide the estimated total harmonic distortion (THD) caused by the VFD. The results shall be based on a computer aided circuit simulation of the total actual system, with information obtained from the power provider and the user.

2.03 FEATURES

A. Safety and Self-Protection Features

1. Input fused disconnect switch and thermal motor overloads.
2. Input line filter capable of protecting the electronics against transient voltage spikes or notches, as well as back-feed of RF (Radio Frequency) interference, into the incoming power supply.
3. Fuseless electronic power protection for ground fault protection. Isolation transformers for ground fault protection are not acceptable. Ground fault shall not cause fuses to open.
4. Current limiter capable of limiting output current to 110% of the inverter rating. Limiter shall function automatically to prevent over current trip on momentary overload.
5. Instantaneous over current trip at 315%.
6. Inverse-time over current protection when current exceeds settings.
7. The drive shall employ three current limit circuits to provide trip free operation:

- a. The slow current regulation limit circuit shall be adjustable to 125% (minimum) of the VFDs variable torque current rating. This adjustment shall be made via the keypad, and shall be displayed in actual amps, and not as percent of full load.
 - b. The Rapid Current Regulation limit shall be adjustable to 170% (minimum) of the VFDs variable torque current rating.
 - c. The Current Switch-off limit shall be fixed at 255% (minimum, instantaneous) of the VFDs variable torque current rating.
8. Under voltage trip at 65% of the VFD rated voltage.
 9. Over voltage trip at 130% of the VFD rated voltage. The VFD shall have nominal input voltage adjustments of 208-230 and 440-480 VAC.
 10. Over temperature trip to protect the inverter from elevated temperatures in excess of component rating.
 11. The inverter logic shall be programmed to allow a trip condition resulting from power failure, power surge, over current, under current, over voltage, under voltage, or over temperature to automatically restart upon correction of the trip condition. The number of restart attempts shall be limited to five. If, after five attempts, the restart is not successful, the inverter shall shut down safely and require manual restart. If a successful restart occurs, the restart circuit counter will reset to zero counts after approximately ten minutes of uninterrupted operation.
 12. Isolated operator controls for increased safety.
 13. Safe shutdown in the event of power loss and automatic return to normal operation and restart, without component damage, on resumption of power.
 14. Safe shutdown, without component damage, in phase-to-phase short circuit.
 15. Integral protection against damage due to input or output power contactor disconnect switch, or circuit breaker, being opened or closed while the control is activated.
 16. Protection against input transient voltage spikes.
 17. Protection against over voltage on the DC bus.
 18. Protection against output short circuit and motor winding shorting to case faults.

19. Input line reactor to minimize harmonics reflected back onto the AC line and to provide improved protection to AC line transients.
20. A door interlock, designed to cut power to the unit when the door is opened.
21. Controller able to operate without a motor or other equipment load connected to the inverter output to facilitate start-up and troubleshooting.

B. Operational Interface Features

1. The following door mounted devices:
 - a. "Power On" light to indicate that the VFD is being supplied line power.
 - b. Fault light to indicate that the VFD has tripped on a fault condition.
 - c. Pre-wired 3-position Hand/Off/Auto (or equivalent) selector switch, with means to communicate hand, off, or auto position.
 - d. Manual speed potentiometer (1000 ohms).
 - e. Plain English, adjustable contrast backlit LCD digital display (code numbers and letters are not acceptable) and keypad. The digital display shall have 40 characters (2 line x 20 character/line). All set-up parameters, indications, faults, warnings, and other information must be displayed in words to allow the user to understand what is being displayed without the use of a manual or cross-reference table.
 - f. Digital meter to indicate speed (percent of full speed and Hz indicated on readout) and percent load.
 - g. Integral amp meter and volt meter, with provisions for readout at panel face.
2. All VFDs shall have the same user interface, including digital display, keypad, and user connections regardless of horsepower rating. A keypad shall be used for local control, for setting all parameters, and for stepping through the displays and menus.
3. A set of form C, dry contacts (status contacts) to indicate when the VFD is running above 0% speed.
4. A set of form C, dry contacts (fault contacts) to indicate when the VFD is in the fault mode.

5. A 4-20 ma output signal to vary in direct linear proportion to the VFD output frequency.
6. Provisions to isolate and allow VFD to operate from a 4-20mA, 0-10vdc, or 3-15psi pneumatic signal as needed now or in the future.
7. Manual speed control during manual control mode.
8. Dedicated terminal strip to allow interconnection of control circuits that accept normally closed safety contacts such as freeze stats, smoke alarms, fire alarms, interlocks, time clocks, energy management and building automation systems, and other input signals. VFD shall safely shut down in any mode when contact(s) opens. System shall be capable of such remote shutdown whether in the drive or bypass mode (if bypass is included in specific applications).
9. Output terminal for remote frequency and current meters (4 to 20 ma).
10. Trip relay for remote fault indication.
11. Internal self-diagnostics and fault detection shall be integral to each VFD. Diagnostics and fault detection shall be viewable from the digital display.

C. Bypass

1. An internal bypass is required for all applications except when redundant pumps or fans are included in the design and each piece of equipment has a dedicated VFD.
2. A thermally protected transfer switch for manual bypass of the VFD.
3. A bypass switch that shall simultaneously isolate the VFD from input and output power, and provide line power directly to the motor. The bypass switch shall also have the capability of starting and stopping the motor. The switch shall consist of an enclosure separate from the VFD. The following shall be mounted on the enclosure door:
 - a. Door interlocked main input disconnect switch.
 - b. Power on light.
 - c. "Drive-off-bypass" manual mode selector switch.

- d. A "normal operation-off-test" selector to facilitate static testing of the drive at startup or while the motor is operating in the bypass mode.
 - e. Speed lockout circuitry to allow the lockout or bypass of at least three speed ranges within the full range of the controller.
4. Line, load and bypass contactors capable of interrupting the locked rotor rating of the driven motor. Bypass and load contactors must be mechanically interlocked to prevent simultaneous closure.
- D. Adjustable Parameters
1. Maximum speed, adjustable 50-120% based speed
 2. Minimum speed, adjustable 30-50% base speed
 3. Acceleration time, adjustable 0.1 to 1800 seconds
 4. Deceleration time, adjustable 0.1 to 1800 seconds
 5. Current limit, adjustable 0-125%
 6. Overload
 7. Offset and gain to condition the input speed signal
 8. 6-70 Hz controlled speed range (minimum to be set at 15 Hz)
- E. Programmable Features
1. The VFD shall give the user the option of selecting either (1) displaying a fault, (2) running at a programmable preset speed, (3) hold the VFD speed based on the last reference received, or (4) cause a warning to be issued, if the input reference (4-20mA or 0-10vdc) is lost.
 2. PID set-point controller shall be standard in the drive, allowing a pressure or flow signal to be connected to the VFD, using the microprocessor in the VFD for the closed loop control.
 3. Two (2) programmable analog inputs shall accept a current or voltage signal for speed reference, or for reference and actual (feedback) signal for PID controller. The minimum and maximum values (gain and offset) shall be adjustable within the range of 0-20mA and 0-10vdc. The reference must be able to be scaled so that maximum reference can represent a frequency less than 60 HZ, without lowering the drive maximum frequency below 60 Hz.
 4. Six (6) programmable digital inputs for maximum flexibility in interfacing with external devices. One digital input is to be utilized as a customer safety connection point for fire, freeze, and smoke interlocks (enable). Upon remote, customer reset (re-closure of interlocks), drive is to resume normal operation.

5. Two (2) programmable analog outputs proportional to Frequency, Motor Speed, Output Voltage, Output Current, Motor Torque, Motor Power, Kilowatts, DC Bus Voltage, or Active Reference.
6. Three (3) programmable digital relay outputs. The relays shall be rated for maximum switching current 8 amps at 24 VDC and 0.4 amps at 250 VAC, with continuous current rating 2 amps RMS. Outputs must be true form C type contacts. Open collector outputs are not acceptable.

F. Information Display

1. Output frequency
2. Motor speed (RPM, %, or engineering units)
3. Motor current
4. Calculated motor torque
5. Calculated motor power
6. DC buss voltage
7. Output voltage
8. Heat sink VFD temperature
9. Analog input values
10. Keypad reference values
11. Elapsed time motor
12. Kilowatt-hour meter
13. Internal self-diagnostics
14. Fault conditions:
 - a. External fault
 - b. Processor line fault
 - c. Low AC line voltage
 - d. High AC line voltage
 - e. Current overload
 - f. High DC buss voltage
 - g. VFD output fault

2.04 ENCLOSURE

- A. All VFD components shall be enclosed in a NEMA-1 enclosure for indoor applications, unless the installed location dictates the need for additional protection from physical or water damage in which case a NEMA-12 enclosure shall be used. For outdoor locations, provide NEMA 3R steel (metal) enclosure.
- B. For VFDs with internal bypass, provide side-by-side configuration, with bypass compartment to the side of the drive compartment, rather than below the drive compartment, to allow a more convenient service access.

2.05 CONTROL

- A. All control adjustments shall be made without the necessity of an extender board of specialized meters, but rather from front access adjustable potentiometers or keypad.
- B. Low voltage logic and 115 V control circuits shall be electrically isolated from the power circuits. Signal circuit common shall be grounded.
- C. The VFD shall include a power ride-through feature to allow continuous operation through up to a three to five cycle line loss.
- D. Electronic output overload protection shall be provided to eliminate the use of bimetallic overloads. The drive shall not be phase sequence sensitive.
- E. The VFD shall have independently adjustable acceleration and deceleration circuits of 5 to 120 seconds. Extended time periods are also acceptable.
- F. The VFD shall have full function output current limit adjustable from 10 to 100 percent.

2.06 SYSTEM OPERATION

- A. Selector switch in the "off" position - the controller run circuit shall be open and the system shall not operate.
- B. Selector switch in the "hand" position - the speeds of the motors shall be controlled by the manual speed potentiometer or keypad.
- C. Selector switch in the "auto" position - operation shall be via the input 0 to 10 VDC signal with the output speed proportional to the input signal. If required for incorporation into the controls scenario, the VFD manufacturer shall furnish a pressure transducer mounted in the drive enclosure to convert a 3 to 15 psi pressure signal to a 0 to 10 VDC signal.
- D. The bypass switch shall provide the ability to service the control in bypass operation while not de-energizing the motor. It shall also allow for start/stop functions for the motor.
- E. In case of an output ground fault or similar abnormal output condition, any VFD serving multiple units shall be able to automatically alternate its output to either the duty device or the standby device. The VFD shall be fully operational after an output ground fault condition.

2.07 COMMUNICATIONS

- A. The VFD shall have EIA-485 and EIA-232 ports as standard.
- B. The VFD shall communicate with PLCs, DDCs, Metasys N2 bus, BACnet, Modbus and other communication protocols as required by the project. Provide components required for interface with the selected Building Automation System. Coordinate with BAS contractor.
- C. Communication capabilities shall include, but not be limited to, run-stop control, speed set adjustment, current limit, and proportional/integral/derivative (PID) controller adjustments, accel/decel time adjustments. The drive shall have the capability of allowing the DDC to monitor feedback such as output speed/frequency, current, % torque, % power, kilowatt-hours, relay outputs, and diagnostic fault information.
- D. The VFD shall have a serial port to download drive parameters and fault logs.
- E. The VFD shall have programmable input and outputs.

PART 3 EXECUTION

3.01 COORDINATION

- A. Coordinate the following VFD options with the University and the Design Engineer.
 - 1. Requirements for external bypass switch to operate equipment while VFD is inoperative or being repaired.
 - 2. Requirements for external 3-contactor Drive/Off/Bypass/Test switch that allows operation of the motor via line power in the event of VFD failure.
 - 3. Communications interface with building and temperature controls.
 - 4. Requirements for input line reactors for harmonic suppression.
 - 5. Requirements for output line reactors for motor protection.
 - 6. Requirements for 6, 12, or 18 pulse shifting transformer or Active Harmonic Filtering (AHF) to minimize total harmonic distortion.
 - 7. Maintenance department desire for removable VFD keypad with LCD and memory storage.

3.02 INSTALLATION

- A. Install VFDs in accordance with manufacturer's instructions.
- B. Install floor mounted units on concrete house-keeping pads.
- C. For wall hung units, Contractor shall provide unistrut mounting bracket for drives. Contractor shall reinforce the wall studs with bracing as required to adequately support the drive.
- D. Installation of the VFD shall allow for clearance in front of the drive as required by the latest revision of the National Electrical Code for an electrical panel.
- E. Drive shall be mounted so that keypad and display height are located between 3' to 5'-6" AFF, or top of drive no higher than 6' AFF when display cannot be mounted per these dimensions. Drive and option cabinet configuration shall be provided which conforms to this requirement.
- F. VFD Protection and Cleaning
 - 1. The VFD shall be protected from all construction dust, debris, physical damage, and electrical damage during construction. The VFD shall not be operated until ventilation inlets and outlets are protected with filter media to prevent dust and debris from entering and damaging electronic components. Filtration shall remain in place throughout construction.
 - 2. The VFD shall be cleaned by a qualified drive technician, both internally and externally, including the heat sinks. All cooling fans shall be replaced with factory replacements. Cleaning and fan replacement shall occur at project substantial completion.

END OF SECTION

SECTION 23 31 00
DUCTWORK

PART 1 GENERAL

1.00 The following sections are to be included as if written herein:

- A. Section 23 00 00 – Basic Mechanical Requirements
- B. Section 23 05 29 – Sleeves, Flashings, Supports and Anchors
- C. Section 23 05 53 – Mechanical Identification

1.01 **WORK INCLUDED**

- A. Low Pressure Ducts
- B. Medium and High Pressure Ductwork
- C. Casings
- D. Kitchen Hood Ductwork
- E. Duct Cleaning

1.02 **RELATED WORK**

- A. Section 09 91 00 - Painting: Weld Priming, Weather Resistant Paint or Coating
- B. Section 23 05 48 - Vibration Isolation
- C. Section 23 07 13 - Duct Insulation
- D. Section 23 33 00 - Ductwork Accessories
- E. Section 23 36 00 - Air Terminal Units
- F. Section 23 37 00 - Air Inlets and Outlets
- G. Section 23 05 93.A - Testing, Adjusting and Balancing

1.03 **REFERENCES**

- A. ASHRAE - Handbook of Fundamentals; Duct Design

- B. ASHRAE - Handbook of Equipment; Duct Construction
- C. ASTM A 90 - Weight of Coating on Zinc-Coated (Galvanized) Iron or Steel Articles
- D. ASTM A 167 - Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
- E. ASTM A 525 - General Requirements for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process
- F. ASTM A 527 - Steel Sheet, Zinc-Coated (Galvanized) by Hot-Dip Process, Lock Forming Quality
- G. ASTM B209 - Aluminum and Aluminum Alloy Sheet and Plate
- H. ASTM C 14 - Concrete Sewer, Storm Drain, and Culvert Pipe
- I. ASTM C 443 - Joints for Circular Concrete Sewer and Culvert Pipe, Using Rubber Gaskets
- J. NFPA 90A - Installation of Air Conditioning and Ventilating Systems
- K. NFPA 90B - Installation of Warm Air Heating and Air Conditioning Systems
- L. NFPA 96 - Installation of Equipment for the Removal of Smoke and Grease-Laden Vapors from Commercial Cooling Equipment
- M. SMACNA - Low Pressure Duct Construction Standards
- N. SMACNA - High Pressure Duct Construction Standards
- O. UL 181 - Factory-Made Air Ducts and Connectors

1.04 REFERENCES

- A. Fundamentals Handbook, American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE).
- B. Equipment Handbook, ASHRAE.
- C. HVAC Duct Construction Standards, Sheet Metal and Air Conditioning Contractors National Association (SMACNA).

- D. HVAC Duct System Design, SMACNA.
- E. Round Industrial Duct Construction Standards, SMACNA.
- F. Engineering Design Manual for Air Handling Systems, United McGill Corporation (UMC).
- G. Assembly and Installation of Spiral Duct and Fittings, UMC.
- H. Engineering Report No. 132 (Spacing of Duct Hangers), UMC.

1.05 DEFINITIONS

- A. Duct Sizes: Inside clear dimensions. For lined ducts, maintain sizes inside lining.
- B. Low Pressure: 2 inch WG positive or negative static pressure and velocities less than 1,500 fpm.
- C. Medium Pressure: 6 inch WG positive static pressure and velocities greater than 1,500 fpm.
- D. High Pressure: 10 inch WG positive static pressure and velocities greater than 2,500 fpm.

1.06 REGULATORY REQUIREMENTS

- A. Construct ductwork to NFPA 90A, NFPA 90B and NFPA 96 standards.

1.07 SUBMITTALS

- A. Shop Drawings shall be submitted on all items of sheet metal work specified herein. Shop Drawings of ductwork at air units shall be submitted at a minimum scale of 3/8" equal to one foot.
- B. Shop Drawings shall be submitted on all other ductwork per Section 23 00 00. Shop Drawings shall indicate location of all supply, return, exhaust and light fixtures from the approved reflected ceiling plans.
- C. Submit shop drawings and product data under provisions of Section 23 00 00.
- D. Submit samples under provisions of Section 23 00 00.
- E. Submit two samples each of [_____,] [and] [_____].

1.08 DELIVERY, STORAGE, AND HANDLING

- A. Deliver products to site under provisions of Section 23 00 00.
- B. Store and protect products under provisions of Section 23 00 00.
- C. Protect [] from [] by [].

PART 2 PRODUCTS

2.01 DUCTWORK GENERAL:

- A. All ductwork indicated on the Drawings, specified or required for the air conditioning and ventilating systems shall be of materials as hereinafter specified unless indicated otherwise. All air distribution ductwork shall be fabricated, erected, supported, etc., in accordance with all applicable standards of SMACNA Duct Manuals where such standards do not conflict with NFPA 90A and where class of construction equals or exceeds that noted herein. All exhaust ductwork including toilet room exhausts shall be constructed and leak tested as specified for medium pressure supply ducts at negative pressure.
- B. All ductwork shown on the Drawings, specified or required for the heating, ventilating and air conditioning systems shall be constructed and erected in a first class workmanlike manner. The work shall be guaranteed for a period of one (1) year from and after the date of acceptance of the job against noise, chatter, whistling, vibration, and free from pulsation under all conditions of operation. After the system is in operation, should these defects occur, they shall be corrected as directed by the Architect.
- C. All duct sizes shown on the Drawings are air stream sizes. Allowance shall be made for internal lining where required, to provide the required cross sectional area.
- D. All holes in ducts for damper rods and other necessary devices shall be either drilled or machine punched (not pin punched), and shall not be any larger than necessary. All duct openings shall be provided with sheet metal caps if the openings are to be left unconnected for any length of time.
- E. Except for special ducts specified elsewhere herein, all sheet metal used on the project shall be constructed from prime galvanized steel sheets and/or coils up to 60" in width. Each sheet shall be stenciled with manufacturer's name and gauge. Coils of sheet steel shall be stenciled throughout on ten foot (10') centers with manufacturer's name and must be visible after duct is installed. Sheet metal must

conform to SMACNA sheet metal tolerances as outlined in SMACNA's "HVAC Duct Construction Standards."

- F. Where ducts that are exposed to view (including equipment rooms), pass through walls, floors or ceilings, furnish and install sheet metal collars around the duct.

NOTE TO THE ENGINEER: DUCTWORK TAPS SHALL BE MADE USING BELLMOUTH OR "BOOT" CONNECTIONS, AND THEY SHALL BE FROM THE SIDE OF THE DUCT, NOT THE BOTTOM UNLESS THERE IS AT LEAST 24" CLEAR FROM THE BOTTOM OF THE DUCT TO THE OUTLET. THIS WILL ALLOW FOR A BETTER LOCATION FOR THE VOLUME DAMPERS. NO MORE THAN 3 ROOMS OF SIMILAR SIZE, ORIENTATION, AND FUNCTION SHOULD BE ON THE SAME ZONE. DIRECTORS' OFFICES, CONFERENCE ROOMS, AND OTHER SPECIAL PURPOSE ROOMS SHOULD BE ON AN INDIVIDUAL ZONE. NOTE THAT A SMALL CORRIDOR AREA OR STOREROOM MAY BE ADDED TO ALMOST ANY SMALL ZONE. ZONES REQUIRING LARGE AMOUNTS OF AIR (SUCH AS AUDITORIUMS OR LABORATORIES) MAY REQUIRE MORE THAN ONE MIXING BOX.

2.02 DUCTWORK LOW PRESSURE: (Includes all exhaust ductwork downstream of fans.)

- A. The scope of low pressure ductwork is defined as all ductwork downstream of terminal units, and all exhaust ductwork downstream of fans. Construction of all low pressure duct shall be in accordance with Low Velocity Duct Construction Standards as published by Sheet Metal and Air Conditioning Contractors National Association (SMACNA) and shall be sealed and tested at 3" static with the same test procedures as medium pressure ductwork.
- B. Spiral wound round duct shall be as manufactured by United McGill Sheet Metal Company or approved equal.
- C. The metal gauges listed in the 1985 SMACNA HVAC Duct Construction Standards for Metal and Flexible Duct are the minimum which shall be used for this project. It shall be noted that the Contractor is responsible that the metal gauge selected is heavy enough to withstand the physical abuse of the installation.
- D. Elbows shall be radius type and have a centerline radius of 1-1/2 times the duct diameter or width. Elbows in round ducts may be smooth radius as described above or 5-piece 90 degree elbows and 3-piece 45 degree elbows. Joints in round ducts shall be slip type with a minimum of three sheet metal screws. Joints in sectional elbows shall be sealed as specified for duct sealing.
- E. SEALANT: All ductwork (except welded exhaust duct) shall be sealed with either "MP" (Multi-Purpose), Hardcast "Iron-grip 601", Polymer Adhesive "Airseal #11", or "United Duct Seal" (United McGill Corp.) water base, latex or acrylic type

sealant. Note that, except as noted, oil or solvent based sealants are specifically prohibited for use on this project. For exterior applications, "Uni-Weather" (United McGill Corp.) neoprene based sealant shall be used. No other sealants may be used. All seams and joints in shop and field fabricated ductwork shall be sealed by applying one layer of sealant, then immediately spanning the joint with a single layer of 3" wide open weave fiberglass tape. Sufficient additional sealant shall then be applied to completely imbed the cloth. All sealants shall be UL rated at no more than flame spread of 5 and smoke developed of 0. At contractor's option Hardcast 1602 sealant tape may be used in lap joints and flat seams.

2.03 DUCTWORK MEDIUM PRESSURE: (Includes all exhaust ductwork upstream of fans).

- A. The scope of medium pressure ductwork is defined as all ductwork downstream of all air handlers, up to and including terminal units, plus all return air ductwork. Construction of all ducts shall be in accordance with High Velocity Construction Standards as published by SMACNA. All round and rectangular duct construction, duct fittings, dampers, etc., are covered in this manual and it is to be adhered to.
 - 1. Spiral wound round duct shall be as manufactured by United McGill Sheet Metal Company or approved equal.
 - 2. The metal gauges are listed herein for round duct and for rectangular duct.
- B. All ductwork (except welded exhaust duct) shall be sealed with either "MP" (Multi-Purpose), Hardcast "Iron-grip 601", or "United Duct Seal" (United McGill Corp.) water base, latex or acrylic type sealant. Note that, except as noted, oil or solvent based sealants are specifically prohibited for use on this project. For exterior applications, "Uni-Weather" (United McGill Corp.) solvent based sealant shall be used. No other sealants may be used. All seams and joints in shop and field fabricated ductwork shall be sealed by applying one layer of sealant, then immediately spanning the joint with a single layer of 3" wide open weave fiberglass tape. Sufficient additional sealant shall then be applied to completely imbed the cloth. At contractor's option Hardcast 1602 sealant tape may be used in lap joints and flat seams.
- C. Oval ducts shall be spiral flat oval or welded flat oval equal to those of United McGill Sheet Metal Company with gauges and reinforcing as recommended by the manufacturer for medium pressure or the ducts may be Shop fabricated of completely welded construction of the following gauge:

Major Axis 12 to 20 No. 24 gauge
Major Axis 20 to 30 No. 22 gauge
Major Axis 30 to 46 No. 20 gauge

Major Axis 46 to 50 No. 18 gauge
Major Axis 50 and Up No. 16 gauge

- D. Oval fittings shall be equal to those of United McGill Sheet Metal Company with requirements, sealing, etc., similar to that specified for round medium pressure work.
- E. Oval duct reinforcing methods shall be submitted as Shop Drawings for approval. Reinforcing galvanized angles shall be of sizes specified for same size rectangular ducts. Galvanized angles shall be used where standing seams are specified for rectangular ducts. Attaching methods shall be shown on Shop Drawings and submitted for approval.
- F. Testing of Medium Pressure Ductwork: (Includes from fan discharge through to the discharge of terminal units.)
1. All medium pressure ducts shall be pressure tested according to SMACNA Chapter 10 test procedures. Design pressure for testing ductwork shall be six inches (6") of water. Total allowable leakage shall not exceed 1% of the total system design air flow rate. When partial sections of the duct system are tested, the summation of the leakage for all Sections shall not exceed the total allowable leakage.
 2. The entire system of medium pressure ductwork shall be tested, including the VAV/Constant Volume Terminal Units (i.e. The ductwork shall be capped immediately prior to the Terminal Units, and tested as described above). After testing has proven that the ductwork is installed and performs as specified, the terminal units shall be connected to the ductwork and the connections sealed with extra care. The contractor shall inform the project inspector when the joints may be visually inspected for voids, splits, or improper sealing of the joints. If any leakage in the terminal unit connections/joints after the systems have been put into service, the leaks shall be repaired by: 1) complete removal of the sealing materials, 2) thorough cleaning of the joint surfaces, and 3) installation of multiple layers of sealing materials.
 3. At the option of the Owner, the Contractor may be allowed to eliminate the terminal units from testing by capping the supply ductwork prior to the terminal units, then inspecting the connection to the terminal units when complete. This option may only be exercised by the Resident Construction Manager, and then only if documented in writing prior to testing.

- G. All exhaust ductwork, including toilet room exhausts, shall be constructed as for medium pressure ducts and shall be tested for leaks in the same manner as for medium pressure supply ducts.
- H. Contractor may at his option use DUCTMATE or Ward coupling system on rectangular ductwork. Contractor may at his option (where space permits) use rectangular ductwork with DUCTMATE or Ward system in lieu of oval ductwork. No other flange-type duct joining systems may be used without written approval from OFPC Engineering.
- I. Rectangular 90 degree elbows shall be constructed with single thickness turning vanes. Radius type rectangular elbows shall have a centerline radius of 1-1/2 times the duct diameter or width. Contractor shall have the option to substitute short radius vanned elbows, but shall request the substitution at the time of submittal of Shop Drawings, and shall request the substitution as required in Section 23 00 00. Elbows in round or oval ducts may be smooth long radius as described above or 5-piece 90 degree elbows and 3-piece 45 degree elbows. Joints in round ducts shall be slip type with a minimum of three sheet metal screws. Joints in sectional elbows shall be sealed as specified for duct sealing.

NOTE TO THE ENGINEER: THE FOLLOWING TWO SUB-SECTIONS (2.04 & 2.05) SHOULD BE USED ONLY WHEN SECTION 23 73 23 - AIR HANDLERS IS NOT USED OR THE PLENUMS ARE OUTSIDE THE SCOPE OF THE FACTORY FABRICATED UNITS.

2.04 MIXED AND R. A. (LOW PRESSURE) CASING PLENUMS:

- A. All low pressure casings and plenums shall be following gauges and construction:

<u>Casing Height</u>	<u>Galv.</u>	<u>Alum.</u>	<u>Angles</u>	<u>Standing Seams</u>
Up to 4'	20 ga.	.051	1 x 1 x 1/8"	1"
4' to 6'	18 ga.	.051	1 x 1 x 1/8"	1"
6' to 8'	18 ga.	.064	1-1/2 x 1-1/2 x 3/16"	1-1/2"
8' to 10'	18 ga.	.064	1-1/2 x 1-1/2 x 3/16"	1-1/2"
Over 10'	16 ga.	.064	2 x 2 x 3/16"	1-1/2"

- B. All low pressure casings shall be fabricated by the Mechanical Contractor enclosing the filter and automatic dampers as shown on the Drawings. The casing shall be fabricated of galvanized sheet metal erected with 3 foot center maximum standing seams reinforced with 1/4 inch bars. The casing shall be stiffened on three foot centers maximum with angle irons tack welded in place.

- C. All openings to the casing shall be properly sealed to prevent any air leakage. Access doors shall be installed as shown and shall be air tight, double skin insulated construction with frames welded in place. Doors shall be rubber gasketed with #390 Ventlok gasketing and equipped with fasteners equal to Ventlok #310 latches and #370 hinges that can be operated from both the inside and the outside.
- D. Casings shall be anchored by the use of angle irons sealed and bolted to the curb and floor of the apparatus casing. Submit Shop Drawings for approval. The casing shall be tested and provided tight at a pressure of three inches water column.
- E. The casing shall have 1" thick duct liner applied as specified under paragraph "Duct Liner" in this section.

2.05 MEDIUM PRESSURE BUILT-UP UNIT CASINGS:

- A. All medium pressure unit casings shall be fabricated by the Mechanical Contractor and shall enclose the filters and automatic dampers. Casings shall be constructed of cellular, standing seam panels with 3" deep reinforced "hat" sections as manufactured by metal deck manufacturers and as shown and described in SMACNA High Velocity Duct Standards Manual. Shop Drawings shall be submitted for approval showing casing construction details and equipment layout and mounting. Shop fabricated cellular sections are acceptable under the foregoing conditions if evidence is provided to show ability of cellular section to withstand the static pressures of the system.
- B. All openings to the casing shall be properly sealed to prevent any air leakage. Access doors shall be installed for easy access to equipment and shall be air tight, double skin insulated construction with frames welded in place. Doors shall be rubber gasketed with #390 Ventlok gasketing and equipped with fasteners equal to Ventlok #310 latches that can be operated from both the inside and the outside. Hinges shall be equal to Ventlok #370.
- C. Casing shall be anchored by the use of galvanized angle irons sealed and bolted to the curb and floor of the apparatus casing as shown on the SMACNA Drawings.
- D. A fan discharge diffuser plate shall be located on the fan discharge and shall be constructed of 10 gauge steel perforated plate installed in 6" channel iron frames (8.2#) rigidly supported to withstand the high velocity discharge of the fan. Perforations shall be 3/8" (.375") staggered on 1 1/16" centers (27% open area). One section shall be hinged to provide an access door between the discharge side of the fan and the entering side of the coils. After fabrication of diffuser plate, coat it with rust resistant paint. After installation, touch-up diffuser plate and paint channel iron frames with rust resistant paint.

- E. Casing shall have sufficient access openings to allow access for maintenance of all parts of the apparatus. Access door size shall be as large as feasible for the duty required.

2.06 ELBOWS:

- A. Where rectangular elbows are shown, or are required for good air flow, contractor shall provide and install turning vanes. Job fabricated turning vanes, if used, shall be fabricated of the same gauge and type of material as the duct in which they are installed. Vanes must be fabricated for same angle as duct offset. Radius elbows shall have a centerline radius of not less than one and one-half (1-1/2) times the duct width. Submit Shop Drawings on factory fabricated and job fabricated turning vanes. Provide turning vanes in all rectangular radius elbows and offsets.
- B. All turning vanes shall be anchored to the cheeks of the elbow in such a way that the cheeks will not breathe at the surfaces where the vanes touch the cheeks. In most cases, this will necessitate the installation of an angle iron support on the outside of the cheek parallel to the line of the turning vanes.
- C. Where turning vanes are to be provided and installed as required above, in ducts of over 12" thickness (vanes are over 12" long), contractor shall provide and install Tuttle and Bailey double thickness vanes or approved equal. The installation of the turning vanes shall be as described for single thickness vanes.

2.07 FLEXIBLE DUCTS:

- A. Low Pressure Insulated Flexible Duct may be used where shown on the drawings. Duct shall be made with factory preinsulated duct composed of dead soft, spiral wound, triple locked corrugated aluminum core covered with a minimum of 1-1/2" thick, 3/4 lb. density fiberglass blanket sheathed in a vapor barrier of fiberglass reinforced aluminum foil and mylar laminate. The insulation shall have a minimum "K" factor of 0.29 at 60 degrees F. mean and a vapor barrier permeability rating of 0.05 per ASTM method E96-66, Procedure A. The C factor shall be 0.24 to meet HUD requirements. The duct shall be rated for a positive working pressure of 10" w.g. and a temperature of up to 250 degrees F. The duct must comply with the latest NFPA Bulletin 90A and be listed and labeled by Underwriters Laboratories, Inc., as Class I Air Duct, Standard 181, and meet GSA, FHA and other U. S. Government standards; flame spread, not over 15; smoke developed, not over 10. Flexible ducts shall be not more than 5'-0" in length, shall be installed as indicated in the diffuser connection detail, and shall be Flexmaster Type TL-M or approved equal.
 - 1. The terminal ends of the duct core shall be secured by compression coupling or stainless steel worm gear type clamp equal to Ideal Series 56 Snaplock. The fittings on air mixing devices and on sheet metal duct shall be coated

with the sealant specified for low pressure ductwork, then flexible duct core slipped over duct and coupling or clamp tightened, then connection sealed with more sealant. Insulation of flexible duct shall be slipped over connection to point where insulation abuts mixing box or insulation on duct.

These insulation connections shall be sealed by imbedding fiberglass tape in the sealant specified for medium pressure ductwork and coating with more sealant to provide a vapor barrier. (This applies to all flex connections to diffusers, grilles, etc. when allowed on the drawings.)

- B. Medium and High Pressure Insulated Flexible Duct shall be the same construction as the Low Pressure Duct, factory applied insulation of 1" minimum thickness, 3/4 lb. density with a permeability rating of 0.30. The duct shall be supported by a corrosion resistant metal spiral, or a coated spring steel helix and solid inner liner mechanically interlocked or permanently bonded to the helix wire. Ratings shall be as described for Low Pressure Duct above. Flexible ducts shall be not more than 2'-0" in length, used for alignment or sound/vibration purposes only, and may only be installed in straight runs. Flexible duct shall NOT be used for changes of direction of air flow. Installation, clamps and sealing shall be the same as specified for rigid duct.

2.08 DUCT LINER: NOTE: ALL DUCTWORK SHALL BE EXTERNALLY INSULATED UNLESS OTHERWISE INDICATED ON THE PROJECT DRAWINGS. (See Section 23 07 19, for the applicable insulation specification.)

- A. Where indicated on the Drawings, ducts shall have lining equal to Fiberglass Aeroflex No. 150 duct liner. Duct liner shall be one inch (1") thick unless otherwise indicated. The liner shall be applied to the inside of the duct with heavy density side to the air stream and shall be secured in the duct with fireproof 3M #37 or St. Clair R41B adhesive, completely coating the clean sheet metal. All joints in the insulation shall be "battered" and firmly butted tightly to the adjoining liner using fireproof adhesive. Where a cut is made for duct taps, etc., the raw edge shall be accurately and evenly cut and shall be thoroughly coated with fireproof adhesive. On ducts over twenty-four (24") in width or depth, the liner shall be further secured with mechanical fasteners. The fasteners shall be A. J. Gerrard Company pronged straps, or approved equal, secured to the ducts by fireproof adhesive. The clips shall be eighteen inch (18") maximum spacing and shall be pointed up with fireproof adhesive. Liner shall be accurately cut and ends thoroughly coated with fireproof adhesive so that when the duct section is installed, the liner shall make a firmly butted and tightly sealed joint. Where ducts are lined exterior insulation will not be needed unless otherwise noted, except that the two insulations shall not lap less than twenty-four inches (24"). Dimensions given on the Drawings are metal sizes. Refer to Section 23 00 00 for Flame-Spread Properties.

- B. Duct liner in medium pressure ducts shall be the same except a perforated metal liner shall be used over duct liner for securement in lieu of fasteners.

2.09 FACTORY LINED ACOUSTICAL DUCTS: (NOTE: Must appear on the Drawings.)

- A. Where indicated on the Drawings, furnish and install double wall internally insulated duct and fittings.
- B. Duct shall consist of outer metal pressure shell, 1" thick glass fiber insulation and internal perforated metal liner.
- C. Duct and fittings shall be equal to Acousti-K 27 as manufactured by United McGill Sheet Metal Company.

2.10 FUME HOOD EXHAUST DUCTWORK:

USE THE FOLLOWING ONLY WHEN SPECIFICALLY DIRECTIONED; OTHERWISE USE STAINLESS STEEL FROM HOODS TO MAIN, THEN USE GALVANIZED FOR MAINS.

- A. DUCTWORK: (except for perchloric acid fume hoods) Round ductwork and fittings shall be filament-wound polyester fiberglass reinforced plastic as manufactured by Peabody Spunstrand, Inc., Beverly Pacific, or an approved equal. The exterior of the duct material shall have a flame spread rating less than 25 and smoke developed rating less than 50. Fire and fire/smoke dampers shall not be installed in fume hood exhaust ductwork.
- B. RESIN: Shall be Ashland Chemicals Hetron #197 which contains fillers as required for thixotropic control or fire retardance, and gun metal gray pigment with ultraviolet (U.V.) inhibitor added to glass fiber resin.
- C. FITTINGS:
 - 1. Laterals: Standard lateral is 45 degree.
 - 2. Elbows: Shall have a standard centerline radius of 1.5 times the diameter:
 - 61 degree to 90 degree ells shall be 5 gore
 - 31 degree to 60 degree ells shall be 3 gore
 - 0 degree to 30 degree ells shall be 2 gore
 - 3. Duct and fittings shall be constructed with 20 mil surface liner.
- D. Wall thickness minimums:

6" to 20" - 0.125 inch
20" to 36" - 0.187 inch
42" to 60" - 0.250 inch

- E. Interior Surfaces: All duct and fittings shall have 20 mil surface mat liner. Interior surfaces shall be free from pits, cracks and crazing. Liner or surface wrinkles are permissible as long as free of pits, etc.
- F. Joints:
 - 1. Wet field joints (mat and resin) shall be a minimum of 4 inches in width and at least the same thickness as adjoining duct wall. Joint shall be minimum one wrap for duct up to 22", two wraps for duct 23" to 48" and three wraps for ducts 49" to 60". Joint material shall be thoroughly saturated with the same type resin as used in duct and fittings. The minimum joint overlap shall be three inches for all sizes. The joint materials for outdoor ducts shall be color enhanced for a resultant color similar to the duct material.
 - 2. Ducts, fitting ends and field cuts shall be completely brush coated with catalyzed resin prior joint wrap so that no raw glass fibers are exposed. The resin used shall be the same type as used in the duct and fitting filament winding.
 - 3. Duct connections to exhaust fans shall be flanged.
- C. Ducts shall be supported similarly to that of low pressure sheet metal ducts except that at all support points the contractor shall provide a 1/8" thick neoprene band securely fastened to the duct, to avoid metal contact with FRP ducts.

2.11 PERCHLORIC ACID FUME HOOD EXHAUST DUCTWORK:

- A. Duct and stack material shall be Type 316 Stainless Steel, welded construction. Duct sealant shall not be used to seal this ductwork. All ductwork shall be installed as vertical as possible within the constraints of the design indicated in the drawings. In all cases, the ductwork shall be installed so that the wash down water shall drain back to the hood.
- B. Metal gauges shall be as specified in 1985 SMACNA Standards for Low Pressure Ductwork. Fittings shall be as specified for FRP ductwork, Paragraph 3.29.
- C. Perchloric exhaust ductwork and stack shall be installed with a complete wash down system, piped from the hood location to points along the ductwork and stack as indicated in the drawings. Spray nozzles shall be installed at the locations of the

piping entry into the ductwork and stack. The stack shall drain back to the fan, which shall include a drain from the bottom of the scroll back to the exhaust ductwork. All piping to and from the ductwork and stack shall be threaded Type 316 Stainless Steel.

2.12 ALUMINUM DUCTWORK:

- A. Provide aluminum ductwork only where indicated on the drawings.
- B. Duct joints shall be all soldered construction, one standard gauge heavier than for the same size galvanized steel ducts.

2.13 DUST COLLECTOR SYSTEMS:

- A. Duct system shall be galvanized, constructed and supported in accordance with SMACNA Industrial Round Duct Construction for Class 2, 8" w.g. pressure.

2.14 KITCHEN HOOD EXHAUST

- A. Minimum 16ga black iron or Stainless steel as indicated on drawings.
- B. Slope back to hood.
- C. Provide access doors at all changes in direction.
- D. Fire protect per NFPA and UMC.
- E. Manufactured double wall duct systems with NFPA certification for grease systems may be used in lieu of above.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Refer also to requirements included in Part 2 of this specification.
- B. Obtain manufacturer's inspection and acceptance of fabrication and installation of fiberglass ductwork prior to beginning of installation.
- C. Provide openings in ductwork where required to accommodate thermometers and controllers. Provide pilot tube openings where required for testing of systems, complete with metal can with spring device or screw to ensure against air leakage. Where openings are provided in insulated ductwork, install insulation material inside a metal ring.

- D. Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities.
- E. Slope underground ducts to plenums or low pump out points at 1:500. Provide access doors for inspection.
- F. Coat buried, metal ductwork without factory jacket with one coat and seams and joints with additional coat of asphalt base protective coating.
- G. Set plenum doors 6 to 12 inches above floor. Arrange door swings so that fan static pressure holds door in closed position.
- H. Connect terminal units to medium or high pressure ducts directly or with two feet maximum length of flexible duct. Do not use flexible duct to change direction. Allow for a minimum of 3 diameters of straight duct to the entrance of all terminal units.
- I. Connect diffusers with 5'-0" maximum length or troffer boots with 2' maximum length of flexible duct to low pressure ducts. Hold in place with strap or clamp, and seal as specified.
- J. Provide residue traps in kitchen hood exhaust ducts at base of vertical risers with provisions for cleanout. Use stainless steel for ductwork exposed to view and stainless steel or galvanized steel for ducts where concealed.
- K. During construction provide temporary closures of metal or taped polyethylene on open ductwork to prevent construction dust from entering ductwork system.

3.02 LOW PRESSURE DUCT SUPPORTS:

- A. See Section 23 05 29.

3.03 MEDIUM PRESSURE DUCT SUPPORTS:

- A. See Section 23 05 29.

3.04 DUCTWORK APPLICATION SCHEDULE

AIR SYSTEM MATERIAL

Low Pressure Supply (Heating Systems)	Steel, Aluminum
Low Pressure Supply (Systems with Cooling Coils)	Steel, Aluminum
Buried Supply or Return	Steel, Concrete, Reinforced Plastic
Medium and High Pressure Supply	Steel
Return and Relief	Steel, Aluminum
General Exhaust	Steel, Aluminum
Kitchen Hood Exhaust	Steel, Stainless Steel
Dishwasher Exhaust	Steel, Stainless Steel, Aluminum
Fume Hood Exhaust	Stainless Steel, Fiber Reinforced Plastic
Outside Air Intake	Steel
Combustion Air	Steel
Emergency Generator Ventilation	Steel

3.05 CLEANING OF SYSTEMS:

- A. Before turning the installation over to the Owner, all ducts should be cleaned and blown free of all dust and dirt that has collected in the ducts.

END OF SECTION

SECTION 23 33 00
DUCTWORK ACCESSORIES

PART 1 GENERAL

1.00 The following sections are to be included as if written herein:

- A. Section 23 00 00 – Basic Mechanical Requirements
- B. Section 23 05 29 – Sleeves, Flashings, Supports and Anchors
- C. Section 23 05 53 – Mechanical Identification

1.01 **WORK INCLUDED**

- A. Manual and Automatic Volume Control Dampers
- B. Fire Dampers
- C. Combination Fire/Smoke Dampers
- D. Backdraft Dampers
- E. Air Turning Devices
- F. Flexible Duct Connections
- G. Duct Access Doors
- H. Duct Test Holes

1.02 **RELATED WORK**

- A. Products installed, but not furnished under this section include airflow stations and automatic control dampers to be provided by Controls Contractor under section 23 09 23.
- B. Section 23 05 48 - Vibration Isolation
- C. Section 23 31 00 - Ductwork
- D. Section 23 36 00 - Air Terminal Units: Medium and High Pressure Damper Assemblies

1.03 **REFERENCES**

- A. NFPA 90A - Installation of Air Conditioning and Ventilating Systems
- B. SMACNA - Low Pressure Duct Construction Standards
- C. UL 33 - Heat Responsive Links for Fire Protection Service
- D. UL 555 - Fire Dampers and Ceiling Dampers

1.04 SUBMITTALS

- A. Submit shop drawings and product data under provisions of Section 23 00 00.
- B. Provide shop drawings for shop fabricated assemblies indicated, including manual volume dampers, automatic control dampers, duct access doors, and duct test holes. Provide product data for hardware used.
- C. Submit manufacturer's installation instructions under provisions of Section 23 00 00 for fire dampers and combination fire and smoke dampers.

PART 2 PRODUCTS

NOTE TO THE ENGINEER: ALL MANUAL AND AUTOMATIC VOLUME DAMPERS KNOWN TO BE REQUIRED, INCLUDING IN THE VERTICAL, SHALL BE SHOWN IN THE PLANS.

2.01 DAMPERS

- A. Furnish and install manual volume dampers where shown on the drawings and wherever necessary for complete control of the air flow, including all supply, return and exhaust branches, "division" in main supply, return and exhaust ducts, each individual air supply outlet and fresh air ducts. Where access to dampers through a fixed suspended ceiling is necessary, the Contractor shall be responsible for the proper location of the access doors.

NOTE TO SPECIFICATION WRITER: IN GALVESTON, OUTSIDE AIR DAMPERS SHALL BE 316L STAINLESS STEEL. MODIFY THIS SPECIFICATION AND DIRECT DIGITAL CONTROL SYSTEM SPECIFICATION 23 09 23 TO SUIT.

- B. Splitter dampers shall be fabricated of steel not lighter than 16-gauge. The leading edge of the damper shall be hemmed. Each splitter shall be a minimum of 12" long or 1-1/2 times the width of the smaller of the two branches it controls, whichever is greater. Dampers shall be carefully fitted, and shall be controlled by locking

quadrants equal to Ventlok No. 555 on exposed uninsulated ductwork, No. 644 on exposed externally insulated ductwork and No. 677 (2-5/8" diameter) chromium plated cover plate for concealed ductwork not above lay-in accessible ceilings. Furnish and install end bearings for the damper rods on the end opposite the quadrant when No. 555 or No. 644 regulators are used, and on both ends when No. 677 regulators are used.

- C. On concealed ductwork above lay-in accessible ceilings use Ventlok No. 555 or No. 644 locking quadrant for splitter dampers.
- D. Dampers larger than three (3) square feet in area shall be controlled by means of rods hinged near the leading edge of the damper with provisions for firmly anchoring the rod and with end bearings supporting the axle.
- E. Manual volume dampers shall be equal to Ruskin, or approved equal. Blades shall not exceed 48 inches (48") in length or twelve inches (12") in width and shall be of the opposed interlocking type. The blades shall be of not less than No. 16-gauge galvanized steel supported on one-half inch (1/2") diameter rust-proofed axles. Axle bearings shall be the self-lubricating ferrule type.
- F. Install all automatic control dampers, furnished by the Temperature Control Manufacturer, in strict accordance with the manufacturer's recommendations and requirements of these Specifications.
- G. All adjustable dampers installed in externally insulated ductwork shall be installed with Ventlok No. 639, or equal, elevated dial operators. Insulation shall extend under the elevated dial. All adjustable dampers installed in internally insulated ductwork shall be installed with Ventlok No. 635, or equal, dial operators. All damper shaft penetrations in the ductwork shall be installed with Ventlok #609 end bearings.

2.02 FIRE AND FIRE/SMOKE DAMPERS

NOTE TO DESIGNER: ALL FIRE AND FIRE/SMOKE DAMPERS MUST BE SHOWN ON THE DRAWINGS. USE FIRE/SMOKE DAMPERS FOR SMOKE DAMPER APPLICATIONS.

- A. Fire Dampers
 - 1. Furnish and install where shown on the drawings or required by the Specifications, fire dampers meeting the following requirements.
 - 2. Each fire damper shall be constructed and tested in accordance with Underwriters Laboratories Safety Standard 555. All dampers shall possess a 1-1/2 hour or 3 hour (as appropriate for the construction shown in the

architectural drawings) protection rating, 165 or 212 degree F fusible link, and shall bear a U.L. label in accordance with Underwriters Laboratories labeling procedures. Fire dampers shall be constructed such that the damper frame material and the curtain material shall be galvanized.

3. Fire dampers shall be curtain blade or multi-blade type and the damper shall be so constructed that the blades are either out of the air stream or installed in an oversized sleeve to provide a 100 percent free area of the duct in which the damper is housed.
4. The damper manufacturer's literature submitted for approval prior to the installation shall include performance data developed from testing in accordance with AMCA 500 Standards and shall show the pressure drops for all sizes of dampers required at anticipated airflow rates. Maximum pressure drop through fire damper shall not exceed 0.05 inch water gauge.
5. Fire dampers shall be equipped for vertical or horizontal installation as required by the locations shown in the drawings. Fire dampers shall be installed in wall and floor openings utilizing steel sleeves, angles and other material and practices required to provide an installation equivalent to that utilized by the manufacturer when the respective dampers were tested by Underwriters Laboratories. Mounting angles shall be a minimum of 1 1/2 inch by 1 1/2 inch by 14-gauge and bolted, tack welded or screwed to the sleeve at maximum spacing of 12 inches and with a minimum of two connections at all sides. Mounting angles shall overlap at least equal to the gauge of the duct defined by the appropriate SMACNA Duct Construction Standard, latest edition, and as described in NFPA 90A. The entire assembly, following installation, shall be capable of withstanding 6" water gauge static pressure.
6. The damper installation shall be in accordance with the damper manufacturer's instructions.
7. All fire dampers shall comply with the specification as written above and shall be Greenheck model DFD-150 or DFDR-150 (type C, CR or CO), Ruskin model DIBD2 (Style C, CR or CO), Nailor model D0120 or D0130, or Pottorff model VFD-10D-A.
8. The contractor shall completely seal the assembly to the building components using Hardcast 1602 sealant tape to allow for expansion and contraction of the sleeve and damper assembly.
9. Dampers shall be UL labeled for use in dynamic systems. Closure reading shall be 110% of the maximum design airflow at the point of installation.

The minimum closure pressure rating shall be 8" wg for airflow in either direction.

B. Combination Fire/Smoke Dampers

1. Furnish and install where shown on the drawings, or as required by the specifications, combination fire/smoke dampers meeting the following requirements.
2. Each combination fire/smoke damper shall be 1 1/2 hour fire rated under UL Standard 555, 4th Edition, and shall be further classified by Underwriters Laboratories as a Leakage Rated Damper for use in smoke control systems under the latest version of UL555S, and bear a UL label attesting to it. The damper manufacturer shall have tested, and qualified with UL, a complete range of damper sizes covering all dampers required by this specification. Testing and UL qualifying a single damper size is not acceptable. The leakage rating under UL555S shall be no higher than Leakage Class I (4 cfm per square foot at one inch water gauge pressure and 8 cfm per square foot at 4 inches water gauge pressure). The maximum air pressure drop through each combination fire/smoke damper shall not exceed 0.10 inch water gauge at the design air quantity. (Note that this may require a larger damper than the connected duct size.)
3. The damper frame shall be a minimum of 20-gauge galvanized steel formed into a structural hat channel shape with tabbed corners for reinforcement, as approved in testing by Underwriters Laboratories. Bearings shall be integral high surface area non electrolytic materials construction to incorporate a friction free frame blade lap seal, or molybdenum disulfide impregnated stainless steel or bronze oilite sleeve type turning in an extruded hole in the frame or an extruded frame raceway. The dampers may be either parallel or opposed blade type. The blades shall be constructed with a minimum of 14-gauge equivalent thickness. The blade edge seal material shall be able to withstand 450 degrees F. The jamb seals shall be flexible stainless steel compression type or lap seal type.
4. In addition to the leakage ratings specified herein, the combination fire/smoke dampers and their operators shall be qualified under UL555S to an elevated temperature of 250 degrees F. Electric operators shall be installed by the damper manufacturer at the time of damper fabrication. The damper and operator shall be supplied as a single entity that meets all applicable UL555 and UL555S qualifications for both dampers and operators. The manufacturer shall provide a factory-assembled sleeve. The sleeve shall be a minimum of either 20-gauge for dampers where neither width nor height exceeds 48 inches or 16-gauge where either dimension equals or exceeds 48 inches.

5. As part of the UL qualification, dampers shall have demonstrated a capacity to operate (open and close) under HVAC system operation conditions, with pressures of at least 4 inches water gauge in the closed position, and 2500 fpm air velocity in the open position.
6. Each combination fire/smoke damper shall be equipped with a UL Classified Firestat/releasing device. The Firestat/releasing device shall electrically and mechanically lock the damper in a closed position when the duct temperatures exceed 165 degrees F and still allow the appropriate authority to operate the damper as may be required for smoke control functions. The damper must be operable while the temperature is above 250 degrees F. The actuator/operator package shall include two damper position indicator switches linked directly to damper blade to provide capability of remotely indicating damper position. One switch shall close when the damper is fully open, and the other switch shall close when the damper is fully closed. The Firestat/releasing device and position indicator switches shall be capable of interfacing electrically with the smoke detectors, building fire alarm systems, and remote indicating/control stations.
7. The damper releasing device shall be mounted within the airstream. The device shall be activated and the damper shall close and lock when subjected to duct temperatures in excess of approximately 285 degrees F.
8. Motors for operation of smoke dampers shall be smoke system fail safe, spring return normally open supplies and normally closed returns, or as indicated in the plans, and shall be furnished and installed by the damper manufacturer as required by the U.L. rating mentioned above. Motors shall be electric or pneumatic to match the type of temperature control system specified elsewhere in this specification. All required relays, EP switches, wiring piping and other labor and material necessary to completely interconnect the smoke detector system shall be furnished by the Contractor.
9. Each damper shall be furnished in a square or rectangular configuration. The Contractor shall furnish and install sleeves manufactured by the approved damper manufacturer for each damper. The sleeves shall be constructed with square or rectangular to square, rectangular, round, or oval adapters as required. Dampers shall be installed in the sleeves in accordance with manufacturers U.L. installation instructions. The entire assembly, following installation, shall be capable of withstanding 6" W.G. static pressure.
10. All combination fire/smoke dampers shall comply with the specification as written above and shall be Greenheck model FSD-33, Ruskin model FSD-60, Nailor model 1220, or Pottorff model FSD-151.

11. The contractor shall completely seal the assembly to the building components using Hardcast 1602 sealant tape to allow for expansion and contraction of the sleeve and damper assembly.
12. Dampers shall be UL labeled for use in dynamic systems. Closure reading shall be 110% of the maximum design airflow at the point of installation. The minimum closure pressure rating shall be 8" wg for airflow in either direction.

C. Submittal and Installation

1. The air quantity and free area through each fire and combination fire and smoke damper has been noted on the drawing adjacent to the duct size or wall opening size where such damper is required.

NOTE TO ENGINEER: IT SHOULD BE NOTED THAT THE ABOVE PARAGRAPH REQUIRES THAT CERTAIN INFORMATION BE FOUND ON THE DRAWINGS. BE SURE THAT THE INFORMATION REFERENCED DOES IN FACT APPEAR AS DESCRIBED TO AVOID CONFLICTS.

2. Submittal(s) for fire and combination fire/smoke dampers shall include the following:
 - a. Assign identification numbers for each damper with corresponding number noted on the drawings.
 - b. Provide air quantity, size, free area of damper, pressure drop and proposed velocity through each damper.
 - c. Provide manufacturer's data of damper and its accessories or options.
3. One sample 18" x 12" damper shall be furnished for the purpose of illustrating damper operation to the Owner's operating and maintenance personnel.
4. Access doors as specified elsewhere shall be provided to make all parts of the damper accessible. Doors shall open not less than 90 degrees following installation and shall be insulated type where installed in insulated ducts.
5. Contractor shall install each damper square and true to the building. The installation shall not place pressure on the damper frame, but shall enclose the damper as required by UL555.
6. After each fire damper and combination fire and smoke damper has been installed and sealed in their prescribed openings and prior to the installation

of the ceilings, the Contractor shall, as directed by the Construction Inspector, activate part or all the dampers as required to verify "first-time" closure. Activation of the damper shall be accomplished by manually operating the resettable link, disconnecting the linkage at the fusible link of the fire damper, and manually operating the fire/smoke damper through the pneumatic or electronic controls as appropriate. Failure of the damper to close properly and smoothly on the first attempt will be cause to replace the entire damper assembly.

2.03 FLEXIBLE CONNECTIONS

- A. Where ducts connect to fans, including roof exhausters, flexible connections shall be made using Ventglas fabric that is fire-resistant, waterproof, mildew resistant and practically air tight, and shall weigh approximately thirty ounces (30 oz.) per square yard. There shall be a minimum of one-half inch (1/2") slack in the connections, and a minimum of two and one-half inches (2-1/2") distance between the edges of the ducts except that there shall also be a minimum of one inch (1") of slack for each inch of static pressure on the fan system. This does not apply to Air Handling Units with internal isolation.

2.04 ACCESS DOORS

- A. Furnish and install in the ductwork, hinged rectangular or round spin-in access doors to provide access to all fire dampers mixed air plenums, upstream of steam reheat coils, automatic dampers, etc. Where the ducts are insulated, the access doors shall be double skin doors with one inch (1") of insulation in the door. Where the size of the duct permits, the doors shall be eighteen inches (18") by sixteen inches (16"), or eighteen inches in diameter, and shall be provided with Ventlok No. 260 latches (latches are not required in round doors). Latches for rectangular doors smaller than 18" x 16" shall be Ventlok No. 100 or 140. Doors for zone heating coils shall be Ventlok, stamped, insulated access doors, minimum 10" x 12", complete with latch and two (2) hinges, or twelve inches (12") in diameter. Round access doors shall be "Inspector Series" spin-in type door as manufactured by Flexmaster USA, or approved equal. Doors for personnel access to ductwork shall be nominal twenty-four inches (24") in diameter.
- B. Where these access doors are above a suspended ceiling, this Contractor shall be responsible for the proper location of the ceiling access doors.

2.05 SCREENS

- A. Furnish and install screens on all duct, fan, etc., openings furnished by this Contractor that lead to, or are, outdoors. Screens shall be No. 16-gauge, one-half inch (1/2") mesh in removable galvanized steel frame. Provide safety screens meeting OSHA requirements for protection of maintenance personnel on all fan inlets and fan outlets to which no ductwork is connected.

2.06 TEST OPENINGS

- A. Furnish and install in the return air duct and in the discharge duct of each fan unit Ventlok No. 699 instrument test holes. The test holes shall be installed in locations as required to measure pressure drops across each item in the system, e.g., O.A. louvers, filters, fans, coils, intermediate points in duct runs, etc.

2.07 LOW PRESSURE TAPS (Conical Bell Mouth Fittings)

- A. Conical fittings may be used for duct taps and shall include quadrant dampers on all lines to air devices (diffusers and grilles), even though a volume damper is specified for the air device. (This does not apply to medium pressure duct.) Spin-in fittings shall be sealed at the duct tap with a gasket, or compression fit, or sealed with sealant specified for medium pressure ductwork. The location of spin-in fittings in the ducts shall be determined after dual or single duct terminal units are hung or the location of the light fixtures is known to minimize flexible duct lengths and sharp bends.
- B. The conical fitting shall be made of at least 26-gauge galvanized sheet metal. The construction to be a two-piece fitting with a minimum overall length of 6 inches and shall be factory sealed for high pressure requirements. Average loss coefficient for sizes 6, 8, and 10 shall be less than 0.055.
- C. Each fitting shall be provided with a minimum 24-gauge damper plate with locking quadrant operator and sealed end bearings. Damper blade shall be securely attached to shaft to prevent damper from rotating around shaft.
- D. Provide flange and gasket with adhesive peel-back paper for ease of application. The fitting shall be further secured by sheet metal screws spaced evenly at no more than 4 inches on-center with a minimum of four screws per fitting.

- E. The conical bellmouth fitting shall be Series 3000G as manufactured by Flexmaster U.S.A., Inc., or Buckley Air Products, Inc., 'AIR-TITE'.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install accessories in accordance with manufacturer's instructions.
- B. Provide balancing dampers at points on low pressure supply, return, and exhaust systems where branches are taken from larger ducts as required for air balancing. Use splitter dampers only where indicated.
- C. Provide balancing dampers on medium and high pressure systems where indicated. Refer to Section 23 36 00 - Air Terminal Units.
- D. Provide fire dampers, and combination fire and smoke dampers at locations indicated, where ducts and outlets pass through fire rated components. Install with required perimeter mounting angles, sleeves, breakaway duct connections, corrosion resistant springs, bearings, bushings and hinges.
- E. Demonstrate re-setting of fire dampers to Owner's representative.
- F. Provide backdraft dampers on exhaust fans or exhaust ducts where indicated.
- G. Provide flexible connections immediately adjacent to equipment in ducts associated with fans and motorized equipment. Cover connections to medium and high pressure fans with leaded vinyl sheet, held in place with metal straps.
- H. Provide duct access doors for inspection and cleaning before and after duct mounted filters, coils, fans, automatic dampers, at fire dampers, and elsewhere as indicated. Provide minimum 8 x 8 inch (200 x 200 mm) size for hand access, 18 x 18 inch (450 x 450 mm) size for shoulder access, and as indicated.
- I. Provide duct test holes where indicated and where required for testing and balancing purposes. Refer also to Section 23 05 93.B.

END OF SECTION

SECTION 23 34 16
FANS

PART 1 GENERAL

1.00 The following sections are to be included as if written herein:

- A. Section 23 00 00 – Basic Mechanical Requirements
- B. Section 23 05 29 – Sleeves, Flashings, Supports and Anchors
- C. Section 23 05 53 – Mechanical Identification

1.01 SECTION INCLUDES

- A. Backward Inclined Centrifugal Fans
- B. Airfoil Centrifugal Fans
- C. Radial Centrifugal Fans
- D. Tubular Centrifugal Fans
- E. Inline Centrifugal Fans
- F. Utility/Vent Sets
- G. Motors and Drives
- H. Fan Accessories

1.02 RELATED WORK

- A. Section 23 05 13 - Motors
- B. Section 23 05 48 - Vibration Isolation
- C. Section 23 07 13 - Ductwork Insulation
- D. Section 23 29 23 – Variable Speed Drives
- E. Section 23 31 00 - Ductwork
- F. Section 23 33 00 - Ductwork Accessories: Backdraft Dampers

G. Section 23 73 00 - Air Handling Units (Up to 10,000 CFM)

H. Section 26 05 19 - Cable, Wire and Connectors, 600 Volt

I. Section 26 27 26 - Wiring Devices and Floor Boxes

1.03 REFERENCES

A. AFBMA 9 - Load Ratings and Fatigue Life for Ball Bearings

B. AFBMA 11 - Load Ratings and Fatigue Life for Roller Bearings

C. AMCA 99 - Standards Handbook

D. AMCA 210 - Laboratory Methods of Testing Fans for Rating Purposes

E. AMCA 301 - Method of Calculating Fan Sound Ratings from Laboratory Test Data

F. NEMA MG1 - Motors and Generators

G. NFPA 70 - National Electrical Code

H. SMACNA - HVAC Duct Construction Standards - Metal and Flexible

1.04 SUBMITTALS

A. Submit under provisions of Section 23 00 00.

B. Shop Drawings: Indicate assembly of centrifugal fans and accessories including fan curves with specified operating point clearly plotted, sound power levels for both fan inlet and outlet at rated capacity, and electrical characteristics and connection requirements.

C. Product Data: Submittal data for approval for all fans of every description furnished under this section of these Specifications driven by 5 (five) HP and larger motors shall include the following:

1. Fan curves with specified operating point clearly plotted. The recommended range of operation shall be stable.

2. Data to substantiate that fans on double duct systems will operate in a stable range at 1/2" (one-half inch) S.P. above scheduled static pressure with motors sized accordingly.
3. Fans shall be capable of operating stably at reduced loads imposed by means of variable speed drives.
4. Data on sound power levels for both fan inlet and outlet at rated capacity.
5. Electrical characteristics and connection requirements.
6. All data on fan accessories.

D. Manufacturer's Installation Instructions.

1.05 OPERATION AND MAINTENANCE DATA

- A. Submit under provisions of Section 23 00 00.
- B. Maintenance Data: Include instructions for lubrication, motor and drive replacement, spare parts list, and wiring diagrams.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Deliver, store, protect and handle products to site under provisions of Section 23 00 00.
- B. Protect motors, shafts, and bearings from weather and construction dust.

1.07 ENVIRONMENTAL REQUIREMENTS

- A. Do not operate fans for any purpose until ductwork is clean, filters in place, bearings lubricated, and fan has been test run under observation.

1.08 EXTRA MATERIALS

- A. Furnish under provisions of Section 23 00 00.
- B. Provide two sets of belts for each fan, not including the set installed on the fans. Tag sets to identify fan.

PART 2 PRODUCTS

2.01 GENERAL

- A. Performance Ratings: Conform to AMCA 210 and bear the AMCA Certified Rating Seal.
- B. Sound Ratings: AMCA 301, tested to AMCA 300, and bear AMCA Certified Sound Rating Seal.
- C. Fabrication: Conform to AMCA 99.
- D. Performance Base: Sea level conditions.
- E. Temperature Limit: Maximum 300 degrees F.
- F. Static and Dynamic Balance: Eliminate vibration or noise transmission to occupied areas.

2.02 EXHAUST FANS:

- A. Belted vent set exhaust fans shall be Chicago Blower, Buffalo Forge, Acme, Greenheck, Twin Cities, Cook, or approved equal. The fans shall be complete with belt guards, heavy-duty gravity shutters, vari-speed drives, drain holes in scroll, flanged inlet and outlet connections, etc. Motor mounts shall be adjustable for proper alignment and adjustment of belts. Furnish with a factory applied prime coat of paint. Fans shall be AMCA rated.
- B. Centrifugal exhaust fans shall be Chicago Blower, Buffalo Forge, Twin Cities, Cook, or approved equal, single inlet, single width belted vent fans conforming to the following requirements.
 - 1. Fans, as shown on the Drawings and having the capacities, characteristics and starting equipment shown in the schedule, shall be V-belt driven and of the centrifugal type, especially selected for ventilating work. The fans shall run in perfect balance at all speeds, up to a 15% increase above the speeds indicated in the schedule, without noise or vibration in fan or motor. Fan wheels shall be made with backward pitched blades. Blades shall be die-formed, true in shape and held in place by rivets or weld.
 - 2. Fans shall be provided with antifriction bearing of the types specified herein. Shafts shall be made of the best quality steel, turned and ground to close tolerance and shall run true and in perfect balance.
 - 3. Fans shall be arranged for multiple V-belt drive and shall be furnished complete with Vari-Pitch sheaves for single or two belt drives and fixed

sheaves for three or more belt drives. Furnish a second fixed sheave for final balancing of size as determined after job operating conditions are known.

4. Fans and motors shall be mounted on a common floating base. See Vibration Isolation Specification, Section 23 05 48.
- C. Industrial exhaust air fans shall be Aladdin Series 2000 or approved equal. The fan shall be complete with belt guards, access doors, etc. Motor mounts shall be adjustable for proper alignment and adjustment of belts. Fan wheel shall be all welded construction with backwardly inclined blades. Bearings shall be heavy-duty pillow block type, self-aligning, grease lubricated ball bearings. Furnish with a factory applied prime coat of paint. Fan shall be AMCA rated for high static pressure and low air quantities.
- D. Inline exhaust fans shall be Woods or Buffalo Forge, in line centrifugal or vane axial as approved. Capacity ratings shall be based upon tests performed in accordance with AMCA Standard 210. Each fan shall carry near the unit nameplate the AMCA seal indicating that capacity ratings are certified. Housings for all inline fans shall be of 14-gauge steel minimum and shall have square mounting frame of heavy steel angle to provide for mounting of fan. The fan housing will provide for slip joint duct connection. Fan wheels shall be axial flow type with cast aluminum blades or tubular centrifugal type constructed of welded steel and have airfoil shaped blades. The fan shall be dynamically balanced for smooth operation. The fan shaft shall be solid be solid steel AISI-C1040 keyed to the fan wheel. Grease lubricated bearings shall be selected for a minimum average life in excess of B-10, minimum life 40,000 hours at maximum catalogued operating conditions. Fans shall be provided with factory mounted inlet and outlet sound attenuators when required to meet the scheduled sound power levels. The increased pressure drop due to attenuation must not cause an increase in power requirements from those specified. If oversized slow speed units are required, the Contractor shall be responsible for any related extra costs, not coming under his contract.
- E. Propeller or centrifugal roof exhaust air fans shall be Greenheck, Penn, Jenn Air, Cook, or approved equal. The fans shall be complete with fans and motors, propeller, motorized shutters factory wired to open when fans are in operation and close when fans are not in operation, nonfused disconnect switches, bird screens, and round spun aluminum weatherproof protection covers. Fans shall be all aluminum. The fans shall be firmly bolted to the curb on which they rest. Fans shall be AMCA rated. Wing nuts of nonferrous construction shall be provided to remove covers.

- F. Propeller wall fans shall be Chicago Blower, Buffalo Forge, Twin Cities, Cook, or approved equal, belt or direct driven as scheduled on the Drawings. The fans shall be complete with guards over motor side, heavy-duty gravity shutters, etc. Furnish with a factory applied prime coat of paint. Fans shall be AMCA rated.

2.03 RETURN AIR FANS:

- A. Centrifugal return air fans shall be Buffalo Forge, Chicago Blower, New York Blower, Twin Cities, Greenheck, Cook, or approved equal, DWDI and Class II or above as scheduled; belt drive fans conforming to the following requirements.
 - 1. Fans, as shown on the Drawings and having the capacities, characteristics and starting equipment shown on the schedule, shall be belt driven and of the centrifugal type, especially selected for ventilating work. The fans shall run in perfect balance at all speeds, up to a 15% increase above the speeds indicated on the schedule, without noise or vibration in any fan or motor. Fan wheels shall be made with FC, BI or airfoil blades as scheduled. Blades shall be die-formed, true to shape and held in place by rivets or welds. Fan shaft shall not reduce in diameter at the outboard bearing (opposite of drive end).
 - 2. Fans shall be provided with antifriction bearing of the types specified herein. Shafts shall be made of the best quality steel, turned and ground to close tolerance and shall run true and in perfect balance.
 - 3. Fans shall be provided with quick opening access doors in the fan scroll.
 - 4. Fans shall be arranged for multiple V-belt drive and shall be furnished complete with Vari-Pitch sheaves for single or two belt drives and fixed sheaves for three or more belt drives. Furnish a second fixed sheave for final balancing of size as determined after job operating conditions are known.
 - 5. Fans and motors shall be mounted on a common pad. See Vibration Isolation Specification, Section 23 05 48.
 - 6. Fan belt guards shall be constructed with heavy steel angle frames and wire mesh panels. Guard shall be removable (four bolt max., or equivalent secure quick dismount) for easy access to belts and pulleys.

2.04 V-BELT DRIVES:

- A. All v-belt drives shall be designed for a minimum of 50% overload. Where more than one belt is required, matched sets shall be used. All belt drives shall be furnished with belt guards.

2.05 RELIEFS:

- A. The relief shall be as manufactured by the supplier of the roof exhausters and shall match, as closely as possible, their silhouette. Furnish complete with bird screen.

2.06 MOTORS:

- A. Refer to Section 23 05 13 for requirements.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install fans with resilient mountings and flexible electrical leads. Refer to Section 23 05 48.
- C. Install flexible connections specified in Section 23 33 00 between fan inlet and discharge ductwork. Ensure metal bands of connectors are parallel with minimum one-inch flex between ductwork and fan while running.
- D. Install fan restraining snubbers as required. Refer to Section 23 05 48. Adjust snubbers to prevent tension in flexible connectors when fan is operating.
- E. Provide fixed sheaves required for final air balance.
- F. Provide safety screen or cage where inlet or outlet is exposed. Plug fans inside walk-in casings shall be provided with hinged safety cage.
- G. Pipe scroll drains over to nearest floor or roof drain.
- H. Provide backdraft dampers on discharge of exhaust fans where indicated. Refer to Section 23 33 00.
- I. Unless specified elsewhere, the fan manufacturer shall dynamically balance the fan with the fan set in place, leveled, and ductwork attached, to a vibration velocity less than or equal to 0.200 inches (0.100 inches for direct-drive applications) per second measured on horizontal, vertical, and axial planes at each bearing pad.

Vibration amplitudes are in inches/second peak velocity. All values recorded are to be filter-in at the fan speed. Confirm the fan/motor vibration velocity limit over the following operating speed range: Fans with VFDs shall be checked from 40 to 110% of rated fan speed. Constant speed fans shall be checked at 100% of rated fan speed. 'Lock-out' ranges may be used to correct up to two ranges of excess vibration. The span of each 'lock-out' range shall be limited to an effective fan speed of 50 RPM. Any 'lock-out' range used shall be clearly identified in the test report and shall be prominently displayed on a typed, laminated legend mounted inside the VFD controller cabinet. This testing shall be witnessed by a representative of the Owner's Test and Balance Consultant.

- J. Failure to confirm vibration velocity limit shall require re-balancing and re-testing until criteria is met. Contractor shall bear all costs involved in the modifications, balancing, and re-testing, including travel and hourly costs associated with the Owner's Test and Balance firm's consultant.

END OF SECTION

SECTION 23 36 00
AIR TERMINAL UNITS (VAV)

PART 1 GENERAL

1.00 The following sections are to be included as if written herein:

- A. 23 00 00 -- Basic Mechanical Requirements
- B. 23 05 29 -- Sleeves, Flashings, Supports and Anchors
- C. 23 05 53 -- Mechanical Identification

1.01 SECTION INCLUDES

- A. Constant Volume Terminal Units
- B. Variable Volume Terminal Units
- C. Dual Duct Terminal Units
- D. Single Duct Terminal Units
- E. Variable Volume Regulators
- F. Integral Sound Attenuator
- G. Integral Heating Coils
- H. Integral Damper Motor Operators
- I. Integral Controls

1.02 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION

- A. Section 23 09 00 - Controls and Instrumentation: Thermostats and Control Components
- B. Section 23 05 93.A - Testing, Adjusting and Balancing
- C. Section 26 05 19 - Cable, Wire and Connectors, 600 Volt
- D. Section 26 27 26 - Wiring Devices and Floor Boxes

1.03 RELATED SECTIONS

- A. Section 23 05 13 - Motors
- B. Section 23 21 00 - Hydronic Piping: Connections to Heating Coils
- C. Section 23 06 20.13 - Hydronic Specialties: Connections to Heating Coils
- D. Section 23 31 00 - Ductwork
- E. Section 23 33 00 - Ductwork Accessories
- F. Section 23 37 00 - Air Outlets and Inlets
- G. Section 23 09 00 - Controls and Instrumentation
- H. Section 23 05 93.A - Testing, Adjusting and Balancing
- I. Section 26 05 19 - Cable, Wire and Connectors, 600 Volt
- J. Section 26 27 26 - Wiring Devices and Floor Boxes

1.04 REFERENCES

- A. NFPA 90A - Installation of Air Conditioning and Ventilation Systems
- B. UL 181 - Factory-Made Air Ducts and Connectors
- C. ADC 1062 - Air Distribution and Control Device Test Code
- D. ARI 880 - Standard for Air Terminals

1.05 SUBMITTALS

- A. Submit shop drawings under provisions of Section 23 00 00.
- B. Submit shop drawings indicating configuration, general assembly, and materials used in fabrication.
- C. Submit product data under provisions of Section 23 00 00.
- D. Submit product data indicating configuration, general assembly, and materials used in fabrication. Include catalog performance ratings which indicate airflow, static pressure, and NC designation.
- E. Include schedules listing discharge and radiated sound power level for each of second through seventh octave bands at inlet static pressures of one inch wg.

- F. Submit Manufacturer's installation instructions under provisions of Section 23 00 00.
- G. A sample 8-inch size production run unit shall be submitted for examination and approval by the Engineer, RCM office and the Owner's Testing and Balancing (TAB) Consultant. This submittal box shall be submitted, in addition to the required written submittal, well in advance of any requirement for installation of boxes, but absolutely no later than 60 days after the date of the start of construction stipulated in the Work Order letter from the Owner to the General Contractor. A minimum of three weeks shall be allowed by the Contractor for the testing of the box from the time of submittal to the time of determination of project worthiness. This period shall restart if the sample box is rejected and another box is resubmitted. If rejected for any reason, the Contractor shall expedite the corrections documented, and shall resubmit a sample box as soon as possible. Any delay in the submittal of the box for approval shall not be grounds for a claim of delay on the part of the Contractor. If approved, the unit shall remain in the possession of the Owner at the job site for comparison with units as shipped to project. The unit shall be installed in the project, at an accessible, marked location. The unit Manufacturer shall test and certify that each box used on this project has been tested as specified.

1.06 OPERATION AND MAINTENANCE DATA

- A. Submit operation and maintenance data under provisions of Section 23 00 00.
- B. Include Manufacturer's descriptive literature, operating instructions, maintenance and repair data, and parts lists.

1.07 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing the products specified in this section with minimum three years' documented experience.

1.08 WARRANTY

- A. Provide one-year Manufacturer's warranty under provisions of Section 23 00 00.

PART 2 PRODUCTS

2.01 VARIABLE OR CONSTANT VOLUME TERMINAL UNITS:

NOTE TO THE ENGINEER: CARE SHALL BE TAKEN IN DESIGNING THE SYSTEMS USING DUAL DUCT TERMINAL UNITS. THE UNITS SHALL BE SHOWN TO SCALE ON THE PLANS, WITH A MINIMUM OF FOUR DIAMETERS OF STRAIGHT DUCT ENTERING THE UNITS. THE MEDIUM PRESSURE SUPPLY DUCTWORK SHALL BE DESIGNED WITH THE MINIMUM OF BENDS AND TURNS, SO THAT STATIC LOSS WILL BE KEPT TO A MINIMUM.

The Contractor shall furnish and install pressure independent dual and/or single duct variable air volume control assemblies with integral attenuator (single duct units) and attenuator-mixers (dual duct units), of the sizes, capacities and configurations shown on the Drawings.

A. CASING CONSTRUCTION:

1. The units shall be constructed of a minimum of 22-gauge galvanized steel and internally lined with a minimum of 1 inch thick, three pound per cubic foot density insulation. The insulation shall be foil faced with the edges and seams sealed or "captured", encapsulating all fibers of the insulation. The insulation shall be neatly installed with no rough edges to interrupt the smooth flow of air through the box. Closed cell polymer insulation may be used instead of the fiberglass described above if UL 25/50 labeled. The casing shall be insulated throughout its interior, up to or at least to within 2" of the heating coil connection. Insulation for the heating coil shall enclose the coil casing and tube bends and shall overlap the box internal lining by at least 3". The external insulation shall be as specified in other sections of this specification for duct insulation with full vapor barrier, and shall be field installed unless coil and plenum section is furnished as an integral part of the box.
2. All interior features of the boxes (such as mixing baffles, damper housings, etc.) shall be secured within the casing to avoid excessive movement or rattling with air movement or externally generated vibration. All external features of the terminal units shall be designed not to extend beyond the ends of the unit. (For example, the actuator mounting brackets, etc. shall not extend beyond the plane of the inlet "bulkhead.") The only exception shall be flow sensors installed in the inlet duct connections. Note that if a separate flow station is installed within a frame within the casing, then it shall be so installed not to allow airflow to bypass the flow measurement station.
3. The terminal units shall be constructed with inlet and discharge ductwork connections. The inlet ductwork connections shall extend a minimum of 4

inches from the unit casing including an allowance for the installation of airflow station(s) or probe(s). The discharge connection shall include 1" extension with slip and drive connections for use by the Contractor to secure the discharge ductwork or appurtenances to the unit and shall be reinforced to provide a rigid assembly.

- B. CASING LEAKAGE: Assembled units shall be so constructed and sealed to limit air leakage to the following listed quantities at 6" static pressure. If sealing is required to obtain the leakage performance, seal as for medium pressure ductwork Hardcast 1602 tape may be used to seal lap joints and flat seams only. Leakage curves or tables will be required as part of the submittal data. The following is the maximum allowable casing leakage including all components:

<u>Diameter</u>	<u>Maximum Allowed CFM (Area x 2000 fpm)</u>	<u>Maximum Allowable CFM Casing Leakage</u>
4"-5"-6"	393	8.0
7"-8"	698	14.0
9"-10"	1091	22.0
11"-12"	1571	30.0
13"-14"	2138	40.0

- C. ACCESS PLENUM AND DOOR: Single duct units provided with reheat coils also shall be provided with an access section or plenum between the terminal and the coil for coil inspection. The construction of the plenum shall be equal to the quality of materials and workmanship to that of the terminal unit. The access plenum may also be used as a transition, and shall be constructed with a transition angle not to exceed 15 degrees. The access plenum shall contain a minimum of a 12 inch diameter or 12 inch by 12 inch (or full width of unit if less than 12") access door as manufactured by Ventlok, Flexmaster Inspector, Ward or equal. Door frame may be bolted, screwed or flanged and sealed to the casing. Door shall be gasketed and shall be double wall construction or insulated similar to main casing. Door shall be held in place with latches or other captive retainer devices. An additional access panel shall be provided immediately downstream of the dampers for inspection and service of the dampers. If the damper assembly is easily removed from the rear of the box, the access size can be reduced to 8" round or 8" x 8" for inspection only.

- D. DAMPER CONSTRUCTION: The damper blades shall be an equivalent of 18-gauge galvanized steel or equal aluminum and shall be securely riveted or bolted through the damper shafts to assure no slippage of the blades. The damper shafts shall operate in rust-proof self-lubricating bearings. Damper shafts penetrating the unit casings shall be sealed against leakage, and bearings shall be installed for protection against wear in the casing penetration. Damper shafts shall be formed of, or cut from solid stock; no hollow shafts will be allowed. The dampers shall seat against gasketed stops or the dampers shall have gasketed edges. Gaskets shall be

mechanically fastened to the blades. If the fastening method is not full contact clamping type, then the addition of adhesive to the gasket shall be required. The dampers shall be so constructed to prevent "oil canning" of the damper blade. The units shall be tested for leakage in both inlets with 6" static pressure imposed on one inlet at a time. The maximum percent leakage from all tests shall be reported. Leakage curves as a function of pressure shall be supplied as part of the submittal data. The damper actuator linkage, if used, shall be constructed of material of sufficient strength to avoid buckling under extreme loads. Also, linkages shall not allow play greater than 5 degrees of damper movement. The controls for the dampers shall cause the dampers to fail in the position of last control (freeze in place), or fail to the open position.

- E. DAMPER LEAKAGE: The following is the maximum damper leakage allowable for the various size diameter inlets at 6" wg differential pressure. The damper leakage shall not exceed the values listed in the table below at 6" S.P., following ARI 880 Testing Procedures.

<u>Diameter</u>	<u>Maximum Allowed CFM (Area x 2000 fpm)</u>	<u>Maximum Allowable CFM Damper Leakage</u>
4"-5"-6"	393	6.0
7"-8"	698	10.5
9"-10"	1091	16.5
11"-12"	1571	20.0
13"-14"	2138	30.0

- F. UNIT PRESSURE DROP: For dual duct units with an integral attenuator-mixer, but with no other accessories, the static pressure across the assembly with an equivalent 2000 fpm inlet velocity through one inlet shall not exceed 0.50 inches water gauge, with the total flow through either inlet. Single duct unit pressure drop shall be limited to 0.15 inches water gauge under the same conditions above.

- G. CERTIFICATION: The Unit Manufacturer shall certify that each unit used on this project will perform as specified. Each unit shall bear a tag or decal listing the following specified information:

1. Test Pressure
2. Leakage CFM (damper)
3. Leakage CFM (casing)
4. Date of Mfg.
5. Room or area served
6. Unit size - 6", 8", etc.
7. Calibrated CFM, i.e. 800 CFM

- H. MIXING: Terminal units as specified herein shall provide mixing within the units, and not rely upon the discharge ductwork to provide for the completion of the mixing process. The horizontal average temperature of the air as it leaves the terminal unit shall not vary more than 1°F for each 20°F. of temperature difference between the two inlet air supplies. (For example, if the cold supply air is 55°F. and the hot supply air is 95°F., the difference is 40 degrees. The allowable temperature variation of the discharge air is, thus, 2°F.) The temperature of the discharge air shall be measured using a pattern of four vertical, evenly spaced columns, and three horizontal, evenly spaced rows. The rows and columns shall be spaced so that the resulting 12 points shall be at the centers of equal areas. The plane of the points shall be perpendicular to the direction of airflow, within 4 inches of the discharge of the terminal unit, within the discharge ductwork. The three readings in each column shall be averaged to determine compliance with the 1° criteria.
- I. FLOW MEASUREMENT: Airflow thru the unit shall be accomplished by the use of a multi-port sensing device with a minimum of four radially distributed pick-up points connected to a center averaging chamber with adequate internal passages to prevent restrictions that can result in control ‘hunting’. On all systems, sensors shall be mounted as required by the temperature controls supplier.
- J. SOUND: (Note that the maximum sound levels listed in this paragraph refer to raw sound levels, with no credits taken for the construction.)

1. DISCHARGE SOUND

Maximum discharge Sound Power Levels at 2000 fpm primary air inlet velocity with 1.5 inch wg inlet static pressure shall not exceed that listed in the following table. No credit for lined discharge duct, branching, flow division, end reflection, room absorption or any other effects shall be allowed.

Octave Band (Hz)	Center Frequency (dB re 10 ⁻¹² Watts)	Sound Power Level
2	125	76
3	250	66
4	500	63
5	1000	58
6	2000	60
7	4000	55

2. RADIATED SOUND

Maximum discharge Sound Power Levels at 2000 fpm primary air inlet velocity with 1.5 inch wg inlet static pressure shall not exceed that listed in the following table. No credit for ceiling plenum, ceiling tiles, room absorption, or any other effects shall be allowed.

Octave Band (Hz)	Center Frequency (dB re 10 ⁻¹² Watts)	Sound Power Level
2	125	72
3	250	67
4	500	64
5	1000	54
6	2000	47
7	4000	45

All sound power levels shall be obtained from testing in accordance with ARI-ADC Standard 880 and shall be certified at ARI-880 certification points.

K. TESTING PRIOR TO INSTALLATION:

NOTE TO ENGINEER: SELECT THE APPROPRIATE PASSAGES OF THE FOLLOWING PARAGRAPH TO FIT THE PROJECT.

1. SHIPMENT TESTING: A minimum of ten percent (10%) of each size of the terminal units (but no less than one unit of each size used) may be tested for conformance to this specification, at the Owner's discretion. The Contractor shall allow sufficient time during construction and space for the Owner's TAB Consultant to perform all testing as may be required.
2. UNIT NON-PERFORMANCE:
 - a. If the results of the SHIPMENT TESTING show that any of the units do not perform as specified, then an additional ten percent (10%) of each size (but no less than one unit of a size, unless 100% of the size has been tested) of the units shall be tested. If this testing, in the Owner's opinion, shows that ten percent (10%) or more of the units tested do not perform as specified, then one hundred percent (100%) of all sizes of the units shall be tested for conformance with these specifications. The results of that testing shall be reviewed carefully between the Contractor, Manufacturer, the Owner's construction administrator(s), and the Owner's design engineer(s). A method of repair or replacing the units will be negotiated. The Owner,

however, shall maintain the right of final approval of any proposed solution.

- b. Should for any reason the testing described above under "SUBMITTAL" and "SHIPMENT TESTING" prove that any of the units do not perform as specified, the Contractor shall be responsible for all subsequent labor, travel, travel expenses, and incidental expenses, penalties, or other costs attendant to any additional testing as described under "UNIT NON-PERFORMANCE", or as required to prove that the units perform as specified. This shall include, but not be limited to, the labor, travel and reasonable incidental expenses of not only the Contractor and Owner's TAB Consultant, but also those incurred by the Owner as may be specifically required for this purpose. The expenses to be reimbursed to the Owner shall be labor at a rate of \$300 per day or any portion of a day, plus travel and travel expenses at actual cost, plus reasonable incidental expenses at actual cost.
- L. MANUFACTURER: All Terminal Units shall be as manufactured by Titus (Model MDV-3100-UT or MDC-3100-UT), Metal*Aire (Series TH500-ECO or Series 400DDUT), or Nailor Industries (3000-UT or 3200-UT), or Price Industries. *Note that the model and series numbers listed may differ slightly from catalogue information.* No other Manufacturers or models are acceptable. Even though specific Manufacturers may be named herein, the material supplied by any approved Manufacturer shall meet all of the provisions of this specification without exception.

NOTE TO ENGINEER: EDIT OUT EITHER THE SPEC FOR THE PNEUMATIC OR THE DDC CONTROL SYSTEMS AS APPLICABLE TO THE PARTICULAR PROJECT AT HAND.

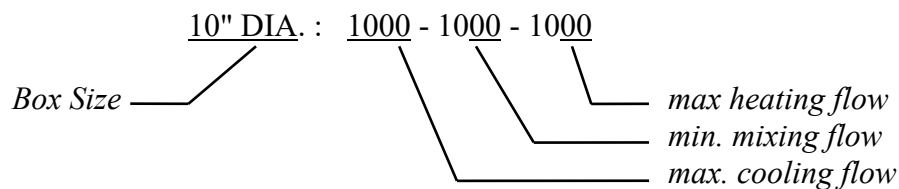
- M. GENERAL PERFORMANCE: Devices using mechanical CFM limiters will not be accepted, nor shall it be necessary to change control components to make airflow rate changes. If used, pneumatic actuator motors, pneumatic controllers, and pneumatic or DDC flow stations shall be furnished, mounted and adjusted by the terminal unit assembly Manufacturer to assure their proper placement within the units. It shall be noted that the terminal unit Manufacturer shall be responsible for the workmanship and materials of the entire assembly of unit and controls if pneumatic controls are specified and supplied with the unit. If DDC controls of another Manufacturer (NOT the terminal unit Manufacturer) are provided for this project, the terminal unit Manufacturer shall be responsible only for the construction of the terminal unit and the installation of internal control components installed at the Manufacturer's factory, and shall not be responsible for the installation of controls not installed at the terminal unit Manufacturer's factory, nor shall the Manufacturer be responsible for the performance of the DDC controls. The performance of DDC controls, especially in connection with terminal units, shall be the responsibility of the DDC controls Manufacturer.

- N. **HOT WATER COILS:** Hot water coils installed in conjunction with single duct terminal units shall be factory installed, one or two row with a maximum of 10 aluminum fins per inch. Air side pressure drop shall be limited to 0.2" wg at box rated cold airflow. Full fin collars shall be provided for accurate fin spacing and maximum fin-to-tube contact. Tubes shall be 1/2 inch diameter seamless copper with a minimum wall thickness of 0.016 inch, tested at 300 psig air pressure under water with a minimum rated burst pressure of 1500 psig. Male sweat-type water connections shall be provided. Side and end plates shall be a minimum of 18-gauge galvanized sheet metal construction. All coils shall be constructed and tested in accordance with UL and/or ARI Standards. The tube ends shall be protected with tube end caps of sheet metal similar to the casing material, and shall be insulated within the caps.
- O. **CONTROL PERFORMANCE:** Assemblies shall be able to be reset to any airflow between zero and the maximum cfm shown on Drawings. To allow for maximum flexibility and future changes, it shall be necessary to make only simple screwdriver or keyboard adjustments to arrange each unit for any maximum airflow within the ranges for each inlet size as scheduled on the Drawings. The control devices shall be designed to maintain the desired flow regardless of inlet flow deflection. All terminal units shall be installed with a minimum of four diameters of straight duct directly prior to the entry into each terminal unit connection and of the same size as the box connection.
- P. **CONTROL SEQUENCES:** The control sequence arrangements shall be as described below, whether the controls used on this project are pneumatic or DDC, and the terminal units shall be shipped from the Manufacturer with all necessary control devices to accomplish each sequence, except as may be prohibited by the controls Manufacturer. The desired sequence shall be adjustable according to space usage or a change in space conditions.

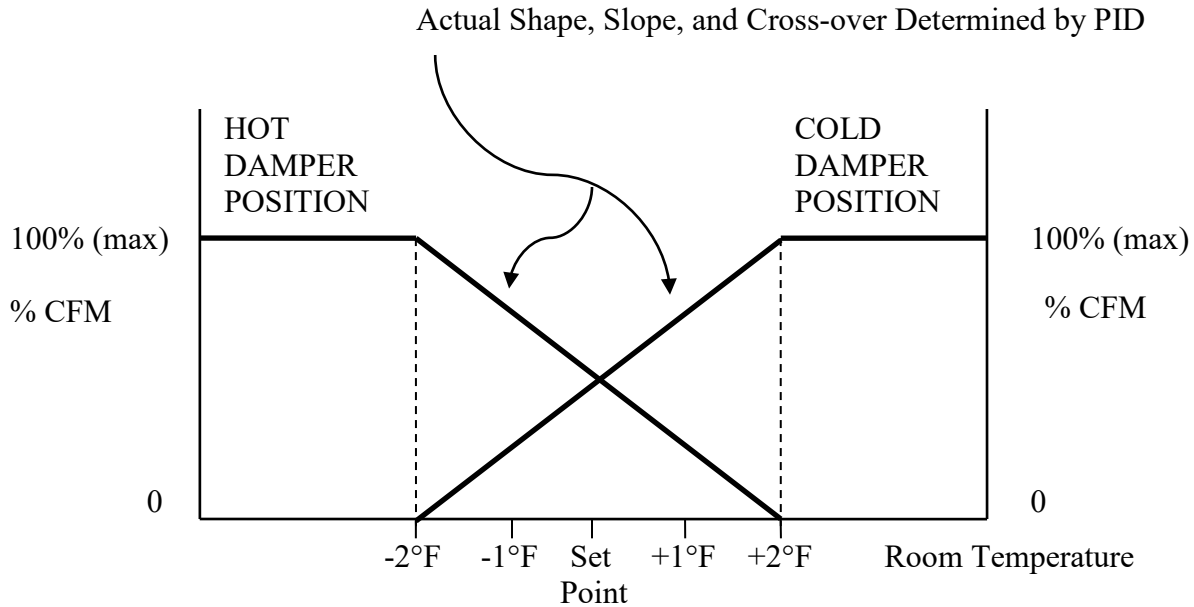
NOTE TO ENGINEER: INCLUDE IN THE DRAWINGS NOTES THAT INDICATE THAT THE VAV BOXES SHALL HAVE FLOW RATES AS INDICATED BELOW. THE "MINIMUM" FLOW IN THE VAV MODE SHALL ALWAYS BE NO GREATER THAN 30 PERCENT OF THE MAXIMUM, EXCEPT WHERE A GREATER FLOW IS NEEDED TO PROVIDE FOR THE MINIMUM SPACE AIR CHANGE REQUIREMENTS.

Constant Volume

Note: Inlets are same diameter.

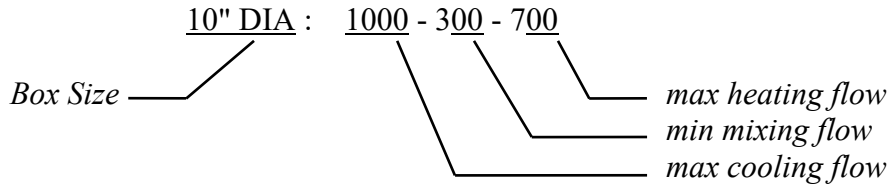


450 fpm min., 2000 fpm max inlet velocity



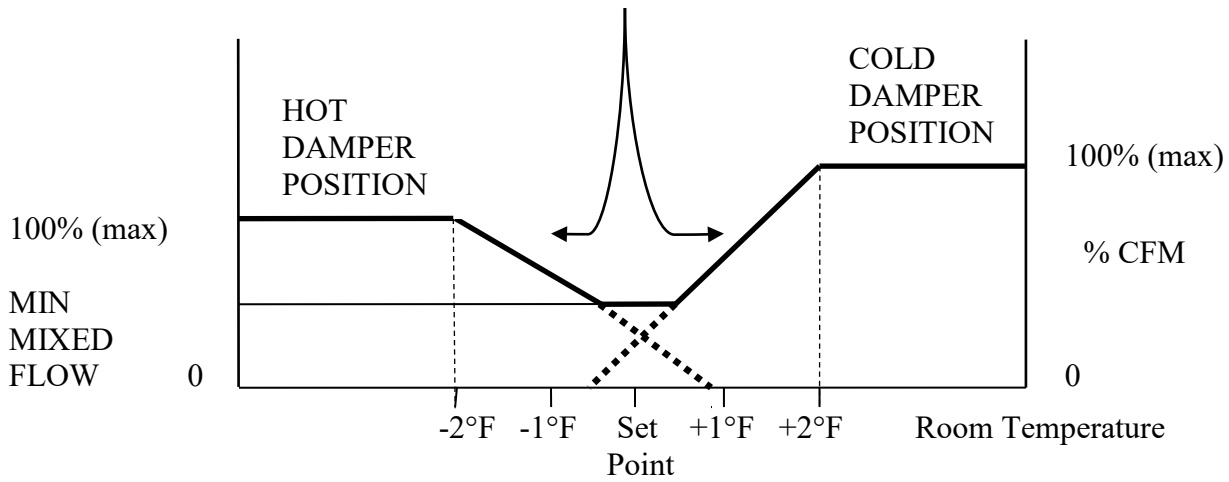
Constant volume operation with full mixing of hot and cold air flow between demands for full heating and full cooling, with adjustable total air flow. The terminal control assembly shall not allow excessive hot air flow to be delivered to the space if the pressure in the cold duct becomes less than design during the mixing or full cooling demand. Therefore, depending on the type of controls, the maximum hot air supplied may necessarily be slightly less than the maximum cold air supplied.

Variable Volume – Dual Duct



450 fpm min., 2000 fpm max. inlet velocity

Actual Shape, Slope, and Cross-over Determined by PID

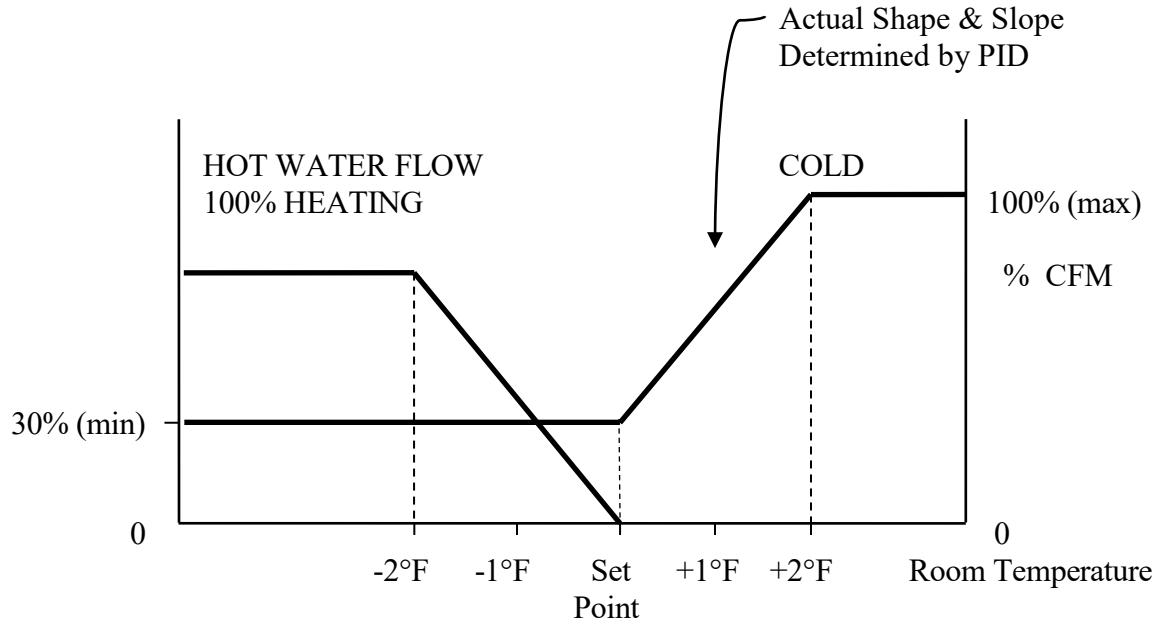


Separate maximum CFM values for hot and cold ducts with zero minimum flow for both hot and cold ducts, with adjustable mixing of hot and cold airflow to allow for adjustable minimum total airflow from the terminal unit. Refer to terminal unit schedule for minimum mixed flow.

Single Duct Units - VAV

Box Size 10" DIA. : 800/300 max/min cooling flow

450 fpm min., 2000 fpm max. inlet velocity



Increasing CFM value for cold air supply occurs only when the hot water valve is fully closed. The hot water valve stays in the closed position (normally closed valve) until the cold supply air reaches its minimum. The hot water flow then increases until reaching its maximum scheduled flow. Note that the minimum air flow is shown as 30 percent of the nominal air flow for the individual terminal unit. Refer to terminal unit schedule for minimum air flow.

Q. PNEUMATIC CONTROL SYSTEMS:

1. Required field pneumatic control air connections by the temperature control Contractor shall consist of one (1) 20 psig main air connection at the double duct assembly and one (1) thermostat signal line at the double duct assembly. All interconnecting tubing between the heating and cooling sides of the assembly is to be installed by the box Manufacturer. A calibration chart and piping diagram shall be submitted for approval. A copy of the approved color-coded piping diagram shall be attached to the side of the unit near the cold duct valve.

2. Pneumatic actuators and controllers shall be selected to operate with a 20 psi main air supply. Only barbed brass pneumatic tubing connectors shall be used. Actuators, flow sensors and controllers shall be pre-piped such that there is one point of connection of main and of branch air lines by temperature control Contractor. Separate external total pressure and static pressure taps shall be provided for connection to a differential pressure gauge for field determination of airflow quantity. To provide for maximum airflow from unit inlet ducts at each unit in the event of control air failure, the units are to be arranged so that all inlet dampers fail to the open position (normally open).
3. The actuators shall be pneumatic piston type with rolling diaphragm and all metal body. Plastic bodied actuators may be used only if specifically approved during the submittal process, and if the plastic bodied actuator is enclosed in a protective metal cover. Note that actuators that combine metal and plastic in the actuator body and/or end cap are not acceptable. Each operator shall be fully proportional type to operate under normal operating conditions to guarantee closure to the position set on the linkage by the terminal unit assembly Manufacturer. The following Manufacturers of pneumatic actuators are acceptable: Kreuter (Model No. 36313), Johnson, and Powers. In all cases, 5 to 10 psi spring ranges are required, and in all cases the pneumatic actuator with damper linkages shall develop 40 in-lbs of torque at the damper shaft, at 10 psi pneumatic pressure. The actuator shall operate smoothly throughout its sequence of operation.
4. The volume controller shall constantly monitor thermostat input, airflow quantity, and system static and total pressure in a manner such that input data is processed and analyzed and the damper actuator is energized to obtain the required system conditions. The results of the damper movement shall be sent as signals through a feedback loop to the controller for evaluation and correction. Minor variations in load and system conditions are to be sensed immediately and acted upon, so that hunting and over controlling are minimized. The pneumatic consumption for the operation of each pneumatic controller shall not exceed 0.025 scfm at 20 psi (with normally open dampers).
5. In the event of malfunction of the volume controller, it shall be possible to service the device from the outside of the assembly. Assemblies with a control arrangement necessitating disassembly of the ductwork from the terminal unit to gain access to integral working parts of the volume controller will be unacceptable.
6. It is required that total versatility in sequence of operation shall be available with the variable volume terminal units. All necessary sequencers, switching and reversing relays, etc., shall be provided with the terminal units as

shipped from the Manufacturer to allow any of the herein described operational modes with only simple screwdriver adjustments for selection of the desired mode. The reset span of the pneumatic volume controller shall be 5 psi for all maximum and minimum airflow rate settings, and the "start" point of the reset span shall be field adjustable but factory set.

R. DDC SYSTEMS:

1. Electronic motors and controllers shall be installed by the terminal unit Manufacturer unless specifically prohibited by the by the controls Manufacturer. In such an event, the controls Manufacturer shall be responsible for the installation of the controls. The controls Manufacturer shall be responsible for the operational performance of the entire system. The terminal unit Manufacturer shall remain responsible only for the performance of the mechanical components of the unit.
2. DDC Controls Protocol/Description:

NOTE TO SPECIFICATION WRITER: INSERT THE APPROPRIATE DDC CONTROLS PROTOCOL/DESCRIPTION HERE.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Refer also to requirements included in Part 2 of this specification.
- B. Install in accordance with Manufacturer's instructions.
- C. Provide ceiling access doors or locate units above easily removable ceiling components.
- D. Support units individually from structure. Do not support from adjacent ductwork.
- E. Connect to ductwork in accordance with Section 23 31 00.
- F. Install heating coils in accordance with Section 23 82 16.

3.02 TERMINAL UNIT SCHEDULE

NOTE TO SPECIFICATION WRITER: THE FOLLOWING TABLE EXAMPLES SHALL BE USED TO DESCRIBE THE UNITS BY SIZE CLASS AS WELL AS INDIVIDUAL UNITS. TABLE INCLUDED HERE FOR INFORMATION. FINAL SCHEDULE TO BE PLACED ON THE DRAWINGS.

SCHEDULE INDICATED HERE FOR INFORMATION ONLY - PLACE
SCHEDULE DATA ON DRAWINGS.

Drawing Code TU-1 TU-2 TU-3 TU-4

Location

Service

Manufacturer

Model Number

Airflow Range

Minimum

Maximum

Coil at Minimum Air

Heat Output

Entering Air Temp

Air Temp Rise

Number of Rows

Entering Water Temp

Leaving Water Temp

Electric Input

END OF SECTION

SECTION 23 36 00.A
AIR TERMINAL UNITS (FPVAV)

PART 1 GENERAL

1.00 The following sections are to be included as if written herein:

- A. Section 23 00 00 – Basic Mechanical Requirements
- B. Section 23 05 29 – Sleeves, Flashings, Supports and Anchors
- C. Section 23 05 53 – Mechanical Identification

1.01 SECTION INCLUDES

- A. Fan-Powered Variable Volume (VAV) Terminal Units
- B. Variable Volume Regulators
- C. Integral Sound Attenuator
- D. Integral Controls

1.02 RELATED SECTIONS

- A. Section 23 05 13 - Motors
- B. Section 23 21 00 - Hydronic Piping: Connections to Heating Coils
- C. Section 23 06 20.13 - Hydronic Specialties: Connections to Heating Coils
- D. Section 23 31 00 - Ductwork
- E. Section 23 33 00 - Ductwork Accessories
- F. Section 23 37 00 - Air Outlets and Inlets
- G. Section 23 09 23 - Direct Digital Control Systems
- H. Section 23 05 93.A - Testing, Adjusting and Balancing
- I. Section 26 05 19 - Cable, Wire and Connectors, 600-Volt
- K. Section 26 27 26 - Wiring Devices and Floor Boxes

1.03 REFERENCES

- A. NFPA 90A - Installation of Air Conditioning and Ventilation Systems
- B. UL 181 - Factory-Made Air Ducts and Connectors
- C. ADC 1062 - Air Distribution and Control Device Test Code

1.04 SUBMITTALS

- A. Submit shop drawings under provisions of Section 23 00 00.
- B. Submit shop drawings indicating configuration, general assembly, and materials used in fabrication.
- C. Submit product data under provisions of Section 23 00 00.
- D. Submit product data indicating configuration, general assembly, and materials used in fabrication. Include catalog performance ratings which indicate air flow, static pressure, and NC designation.
- E. Include schedules listing discharge and radiated sound power level for each of second through seventh octave bands at inlet static pressures of one inch wg.
- F. Submit manufacturer's installation instructions under provisions of Section 23 00 00.
- G. A sample 10-inch size (450 - 950 CFM) production run unit shall be submitted for examination and approval by the Architect/Engineer, RCM office and the Owner's Testing and Balancing (TAB) Consultant. This submittal box shall be submitted, in addition to the required written submittal, well in advance of any requirement for installation of boxes, but absolutely no later than 60 days after the date of the start of construction stipulated in the Work Order letter from the Owner. A minimum of three weeks shall be allowed for the testing of the box from the time of submittal to the time of determination of project worthiness. This period shall restart if the sample box is rejected and another box is resubmitted. If rejected for any reason, the contractor shall expedite the corrections documented, and shall resubmit a sample box as soon as possible. Any delay in the submittal of the box for approval shall not be grounds for a claim of delay. If approved, the unit shall remain in the possession of the Owner at the job site for comparison with units shipped to project. The unit shall be installed in the project at an accessible, marked location. The unit manufacturer shall test and certify that each box used on this project has been tested as specified.

1.05 OPERATION AND MAINTENANCE DATA

- A. Submit operation and maintenance data under provisions of Section 23 00 00.
- B. Include manufacturer's descriptive literature, operating instructions, maintenance and repair data, and parts lists.

1.06 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing the products specified in this Section with minimum three years' documented experience.

1.07 WARRANTY

- A. Provide one-year manufacturer's warranty under provisions of Section 23 00 00.

PART 2 PRODUCTS

2.01 FAN-POWERED VAV (VARIABLE AIR VOLUME) TERMINAL UNITS:

- A. Units shall be constant air volume secondary, variable air volume primary air distribution assemblies complete with casing, insulation, fan, hot water heating coil, dampers, actuators, controls, transformers, and other appurtenances required for a complete installation. Units shall be of the sizes and capacities scheduled.
- B. Casing assembly shall be 22-gauge (minimum) galvanized steel. Interior surfaces of casing shall be acoustically and thermally lined with a 1" thick, 1 1/2-pound density glass fiber insulation with a smooth black coated mat finish equal to Manville "Linacoustic" Fiber Glass Duct Liner or IMCOA closed cell polymer material of equal thermal value. Casing leakage shall not exceed 2% of the box's maximum scheduled CFM at 6" static pressure. Insulation shall be UL-listed and in compliance with NFPA 90A requirements.
- C. Damper (air valve) shall have a leakage rate of less than 2% of the box's maximum scheduled CFM at two times primary supply air duct static pressure or 6" (whichever is smaller). Unit shall incorporate primary air flow sensing devices to provide input for volume regulation as indicated hereinafter.
- D. Fans shall be forward curved, centrifugal, direct-drive type with 120-volt/1-phase motor and SCR controller for air flow adjustment from 60 - 100% of nominal box scheduled CFM. Fan and motor assembly shall be internally suspended and isolated from the casing on rubber in shear isolators. Fan and motor assembly shall be easily accessible through access panels without disassembling the entire

unit. The SCR controller and fan motor shall be harmonically balanced to reduce electrical noise. Fan assembly shall include an anti-backward rotation device.

- E. The fan-powered boxes shall be provided with a flow cross sensor located in the primary air inlet duct suitable for interfacing with the DDC system flow transducer (if required).
- F. The boxes shall be provided with a 24 VAC transformer connected to the unit's incoming power source and properly protected. The transformer shall be of adequate size to provide 24 VAC power for all DDC system components associated with the box.
- G. Hot water control valves associated with each fan-powered box shall be furnished and installed by the Contractor and connected to the DDC system under Section "Direct Digital Control System".
- H. Room temperature sensors associated with these fan-powered boxes shall be furnished by the Automation Contractor (DIV. 17) and installed under Section "Direct Digital Control System".
- I. The Automation Contractor (DIV. 17) shall furnish a DDC Controller and an electronic inlet damper actuator for installation on each fan-powered box by the fan-powered box manufacturer. These DDC (Direct Digital Control) devices shall be delivered to the fan-powered box manufacturer's factory in sufficient time for the manufacturer to meet its scheduled delivery obligations. The fan-powered box manufacturer shall factory mount and connect these devices as required for proper operation as required under Division 23, Section 23 09 23 and 23 09 93. The cost of factory-mounting these devices shall be included in the cost of the fan-powered boxes.
- J. Hot Water Coils: Hot water coils installed in conjunction with fan-powered VAV terminal units shall be factory-installed, one or two row with a maximum of 10 aluminum fins per inch. Air side pressure drop shall be limited to 0.2" wg at box rated flow. Full fin collars shall be provided for accurate fin spacing and maximum fin-to-tube contact. Tubes shall be 1/2 inch diameter seamless copper with minimum wall thickness of 0.016 inch, tested at 400 psig air pressure under water with a minimum rated burst pressure of 1500 psig. Male sweat-type water connections shall be provided. Side and end plates shall be a minimum of 18-gauge galvanized sheet metal construction. All coils shall be constructed and tested in accordance with UL and/or ARI Standards. The tube ends shall be protected with tube end caps of sheet metal similar to the casing material, and shall be insulated within the caps.
- K. CONTROL PERFORMANCE: Assemblies shall be able to reset the primary air to any airflow between zero and the maximum CFM shown on Drawings. To

allow for maximum flexibility and future changes, it shall be necessary to make only keyboard adjustments to arrange each unit for any maximum air flow within the ranges for each inlet size as scheduled on the Drawings. The control devices shall be designed to maintain the desired flow regardless of inlet flow deflection. All terminal units shall be installed with a minimum of four diameters of straight duct directly prior to the entry into each terminal unit connection.

L. GENERAL PERFORMANCE: Devices using mechanical CFM limiters will not be accepted, nor shall it be necessary to change control components to make airflow rate changes. If used, Automation Contractor furnished flow stations shall be furnished, mounted and adjusted by the Automation Contractor with assistance from the Terminal Unit Manufacturer to assure their proper placement. The terminal unit manufacturer shall be responsible only for the construction of the terminal unit and the installation of internal control components installed at the manufacturer's factory, and shall not be responsible for the installation of controls not installed at the terminal unit manufacturer's factory, and shall not be responsible for the performance of the DDC controls. The performance of DDC controls, especially in connection with terminal units, shall be the responsibility of the DDC Trades and the Automation Contractor (DIV. 17).

M. TESTING PRIOR TO INSTALLATION:

1. Terminal unit manufacturer shall be required to perform, at its expense, the following tests to demonstrate its compliance with the specification. Tests shall be witnessed by the Owner's Representative, Campus Representative, Mechanical Consultant and Project Testing, Adjusting, and Balancing Personnel. Tests shall be conducted in a laboratory acceptable to these personnel. Travel costs for these personnel will be the responsibility of the manufacturer.
2. SOUND TEST: Manufacturer shall perform a sound pressure in situ test for this unit. In situ test space shall be certified by the project sound consultant as being representative of a typical office space. Test space and ceiling plenum shall be constructed as follows:
 - a. The area of the test space shall be no larger than 350 square feet. Walls shall consist of sheetrock with one floor-to-ceiling glass wall to simulate a perimeter zone. The ceiling height shall be no greater than 9 feet. Acoustical ceiling tile shall be STC 35-39. At least 15% of the ceiling area shall be comprised of light fixtures. No furnishings shall be within the test space. Ceiling plenum depth shall be no deeper than 35 inches. The upper deck of the ceiling plenum shall be constructed of sheetrock with all four sides of the ceiling plenum closed entirely.

- b. Test shall be conducted using terminal performance conditions which will be similar to those to be encountered on this project.
 - c. Test results for sound power levels will be observed by the listed personnel and results shall be correlated by the manufacturer to establish the results and to establish that the unit complies with the values scheduled in the drawings. See 15930-J for additional requirements.
- 3. MIXING – See 15930-H for requirements.
- 4. SHIPMENT TESTING: A minimum of ten percent (10%) of each size of the terminal units (but no less than one unit of each size used) may be tested for conformance to this specification, at the Owner’s discretion. The contractor shall allow sufficient time during construction and space for the Owner’s TAB Consultant to perform all testing as may be required.
- 5. UNIT NON-PERFORMANCE:
 - a. If the results of the SHIPMENT TESTING show that any of the units does not perform as specified, then an additional ten percent (10%) of each size (but no less than one unit of a size,
 - b. Should for any reason the testing described above under “SUBMITTAL” and “SHIPMENT TESTING” prove that any of the units does not perform as specified, the contractor shall be responsible for all subsequent labor, travel, travel expenses, and incidental expenses, penalties, or other costs attendant to any additional testing as described under “UNIT NON-PERFORMANCE”, or as required to prove that the units perform as specified. This shall include, but not be limited to, the labor, travel and reasonable incidental expenses of not only the contractor and Owner’s TAB Consultant, but also those incurred by the unless 100% of the size has been tested) of the units shall be tested. If this testing, in the Owner’s opinion, shows that ten percent (10%) or more of the units tested does not perform as specified, then one hundred percent (100%) of all sizes of the units shall be tested for conformance with these specifications. The results of that testing shall be reviewed carefully between the contractor, manufacturer, the Owner’s construction administrator(s), and the Owner’s design engineer(s). A method of repair or replacing the units will be negotiated. The Owner, however, shall maintain the right of final approval of any proposed solution. Owner as may be specifically required for this process. The expenses to be reimbursed to the Owner shall be labor at a rate of \$300 per day or any portion of a

day, plus travel and travel expenses at actual cost, plus reasonable incidental expenses at actual cost.

- N. CONTROL SEQUENCE: The control sequence arrangements shall be as described below and the terminal units shall be shipped from the manufacturer with all necessary control devices to accomplish each sequence, except as may be provided by the controls manufacturer. The desired sequence shall be adjustable according to space usage or a change in space conditions.
- O. DDC SYSTEMS:
1. Electronic operators and controllers shall be installed by the terminal unit manufacturer. The Direct Digital Control System Trades and the Automation Contractor shall be responsible for the operational performance of the entire system. The terminal unit manufacturer shall be responsible for the performance of the mechanical components of the unit.
 2. DDC Controls Description:
 - a. These fan-powered boxes shall each be provided with a unit-mounted DDC terminal equipment controller (TEC) provided by the DDC Trades to accept input signals from a room space temperature sensor, the box's velocity sensor and the DDC system controller and output start/stop signals to the unit's fan, a modulating signal to the unit's primary damper, and a modulating signal to the unit's two-way modulating hot water valve as required to start/stop the unit and maintain the desired space temperature via the DDC System.
 - b. These fan-powered boxes served by primary air handling units shall be energized before the air handling unit is energized. The boxes shall be individually energized by the DDC System when the respective air handling unit is to operate or when a Space Sensor is below its "Low Limit" setpoint.
 - c. A DDC Trades furnished electronic space sensor shall modulate, through the unit's TEC, the unit's primary air damper and its respective heating coil valve as required to maintain the desired space temperature.
 - d. The fan-powered boxes shall be furnished by the box manufacturer complete with all necessary operating hardware and sensing devices to accept the modulating signals from the Terminal/Equipment Controller (TEC) for the unit's DDC Trades furnished electronic damper operator and DDC Trades furnished

electronic control valve for the hot water heating coil and a contact closure to energize/de-energize the unit fan and controls operations.

- e. Coordinate requirements for all controls components for proper operation of these fan-powered boxes with the DDC Trades.

- P. MANUFACTURER: All Terminal Units shall be as manufactured by Titus (Model DTFQ) Metal*Aire (Series 400), or Trane (Series VFPE). Note that the model and series numbers listed may differ slightly from catalogue information. No other manufacturers or models are acceptable. Even though specific manufacturers may be named herein, the material supplied by any approved manufacturer shall meet all of the provisions of this specification without exception.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Refer also to requirements included in Part 2 of this specification.
- B. Install in accordance with manufacturer's instructions.
- C. Provide clearance for inspection, repair, replacement, and service. The mechanical contractor shall ensure all fan-powered VAV terminal unit controllers and operators are located a minimum of 30" from all obstructions (walls, pipes, etc.).
- D. Provide ceiling access doors or locate units above easily removable ceiling components.
- E. Support units individually from structure. Do not support from adjacent ductwork.
- F. Connect to ductwork in accordance with Section 23 31 00.
- G. Install heating coils in accordance with Section 23 81 16.

END OF SECTION

SECTION 23 37 00
AIR OUTLETS AND INLETS

PART 1 GENERAL

1.00 The following sections are to be included as if written herein:

- A. Section 23 00 00 – Basic Mechanical Requirements
- B. Section 23 05 29 – Sleeves, Flashings, Supports and Anchors
- C. Section 23 05 53 – Mechanical Identification

1.01 **WORK INCLUDED**

- A. Diffusers
- B. Diffuser Boots
- C. Registers/Grilles
- D. Door Grilles
- E. Louvers
- F. Louvered Penthouses
- G. Roof Hoods
- H. Goosenecks

1.02 **RELATED SECTIONS**

- A. Section [____ - _____]: Door Louvers
- B. Section [____ - _____]: Metal Wall Louvers
- C. Section 09 91 00 - Painting: Painting of Ductwork Visible behind Outlets and Inlets
- D. Section 23 31 00 - Ductwork
- E. Section 23 33 00 - Ductwork Accessories

1.03 **REFERENCES**

- A. ADC 1062 - Certification, Rating and Test Manual
- B. AMCA 500 - Test Method for Louvers, Dampers and Shutters
- C. ANSI/NFPA 90A - Installation of Air Conditioning and Ventilating Systems
- D. ARI 650 - Air Outlets and Inlets
- E. ASHRAE 70 - Method of Testing for Rating the Air Flow Performance of Outlets and Inlets
- F. SMACNA - Low Pressure Duct Construction Standard.

1.04 QUALITY ASSURANCE

- A. Test and rate performance of air outlets and inlets in accordance with ADC Equipment Test Code 1062 and ASHRAE 70.
- B. Test and rate performance of louvers in accordance with AMCA 500.

1.05 REGULATORY REQUIREMENTS

- A. Conform to ANSI/NFPA 90A.

1.07 SUBMITTALS

- A. Submit product data under provisions of Section 23 00 00.
- B. Provide product data for items required for this project.
- C. Submit schedule of outlets and inlets indicating type, size, location, application, and noise level.
- D. Review requirements of outlets and inlets as to size, finish, and type of mounting prior to submitting product data and schedules of outlets and inlets.
- F. Submit manufacturer's installation instructions under provisions of Section 23 00 00.

PART 2 PRODUCTS

2.01 AIR SUPPLIES AND RETURNS:

- A. Grilles, registers and ceiling outlets shall be as scheduled on the Drawings and shall be provided with sponge rubber or soft felt gaskets. If a manufacturer other than the

one scheduled is used, the sizes shown on the Drawings shall be checked for performance, noise level, face velocity, throw, pressure drop, etc., before the submittal is made. Selections shall meet the manufacturer's own published data for the above performance criteria. The throw shall be such that the velocity at the end of the throw in the five foot occupancy zone will be not more than 50 FPM nor less than 25 FPM. Noise levels shall not exceed those published in the ASHRAE Guide for the type of space being served (NC level). Grilles, registers and ceiling outlets shall be Titus, or Metal*Aire.

- B. Locations of outlets on Drawings are approximate and shall be coordinated with other trades to make symmetrical patterns and shall be governed by the established pattern of the lighting fixtures or architectural reflected ceiling plan. Where called for on the schedules, the grilles, registers and ceiling outlets shall be provided with deflecting devices and manual damper. These shall be the standard product of the manufacturer, subject to review by the Architect, and equal to brand scheduled.

NOTE TO REVIEWER: The balance of Part 2 of this specification is the specification suggested by CSI. It is included to give guidance to improve this specification in the future. It is the feeling of the writer that this section of the specifications is in need of improvement, but with time constraints, improvement prior to this release was not possible.

2.02 ACCEPTABLE MANUFACTURERS - CEILING DIFFUSERS

- A. Titus.
- A. Krueger.
- A. Metal * Aire.
- A. [_____.]
- B. [_____.]
- C. [_____.]
- D. Substitutions: Under provisions of Section [01 25 00.] [01 62 00.]

2.03 ROUND CEILING DIFFUSERS

- A. Round, [adjustable pattern,] stamped or spun, multicore type diffuser to discharge air in 360 degree pattern, with sectorizing baffles where indicated; [Model [_____] manufactured by [_____].]

- B. Project diffuser collar [not more than one inch (25mm)] above ceiling face and connect to duct with duct ring. [In plaster ceilings, provide plaster ring and ceiling plaque.]
- C. Fabricate of steel with baked enamel [off-white] [] finish.
- D. Provide [radial opposed blade] [butterfly] [combination splitter] damper and multi-louvered equalizing grid with damper adjustable from diffuser face.

2.04 RECTANGULAR CEILING DIFFUSERS

- A. Rectangular, [adjustable pattern,] stamped, multicore type diffuser to discharge air in 360 degree pattern with sectorizing baffles where indicated; [Model [] manufactured by [].]
- B. Provide [surface mount] [snap-in] [inverted T-bar] [spline] type frame. [In plaster ceilings, provide plaster frame and ceiling frame.]
- C. Fabricate of steel with baked enamel [off-white] [] finish.
- D. Provide [radial opposed blade] [butterfly] [combination splitter] damper and multi-louvered equalizing grid with damper adjustable from diffuser face.

2.05 PERFORATED FACE CEILING DIFFUSERS

- A. Perforated face with fully adjustable pattern and removable face; [Model [] manufactured by [].]
- B. Provide [surface mount] [snap-in] [inverted T-bar] [spline] type frame. [In plaster ceilings, provide plaster frame and ceiling frame.]
- C. Fabricate of steel with steel or aluminum frame and baked enamel [off-white] [] finish.
- D. Provide [radial opposed blade] [butterfly] [combination splitter] damper and multi-louvered equalizing grid with damper adjustable from diffuser face.

2.06 ACCEPTABLE MANUFACTURERS - MODIFIED LIGHT TROFFER DIFFUSERS

- A. Titus.
- A. Krueger.
- A. Metal * Aire.

- A. [_____.]
- B. [_____.]
- C. [_____.]
- D. Substitutions: Under provisions of Section [01 25 00.] [01 62 00.]

2.07 MODIFIED LIGHT TROFFER DIFFUSERS

- A. [Single] [Double] plenum type constructed independent of light troffers with volume and pattern controllers, [4] [5] [6] inch ([100] [125] [150] mm) round or oval [top] [side] air inlet; [Model [_____]] manufactured by [_____].]
- B. Match diffusers to light troffers and connect in airtight connection without tools.
- C. Fabricate of galvanized steel with welded or soldered joints and finish matte black inside.

2.08 ACCEPTABLE MANUFACTURERS - CEILING REGISTERS/GRILLES

- A. Titus.
- A. Krueger.
- A. Metal * Aire.
- A. [_____.]
- B. [_____.]
- C. [_____.]
- D. Substitutions: Under provisions of Section [01 25 00.] [01 62 00.]

2.09 CEILING SUPPLY REGISTERS/GRILLES

- A. Streamlined and individually adjustable curved blades to discharge air along face of grille, [one-way] [two-way] deflection; [Model [_____]] manufactured by [_____].]
- B. Fabricate [1-1/4] [one] [_____] inch ([32] [25] [_____] mm) margin frame with [countersunk screw] [concealed] mounting and gasket.

- C. Fabricate of aluminum extrusions with factory [clear lacquer] [prime coat] [_____] finish.
- D. Provide integral, gang-operated opposed blade dampers with removable key operator, operable from face.

2.10 CEILING EXHAUST AND RETURN REGISTERS/GRILLES

- A. Streamlined blades, depth of which exceeds 3/4 inch (19 mm) spacing, with spring or other device to set blades, [vertical] [horizontal] face; [Model [_____] manufactured by [_____].]
- B. Fabricate [1-1/4] [one] [_____] inch ([32] [25] [_____] mm margin frame with [countersunk screw] [concealed] mounting.
- C. Fabricate of steel with 20-gauge (0.90 mm) minimum frames and 22-gauge (0.80 mm) minimum blades, steel and aluminum with 20-gauge (0.90 mm) minimum frame, or aluminum extrusions, with factory [baked enamel] [prime coated] [clear lacquer] [_____] finish.
- D. Where not individually connected to exhaust fans, provide integral, gang-operated opposed blade dampers with removable key operator, operable from face.
- E. In gymnasiums, blades shall be front pivoted, welded in place or securely fastened to be immobile.

2.11 CEILING GRID CORE EXHAUST AND RETURN REGISTERS/GRILLES

- A. Fixed grilles of 1/2 x 1/2 x 1/2 inch (13 x 13 x 13 mm) louvers; [Model [_____] manufactured by [_____].]
- B. Fabricate [1-1/4] [one] [_____] inch ([32] [25] [_____] mm) margin frame with [countersunk screw mounting.] [concealed mounting.] [lay-in frame for suspended grid ceilings.]
- C. Fabricate of aluminum with factory [clear lacquer] [baked enamel] finish.
- D. Where not individually connected to exhaust fans, provide integral, gang-operated opposed blade dampers with removable key operator, operable from face.

2.12 CEILING LINEAR EXHAUST AND RETURN GRILLES

- A. Streamlined blades with 90 degree [one-way] [two-way] deflection, 1/8 x 3/4 inch (3.2 x 19 mm) on [1/4] [1/2] inch ([6] [13] mm) centers; [Model [_____] manufactured by [_____].]
- B. Fabricate [1-1/4] [one] [_____] inch ([32] [25] [_____] mm) margin frame [extra heavy for floor mounting,] with [countersunk screw] [concealed] mounting.
- C. Fabricate of steel with 20-gauge (0.90 mm) minimum frames and 22-gauge (0.80 mm) minimum blades, steel and aluminum with 20-gauge (0.90 mm) minimum frame, or aluminum extrusions, with factory [baked enamel] [prime coated] [clear lacquer] [_____] finish.
- D. Where not individually connected to exhaust fans, provide integral, gang-operated opposed blade dampers with removable key operator, operable from face.

2.13 ACCEPTABLE MANUFACTURERS - CEILING SLOT DIFFUSERS

- A. Titus.
- A. Krueger.
- A. Metal * Aire.
- A. [_____].
- B. [_____].
- C. [_____].
- D. Substitutions: Under provisions of Section [01 25 00.] [01 62 00.]

2.14 CEILING SLOT DIFFUSERS

- A. Continuous [1/2] [3/4] [one] inch ([13] [19] [25] mm) wide slot, [one] [two] [three] [four] slots wide, with adjustable vanes for left, right, or vertical discharge.
- B. Fabricate of aluminum extrusions with factory [clear lacquer] [baked enamel] [_____] finish.
- C. Fabricate [1-1/4] [one] [_____] inch ([32] [25] [_____] mm) margin frame with [countersunk screw] [concealed] [support clips for suspension system] [support clips for T bar] mounting and gasket, [mitered end border.] [open end construction.] [end cap.]

2.15 ACCEPTABLE MANUFACTURERS - WALL REGISTERS/GRILLES

- A. Titus.
- B. Krueger.
- C. Metal * Aire.
- D. Price
- E. Nailor
- F. [_____.]
- G. [_____.]
- H. [_____.]

Substitutions: Under provisions of Section [01 25 00.] [01 62 00.]

2.16 WALL SUPPLY REGISTERS/GRILLES

- A. Streamlined and individually adjustable blades, depth of which exceeds 3/4 inch (19 mm) maximum spacing with spring or other device to set blades, [vertical] [horizontal] face, [single] [double] deflection; Model [_____] manufactured by [_____.]
- B. Fabricate [1-1/4] [one] [_____] inch ([32] [25] [_____] mm) margin frame with [countersunk screw] [concealed] mounting and gasket.
- C. Fabricate of steel with 20-gauge (0.90 mm) minimum frames and 22-gauge (0.80 mm) minimum blades, steel and aluminum with 20-gauge (0.90 mm) minimum frame, or aluminum extrusions, with factory [baked enamel] [prime coat] [clear lacquer] [_____] finish.
- D. Provide integral, gang-operated opposed blade dampers with removable key operator, operable from face.
- E. In gymnasiums, blades shall be front pivoted, welded in place or securely fastened to be immobile.

2.17 WALL SUPPLY REGISTERS/GRILLES

- A. Streamlined and individually adjustable curved blades to discharge air along face of grille, [one-way] [two-way] deflection; [Model [_____] manufactured by [_____].]

- B. Fabricate [1-1/4] [one] [_____] inch ([32] [25] [_____] mm) margin frame with [countersunk screw] [concealed] mounting and gasket.
- C. Fabricate of aluminum extrusions with factory [clear lacquer] [prime coat] [_____] finish.
- D. Provide integral, gang-operated opposed blade dampers with removable key operator, operable from face.

2.18 WALL EXHAUST AND RETURN REGISTERS/GRILLES

- A. Streamlined blades, depth of which exceeds 3/4 inch (19 mm) spacing, with spring or other device to set blades, [vertical] [horizontal] face; Model [_____] manufactured by [_____].]
- B. Fabricate [1-1/4] [one] [_____] inch ([32] [25] [_____] mm) margin frame with [countersunk screw] [concealed] mounting.
- C. Fabricate of steel with 20-gauge (0.90 mm) minimum frames and 22-gauge (0.80 mm) minimum blades, steel and aluminum with 20-gauge (0.90 mm) minimum frame, or aluminum extrusions, with factory [baked enamel] [prime coated] [clear lacquer] [_____] finish.
- D. Where not individually connected to exhaust fans, provide integral, gang-operated opposed blade dampers with removable key operator, operable from face.
- E. In gymnasiums, blades shall be front pivoted, welded in place, or securely fastened to be immobile.

2.19 WALL GRID CORE EXHAUST AND RETURN REGISTERS/GRILLES

- A. Fixed grilles of 1/2 x 1/2 x 1/2 inch (13 x 13 x 13 mm) louvers; [Model [_____] manufactured by [_____].]
- B. Fabricate [1-1/4] [one] [_____] inch ([32] [25] [_____] mm) margin frame with [countersunk screw mounting.] [concealed mounting.] [lay-in frame for suspended grid ceilings.]
- C. Fabricate of aluminum with factory [clear lacquer] [baked enamel] finish.
- D. Where not individually connected to exhaust fans, provide integral, gang-operated opposed blade dampers with removable key operator, operable from face.

2.20 LINEAR WALL REGISTERS/GRILLES

- A. Streamlined blades with [0] [15] degree deflection, 1/8 x 3/4 inch (3.2 x 19 mm) on [1/4] [1/2] inch ([6] [13] mm) centers; [Model [_____] manufactured by [_____].]
- B. Fabricate of aluminum extrusions, with factory [clear lacquer] [prime coat] [_____] finish.
- C. Fabricate [1-1/4] [one] [_____] inch ([32] [25] [_____] mm) margin frame with [countersunk screw] [concealed] mounting and gasket.
- D. Provide integral [gang-operated opposed blade] [hinged single blade] damper with removable key operator, operable from face.

2.21 ACCEPTABLE MANUFACTURERS - FLOOR REGISTERS/GRILLES

- A. Titus.
- A. Krueger.
- A. Metal * Aire.
- A. [_____].]
- B. [_____].]
- C. [_____].]
- D. Substitutions: Under provisions of Section [01 25 00.] [01 62 00.]

2.22 LINEAR FLOOR SUPPLY REGISTERS/GRILLES

- A. Streamlined blades with [0] [15] degree deflection, 1/8 x 3/4 inch (3 x 19 mm) on [1/4] [1/2] inch ([6] [13] mm) centers; [Model [_____] manufactured by [_____].]
- B. Fabricate of aluminum extrusions with factory clear lacquer finish.
- C. Fabricate [1-1/4] [one] [_____] inch ([32] [25] [_____] mm) margin heavy] margin frame with [countersunk screw mounting] [concealed mounting and gasket] [, and mounting frame.]

- D. Provide integral [gang-operated opposed blade] [hinged single blade] damper with removable key operator, operable from face.

2.23 FLOOR SUPPLY REGISTERS/GRILLES

- A. Individually adjustable blades, wide stamped border, singled or double blade damper with set screw adjustment; [Model [_____] manufactured by [_____].]
- B. Fabricate of steel, welded construction, with factory baked enamel finish.

2.24 ACCEPTABLE MANUFACTURERS - DOOR GRILLES

- A. Titus.
- A. Krueger.
- A. Metal * Aire.
- A. [_____].]
- B. [_____].]
- C. [_____].]
- D. Substitutions: Under provisions of Section [01 25 00.] [01 62 00.]

2.25 DOOR GRILLES

- A. V-shaped louvers of 20-gauge (0.90 mm) steel, one inch (25 mm) deep on 1/2 inch (13 mm) centers; [Model [_____] manufactured by [_____].]
- B. Provide 20-gauge (0.90 mm) steel frame with auxiliary frame to give finished appearance on both sides of door, with factory prime coat finish.

2.26 ACCEPTABLE MANUFACTURERS - LOUVERS

- A. Titus.
- A. Krueger.
- A. Metal * Aire.
- A. [_____].]

- B. [_____.]
- C. [_____.]
- D. Substitutions: Under provisions of Section [01 25 00.] [01 62 00.]

2.27 LOUVERS

- A. Provide [4] [6] inch ([100] [150] mm) deep louvers with blades on 45 degree slope [with center baffle and return bend], heavy channel frame, bird screen with 1/2 inch (13 mm) square mesh for exhaust and 3/4 inch (19 mm) for intake; [Model [_____] manufactured by [_____].]
- B. Fabricate of [16-gauge (1.50 mm) galvanized steel] [or] [12-gauge (2.50 mm) extruded aluminum], welded assembly, with factory [prime coat] [baked enamel] [color anodized] finish.
- C. Furnish with [interior] [exterior] [flat flange] [angle flange] [screw holes in jambs] [masonry strap anchors] for installation.
- D. Fabricate louver penthouses with mitered corners and reinforce with structural angles.

2.28 ACCEPTABLE MANUFACTURERS - ROOF HOODS

- A. [_____.]
- B. [_____.]
- C. [_____.]
- D. Substitutions: Under provisions of Section [01 25 00.] [01 62 00.]

2.29 ROOF HOODS

- A. Fabricate air inlet or exhaust hoods in accordance with SMACNA Low Pressure Duct Construction Standards; [Model [_____] manufactured by [_____].]
- B. Fabricate of galvanized steel, minimum 16-gauge (1.50 mm) base and 20-gauge (0.90 mm) hood, or aluminum, minimum 16-gauge (1.50 mm) base and 18-gauge (1.20 mm) hood; suitably reinforced; with removable hood; bird screen with 1/2 inch (13 mm) square mesh for exhaust and 3/4 inch (19 mm) for intake, and factory [prime coat] [baked enamel] finish.

- C. Mount unit on minimum 12 inch (300 mm) high curb base with insulation between duct and curb.
- D. Make hood outlet area minimum of twice throat area.

2.30 GOOSENECKS

- A. Fabricate in accordance with SMACNA Low Pressure Duct Construction Standards of minimum 18-gauge (1.20 mm) galvanized steel.
- B. Mount on minimum 12-inch (300 mm) high curb base where size exceeds [9 x 9-inch (230 x 230 mm).] [____.].

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install items in accordance with manufacturers' instructions.
- B. Check location of outlets and inlets and make necessary adjustments in position to conform with architectural features, symmetry, and lighting arrangement. Refer to Section 09 91 00.
- C. Install diffusers to ductwork with air tight connection.
- D. Provide balancing dampers on duct take-off to diffusers, and grilles and registers, regardless of whether dampers are specified as part of the diffuser, or grille and register assembly.
- E. Paint ductwork visible behind air outlets and inlets matte black. Refer to Section 09 91 00.

END OF SECTION

SECTION 23 38 16
FUME HOODS

PART 1 GENERAL

1.00 The following sections are to be included as if written herein:

- A. Section 23 00 00 – Basic Mechanical Requirements
- B. Section 23 05 29 – Sleeves, Flashings, Supports and Anchors
- C. Section 23 05 53 – Mechanical Identification

1.01 RELATED DOCUMENTS

- A. The Conditions of the Contract and applicable requirements of Division 01 govern this Section.

1.02 DESCRIPTION OF WORK

- A. Work Included: Laboratory equipment work includes the fabrication and installation of fume hoods and other accessories. Provide where indicated on the Drawings following these specifications.
 - 1. Provide radioisotope style (stainless steel liner with coved corners) hoods including base cabinets as indicated on the drawings. Provide cup sink and pre-piped gas, vacuum and cold water valves. Plan designation RH-a, b, c, where "a" indicates hood length, "b" indicates left or right service fitting location and "c" indicates utility type.
 - 2. Provide chemical hoods including base cabinets as indicated on the drawings. Provide cup sink and pre-piped gas, vacuum and cold water valves. Plan designation CH-a, b, c, where "a" indicates hood length, "b" indicates left or right service fitting location and "c" indicates utility type.

3. Service piping, vents, drain lines, traps, conduits and wiring required for the operation of service fixtures common to fume hoods.
4. Exhaust connections and hood controls interface.
5. Fume hood performance test and balancing provided by Owner. Coordinate with Owner's TAB Consultant.

B. Work of Other Sections:

1. Any framing or reinforcement in the walls or ceiling to provide adequate support for this equipment: Divisions 04 and 09.

1.03 QUALITY ASSURANCE

- A. Single Source Responsibility: Provide each type laboratory fume hood equipment as specified herein, manufactured or furnished by the same laboratory fume hood equipment company for single responsibility.
- B. Manufacturer's Catalog Standards: Manufacturer's catalog numbers shown on the drawings are for the convenience in identifying certain types of laboratory equipment and service fixtures. Unless modified by notation on the drawings or otherwise specified, catalog description for indicated number constitutes requirements for each item of laboratory equipment or service fixture.
 1. Catalog numbers shown on the drawings are based on units and service fixtures manufactured or supplied by _____.
- C. Chemical and Physical Resistance of Finish: Submit an independent testing laboratory report certifying that the exterior finish of laboratory casework is capable

of withstanding following tests, with no change, or slight change of gloss, slight discoloration, or slight temporary softening of film with no loss of adhesion and no loss of film protection.

1. Acids: Not less than 5 drops (0.25 cc) applied to finish surface, covered with watch glass for 60 minutes, then washed and dried.
 - a. 20% Hydrochloric Acid
 - b. 10% Nitric Acid
 - c. 25% Phosphoric Acid
 - d. 50% Acetic Acid

2. Solvents: Not less than 5 drops (0.25 cc) applied to finish surface, covered with watch glass for 60 minutes, then washed and dried.
 - a. 100% Trichlorethylene
 - b. 100% Ethyl Alcohol
 - c. 100% Ethyl Ether
 - d. 100% Ethyl Acetate
 - e. 100% Acetone
 - f. 100% Carbon Tetrachloride
 - g. 37% Formaldehyde
 - h. 100% Naphtha
 - i. 100% Xylene
 - j. 40% Phenol

3. Bases and Salts: Not less than 5 drops (0.25 cc) applied to finish surface, covered with watch glass for 60 minutes, then washed and dried.
 - a. 10% Sodium Hydroxide
 - b. 10% Ammonium Hydroxide
 - c. 05% Hydrogen Peroxide
 - d. 30% Trisodium Polyphosphate

 4. Moisture Resistance: No visible effect when finish surface exposed to the following:
 - a. Hot water at a temperature of 190 degrees F (91 degrees C) to 205 degrees F (96 degrees C), trickled down surface at 45 degree angle for 5 minutes.

 - b. Constant Moisture using a 2" x 3" x 1" cellulose sponge, soaked with water, in contact with surface for 100 hours.

 5. Cold Crack: No effect when subjected to 10 cycles of temperature change from 20 degrees F (14 degrees C) for 60 minutes to 125 degrees F (52 degrees C) for 60 minutes.

 6. Adhesion and Flexibility: No peeling or cracking or exposure of metal when metal is bent 180 degrees over a 1/4" diameter mandrel.
- D. Instruction Plate: Instructions covering safe and proper operation of the fume hood shall be provided in two forms:
1. A corrosion resistant plate attached to the fume hood exterior with condensed information covering recommended locations for apparatus and accessories, baffle settings and use of sash.

2. Written instructions in booklet form providing additional details of safe and proper operation and maintenance.
 3. Samples of above instructions shall be submitted to the owner for his review and approval before proceeding.
- E. Field Conditions: Confirm dimensions controlled by job conditions. This Contractor and the General Contractor shall cooperate to establish and maintain field dimensions.
- F. For each style and size hood, manufacturer shall submit test data showing compliance with ASHRAE 110-95, under as manufactured basis and a AM 0.5 test rating with a 4.0 lpm flow rate. Also data shall be furnished for sash movement performance rating with SMEAM 0.5, 4.0 lpm criteria.

1.04 FUME HOOD PERFORMANCE TEST

A. General:

1. An independent Testing Laboratory selected, engaged and paid by the Owner shall conduct the Performance Test, as hereinafter specified, of all fume hoods supplied by Contractor.
2. The Contractor shall provide fully operational fume hoods as specified. The hood shall be completely installed with understructure, service fittings and other specified incidentals and accessories. Hood shall be operating in accordance with design requirements specified in this section of this project specifications.
3. The fume hood shall be equipped and adjusted to provide an average face velocity of 100 fpm in the "operating position" (18" open) at a maximum of 0.3" water gage at the exhaust connection. This value is defined as the "rated flow."

4. With hood in full closed position, no more than 20% of rated flow shall be passed thru the hood at the same 0.3" water gage at the exhaust connection.
5. With hood in full closed position and any upper bypass openings and lower airfoil bypass sealed, no more than 10% of rated flow shall be leaked thru the hood at 0.5" water gage at the exhaust connection. Provide seals or enclosure at cabinet top at sash exit as required to prevent air from entering hood cabinet.

B. Scope:

1. The Testing Agency shall inspect and observe the operation of the fume hood by Contractor. The Testing Agency shall assist in the balancing and adjusting of hood; conduct, measure and record tests; and report tests results all as hereinafter specified.
2. The Contractor and the suppliers of the equipment installed shall provide all supervision, personnel, equipment, and materials and perform all work necessary to assist the Testing Firm in performing the Fume Hood Performance Test and to make adjustments required.
3. Contractor shall eliminate adverse conditions such as air drafts due to HVAC operation, open doors or similar conditions. Remove objects within five feet of hood opening.

C. Performance Requirements:

1. The fume hood shall provide a uniform flow of air through the hood (sash) opening set at "operating position" at the specified design average face velocity. The fume hood shall exhaust light and heavy gases efficiently, and without reverse flows along sides, top, bottom and front when tested under each of the following three Operating Conditions. The less than 90% specified to insure

full protection to the user and instruments, or more than 110% specified to prevent waste of conditioned air.

2. In laboratories with varying supply airflows, test each hood with the smoke test prescribed below and measure face velocities with the sash height 100% open, 18" open and 4 ½" open with the supply airflow at its maximum delivering 55 deg F and at its minimum delivering 55 deg F.

D. Performance Test Procedures for Each Condition:

1. Prior to testing the hood, a check shall be made using smoke and the Anemometer to make sure there are no room air currents that would affect the hood performance. Any drafts that are found shall be eliminated before proceeding with the hood tests.
2. Turn on exhaust system and adjust hood controls to provide the specified average fume hood face velocity at hood "operating position." Calculate and record exhaust volume (CFM) by measuring air flow in exhaust duct just forward of hood flow device. This shall be accomplished by measuring air velocity using pitot traverse method. For velocities under 1,000 FPM a micromanometer shall be used; for velocities over 1,000 FPM, an inclined manometer shall be used. Multiply average duct velocity by the cross sectional area of the duct to calculate CFM.
3. Face velocity readings will be taken at approximately 6" centers (maximum) with each corner being read on 3" centers over the entire hood face opening, with the hood sash open to the "operation position." Use an electrically operated Anemometer, mounted on a ring stand, direct reading, with graduations from 0-350 ft/minute maximum. At each reading position, record at least 30 readings taken at one-second intervals. Calculate and record the average face velocity (FPM) by averaging all velocity readings. The minimum for any one reading position shall not be less than 90% of the average face velocity. Compare the design face velocity specified.

4. Calculate and record the volume (CFM) of exhaust air at hood face by multiplying the calculated average face velocity by the square feet of the hood face opening. Volume must be a minimum of 95% to 115% of volume measured in procedure D.2, above.
5. Measure reference face velocities on all fume hoods as prescribed in D.3 with the sash at 100% open, 18" open, and 4 ½" open. In laboratories with variable volume, measure the face velocities in the 3 positions mentioned above with the supply air at maximum and at minimum volume and supply temperature at 55 deg F. All face velocity readings should be tested with the baffles inside the hood set so that all the air flows across the hood's work surface. Show static pressure at the hood's collar with baffles set for flow across the work surface and at the top of the hood.
6. When the specified average face velocity has been established and verified, the following tests shall be made to verify compliance with performance specifications.
 - a. Make a complete traverse of the hood face with a cotton swab dipped in Titanium Tetrachloride to demonstrate that a positive flow of air is entering the hood over the entire hood face. No reverse flows or dead air space will be permitted.
 - b. Paint a strip of smoke on tape along each end and across the working surface of the hood, in a line parallel with the hood face and 6" back into the hood from the hood face to demonstrate that no reverse airflow exists. The flow of smoke shall be directly to the rear of the hood without swirling turbulence or reverse flows.
 - c. A one minute 8,000 cu. ft. capacity smoke candle, Superior or equal, shall be discharged within the hood area to observe the exhaust capacity of the hood and its design efficiency with sash door in open position. The jet of smoke shall show no reverse flows of air when discharged across the bottom of the hood or at the ends of the hoods, and shall be overcome and carried to the rear of the hood and out of the hood even when the jet of smoke is discharged directly toward the front of the hood. Place another smoke candle on the hood

working surface and close the sash (hood door) to observe that sufficient air is passing through the working area of the hood to dilute and exhaust the smoke out of the hood.

d. Place a pan of hot water in the hood at the approximate center of the working area and add chunks of dry ice to make a copious volume of heavy white fumes. The heavy gas generated shall be carried directly to the rear of the hood. No reverse flows of fume along the work surfaces shall be permitted as determined by the Owner's representative.

e. Check sash hood door operation by raising and lowering sash, using one hand and gripping sash at first on the extreme right end of sash and then the extreme left end of the sash. Sash shall glide smoothly and freely and hold at any height without creeping, assuring proper counterbalance. No metal-to-metal contact shall be allowed.

7. Measure the differential pressure at the lab's door to verify the lab remains at a negative pressure relative to the corridor as the system is changed from maximum to minimum flow and from minimum to maximum flow.

E. COORDINATION:

1. The Contractor shall notify the Owner's Representative when fume hoods have been completely installed with ducts and exhaust and supply systems adjusted and operating. The testing agency will then schedule the testing and shall notify the Owner's Representative, Architect and Contractor of the time and place of the planned testing five days prior to initiating the tests. Should the Fume Hoods not be ready for testing, all costs incurred by the Testing Firm shall be paid for by the Contractor. Furthermore, such items as are not ready for testing shall be completed and placed in operational readiness by the Contractor and the Owner's Representative will be notified again.

1.05 SUBMITTALS

- A. Shop Drawings: Submit shop drawings for Architect's and Engineer's review. Completeness of shop drawings shall be sufficient to indicate compliance with Contract Documents and to correlate with other materials. Indicate size, material, quantity, finish, attachment methods, connections, weight and performance data depending on the specifications. Include layout of units with relation to surrounding walls, doors, windows and other building compounds. Provide roughing-in drawings with other work involved.
- B. Product Data: Submit manufacturer's data, drawings, photographs and installation instructions for each type of laboratory unit.
- C. Laboratory Certification: Submit independent laboratory certification that the fume hoods meet performance tests and the applied finish complies with specific chemical and physical resistance requirements.
- D. Dimensional drawing indicating location mounting and any holes required for control components showing approval by controls vendor.
- E. Provide 1-year manufacturer's warranty.

1.06 PRODUCT HANDLING

- A. Deliver metal laboratory equipment cartoned or crated to provide protection during transit and job storage.
- B. Inspect metal laboratory equipment upon delivery for damage. Minor damages may be repaired provided the finish items are equal in all respects to the new work and are acceptable to the Architect. Remove and replace damaged items as directed.

PART 2 PRODUCTS

2.01 FUME HOODS

A. Approved Manufacturers:

Hamilton

Kewaunee

Jamestown

B. Type:

1. Hoods shall have a "picture frame" airfoil at the sides, top and bottom (preferably six inches). The lower airfoil shall be stainless steel or have a urethane powder coat finish. Hoods draw 100% of the air exhausted through the hood front. All of the air exhausted by these fume hoods is effectively utilized in moving fumes and contaminants back to the baffle exhaust openings.
2. Design fume hoods so that, when connected to variable air volume exhaust system that provides proper exhaust volume under normal laboratory conditions, fume hoods will operate in a safe efficient manner, within acceptable tolerances for face velocities specified. Provide all hoods with a mini-bypass feature to exhaust 20% of total air flow with sash closed. Dead air pockets and reverse air currents will not be permitted along surface of hood interiors. Laboratory fume hoods shall be designed to exhaust 100 CFM per square foot of open sash area when the sash is in the full operating position (18" open). The hood work surface shall be dished, beginning six inches inside the hood. This shall not interfere with the bottom airfoil. The hood bench shall be 3/8 in. dished epoxy resin, unless otherwise specified. Sinks and service fitting shall be located at least six inches beyond the hood face.
3. Hood assemblies consist of a superstructure, a metal or wood cabinet understructure, service fittings and electrical equipment. The superstructures are complete with a lining and rear baffle with a fixed open center slot and

adjustable upper and lower exhaust slots, a deflector vane (air foil bypass), a working surface and a counterbalanced sash.

NOTE: VERIFY DESIRED BAFFLE ARRANGEMENT WITH USERS.

[Baffle shall be nonadjustable, fixed in an intermediate position to provide controlled air vectors into and through the hood through exhaust slots located at the work surface and 17 and 30" above the work surface with full height vertical slots on each side.]

[Baffle adjustment shall permit setting for (1) high thermal loading, (2) heavier than air gases or fumes generated near the work surface, and (3) normal or average operation. Adjustment shall be instantaneous, one-handed, with a single point control, accomplished while hood is in use, without disturbing apparatus. For safety, hood shall maintain a constant exhaust volume at any baffle position. Regardless of setting, there shall always be at least 20% of the air flow thru the lower slot.]

Lower slot of baffle shall be fitted with a stainless steel perforated plate to prevent ingestion of foreign objects into exhaust system.

Changes in average face velocity and exhaust volumes as a result of baffle adjustment shall not exceed 5% for any baffle position at the specified face velocity. An acid resistant label indicating proper baffle operation shall be located next to the adjustment knob. Baffle designs which permit close off of all slots or which require insertion of more than the operator's hand and arm for adjustment, are not acceptable. Nonadjustable baffles not acceptable.]

[Remote baffle adjustment shall permit setting for (1) high thermal loading, (2) heavier than air gases or fumes generated near work surface, (3) normal or average operation. Regardless of setting, there shall always be at least 20% of the air flow thru the lower slot. Adjustment shall be instantaneous, one-handed, with a single point control, accomplished while hood is in use, without disturbing apparatus, from the outside right hand corner post of the fume hood with the sash in either the open or closed position. Remote adjuster shall have

color coordinated indicator and an acid resistant label indicating proper control handle location for baffle function. Control handles shall be rigidly correlated to the baffle positioner. Cable-type adjustments are not acceptable. Baffle adjuster shall be engaged or disengaged from the adjustable baffle without the use of tools. Baffle designs which provide no adjustment or require internal manipulations are not acceptable.]

4. Hood superstructure exteriors and metal cabinet understructures are fabricated of cold rolled steel, phosphate coated and have a baked chemical resistant urethane powder coat or enamel factory finish.
5. Interior of radioisotope fume hood lining and baffle shall be 16 gauge, type 304 stainless steel, with a 1/2 inch high ledge to retain spillage, and has an integrally welded 3 inch x 6 inch cup drain. One piece stainless steel counter and walls shall be welded ground smooth and given a uniform polished finish to eliminate pits, beads and any possibility of material build-up. All corners shall be coved.
6. Interior walls, ceilings and baffles of chemical hoods shall be poly-resin. This fiberglass reinforced polyester panel shall be white in color and 1/4 inch thick. Work counter and cup sink in hood shall be dish shaped cast black epoxy, with flame spread index of 25 or less, according to ASTM E-84. The hood work surface shall be dished, beginning six inches inside the hood. This shall not interfere with the bottom airfoil. The hood bench shall be 3/8 inch dished epoxy resin, unless otherwise specified. Sinks and service fittings shall be located at least six inches beyond the hood face. Work top and penetrations shall be sealed with silicone sealant to prevent leaks thru the base cabinet.
7. Structure under radioisotope or chemical hood: A 10 gauge channel at the front and adequate structural channel reinforcements at the center and rear are provided beneath the work surface to enable it to support up to 250 lbs. /sq. ft. and a single concentrated load of about 500 lbs. per square foot in addition to the weight of the hood itself. Refer to paragraph 2.02 for additional requirements.

C. Accessories Included:

1. Three remote controlled service fittings (one each gas, vacuum and cold water), four 115 volt AC NEMA 5-20R receptacles and a two-tube fluorescent light fixture, bulbs included, with wiring to switch, a cup drain. Lighting is to be vapor proof with bulbs changeable from the outside of the hood. Service fittings shall be located on the left or right side of the hood, as shown on the drawings.
2. Piping and electric conduit and wiring from the service and electrical fittings shall be included with each hood. Fume hoods shall be provided pre-wired and pre-plumbed for "one-point" hook-up to building utilities at top of unit.
3. Screws used to attach exterior members shall be truss head type, zinc plated. Interior fastening devices shall be truss head stainless steel screws or nylon screws and rivets.
4. Sash cables shall be stainless steel or nylon covered zinc plated.
5. Sash guides shall be corrosion resistant plastic.
6. Ceiling closure panels shall be steel, finished to match hood exterior, 18 gauge minimum.
7. Sash pull shall be stainless steel or corrosion resistant plastic.

D. Construction and Design:

1. Fume hood superstructure shall be double wall construction consisting of an outer shell of sheet steel and an inner liner of corrosion resistant material as specified. Double wall shall house and conceal steel framing members, attaching brackets and remote operating service fixture mechanisms. Frame,

inner shell and outer shell shall be assembled, fastened and connected into a rigid, self supporting entity.

2. Fume hood roof shall have a safety glass panel sealed into a Neoprene or PVC Glazing Molding isolating the light fixture from fumes and vapors.
3. Exhaust outlet shall be rectangular at the hood with ends radiused, bell shaped to round flanged termination. Outlet material shall be 18 gauge steel finished with black epoxy powder coating or stainless steel. Hoods with stainless steel liners shall have 18 gauge stainless steel exhaust collars welded in place. Outlet fitting shell shall be sized for maximum velocities of 800 fpm at hood opening and 1500 fpm at duct connection, at hood rated flow.
4. Fume hood sash shall be full view type providing a clear and unobstructed side to side view of fume hood interior and service fixture connections. Sash shall be laminated safety glass set into a deep form, extruded Polyvinyl Chloride guide. Top and bottom sash rails shall be 2 inch maximum of 18 gauge steel finish with a factory applied chemical-resistant epoxy, powder or baked enamel coating. Glass shall be set into rails with Neoprene on Polyvinyl Chloride.
5. Pre-punched openings shall be provided in the hood structure for installation of sash position sensors and hood monitor panels provided under Division 23. Verify and coordinate requirements with controls vendor. With submittal data include dimensioned drawing approved by controls vendor.
6. Decorative closure panels used to enclose area from top of hood to ceiling shall be steel properly fitted to hood and ceiling. Panel shall be removable or provided with access panel. All hoods shall be provided with panels to provide air tight seal of upper portion of the hood, with or without decorative closure panels.

2.02 BASE CABINETS

NOTE: OFPC PREFERENCE IS OPEN SHELF BASE CABINET WITH FREESTANDING FUME AND FLAMMABLE STORAGE CABINETS.

VERIFY WITH CAMPUS SAFETY OFFICE AND USER STRONG DESIRE FOR UNDER HOOD STORAGE CABINETS.

- A. Matching materials, colors and finishes of the fume hood. Separate from the fume hood so that base cabinet can be slid in under hood after the hood has been lifted to fit tightly to the exhaust duct.

- B. Utility Type 1: The fume hood base structure shall be a corrosion resistant, unvented flammable solvent or vented acid storage cabinet with metal shelves. This cabinet shall meet the standards of OSHA 1910.106(d) or NFPA 30 Section 4-3. The vent pipe shall be schedule 40 galvanized pipe and installed to connect into fume hood duct approximately 90" above finish floor. This must not occur in the work surface. The vent pipe/duct connection must be welded or hard cast.
 - 1. 4 ft. hoods will have one vented solvent storage cabinet.

 - 2. 5 ft. hoods will have a 30 inch wide vented solvent storage cabinet plus a 30 inch wide vented acid storage cabinet.

- C. Utility Type 2: The fume hood base structure shall be a fully insulated double wall construction drying cabinet with interior top, bottom and side walls of corrosion resistant steel and exterior walls finished with chemical resistant factory oven-baked coating. Cabinets shall be self-venting. Provide two perforated corrosion resistant steel shelves in each cabinet. 120 volt electric heating elements with thermostatic controls shall be provided with a temperature range to 150 degrees F with shut-off at 160 degrees F. All hood supporting units have leveling devices on legs. Doors have chrome or stainless steel handles, ball bearing catches and hinges on double-wall steel insulated doors, finished as per cabinet walls.

- D. Utility Type 3: The fume hood base structure shall be a light tight cabinet with top, bottom and side walls and doors matching Type 1 and 2. Doors shall be gasketed inside with light-tight vinyl strips. Provide two moveable corrosion resistant shelves, adjustable in 1/2 inch increments, in each cabinet.
- E. Provide a cup sink with integral drain and tail piece in the chase at the back of the hood. Material shall match and be integral with the counter.

2.03 PLUMBING SERVICE FIXTURES

- A. Service Fixtures: Provide units complete with washers, locknuts, unions, nipples and other accessories for positive mounting to supporting laboratory units. Include wall and deck flanges, escutcheons, handle extension rods, remote valves and similar items required. Fabricate units to withstand test pressure of 100 psig.
- B. Material and Finish: Fabricate service fixtures from cast or forged red brass containing a minimum of 85% copper. Exposed surfaces including fittings and escutcheons, bronze finish. All laboratory fittings shall contain standardized operating valve units which are interchangeable with plumbing faucets and fittings specified under Plumbing Fixtures and Equipment and shall be Water Saver, Chicago faucet or approved equal.
 - 1. For fixtures inside fume hoods, coat with acid and solvent resistant baked-on plastic coating. Color, manufacturer's standard metallic brown, aluminum or as otherwise acceptable to Architect.
- C. Service Outlets Identification: Provide colored plastic index discs with embossed identification letters at each service fixture handle or knob. Secure discs to fixture handles to be virtually tamperproof. Color-code discs as follows:

<u>Service</u>	<u>Color</u>	<u>Code</u>	<u>Letter</u>
			<u>Color</u>
Gas	Blue	Gas	White

Vacuum	Yellow	Vac	Black
Cold Water	Green	CW	White

- D. Ground Key Type Hose Cocks: Tapered core and handle of one-piece forged brass, ground and lapped, held in place under constant spring pressure.
- E. Handles: Provide 3-arm or 4-arm forged brass handles for valves, stops, faucets, remote controls and cocks, except for ground key cocks and micro-adjustable needle cocks.
- F. Needle Valves: Provide units with renewable self-centering floating cones and renewable seats of stainless steel or monel metal.
- G. Water Valves or Faucets: Provide units with renewable barrel locked in valve body. Barrel shall contain all wearing parts with renewable discs.
- H. Remote Control Valves: Although straight through types are indicated, use angle valves wherever required.
- I. Vacuum Breakers: Provide vacuum breakers on all water fixtures equipped with serrated outlets.
- J. Pre-piped isolation valves for all services shall be provided behind a removable hood compartment access door in all chemical hoods. Radioisotope hoods shall have external isolation valves.

2.04 ELECTRICAL

- A. Service Fixtures: Provide units complete with metal housing or box; necessary receptacles, terminals, switches, pilot lights, device plates; and fittings and gaskets required for mounting on casework. All fixtures UL labeled.
- B. Recessed Type Fixtures: Galvanized steel outlet box, size as required complete with cover plate and receptacles or other devices as indicated.
- C. Cover Plates: Provide black acid resistant thermoplastic.
- D. Finishes for Service Fixture Components: Furnish housings or boxes for pedestal type and line type fixtures with manufacturer's standard finish. For painted surfaces, use baked-on chemical resistant enamel in color as selected by Architect from manufacturer's standard.
- E. Receptacles: Provide duplex, specification grade, 20 amp, 125 volt, NEMA 5-20R receptacles.
- F. Wiring: All hood wiring shall be Type THHN/THWN insulated copper as a minimum.
- G. Connection: 120V, 20 amps, 460 watts.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install plumb, level, true and straight with no distortions. Shim as required, using concealed shims. Where laboratory casework abuts other finished work, scribe and apply filler strips for accurate fit with fasteners concealed where practicable.

- B. Base Cabinets: Set cabinets straight, plumb and level. Adjust sub-tops with 1/16" of a single plane. Fasten each individual cabinet to floor at toe space, with fasteners spaced 24" o.c. Bolts continuous cabinets together. Secure individual cabinets with not less than 2 fasteners into floor, where they do not adjoin other cabinets.
 - 1. Where required, assemble units into one integral unit with joints flush, tight and uniform. Align similar adjoining doors and drawers to a tolerance of 1/16".

3.02 INSTALLATION OF SERVICE FIXTURES

- A. All service and electrical fixtures will be mounted with internal wiring and piping complete to top of superstructure for final connection by other sections of Division 23 and Division 26. Coordinate utility connection requirements with other sections of Division 23 and Division 26.
- B. All cabinet penetrations for piping, conduit, etc. shall be sealed airtight.

3.03 MECHANICAL COORDINATION

- A. Coordinate requirements for openings and provisions for sash position sensors and hood monitor panels with other Division 23 sections.

3.04 CLEANING AND PROTECTION

- A. Repair or remove and replace defective work as directed upon completion of installation.
- B. Clean shop-finished surfaces, touch-up as required and remove or refinish damaged or soiled areas as acceptable to Architect.

- C. Protection: Advise Contractor of procedures and precautions for damage by work of other trades.

3.05 SUBMITTALS

- A. As a part of the submittal process, and in addition to the technical and dimensional data, one of each hood style specified shall be shipped to the Owner's designated testing agency. Final approval of the hood submittal is contingent on the favorable testing agency report. Failure to pass the described tests shall be the basis for rejection of the hoods. Any retesting of the hoods shall be at the Contractor's expense.

END OF SECTION

SECTION 23 41 00
FILTERS

PART 1 GENERAL

1.00 The following sections are to be included as if written herein:

- A. Section 23 00 00 – Basic Mechanical Requirements
- B. Section 23 05 29 – Sleeves, Flashings, Supports and Anchors
- C. Section 23 05 53 – Mechanical Identification

1.01 SECTION INCLUDES

- A. Filters
- B. Housings and Frames
- C. Filter Gauges

1.02 RELATED SECTIONS

- A. Section 23 05 13 - Motors
- B. Section 23 07 13 - Ductwork Insulation
- C. Section 23 31 00 - Ductwork
- D. Section 26 05 19 - Cable, Wire and Connectors, 600 Volt
- E. Section 26 27 26 - Wiring Devices and Floor Boxes

1.03 REFERENCES

- A. AMCA 99 - Standards Handbook
- B. AMCA 500 - Test Methods for Louver, Dampers, and Shutters
- C. NFPA 70 - National Electrical Code
- D. SMACNA - HVAC Duct Construction Standards - Metal and Flexible
- E. ANST/UL-900 - Test Performance of Air Filter Units

F. ANSI/UL 586 - Test Performance of High Efficiency Portacalate, Air Filter Units

G. ASHRAE 52 - Method of Testing Air Cleaning Devices

1.04 SUBMITTALS

A. Submit under provisions of Section 23 00 00.

B. Shop Drawings: Indicate assembly, unit dimensions, weight loading, required clearances, construction details, field connection details, and electrical characteristics and connection requirements.

C. Product Data:

1. Provide literature which indicates dimensions, weights, capacities, ratings, performance, gauges and finishes of materials, and electrical characteristics and connection requirements.

2. Provide data of media, performance data, assembly, and frames.

3. Submit electrical requirements for power supply wiring including wiring diagrams for interlock and control wiring, clearly indicating factory-installed and field-installed wiring.

D. Manufacturer's Installation Instructions.

1.05 OPERATION AND MAINTENANCE DATA

A. Submit under provisions of Section 23 00 00.

B. Maintenance Data: Include instructions for lubrication, filter replacement, motor and drive replacement, spare parts lists, and wiring diagrams.

1.06 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience, who issues complete catalog data on total product.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, protect and handle products to site under provisions of Section 23 00 00.

- B. Accept products on site in factory-fabricated protective containers, with factory-installed shipping skids and lifting lugs. Inspect for damage.
- C. Store in clean dry place and protect from weather and construction traffic. Handle carefully to avoid damage to components, enclosures, and finish.

1.08 ENVIRONMENTAL REQUIREMENTS

- A. Do not operate units for any purpose, temporary or permanent, until ductwork is clean, filters are in place, bearings lubricated, and fan has been test run under observation. During construction, if the air units operate at any time, minimum MERV 13 filters shall be installed and kept clean.
- B. Provide two sets of belts and three sets of filters for each unit. One set of filters to be installed when unit is started up and shall be protected from construction debris with additional media either at the first bank of filters, or covering each air intake (outside air and return air). Second set of filters to be installed when test and balance activities begin. At substantial completion, OFPC RCM shall inspect filters to determine if the third set should be installed or delivered to campus operations personnel. [_____]. Tag to identify associated unit.

1.09 EXTRA MATERIALS

- A. Furnish under provisions of Section 23 00 00.
- B. Provide two sets for each unit of filters. Tag to identify associated unit.

1.10 SCHEDULES ON DRAWINGS:

- A. In general, all capacities and characteristics are shown in schedules on the Drawings. Reference shall be made to the schedules for such information. The capacities shown are minimum capacities. Variations in the capacities of the scheduled equipment supplied under this contract will be permitted only with the written direction of the owner. All equipment shall be shipped to the job with not less than a prime coat of paint or as specified hereinafter. Where installation instructions are not included in these Specifications or on the Drawings, the manufacturer's instructions shall be followed. All equipment affected by altitude shall be rated to operate at the altitude where it is installed.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Type "A": Permanent Washable

1. American Air Filter HV-2
 2. Farr Type 44
 3. Air-Maza P-5
- B. Type "B": 2" Sectional Renewable
1. American Air Filter RENU
 2. Farr D/C 22
- C. Type "C": Replaceable Dry type, Moderate Efficiency
1. Farr 30/30 – Class I
- D. Type "D": Replaceable Dry Type Medium and/or High Efficiency (MERV 13)
1. American Air Filter
 2. Cambridge
 3. Farr RIGA-FLO
- E. Type "E": 30" Replaceable Dry Type Medium and/or High Efficiency
1. Farr N/S Model III
 2. American Air Filter
 3. Cambridge
- F. Type "G": Ultra High Efficiency (HEPA)
1. Flanders (011-C-04-00-1U) (007-C-04-00-1U)
- G. Type "G": Activated Carbon
1. Farr Model 3CF
 2. Barnaby-Chaney
- H. Side Access Housings
1. Farr (4P) (3P) Universal Glide Pack
 2. American Air Filter
- I. Frames
1. American Air Filter
 2. Farr Type 8

J. Filter Gauges

1. Dwyer "Magnehelic"
2. Dwyer #25 Manometer

K. Substitutions: Under provisions of Section 23 00 00. The equipment or material supplied by any of these acceptable manufacturers or an approved equal shall comply with all of the provisions of this specification.

2.02 GENERAL DESCRIPTION

A. Configuration: Fabricate with fan(s), coils, etc. plus accessories, including:

1. Filters
2. Filter Housings and Frames
3. Filter Gauges

B. Performance Base: Sea level conditions.

C. Fabrication: Conform to AMCA 99 and ARI 430.

D. Performance: Refer to schedules.

2.03 FILTERS:

All air filters shall be listed as (Class 1, Class 2) in accordance with Underwriters Laboratories, Inc., Building Materials Director requirements, except ultra-high efficiency filters, (HEPA or ULPA,) shall be manufactured of materials that are so listed by UL. All filters other than the ultrahigh efficiency type are to be rated in accordance with ASHRAE Test Standard 52-76 and performance characteristics are to be published in the manufacturer's literature. When specified performance characteristics are not published in the manufacturer's literature, the submittal data shall include certified documentation of performance by an approved independent test laboratory.

A. Type "A": Permanent, Washable: Viscous coated, high velocity filters. The net velocity through the filters shall not exceed 500 fpm. Filters shall be 2" (two inches) thick and the initial clean resistance to air flow shall not exceed 0.10" (one tenth inch) w.g. Filters shall be installed in side access or front access frames, as shown on the drawings. Filters in front access frames shall be furnished with lift handles. Furnish one complete set of spare filters for each system.

- B. Type "B": Sectional, Renewable Media: Air filters shall be 2" (two inches) thick adhesive coated glass fiber media pads enclosed in sectional frames of not less than 16 (sixteen) gauge galvanized steel and equipped with a quick opening mechanism for changing filter media. The airflow capacity of the filters shall be based on a net filter face velocity not exceeding 350' (three hundred and fifty feet) per minute with an initial resistance no greater than 0.10" (one tenth inch) water gauge. When used as prefilters, and mounted in the same holding frames as higher efficiency secondary air filters, the airflow capacity may be based on 500' per minute with an initial resistance not to exceed 0.17" water gauge. Filters shall have an average arrestance of not less than 70 to 75% when tested in accordance with ASHRAE Test Standard 52.
- C. Type "C": Replaceable, Dry Type, Moderate Efficiency: Filters shall be of the pleated media, disposable type, 2" (two inches) deep in direction of airflow, Class 1 MERV 8. Each filter cell shall utilize a nonwoven, lofted cotton media with a net effective area of not less than (4.6) (7.0) square feet of media per 1.0 square feet of filter face area, a media support grid, and enclosing high wet strength cell sides. The 96% free area welded wire support grid shall be continuously bonded to the leaving air face of the media to properly support the radially tapered, pleated media in the air stream through the life span of the filter. The media itself shall be cemented to the inside perimeter of the cell sides to prevent bypass of unfiltered air. Filter efficiency shall average not less than 25 to 30% when tested in accordance with ASHRAE Test Standard 52-76. Initial clean resistance to air flow shall not exceed 0.30" w.g. at 500 fpm filter face velocity. The 24" x 24" size shall be certified to have a dust holding capacity of not less than (200) (265) grams of ASHRAE Test Dust when operated at 500 fpm to a final resistance of 1.0" w.g.
- D. Type "D": Replaceable, Dry Type, Medium and/or High Efficiency (minimum MERV 13): Filters shall be 12" deep of the extended surface, supported pleat type. Each filter shall consist of high density, microfine glass fiber media, media support grid, contour stabilizers, and enclosing galvanized steel frame. Media shall be laminated to a nonwoven synthetic backing to form a lofted surface for maximum dust holding capacity. The edges of the media shall be continuously bonded to the internal surfaces of the galvanized steel frame to prevent bypass of unfiltered air. Filter efficiency shall average not less than (40 to 45%) (50 to 55%) (80 to 85%) (90 to 95%) when tested in accordance with ASHRAE Test Standard 52-76. Filters shall be 24" x 24" x 12" deep with an initial clean resistance not to exceed (0.25) (0.35) (0.50) (0.65) inches w.g. at 500 fpm face velocity. The filters shall be certified to have a dust holding capacity of not less than (700) (400) (235) (130) grams of ASHRAE Test Dust when operated at 500 fpm face velocity to a final resistance of 1" w.g.
- E. Type "E": Replaceable Dry Type, Medium and/or High Efficiency: Filters shall be of the extended surface, unsupported, pocket type, approximately 30" deep in

direction of airflow. Each filter shall consist of pockets of high density, microfine glass fiber media, laminated to a nonwoven synthetic backing to form a lofted surface for maximum dust holding capacity, sealed to an enclosing frame (header) of not less than 26 gauge formed galvanized steel. The configuration of the pockets shall be controlled by progressive link stitching so that uniform velocities are maintained in the air passages through the filter. Stapling of media will not be acceptable. All stitching points shall be sealed with a hot melt adhesive. Net effective filter area shall be at least 22.5 square feet per 1.0 square feet of filter face area. Filter efficiency shall average not less than (50 to 55%) (80 to 85%) (90 to 95%) when tested in accordance with ASHRAE Test Standard 52-76. Initial clean resistance shall not exceed (0.29) (0.39) (0.48) inch w.g. at 500 fpm face velocity. The 24" x 24" filters shall be certified to have a dust holding capacity of not less than (740) (480) (325) grams of ASHRAE Test Dust when operated at 500 fpm face velocity to a final resistance of 1" w.g.

- F. Type "F": Ultra High Efficiency: Filters shall be individually tested, certified and labeled to have an efficiency of not less than 99.97% when challenged with diocylphthalate smoke consisting of uniform particles of 0.3 micron size. Test procedure shall conform to the latest revision of MIL-STD-282. The 24" x 24" x 11-1/2" deep size shall be rated at an air flow of not less than (2,000) (1,200) cfm at an initial clean resistance of not more than 1" w.g. Performance data, including penetration and air friction values, shall be stated on a nameplate affixed to the exterior of the frame of each filter. The filter element shall be constructed by pleating a continuous sheet of molded, waterproof, all glass medium with interleaved corrugated aluminum separators. The filter medium shall be manufactured in accordance with the latest revision of MIL-F-51079. The filter element shall be permanently bonded to a 3/4" (three fourth inch) thick fire retardant plywood frame with a rubber base sealant.
- G. Type "G": Activated Carbon Absorbent: Filters are to be furnished as all welded, factory fabricated, 16-gauge galvanized steel side access housings containing the required quantity of filter panels holding coconut shell or petroleum base carbon. The carbon used to fill the panels shall have a minimum CC14 activity of 60 minutes, a maximum ash content of 3.5%, and a maximum moisture content of 2%. Filter panels shall be 1" deep, field refillable, fabricated of polystyrene plastic or 304 stainless steel to withstand the corrosive effect of the carbon as it becomes saturated with gases, in sufficient quantity to provide not less than 45 lbs. of dry activated carbon for each 1,000 cfm of system design air volume. Panels shall slide in place in anodized aluminum tracks. Access door gasketing shall consist of strips of closed cell neoprene around the perimeter and 1" thick sheets of polyurethane opposite the ends of the panels. Housings shall include prepunched standing flanges for ease of attachment to adjacent equipment or ductwork.

2.04 HOUSINGS AND FRAMES

- A. Side access housings shall be fabricated of not less than 16 gauge galvanized steel. Housings shall each be equipped with hinged access doors at both ends, provision for receiving filters of any manufacturer without alteration to the housings, and extruded aluminum channels capable of receiving both the after filters and 2" deep panel type prefilters. The housings shall incorporate a permanent provision for sealing the filters against leakage around the entire perimeter of each filter, eliminating the need to purchase replacement filters with factory applied gasket strips. Replaceable woven pile seals shall be an integral component of the downstream flange of each extrusion so that the seals are compressed by the pressure drop across the filters, preventing bypass of unfiltered air. Side access housing shall not exceed (12) (21) inches in direction of air flow and shall be of all welded construction with factory prepunched standing flanges for ease of attachment to adjacent equipment and/or ductwork. Doors are to be fitted with positive sealing, heavy duty multiple latches and with sponge neoprene gaskets.
- B. Unitary front access holding frames shall be fabricated of not less than 16-gauge galvanized steel with holes pre-punched for convenient assembly into banks. Frames shall be a minimum of 2-5/8" deep for maximum structural strength and resistance to racking. All joints in the field-assembled banks of frames shall be thoroughly caulked to prevent bypass of unfiltered air between frames and surrounding ductwork or plenum chambers. Frames shall each be fitted with polyurethane foam gaskets, held in place by long lasting adhesive, and with a minimum of four heavy-duty spring type fasteners. Fasteners shall attach to the frames without requiring tools and shall be capable of withstanding 25 pounds of pressure without deflection.

2.05 FILTER GAUGES

- A. Each individual filter or filter bank handling 2,000 cfm or more shall be equipped with a diaphragm actuated dial and pointer type gauge with zero adjustment capability. The range of the scale shall be no greater than 1" w.g. above the filter manufacturer's recommended final resistance for the type of filter to which the gauge is being applied. Each gauge shall be provided with an adjustable signal flag, two static pressure taps with compression fittings, two three-way vent valves with compression fittings, two lengths of aluminum tubing, and a mounting plate with screws.
- B. Provide dry contact switch to indicate high-pressure limit (adjustable) for connection by others to FCMS system.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
1. Type "A" - Permanent Washable: Install one set at startup. Clean and recoat filters with adhesive as required prior to final acceptance. At final acceptance, remove and install second set. Wash and recoat first set and turn over to Owner.
 2. Type "B" - Sectional, Renewable Media: Install set of pads at startup. Replace filter pads as required prior to final test and balance. At final test and balance, remove and discard the partially used pads and install a new set. Furnish Owner with one additional set of clean filter pads.
 3. Type "C" - Replaceable, Dry Type, Moderate Efficiency: Install 2" deep fiberglass throwaway filters at startup. Replace throwaway filters as required prior to final acceptance. At final acceptance, remove and discard the partially used throwaway filters and install a set of moderate efficiency filters. Furnish Owner with an additional set of unused moderate efficiency filters.
 4. Types "D" and "E" - Replaceable, Dry Type, Medium and/or High Efficiency: Install 2" (two inch) deep fiberglass throwaway filters at startup. Replace throwaway filters as required prior to final acceptance. At final acceptance, remove and dispose of the used throwaway filters. Install first set of medium and/or high efficiency filters and, where called for, required prefilters. Furnish Owner with an additional set of unused medium and/or high efficiency filters.
 5. Type "F" - Ultra high Efficiency Filters: Install Ultra High Efficiency Filters at startup. Where Ultra High Efficiency filters are used in a system with prefilters, temporary filters shall not be used for prefilters and all specified filters must be in place at all times during system operation. Maintain filters as otherwise specified for temporary filters.
 6. Type "G" - Activated Carbon Absorbent Filters: Install artificial means of simulating carbon filter air friction at startup. Activated carbon filter panels are to be stored in sealed, moisture proof, plastic bags until system is ready for final acceptance. At final acceptance, remove artificial air friction loss device and install carbon filter panels. Furnish Owner with a sufficient quantity of spare carbon filter panels, sealed in moisture proof plastic bags, to replace the largest system.

- B. Install in conformance with UL 900.
- C. Assemble high-pressure units by bolting sections together.

END OF SECTION

**SECTION 23 57 00
HEAT EXCHANGERS**

PART 1 GENERAL

1.00 The following sections are to be included as if written herein:

- A. Section 23 00 00 – Basic Mechanical Requirements
- B. Section 23 05 29 – Sleeves, Flashings, Supports and Anchors
- C. Section 23 05 53 – Mechanical Identification

1.01 SECTION INCLUDES

- A. Shell and tube type heat exchangers
- B. Accessories and trim

1.02 RELATED SECTIONS

- A. Section 23 21 00 - Hydronic Piping
- B. Section 23 06 20.13 - Hydronic Specialties
- C. Section 23 22 00 - Steam and Steam Condensate Piping
- D. Section 23 22 00.A - Steam and Steam Condensate Specialties
- E. Section 23 09 00 - Controls and Instrumentation

1.03 REFERENCES

- A. ANSI/ASME - Boilers and Pressure Vessels Code

1.04 REGULATORY REQUIREMENTS

- A. Conform to Section 8D of the ANSI/ASME Boilers and Pressure Vessels Code for manufacture of tubular heat exchangers and heat exchanger shells.

1.05 SUBMITTALS

- A. Submit shop drawings and product data under provisions of Section 23 00 00.

- B. Submit shop drawings and product data for manufactured products and assemblies required for this project.
- C. Indicate dimensions, locations, and size of tappings and performance data.
- D. Submit manufacturer's installation instructions under provisions of Section 23 00 00.
- E. Submit manufacturer's certificate under provisions of Section 23 00 00 that heat exchangers meet or exceed specified requirements.
- F. Submit design data in sufficient detail to verify that heat exchangers meet or exceed specified requirements.
- G. Submit test reports of tube bundle pressure tests.

1.06 OPERATION AND MAINTENANCE DATA

- A. Submit operation and maintenance data under provisions of Section 23 00 00.
- B. Include start up and shut down instructions, assembly drawings, and spare parts lists.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Deliver products to site under provisions of Section 23 00 00.
- B. Store and protect products under provisions of Section 23 00 00.
- C. Protect internals from entry of foreign material by temporary caps on flanged openings.

1.08 EXTRA MATERIALS

- A. Provide two sets of replacement gaskets under provisions of Section 23 00 00.
- B. Provide one set of wrenches for disassembly of plate type heat exchangers.

PART 2 PRODUCTS

2.01 HOT WATER CONVERTERS:

- A. Provide converters of shell and U-tube type, steam in shell, 100 psi minimum steam working pressure, 150 psi water pressure, conforming to ASME Code and Unfired

Pressure Vessels. Provide units with steel shell, mounting saddles, Muntz Metal or other approved corrosion resistant tube sheet and tube supports, 3/4" (three-fourths inch) type K copper tubes and removable cast iron or fabricated steel head; 2 (two) pass heater with capacity scheduled, when selected for a 0.005 total scale factor; water velocity approximately 4.0 fps. Provide unit with steam inlet, condensate outlet, vent, water inlet and outlet, and other connections as may be required.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install to permit removal of tube bundle with minimum disturbance to installed equipment and piping.
- C. Support heat exchangers on welded steel pipe and angle floor stand.
- D. Pitch shell to completely drain condensate.
- E. Pipe relief valves to nearest floor drain.
- F. Pipe drain valves to nearest floor drain.
- G. Install all water and steam connections to heat exchanger with dielectric fittings.

3.02 STEAM TO WATER HEAT EXCHANGER TRIM

- A. Shell: Pressure gauge tapping with pigtail siphon, vacuum breaker.
- B. Water Inlet: Thermometer well, pressure gauge tapping, valved drain.
- C. Water Outlet: Thermometer well for temperature regulator sensor, ASME rated pressure and temperature relief valve, thermometer well, pressure gauge tapping.

3.03 WATER TO WATER HEAT EXCHANGER TRIM

- A. Water Inlets and Outlets: Thermometer wells, pressure gauge tappings.
- B. Heated Water Outlet: Thermometer well for temperature regulator sensor, ASME rated pressure and temperature relief valve, valved drain.

3.04 SCHEDULE

Drawing Code HE-1 HE-2 HE-3 HE-4

Location
Service
Manufacturer
Model Number
Diameter or Width
Length
Transfer Area

Heating Media
Type
Number of Passes
Flow Rate
Entering Pressure
Pressure Drip
Fouling Factor
Working Pressure
Heated Media
Type
Flow Rate
Pressure Drop
Entering Temperature
Leaving Temperature
Fouling Factor
Working Pressure

END OF SECTION

SECTION 23 73 00
AIR HANDLING UNITS UP TO 10,000 CFM

PART 1 - GENERAL

1.1 THE FOLLOWING SECTIONS ARE TO BE INCLUDED AS IF WRITTEN HEREIN:

- A. Section 23 00 00 – Basic Mechanical Requirements
- B. Section 23 05 29 – Sleeves, Flashings, Supports and Anchors
- C. Section 23 05 53 – Mechanical Identification

1.2 SECTION INCLUDES

- A. Packaged Air Handling Units
- B. Heating Coils
- C. Filter Sections
- D. Face and Bypass Dampers
- E. Multi-zone Dampers
- F. Cooling Coils
- G. Humidifiers
- H. Drives

1.3 RELATED SECTIONS

- A. Section 23 05 16 - Expansion Compensation
- B. Section 23 05 13 - Motors
- C. Section 23 05 48 - Vibration Isolation
- D. Section 23 07 13 - Ductwork Insulation
- E. Section 22 13 16 - Plumbing Piping: Equipment Drains
- F. Section 23 82 16 - Air Coils
- G. Section 23 84 13 - Steam Grid Humidifier
- H. Section 23 34 16 - Centrifugal Fans
- I. Section 23 31 00 - Ductwork
- J. Section 26 05 19 - Cable, Wire and Connectors, 600 Volt

- K. Section 26 27 26 - Wiring Devices and Floor Boxes

1.4 REFERENCES

- A. ABMA 9 - Load Ratings and Fatigue Life for Ball Bearings
- B. ABMA 11 - Load Ratings and Fatigue Life for Roller Bearings
- C. AMCA 99 - Standards Handbook
- D. AMCA 210 - Laboratory Methods of Testing Fans for Rating Purposes
- E. AMCA 300 - Test Code for Sound Rating Air Moving Devices
- F. AMCA 301 - Method of Publishing Sound Ratings for Air Moving Devices
- G. AMCA 500 - Test Methods for Louver, Dampers, and Shutters
- H. AHRI 410 – Forced Circulation Air Cooling and Air Heating Coils
- I. AHRI 430 – Central Station Air Handling Units
- J. ARI 610 - Central System Humidifiers
- K. ASTM D1654 – Standard Test Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments
- L. NEMA MG1 - Motors and Generators
- M. NFPA 70 - National Electrical Code
- N. SMACNA - HVAC Duct Construction Standards - Metal and Flexible
- O. UL 900 - Test Performance of Air Filter Units

1.5 QUALITY ASSURANCE

- A. Performance Ratings: Unit shall be tested in accordance with ARI 430 to establish acceptability (note that the unit does not have to be ARI 430 certified).
- B. Sound Ratings: Test air handling unit in accordance with AMCA 300 (ASHRAE 68) and ARI 260 Guidelines.

1.6 SUBMITTALS

- A. Product Data and Record Documents:
 - 1. Provide literature that indicates dimensions, weights, capacities, ratings, fan performance, gages and finishes of materials, electrical characteristics and connection requirements. Refer to detailed list of submittal data in this Section.
 - 2. Note each deviation and reason for the deviation on the shop drawing submittal.

3. Provide fan curves with specified operating point clearly plotted, as tested and certified per AMCA standards (refer to fan array section for AMCA requirements on fan arrays). Ratings to include system effects inside the air handling units. Bare fan ratings will not satisfy this requirement, but shall be submitted for comparison purposes. All fan data shall be generated from specified testing.
4. Submit sound power level data for both fan outlet and casing radiation at rated capacity, as tested and certified per AMCA and ARI 260 standards. All fan data shall be generated from specified testing.
5. Submit electrical requirements for power supply wiring including wiring diagrams for interlock and control wiring, clearly indicating factory-installed and field-installed wiring.
6. All electrical power, lighting, and TAB access ports are to be noted on the submittal Drawings.

B. Operation and Maintenance Data:

1. Include instructions for lubrication, filter replacement, motor and drive replacement, spare parts lists, and wiring diagrams.
2. Provide Operating and Maintenance (O&M) Manuals for air handling units.
3. Manufacturer's Instructions: Provide Start-up information and maintenance required prior to Start-up. Coordinate with Division 01, 23, and 26 Commissioning Specifications.

1.7 DELIVERY, STORAGE AND HANDLING

- A. Deliver, store, protect and handle products to the Project Site under provisions of Division 01 and Section 23 00 00.
- B. Accept products on Site in factory-fabricated protective containers or covered to protect from weather and construction debris, with factory-installed shipping skids and lifting lugs. Inspect for damage and make any necessary repairs at no expense to the Owner.
- C. Store in clean dry place and protect from weather and construction traffic. Handle carefully to avoid damage to components, enclosures, and finish. Replace damaged equipment.
- D. Protect openings in casing and seal them with plastic wrap to keep out dirt and debris. Protect coil pipe connections from entry of dirt and debris with pipe caps or plugs.
- E. Under no circumstances are air handling units to be used for storage of construction materials.

1.8 SCHEDULES ON DRAWINGS

- A. In general, all capacities of equipment, and motor and starter characteristics are shown in schedules on the Drawings. Reference shall be made to the schedules for such

SECTION 23 73 00

AIR HANDLING UNITS UP TO 10,000 CFM

information. The capacities shown are minimum capacities. Fan motor horsepower (unless noted otherwise) is maximum horsepower. Fan Brake horsepower cannot be exceeded by more than 5%. Variations in the capacities of the scheduled equipment supplied under this Contract will be permitted only with the written direction of the Engineer and Owner.

- B. Where installation instructions are not included in the Contract Documents, the manufacturer's instructions shall be followed.

1.9 ENVIRONMENTAL REQUIREMENTS

- A. Do not operate units for any purpose, temporary or permanent, until ductwork is clean, filters are in place, bearings lubricated, and fan has been test run under observation.

1.10 EXTRA MATERIALS

- A. Furnish under provisions of Section 23 00 00.
- B. Provide one set for each unit of fan belts, and filters.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Climate Craft
- B. Carrier
- C. Trane
- D. York
- E. Temtrol
- F. Thermal Corporation
- G. Substitutions: Under provisions of Section 23 00 00

2.2 GENERAL DESCRIPTION

- A. Configuration: Fabricate with fan and coil section plus accessories, including:
 - 1. Filter section
 - 2. Heating coil
 - 3. Cooling coil section
 - 4. Fan section
 - 5. Humidifier
- B. Performance Base: Sea level conditions

- C. Fabrication: Conform to AMCA 99 and AHRI 430

2.3 CASING CONSTRUCTION

- A. AHU shall maintain structural integrity when wall panels are removed. Provide a unit frame of galvanized steel that provides the overall structure of the unit and does not rely on casing panels for structural integrity. Insulate frame in the same manner as the panels, roof, and floors.
- B. Base Rail: Provide a structural base rail under the full perimeter of the unit, formed from mill galvanized steel. Provide clearance for proper external trapping of drain pans. Base rail and lifting lug system shall not require additional support for rigging. Include base rail lifting lugs at each side of shipping splits and at unit corners.
- C. Panel Construction: Provide double wall AHU casing with panel insulation located between casing walls. Exposed insulation is unacceptable. Insulation shall be encapsulated with sheet metal so that air does not contact insulation. Panels shall be sealed at each corner and around their entire perimeter to eliminate airflow through the panel. The roof and floor shall have the same sealing and insulation requirements as the side panels. Casing shall leak no more than 1.5% of design CFM at +/- 8" w.g..
 - 1. Panel Fire Requirements: Panel assembly shall meet UL standard 1995 for fire safety and shall comply with the requirements of NFPA 90A.
 - 2. Insulation: Casing shall have no less than R-10 thermal resistance at any point on the unit. Panels shall be 2" thick at a minimum.
 - 3. Materials: Panels shall be constructed of 16 gauge galvanized steel.
- D. Access Doors: Access doors shall meet the same construction and thermal requirements as panels as described in section 2.3 C, Panel Construction, above. Provide industrial style stainless steel hinges that permit 180 degrees of door swing. Provide latches with roller cams that ensure a tight seal. Provide a separate handle for each latching point. Doors serving access segments shall have an interior latch handle. Provide access doors with a locking hasp to accommodate a lockout device.
- E. Floor Liner: Provide an additional 0.125" aluminum diamond tread plate floor liner in access sections.
- F. Drain Pans: Drain pans shall meet the same construction and thermal requirements as panels, as described in section 2.3 C, Panel Construction, above, with the exception that the drain pan shall be constructed of No. 14-gauge 316-L stainless steel or heavier as standard with the manufacturer and shall be non-skid. Drain pan and drain connection shall be sized to provide the design rate of condensate drainage at all times.
 - 1. Drain pan shall slope at least 1/8" per foot from horizontal toward the drain outlet.
 - 2. Drain pan shall be sloped towards drain in at least two planes.

3. Drain pan shall be insulated like panels. Insulate plumbing associated with drain pans and connections.
4. Provide a drain connection made of the same material as the drain pan located at the lowest point of the pan and welded to the drain pan.
5. Provide drain pan under the complete width and length of the cooling coil and humidifier sections (if applicable).
6. Drain pan shall allow visible inspection and physical cleaning on 100% of pan surface without removal of coil or humidifier.

2.4 FANS

- A. Type: Provide double width double inlet (DWDI) housed fans or single width single inlet (SWSI) as shown on equipment schedule and drawings.
- B. Provide fans with true airfoil blades unless otherwise scheduled.
- C. Provide fans with the following accessories:
 1. OSHA-compliant belt guard enclosing the fan motor drive.
- D. Performance Ratings: Conform to AMCA 210. Fan shall meet performance requirements indicated on schedule. Fans shall be Class I.
- E. Sound Ratings: AMCA 301; tested to AMCA 300.
- F. Bearings: Self-aligning, grease lubricated, ball or roller bearings with lubrication fittings extended to exterior of casing with copper tube and grease fitting rigidly attached to casing.
- G. Mounting: Locate fan and motor internally on vibration isolated welded steel base. Base shall be isolated from unit casing by springs with 1" or 2" static deflection as scheduled. Base shall be mounted to structural support members which shall span the AHU floor and mount directly to the air handling unit frame. Isolate discharge of fan from casing. Provide access to motor, drive, and bearings through removable casing panels or hinged access doors. Refer to Section 23 05 48.

2.5 DAMPERS

- A. Refer to section 23 33 00 – Ductwork Accessories.

2.6 DRIVES

- A. V-Belt Drives: All v-belt drives shall be designed for a minimum of 50% overload. Where more than one belt is required, matched sets shall be used. All belt drives shall be furnished with belt guards.
- B. Variable Frequency Drives: See Section 23 29 23.

2.7 COILS:

- A. Refer to Schedule and Section 23 82 16 – Air Coils for requirements.

2.8 FILTER

- A. Refer to Schedule and Section 23 41 00 – Filters for requirements

2.9 MOTOR

- A. Motor shall be inverter duty, high efficiency type per Section 23 05 13.

2.10 FINISH:

- A. All external parts of the unit shall be Brite G-90 galvanized.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install in conformance with ARI 435.

END OF SECTION

SECTION 23 73 23
AIR HANDLING UNITS

PART 1 - GENERAL

1.1 THE FOLLOWING SECTIONS ARE TO BE INCLUDED AS IF WRITTEN HEREIN:

- A. Section 23 00 00 – Basic Mechanical Requirements
- B. Section 23 05 29 – Sleeves, Flashings, Supports and Anchors
- C. Section 23 05 53 – Mechanical Identification

1.2 SECTION INCLUDES

- A. Drawings and general provisions of the Contract, including General Conditions and Division 01 Specification Sections, apply to this Section.
- B. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.
- C. Air Handling Units
- D. Factory Installed Fans
- E. Dampers
- F. Filters
- G. Coils
- H. Drives
- I. Humidifiers

1.3 RELATED SECTIONS

- A. Section 23 05 48 - Vibration Isolation
- B. Section 22 13 16 - Plumbing Piping: Equipment Drains
- C. Section 23 05 13.- Motors
- D. Section 23 05 16 - Expansion Compensation
- E. Section 23 07 13 - Ductwork Insulation
- F. Section 23 29 23 – Variable Frequency Drives

- G. Section 23 31 00 - Ductwork
- H. Section 23 33 00 - Ductwork Accessories: Flexible Duct Connections
- I. Section 23 34 16 - Fans
- J. Section 23 41 00 - Filters
- K. Section 23 82 16 - Air Coils
- L. Section 23 84 13 - Steam Grid Humidifier
- M. Section 26 05 19 - Cable, Wire and Connectors, 600 Volt
- N. Section 26 27 26 - Wiring Devices and Floor Boxes

1.4 REFERENCES

- A. AFBMA 9 - Load Ratings and Fatigue Life for Ball Bearings
- B. AFBMA 11 - Load Ratings and Fatigue Life for Roller Bearings
- C. AMCA 99 – Standards Handbook.
- D. AMCA 210 – Laboratory Methods of Testing Fans for Rating Purposes.
- E. AMCA 300 – Test Code for Sound Rating Air Moving Devices.
- F. AMCA 301 – Method of Publishing Sound Ratings for Air Moving Devices.
- G. AMCA 500 – Test Methods for Louver, Dampers, and Shutters.
- H. ARI 260 – Sound Rating of Ducted Air Moving and Conditioning Equipment
- I. ARI 410 – Forced Circulation Air Cooling and Air Heating Coils.
- J. ARI 430 – Standard for Central Station Air Handling Units.
- K. ARI 435 – Application for Central Station Air-Handling Units.
- L. ARI 610 – Central System Humidifiers.
- M. NEMA MG1 – Motors and Generators.
- N. NFPA 70 – National Electrical Code.
- O. NFPA 90A – Standard for the Installation of Air-Conditioning and Ventilating Systems.
- P. NFPA 262 – Standard Method of Test for Flame Travel and Smoke of Wires and Cables for use in Air-Handling Spaces.

- Q. SMACNA – HVAC Duct Construction Standards Metal and Flexible.
- R. UL 900 – Test Performance of Air Filter Units.
- S. ANSI/ASHRAE/IESNA Standard 90.1 – Energy Standard for Buildings Except Low-Rise Residential Buildings.

1.5 SUBMITTALS

- A. Submit under provisions of Section 23 00 00.
- B. Include with the initial submittal a letter signed by the manufacturer’s national sales manager (or any corporate officer) and the production manager, acknowledging that this equipment is intended for a University of Texas facility and that all specification requirements shall be complied with. Submit copy of letter to UHealth ODR.
- C. Shop Drawings: Indicate assembly, unit dimensions, weight loading, required clearances, construction details, field connection details, electrical characteristics, connection requirements, and.
- D. Product Data and Record Documents:
 - 1. Provide literature that indicates dimensions, weights, capacities, ratings, fan performance, gages and finishes of materials, electrical characteristics and connection requirements. Refer to detailed list of submittal data in this Section.
 - 2. Provide data of filter media, filter performance data, filter assembly, and filter frames as tested and certified per ASHRAE 52.2, UL-900 class 1, and NFPA 90 flame spread and smoke rating standards.
 - 3. Provide fan curves with specified operating point clearly plotted, as tested and certified per AMCA standards (refer to fan array section for AMCA requirements on fan arrays). Ratings to include system effects inside the air handling units. Bare fan ratings will not satisfy this requirement, but shall be submitted for comparison purposes. All fan data shall be generated from specified testing..
 - 4. Submit sound power level data for both fan outlet and casing radiation at rated capacity, as tested and certified per AMCA and ARI 260 standards. All fan data shall be generated from specified testing.
 - 5. Provide data on all coils as tested and certified per ARI standards.
 - 6. Submit electrical requirements for power supply wiring including wiring diagrams for interlock and control wiring, clearly indicating factory installed and field installed wiring.
 - 7. All electrical power, lighting, control, sensor, and pressure taps, and TAB access ports are to be noted on the submittal Drawings. Wiring shall have smoke and flammability of 25/50 or better per test method of NFPA 262. Note that the liquid tight flexible metal conduit connections to the fan motor are exempt from this portion of the specification.

8. Note each deviation and reason for the deviation on the shop drawing submittal.
 9. Base Rail Height Calculations: Provide calculations for required base rail heights to allow for proper condensate trapping per condensate drain details.
- E. Operation and Maintenance Data:
1. Include instructions for lubrication, filter replacement, motor and drive replacement, spare parts lists, and wiring diagrams.
 2. Provide Operating and Maintenance (O&M) Manuals for air handling units.
 3. Manufacturer's Instructions: Provide Start-up information and maintenance required prior to Start-up. Coordinate with Division 01, 20, and 26 Commissioning Specifications.

1.6 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing the products specified in this section with minimum three years documented experience, who issues complete catalog data on total product.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Deliver, store, protect and handle products to site under provisions of Section 23 00 00.
- B. Accept products on site in factory-fabricated protective containers, with factory-installed shipping skids and lifting lugs. Inspect for damage.
- C. Store in clean dry place and protect from weather and construction traffic. Handle carefully to avoid damage to components, enclosures, and finish.
- D. Protect openings in casing and seal them with plastic wrap to keep out dirt and debris. Protect coils from entry of dirt and debris with pipe caps or plugs.
- E. Air handling units are not to be used for storage of construction materials under any circumstance.

1.8 ENVIRONMENTAL REQUIREMENTS

- A. Do not operate units for any purpose, temporary or permanent, until ductwork is clean, filters are in place, bearings lubricated, and fan has been test run under observation of the Owner's RCM.

1.9 EXTRA MATERIALS

- A. Furnish under provisions of Section 23 00 00.

- B. Provide two sets of belts, if used, and three sets of filters for each unit. One set of filters is to be installed when unit is started up, and shall be protected from construction debris with additional media either at the first bank of filters, or covering each air intake (outside air and return air). The second set of filters is to be installed when test and balance activities begin. At substantial completion, UHealth ODR shall inspect filters to determine if the third set should be installed or delivered to campus operations personnel. [_____]. Tag to identify associated unit.

1.10 SCHEDULES ON DRAWINGS:

- A. In general, all capacities of equipment, and motor and starter characteristics are shown in schedules on the drawings. Reference shall be made to the schedules for such information. The capacities shown are minimum capacities. Fan motor horsepower (unless noted otherwise) is maximum horsepower. Fan brake horsepower cannot be exceeded per scheduled maximum BHP. Variations in the capacities of the scheduled equipment supplied under this contract will be permitted only with the written direction of the owner.
- B. Where installation instructions are not included in these specifications or on the drawings, the manufacturer's instructions shall be followed.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Climate Craft
- B. Haakon
- C. Temtrol
- D. Air Enterprises
- E. Energy Labs
- F. Thermal Corporation
- G. Substitutions: Under provisions of Section 23 00 00. The equipment as supplied by any of the acceptable manufacturers or an approved equal shall comply with all of the provisions of this specification.

2.2 GENERAL DESCRIPTION

- A. Configuration: Unit Configuration is indicated on the drawings and may vary from unit to unit.
- B. Performance Base: Sea level conditions

- C. Fabrication: Conform to AMCA 99 and ARI 430 in the absence of direction in this specification.
- D. Performance: Refer to schedule in drawings.

2.3 AIR HANDLER CASING AND GENERAL CONSTRUCTION:

- A. Unit casing exterior (walls and roof) shall be a minimum 16-gauge thickness galvanized steel insulated internally, throughout (double wall construction with no thru metal). Internal insulation shall have an R-value of at least 10. All internal insulation shall be protected with solid galvanized sheet metal, of a minimum of 20-gauge thickness (note that fan sections may be lined with a perforated metal liner if this is indicated elsewhere in the specifications or the contract drawings). All sheet metal joints throughout the air handler, and between panelized sections, shall be gasketed with closed cell, soft rubber gaskets, fabricated from neoprene, EPDM, or other approved material. Internal walls and roof outside shall be sealed such that there is no passage of air from inside the unit to the outer casing.
- B. Casing assembly shall be configured to eliminate all thru-metal in portions of the unit subject to below ambient temperatures. Where fasteners are used in the assembly of the unit components, they shall not extend from the outside of the unit into the air stream.
- C. Drain pan liners shall be constructed of No. 14-gauge 316-L stainless steel or heavier as standard with the manufacturer and shall be non-skid. Drain pan shall extend past the cooling coil in the direction of airflow by a minimum of 18". Entire drain pan shall be insulated with R-14 rigid insulation. Drain pans shall be sloped to the outside edge of the unit. On units over six feet wide, slope to each side of the unit. The insulation shall be installed and sealed as is appropriate for the equipment construction. All drain pans shall be equipped with stainless walk-on grating to allow for access downstream of coil.
- D. Unit shall have a complete perimeter channel base of at least 6" galvanized steel or 6" carbon steel with marine quality primer. All floors shall be insulated with R-10 insulation with 14-gauge non-skid galvanized floor (or equivalent aluminum). An 18-gauge galvanized sheet shall enclose and form a vapor barrier for the insulation on the bottom of the unit. All points of contact between the floor, vapor barrier and structure shall be thermally isolated with gasketing of closed cell soft rubber or EPDM.
- E. Access doors shall be provided to allow access upstream and downstream of the filter racks, the fan section, and coils. Access doors shall be double wall, insulated the same as wall panels, and the opening framed with thermal break construction. Door size shall be at least 18" wide (inside free and clear dimension) and full height of the panel (minus allowance for framing and panel support) up to 80" tall. The construction of the access doors shall equal or exceed the quality and quantity of the air handler casing materials as specified herein. Each door shall have a minimum of an 8-inch by 6-inch double-glazed view window, capable of withstanding the total developed pressure of the unit. The doors shall be hinged using either heavy-duty stainless butt hinges, or a continuous stainless steel piano hinge, extending along the entire edge of the door, except for a maximum of

two inches at each end. If butt hinges are used, provide two per door for up to 36” high doors and three per door for longer doors. There shall be a minimum of two latches on doors longer than 18,” and three latches in doors over 36” long. Latches shall be Ventlok 310, heavy-duty latch, or approved equal. All access doors shall open against air pressure.

1. Access doors for the fan section must be large enough to allow removal of fan (s) without cutting the fan or base into pieces.
- F. Coils in the air-handling units shall be individually removable and shall not be used to provide structural stability for the casing. All coils shall be arranged for and piped to provide counterflow operation. All coil frames shall be fabricated of 316 L stainless steel. The coils shall be completely enclosed within the coil housing of the air unit casing. All penetrations of the air handler casing shall be neatly sealed using a resilient sealant or tight fitting rubber grommet. Stacked coils shall have intermediate drain pans extending no less than 12” in the direction of airflow with at least 1” rigid drain piping and pipe supports to main drain pan. Stacked coils shall be constructed with a blank off plate between upper and lower coils to eliminate coil bypass air from contacting intermediate drain pan.
- G. Panels shall be reinforced with sufficient internal bracing to prevent excessive deflection of the panels. Maximum deflection of the unit casing shall be limited to L/250th of the largest overall panel dimension. Refer to deflection testing requirements in Section 3 of this specification.
- H. Panel construction shall provide the following acoustical performance.

1. Sound Transmission Loss (dB) per ASTM E-90 & E-4130

Octave	2	3	4	5	6	7	STC+
Coated Liner	22	26	37	44	53	55	39
Solid Liner	22	38	49	50	57	62	42

2. Sound Absorption Coefficients per ASTM C-423 & E-795

Octave	2	3	4	5	6	7	NRC+
No liner	.26	.71	1.09	1.02	.96	.83	.95
Coated Liner	.25	.79	1.06	1.06	1.04	.78	1.00

The above ratings represent minimum performance. Unit manufacturer shall submit full sound performance per the requirements of Section 1 of this specification.

- I. Provide a unit housing, including joints, seams, and access doors, that will not condense moisture on the external surfaces of this housing when subjected to a surrounding ambient environment of 82 °F dry-bulb/75 °F dew-point temperature air with chilled water temperatures of 40 °F and a discharge air temperature of 50 °F.

- J. Equivalent aluminum material may be used where galvanized steel panel components are called for.
- K. Provide sealable test ports on either side of each filter bank and each coil section, in inlet plenum and discharge plenum, and suction and discharge side of all fans. Ports shall be equal to Ventfabrics test port Model 699-2.

2.4 FANS (SEE ALSO SECTION 23 34 16)

- A. Shall be both dynamically and statically balanced. Housed fans shall be equipped with quick opening access doors in the fan scroll. The motor mounting for each unit shall be an integral part of the fan support frame. The fan/motor unit shall be mounted on spring isolators within the air handler casing. Housed fans shall have an appropriately designed fabric duct vibration isolator installed within the air handler casing. The unit shall be supplied with a factory installed and sealed flange for connection to ductwork. For belt drive units, manufacturer shall provide fixed sheave on units of 10 HP and larger. Contractor shall provide one additional sheave set, size to be determined after job-operating conditions are known. The additional sheave set shall be of equivalent quality to that originally installed by the manufacturer.
- B. The fan unit bearings shall be of the antifriction type, either ball or roller, lubricated at the factory, and shall be equipped with means for lubrication with a grease fitting on the outside of the bearing housing. Both inboard and outboard bearings shall be the same, identical size. The bearings shall be a catalogued type as manufactured by Fafnir, SKF, Sealmaster, or approved equal, and stocked locally. Bearings shall have an L-10 minimum life of 200,000 hours. Intermediate bearings will not be acceptable. Grease fittings for bearings shall be remotely mounted within line of sight of the bearing, where possible. Where it is not possible, then the fitting shall be mounted where it is most easily accessible for service. The tubing used for removing the fitting shall be stainless steel, installed with a strain relief pigtail approximately 4 inches in diameter and located on the drive side of the assembly.
- C. After assembly, the unit manufacturer shall balance the fan (per ANSI/AMCA 204-96 fan application category BV-3) at design fan speed with belts and drives in place to a vibration velocity less than or equal to 0.157 inches (0.100 inches for direct-drive applications) per second measured on horizontal, vertical, and axial planes at each bearing pad. Vibration amplitudes are in inches/second peak velocity. All values recorded are to be filter-in at the fan speed.
- D. Plug fans installed in walk-in units shall be provided with a safety cage around the wheel or with a fan shut down switch in the access door. Cage shall be large enough to allow working room for wheel and bearing service and shall have removable sections to allow wheel removal.
- E. Fans shall be selected at a maximum of 1800 RPM and a maximum motor speed of 60 Hz unless specifically scheduled otherwise.

- F. Fans shall be selected to operate outside of the surge line with a variance of up to 20% of TSP.
- G. Fans shall be repaired and replaced within the allotted space without modification to walls, structure, architecture or finishes.

2.5 MULTIPLE FANS (SEE ALSO SECTION 23 34 16)

- A. Unless specifically scheduled otherwise, fan performance is to be accomplished using a single fan. Where multiple fans are scheduled, this section applies.
- B. Multiple fans shall comprise the scheduled number of fans each rated for equal flow and static pressure. Fans shall be selected for N+1 redundancy where noted on the schedule.
- C. Multiple fans will be furnished with unit mounted panel that provides separate on/off relays, disconnect, and thermal overload connection for each fan in the array.
- D. Each fan shall be furnished with a backdraft damper to prevent recirculation through inactive fans. The performance effect of this damper shall be included in the performance of the fan.
- E. Each fan will be provided with a fan inlet cone venturi air flow measuring station complete with probes, tubing, and controls selected for the fan flow and differential pressure. Accuracy shall be +/- 3% of actual flow. Air flow measuring stations that reduce fan flow or increase TSP will not be accepted. Outputs from the flow stations shall be routed to a terminal strip in a control panel on the outside of the air unit for easy integration with the Building Automation System.
- F. Fans are not required to be AMCA certified for performance or sound, however, each individual fan shall be AMCA certified.
- G. Fan shall be provided with a blank off panel permanently attached to the air unit frame using air craft cable long enough to allow installation on any fan space in the array and constructed to allow blanking off of a fan section with the fan removed.
- H. Each fan motor shall be independently grounded. Common or ungrounded motors will not be accepted.
- I. Total brake horsepower shall be selected within 5% of maximum brake horsepower scheduled.

FAN WHEEL AND HOUSINGS IN COASTAL AREAS SHALL BE HOT DIP GALVANIZED OR COATED WITH ZINCILATE.

2.6 DAMPERS

- A. All automatic control dampers and manual volume control dampers located within the air handling unit or at the air opening on the air handling unit shall be furnished by AHU manufacturer.
 - 1. The actuators for the dampers shall be furnished by the Building Automation Contractor.
- B. Mixing Boxes: Section with factory built, factory mounted outside and return air dampers of aluminum or stainless steel and edge seals in aluminum or stainless steel frame, with aluminum or stainless steel axles in self-lubricating nylon bearings, in opposed blade arrangement with damper blades positioned across short air opening dimension. Provide removable, full width rack for supporting freeze protection thermostat, with removable end panel to permit rack removal.
- C. Damper Leakage: Maximum 4 CFM/Sq. Ft. at 4 inch WG differential pressure. Dampers shall be sized for 2000 fpm maximum face velocity or the same size as the duct connection where one is present.
- D. Refer to Section 23 33 00-2.01 for additional requirements.

2.7 DRIVES

- A. V-belt drives: Shall be designed for a minimum of 50% overload. Where more than one belt is required, matched sets shall be used. All belt drives shall be furnished with belt guards.
- B. Variable frequency drives: See Section 23 29 23.

2.8 COILS

- A. Refer to Section 23 82 16 - Air Coils, and Unit Schedules for requirements.

2.9 FILTERS

- A. Refer to Section 23 41 00 - Filters, and Unit Schedules for requirements.

2.10 HUMIDIFIER

- A. Refer to Section 23 84 13 Steam Grid Humidifiers.

2.11 MOTOR

- A. Motors shall be inverter duty, high efficiency type per Section 23 05 13. See Section 23 05 13 for additional requirements.

2.12 ENERGY RECOVERY EQUIPMENT

- A. Refer to Section XXXXX for Energy Recovery Wheels, heat exchangers, heat pipes, etc

2.13 ELECTRICAL

- A. Fan motors shall be interlocked with fan access door to shut down when door is opened.
 - 1. Refer to Multiple Fan Section for specific fan requirements
- B. Fan motors shall be factory mounted and wired to an external disconnect switch adjacent to the motor access door.
- C. Vapor proof lights (ceiling or wall mounted so that fixture shall be no higher than 88" above floor) shall be provided in each compartment with access doors. Lights shall have a switch at each door into the compartment. Provide two GFI convenience outlets evenly spaced on the long dimension of the unit. Wire lights and outlets to two external 120v, 20a power connections (one for each service) for connection by Division 26.
- D. All wiring shall be 600v rated type MTW/THWN stranded copper in EMT or LiquidTite conduit (max 3 feet). All junction boxes shall be UL approved and gasketed.

2.14 FINISH

- A. All external parts of the unit shall be Brite G-90 galvanized. No painting will be required.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Field assembly of the unit shall be the responsibility of the manufacturer.
- B. Install in conformance with ARI 435.
 - 1. Assemble high-pressure units by bolting sections together. Isolate fan section with flexible duct connections for units equipped with housed fans
 - 2. Unit shall be installed level and plumb. Where units are installed on a concrete housekeeping pad, units shall be installed on neoprene pads as indicated on installation details and in Section 23 05 48 - Vibration Isolation.
 - 3. Piping and duct connections shall be installed so that all access doors swing freely.

3.2 TESTING

- A. Units with cabinet mounted fans shall be tested and certified at rated conditions using AMCA 210 and AMCA 300 test procedures with fan mounted in the cabinet. Bare fan data will not be accepted.
- B. Travel costs (airfare, meals, lodging, ground transportation) for the Owner's TAB consultant and ODR to witness tests shall be paid by the manufacturer.
- C. Casing Deflection Test

1. Deflection limit of L/250 shall be demonstrated in the factory prior to shipping and witnessed by a representative of the Owner's Test and Balance Consultant.
 2. 'L' is defined as the height of the largest panel on the sides, width across the top of the largest panel on the unit, and the smaller of width or height of the largest panel for the ends. These are known as the governing panels.
 3. That portion of the unit after the fan discharge shall be tested at positive pressure. The remainder of the unit shall be tested at negative pressure.
 4. Measurements shall be taken at midpoint of 'L' using dial indicators reading in 1/1000ths. Mounting of dial indicators shall be independent of the unit casing. Multiple measurements shall be made. Dial indicator shall be mounted at midpoint of 'L'. Measurements shall then be spaced along the sides, ends and top at mid point and quarter points of the negative section and the positive section. Spacing shall be adjusted to fall on nearest flange or panel joint. Any section of less than five feet shall require only one measurement at the center.
 5. Unit shall be furnished with proper blank offs to facilitate the pressure testing.
 6. In order to reduce the number of pressure cycles, it is recommended that multiple dial indicators be used at the measurement points. Separate set-ups will be required for the positive pressure tests and the negative pressure tests.
- D. Casing Leakage Test. With unit set in place, leveled and ready to receive duct work connections after delivery [on-site], unit shall be tested for casing leakage by sealing all openings and pressurizing to 2.5 times rated pressure (defined as total static pressure of unit) or 10" WG, whichever is smaller. Maximum allowable leakage rate is 1.5% of rated unit flow. Test is to be performed using flow measurement devices and shall be witnessed by a representative of the Owner's Test & Balance firm.
- E. Fan/Motor Vibration Test. With the unit set in place, leveled, and ductwork attached, the manufacturer shall perform a final dynamic vibration trim balance to verify the fan/motor vibration velocity limit over the following operating speed range: Fans with VFDs shall be checked by operating at VFD speeds from 20 to 65 Hz. Constant speed fans shall be checked at 100% of rated fan speed. 'Lock-out' ranges may be used to correct up to three ranges of excess vibration. The span of each 'lock-out' range shall be limited to an effective fan speed of 50 RPM. Any 'lock-out' range used shall be clearly identified in the test report and shall be prominently displayed on a typed, laminated legend mounted inside the VFD controller cabinet. This testing shall be witnessed by a representative of the Owner's Test and Balance firm.
1. Note that for air handling units equipped with multiple fans, each fan shall be tested individually and the fan array shall be tested as an assembly.
- F. Failure of the leakage and/or deflection test shall require sealing and bracing of the unit and retesting until criteria is met. Failure of the trim balance to confirm vibration limit shall require rebalancing and re-testing until criteria is met. Contractor shall bear all costs involved in the modifications, balancing, and re-testing, including travel and hourly costs associated with the representatives of the Owner's Test and Balance firm.

3.3 FINAL CLEANING AND PREPARATION

- A. Prior to substantial completion, contractor will clean and prepare the unit for acceptance by the owner by doing the following:
1. Wipe down and clean the unit inside and outside. The unit shall be free of dirt, dust, foot prints, paint splatter, etc.
 2. All coils shall be combed to straighten any bent fins.
 3. Filters that were used in the construction phase shall be replaced with new filters.
 4. All penetrations made in the unit cabinet (power, controls, tab, etc) shall be sealed air tight.
 5. Any devices that require lubrication, tensioning, etc shall be serviced.

END OF SECTION

SECTION 23 73 23.A
BUILT UP AIR HANDLING UNITS
(ABOVE 50,000 CFM)

PART 1 GENERAL

1.00 The following sections are to be included as if written herein:

- A. Section 23 00 00 – Basic Mechanical Requirements
- B. Section 23 05 29 – Sleeves, Flashings, Supports and Anchors
- C. Section 23 05 53 – Mechanical Identification

1.01 SECTION INCLUDES

- A. Built Up Air Handling Units
- B. Mixing Boxes
- C. Supply Air Fans
- D. Filter Sections
- E. Heating Coils
- F. Cooling Coils
- G. Humidifiers
- H. Drives

1.02 RELATED SECTIONS

- A. Section 23 05 16 - Expansion Compensation
- B. Section 23 05 13 - Motors
- C. Section 23 05 48 - Vibration Isolation
- D. Section 23 07 13 - Ductwork Insulation
- E. Section 22 13 16 - Plumbing Piping: Equipment Drains
- F. Section 23 82 16 - Air Coils

- G. Section 23 84 13 - Steam Grid Humidifier
- H. Section 23 34 16 - Fans
- I. Section 23 41 00 - Filters
- J. Section 23 31 00 - Ductwork.
- K. Section 26 05 19 - Cable, Wire and Connectors, 600 Volt
- L. Section 26 27 26 - Wiring Devices and Floor Boxes

1.03 REFERENCES

- A. AFBMA 9 - Load Ratings and Fatigue Life for Ball Bearings
- B. AFBMA 11 - Load Ratings and Fatigue Life for Roller Bearings
- C. AMCA 99 - Standards Handbook
- D. AMCA 210 - Laboratory Methods of Testing Fans for Rating Purposes
- E. AMCA 300 - Test Code for Sound Rating Air Moving Devices
- F. AMCA 301 - Method of Publishing Sound Ratings for Air Moving Devices
- G. AMCA 500 - Test Methods for Louver, Dampers, and Shutters
- H. ARI 410 – Forced Circulation Air-Cooling and Air-Heating Coils
- I. ARI 430 – Central Station Air Handling Units
- J. ARI 435 - Application of Central Station Air Handling Units
- K. ARI 610 - Central System Humidifiers
- L. NEMA MG1 - Motors and Generators
- M. NFPA 70 - National Electrical Code
- N. SMACNA - HVAC Duct Construction Standards - Metal and Flexible
- O. UL 900 - Test Performance of Air Filter Units

1.04 SUBMITTALS

- A. Submit under provisions of Section 23 00 00.
- B. Shop Drawings: Indicate assembly, unit dimensions, weight loading, required clearances, construction details, field connection details, and electrical characteristics and connection requirements.
- C. Product Data:
 - 1. Provide literature that indicates dimensions, weights, capacities, ratings, fan performance, gauges and finishes of materials, and electrical characteristics and connection requirements.
 - 2. Provide data of filter media, filter performance data, filter assembly, and filter frames.
 - 3. Provide fan curves with specified operating point clearly plotted.
 - 4. Submit sound power level data for both fan outlet and casing radiation at rated capacity.
 - 5. Submit electrical requirements for power supply wiring including wiring diagrams for interlock and control wiring, clearly indicating factory-installed and field-installed wiring.
- D. Manufacturer's Installation Instructions.

1.05 OPERATION AND MAINTENANCE DATA

- A. Submit under provisions of Section 23 00 00.
- B. Maintenance Data: Include instructions for lubrication, filter replacement, motor and drive replacement, spare parts lists, and wiring diagrams.

1.06 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing the products specified in this section with minimum three years documented experience, who issues complete catalog data on total product.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Deliver, store, protect and handle products to site under provisions of Section 23 00 00.
- B. Accept products on site in factory-fabricated protective containers, with factory-installed shipping skids and lifting lugs. Inspect for damage.

- C. Store in clean dry place and protect from weather and construction traffic. Handle carefully to avoid damage to components, enclosures, and finish.

1.08 ENVIRONMENTAL REQUIREMENTS

- A. Do not operate units for any purpose, temporary or permanent, until ductwork is clean, filters are in place, bearings lubricated, and fan has been test run under observation.

1.09 EXTRA MATERIALS

- A. Furnish under provisions of Section 23 00 00.
- B. Provide two sets for each unit of fan belts, filters, [_____]. Tag to indicate associated unit.

1.10 SCHEDULES ON DRAWINGS:

- A. In general, all capacities of equipment, and motor and starter characteristics are shown in schedules on the drawings. Reference shall be made to the schedules for such information. The capacities shown are minimum capacities. Variations in the capacities of the scheduled equipment supplied under this contract will be permitted only with the written direction of the owner. All equipment shall be shipped to the job with not less than a prime coat of paint or as specified hereinafter. Insofar as is possible, all items of the same type (i.e., pumps, fans, etc.) shall be by the same manufacturer. Where installation instructions are not included in these specifications or on the drawings, the manufacturer's instructions shall be followed. All equipment affected by altitude shall be rated to operate at the altitude where it is installed.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Aero-fin - Product: coils
- B. York - Product: coils
- C. Thermal - Product: coils
- D. Barry Blower - Product: fans
- E. Buffalo Forge - Product: fans
- F. Chicago Blower - Product: fans
- G. New York Blower - Product: fans

- H. Farr - Product: filters
- I. American Air Filter - Product: filters
- J. Cambridge - Product: filters
- K. Greenheck - Product: dampers
- L. Prefco - Product: dampers
- M. Ruskin - Product: dampers
- N. [] - Product: []
- O. [] - Product: []
- P. [] - Product: []
- Q. [] - Product: []
- R. Substitutions: Under provisions of Section 23 00 00. The equipment or material supplied by any of these acceptable manufacturers or an approved equal shall comply with all of the provisions of this specification.

2.02 GENERAL DESCRIPTION

- A. Configuration: Fabricate with fan(s), coils, etc. as scheduled, plus accessories, including:
 - 1. Control dampers
 - 2. Mixing box section
 - 3. Filter section
 - 4. Preheat coil
 - 5. Cooling coil section
 - 6. Heating coil
 - 7. Supply air fan
 - 8. Humidifier
- B. Performance Base: Sea level conditions.

C. Fabrication: Conform to AMCA 99 and ARI 430.

D. Performance: Refer to schedules.

2.03 BUILT-UP AIR HANDLING UNIT CONSTRUCTION

NOTE TO SPECIFICATION WRITER: IN GALVESTON ONLY, ALL SURFACES IN THE AIR STREAM FROM THE OUTSIDE AIR INTAKE TO THE COOLING COIL, INCLUDING BUT NOT LIMITED TO CASING, DAMPERS, FLOOR AND FILTER FRAMES, SHALL BE 316L STAINLESS STEEL. EXCEPTION TO THIS REQUIREMENT IS THE PREHEAT COIL. MODIFY THIS SPECIFICATION TO SUIT.

- A. Casings for built-up air units shall be fabricated by the Contractor, enclosing the fan, filter, chilled water coils, steam preheat coils, etc.
- B. Unit casing shall be a minimum 14-gauge thickness galvanized steel double wall, insulated internally, throughout. Internal insulation shall be minimum 2" thick, 3 pound per cubic foot density, fiberglass, neoprene or mylar protected where inside wall is perforated, or unless specifically noted otherwise, and shall be fire and fungus proof. All internal insulation shall be protected with either perforated aluminum (only where specifically designated on drawings) or solid galvanized sheet metal, of a minimum of 18-gauge thickness. All sheet metal joints throughout the air handler, and between panelized sections, shall be gasketed with closed cell, soft rubber gaskets, fabricated from neoprene, EPDM, or other approved material, and solidly fastened with stainless steel bolts or screws, as instructed by the manufacturer.
- C. Chilled water coil drain pans shall be 316L SS or copper of 14-gauge or heavier sheet metal. Coil drain pan pipe shall be of the same material. The drain pan arrangement shall be as shown on drawings. In the event floor drains are not provided in the plenum floor, a drain line shall be provided from the bottom-most coil drain pan, thru the concrete curb supporting the plenum wall to the nearest floor drain. The pipe shall be Type L copper or galvanized steel of at least 1-1/2" (one and one-half inch) diameter. The external drain line shall have a minimum 6" deep trap and be insulated with 3/4" (three-fourths inches) Armaflex or approved equal.
- D. Access doors shall be installed to each access section between each coil, and to each service area within the air handler, including but not limited to, fan chamber, humidifier section, between coils, filter section, and mixing box (air return/outside air supply). The construction of the access doors shall equal or exceed the quality and quantity of the air handler casing materials as specified herein. Each access door shall be approximately 7 feet high, and shall permit a clear access of a minimum of 30 inches. A nominal width of 36 inches is desirable. Each access door shall also contain a double glazed view window of a minimum of 12 inches by 12 inches. The doors shall be hinged using a continuous minimum 10-gauge piano type hinge to within 1 inch of both

top and bottom of the door. The door shall have a compressible bulb automotive type windlace, and shall provide a seal to limit leakage beyond the level of detection. Doors shall have multiple latches and shall be Ventlok 310, heavy duty latch, or approved equal. All access doors shall open against air pressure, unless approved by the owner in writing.

2.04 DAMPERS

- A. All automatic control dampers and manual volume control dampers located with air handling unit shall be furnished by AHU manufacturer.
- B. Mixing Boxes: Section with factory built, field-mounted outside and return air dampers of galvanized steel and edge seals in galvanized frame, with galvanized steel axles in self-lubricating nylon bearings, in opposed blade arrangement with damper blades positioned across short air opening dimension. Provide removable, full width rack for supporting freeze protection thermostat, with removable end panel to permit rack removal.
- C. Damper Leakage: Maximum 2 percent at 4 inch WG differential pressure when sized for 2000 fpm face velocity.
- D. Face and Bypass Dampers: Factory mounted in casing field mounted with access doors, of galvanized steel blades, and edge seals, galvanized steel frame, and axles in self-lubricating nylon bearings, arranged to match coil face with bypass, blank-off and division sheets, external linkage, access doors, and adjustable resistance plate.

2.05 FAN

- A. The fan shall be DWDI, Class II, as scheduled with backward inclined blades or airfoil as scheduled and shall be both dynamically and statically balanced. Fan housings shall be furnished with Quick Opening Access Doors. Fan bearings shall be self-aligning, grease lubricated ball bearings of the pillow block type. Equip with a belt guard having an opening for a speed counter. Mount fan and motor on an integral frame. Furnish a second fixed sheave for final balancing of size as determined after job operating conditions are known. All fans shall be equipped with variable frequency drives.
- B. Fans shall be both dynamically and statically balanced. All fans shall be equipped with quick opening access doors in the fan scroll. Fan sections shall be provided with a minimum of two (each side of coil), insulated quick fastener attached gasketed hinged access doors, minimum size of 18" x 36". Motors shall be high efficiency type as manufactured by Century or Baldor. The motor mounting for each unit shall be an integral part of the fan support frame. The fan/motor unit shall be mounted on spring isolators within the air handler casing, with an appropriately designed fabric duct vibration isolator installed between the fan scroll and the fan chamber casing. Contractor shall provide one additional sheave set, size to be determined after job

operating conditions are known. The additional sheave set shall be of equivalent quality to that originally installed by the manufacturer.

- C. The fan unit bearings shall be of the antifriction type, either ball or roller, lubricated at the factory, and shall be equipped with means for lubrication with a grease fitting on the outside of the bearing housing. Both inboard and outboard bearings shall be the same, identical size. The bearings shall be a catalogued type as manufactured by Fafnir, SKF, Sealmaster, or approved equal, and stocked locally. Bearings shall have a B-10 minimum life of 40,000 hours. Intermediate bearings will not be acceptable. Grease fittings for bearings shall be remotely mounted within line of sight of the bearing, where possible. Where it is not possible, then the fitting shall be mounted where it is most easily accessible for service. The tubing used for removing the fitting shall be stainless steel, installed with a strain relief pigtail approximately 4 inches in diameter.

NOTE: FAN WHEEL AND HOUSINGS IN COASTAL AREAS SHALL BE HOT DIP GALVANIZED OR COATED WITH ZINCILATE.

2.06 DRIVES

- A. V-Belt: All v-belt drives shall be designed for a minimum of 50% overload. Where more than one belt is required, matched sets shall be used. All belt drives shall be furnished with belt guards.
- B. Variable Speed: See Section 23 29 23.

2.07 COILS Refer to Section 23 82 16 - Air Coils and Unit Schedules for requirements.

2.08 FILTERS Refer to Section 23 41 00 - Filters and Unit Schedules for requirements.

2.09 HUMIDIFIER Refer to Section 23 84 13 - Steam Grid Humidifiers.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install in conformance with ARI 435.
- C. Assemble high-pressure units by bolting sections together.
- D. Install assembled unit on vibration isolators. Refer to Section 23 05 48.

3.02 AIR HANDLING UNIT SCHEDULE (Shown here for information only. Schedule Data to be placed on Drawings.)

Drawing Code

AHU-1AHU-2AHU-3AHU-4

Location

Service

Manufacturer

Model Number

Fan (Supply - Return)

Capacity

Total Static Pressure

BHP

Motor HP

Drive

Type

Manufacturer

Model

Heating Coil

Fin Series

Type

Height

Width

Rows/Fins

Capacity

Air Entering

Dry Bulb

Wet Bulb

Air Leaving

Dry Bulb

Air SP Drop

Water Entering

Water Leaving

Water Pressure Drop

Steam Capacity

Steam Pressure

Electrical Input

Cooling Coil

Fin Series

Type

Height

Width

Rows/Fins

Capacity

Air Entering

Dry Bulb

Wet Bulb
Air Leaving
Dry Bulb
Wet Bulb
Water
Flow
Entering
Leaving
Pressure Drop
Saturated Suction
Filters
Type
Quantity/Size
SP Drop ("WG" @ 500 FPM)
Initial
Final
Sound Power
Fan Discharge
1st Octave
2nd Octave
3rd Octave
4th Octave
5th Octave
6th Octave
7th Octave
8th Octave
Casing Radiated
1st Octave
2nd Octave
3rd Octave
4th Octave
5th Octave
6th Octave
7th Octave
8th Octave
Accessories

END OF SECTION

**SECTION 23 81 23
COMPUTER ROOM AIR CONDITIONING UNITS**

NOTE THAT THIS IS A NEW SPECIFICATION. IT IS INTENDED TO BE INCLUDED AS A "SHELL" FOR THE ENGINEER TO USE IN FUTURE PROJECTS. PLEASE SUBMIT COMMENTS AS MIGHT BE APPROPRIATE.

NOTE TO ENGINEER: WHEN USING THIS SECTION, IT WILL BE NECESSARY TO ADD A SPECIFICATION FOR AN OUTSIDE CONDENSING UNIT IF CHILLED WATER IS NOT USED AS A COOLING MEDIUM.

PART 1 GENERAL

1.00 The following sections are to be included as if written herein:

- A. Section 23 00 00 – Basic Mechanical Requirements
- B. Section 23 05 29 – Sleeves, Flashings, Supports and Anchors
- C. Section 23 05 53 – Mechanical Identification

1.01 SECTION INCLUDES

- A. Air conditioning units
- B. Controls and control panels

1.02 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION

- A. Section 23 09 00 - Controls and Instrumentation: Installation and wiring of thermostats and control components
- B. Section 26 05 19 - Cable, Wire and Connectors, 600 Volt: Electrical characteristics, cable, wire, materials
- C. Section 26 27 26 - Wiring Devices and Floor Boxes: Wiring connections

1.03 RELATED SECTIONS

- A. Section 09 69 00 - Access Flooring
- B. Section 23 05 13 - Motors: Evaporator and condenser fan motors
- C. Section 23 07 13 - Ductwork Insulation: Duct liner

- D. Section [] [21 22 00] – Interlock with ~~halon~~ clean agent system
- E. Section 23 20 00 - HVAC Pumps: Chilled water system pumps
- F. Section 23 82 16 - Air Coils: Chilled water, hot water, steam, glycol coils
- G. Section 23 09 00 - Controls and Instrumentation
- H. Section 26 05 00 - Equipment Wiring Systems: Electrical supply to units

1.04 REFERENCES

- A. ANSI/ASME - Boilers and Pressure Vessels Code
- B. ANSI/NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum)
- C. ANSI/NFPA 90A - Installation of Air Conditioning and Ventilation Systems
- D. ASHRAE 52 - Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter
- E. FS TT-C-490 - Cleaning Method and Pretreatment of Ferrous Surfaces for Organic Coatings.
- F. UL - Underwriters Laboratories

1.05 REGULATORY REQUIREMENTS

- A. Conform to ANSI/NFPA 90A for the installation of computer room air conditioning units.

1.06 SUBMITTALS

- A. Submit shop drawings and product data under provisions of Section 23 00 00.
- B. Submit shop drawings and product data for manufactured products and assemblies required for this project.
- C. Indicate water, drain, electrical, and refrigeration rough-in connections on shop drawings or product data.
- D. Submit manufacturer's installation instructions under provisions of Section 23 00 00.

1.07 OPERATION AND MAINTENANCE DATA

- A. Submit operation and maintenance data under provisions of Section 23 00 00.
- B. Include manufacturer's descriptive literature, operating instructions, installation instructions, and maintenance and repair data.

1.08 WARRANTY

- A. Provide five-year manufacturer's warranty under provisions of Section 23 00 00.
- B. Warranty: Include coverage of entire unit including refrigeration compressors.

1.09 EXTRA MATERIALS

- A. Provide one set of filters under provisions of Section 23 00 00.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Leibert
- B. Compair
- C. [_____].]
- D. Substitutions: Under provisions of Section 23 00 00

2.02 MANUFACTURED UNITS

- A. Provide packaged, [water] [air] cooled, factory assembled, pre-wired and pre-piped unit, consisting of cabinet, fans filters, humidifier, controls.
- B. Assemble unit for [up-flow] [down-flow] air delivery, in [draw-through] [or] [blow-through] configuration.

2.03 CABINET AND FRAME

- A. Structural Frame: [10] [14] [_____] gage welded steel suitably braced for rigidity, capable of supporting compressors and other mechanical equipment and fittings[;][.]
[welded tubular steel floor stand with adjustable legs and vibration isolation pads.]

- B. Doors and Access Panels: [18] [20] [_____] gage [galvanized] steel with polyurethane gaskets, hinges to allow removal of panels, and concealed fastening devices.
- C. Insulation: Thermally and acoustically line cabinet interior with one inch thick acoustic duct liner.
- D. Finish of Exterior Surfaces: FS TT-C-490 prepared, baked-on textured vinyl enamel; [_____] color[.] [to match computer equipment.] [as selected.]

2.04 EVAPORATOR FANS AND MOTORS

- A. Fans: Double inlet, forward curved centrifugal fans, statically and dynamically balanced[,] [on steel shaft with self-aligning [grease] [permanently] lubricated ball bearings, and V-belt drive.] [directly driven.]
- B. Motor: [Refer to Section 23 05 13 - Motors.] [Drip proof, permanently lubricated ball bearing motor with built-in current and overload protection.]
- C. V-Belt Drive: Cast iron or steel sheaves, dynamically balanced, keyed, variable and adjustable pitch motor sheave, minimum of two matched belts, drive rated minimum 2.0 times nameplate rating of motor.

2.05 COMPRESSORS

- A. [Semi-hermetic with suction gas cooled motors, vibration isolators, thermal overloads, oil sight glass, manual reset high pressure switch, pump down low pressure switch, suction line strainer, reversible oil pumps, 1750 rpm][.] [or,] [Hermetic with resilient suspension system, oil strainer, crankcase sight glass, internal motor protection, low-pressure switch, manual reset high-pressure switch.]
- B. Compressors shall be individually serviceable without dismantling other components[.] [or removing unit from service.]

2.06 EVAPORATOR COILS

- A. [Alternate row] [Split face] circuits, direct expansion cooling coils of seamless copper tubes expanded into aluminum fins[,][.] [in A-frame configuration.] [in vertical flat face configuration.]
- B. Two refrigeration circuits, each with hot gas mufflers, thermal expansion valve with external equalizer, liquid line solenoid valve, liquid line filter-drier, refrigerant sight

glass with moisture indicator, service shut-off valves and charging valves[.][.]
[accumulator sized for liquid seal under light load.]

C. Mount coil assembly in stainless steel drain pan.

2.07 CONDENSERS

A. Water Cooled: [Shell and tube type to Section 8D of ANSI/ASME code] [or]
[Coaxial tube in tube type] with liquid line stop valve and head pressure actuated
water regulating valve. Terminate cabinet for easy external connections.

B. Air Cooled: Air cooled refrigerant condenser[.] [refer to Section 23 63 00,]
consisting of corrosion resistant cabinet, copper tube aluminum fin coils arranged
for two circuits, multiple direct drive propeller fans with [permanently lubricated
ball bearing] single phase motors with internal overload protection. [Refer to
Section 23 05 13.]

2.08 [CHILLED WATER] [HOT WATER REHEAT] [STEAM REHEAT] [GLYCOL COOLING] COIL

A. Seamless copper tubes expanded into aluminum fins with [three way modulated
valve.] [two way modulating control valve and strainer.] [two way modulating
control valve, strainer, and float and thermostatic trap.] [head pressure actuated three
way glycol regulating valve.]

2.09 REHEAT COIL

A. Hot gas refrigerant coil of seamless copper tubes expanded into aluminum fins with
three way solenoid valve on first stage refrigerant circuit.

2.10 FILTERS

A. Media: Pleated, lofted, non-woven, reinforced cotton fabric; supported and bonded
to welded wire grid; enclosed in cardboard frame; [2 inch] [4 inch] nominal
thickness.

B. Rating: ASHRAE 52; 25-30 percent dust spot efficiency, 90-92 percent weight
arrestance; 500 ft/min face velocity, 0.30 inch WG initial resistance, 1.0 inch WG
recommended final resistance.

C. Model: [_____] manufactured by [_____].]

2.11 HEATING COILS

- A. Heating Coils: Enclosed fin electrical elements arranged for minimum of [two] [three] stages.
- B. Circuit Protection: Primary and secondary thermal cutouts, differential air pressure switch, and manual reset overload protection, branch circuit overcurrent protection.

2.12 HUMIDIFIER

- A. Infrared Type: High intensity quartz lamps mounted above stainless steel evaporator pan, serviceable without disconnecting water, drain, or electrical connections; pre-piped and utilizing condensate water from cooling coils with stainless steel or brass float valve mechanism; located in bypass air stream[;][.] [with flush cycle timer and solenoid drain valve.]
- B. Evaporative Pan Type: Stainless steel pan and cover, serviceable without disconnecting water, drain, or electrical connections; pre-piped with stainless steel or brass float valve mechanism; electric heating coil and low water cut-off switch; with flush cycle timer and solenoid drain valve.

2.13 REMOTE GLYCOL COOLER

- A. Corrosion resistant [aluminum] [_____] cabinet with copper tube aluminum fin coil, multiple direct drive propeller fans with fan guard and [permanently lubricated ball bearing] single phase motors with internal overload protection. [Refer to Section 23 05 13.]

2.14 GLYCOL PUMP PACKAGE

- A. Cabinet: Weatherproof and vented enclosure of enameled, galvanized steel on structural base frame.
- B. Pumps: [One] [Two] centrifugal pumps with mechanical seal. [Refer to Section 23 30 00.]
- C. Controls: Electrical control cabinet with starters, disconnect, lead/lag switch, and automatic switch-over and alarm light.
- D. Piping: Interconnecting piping, from suction to discharge with shut-off valves, flow switches, check valves in pump discharge, unions, and pressurized expansion tank with air purge vent and system charging connection.

2.15 ELECTRICAL PANEL

- A. Service Connections, Wiring, and Disconnect Requirements: Conform to Sections 26 05 19 and 26 27 26.
- B. Control Cabinet: NEMA 250; Type [2] [] enclosure, UL listed, with piano hinged door, grounding lug, combination magnetic starters with overload relays, circuit breakers and cover interlock, and fusible control circuit transformer.
- C. Disconnect Switch: Non-automatic molded case circuit breaker with handle accessible with panel closed[.] [and capable of preventing access until switched to "off" position.]

2.16 ELECTRONIC CONTROL SYSTEM

- A. Solid state with start button, stop button, temporary loss of power indicator, manual reset circuit breakers, temperature control humidity control, and monitor panel.
- B. Monitor Panel: Back lighted with no visible indicator lights until operating function is activated; indicators include cooling, humidification, loss of air flow, change filters, high temperature, low temperature, high humidity, low humidity, high head pressure (each compressor), and low suction pressure (each compressor).
- C. Temperature and Humidity Control Modules: Solid state plug-in with adjustable set point, "push-to-test" calibration check button, and built-in visual indicators to indicate mode of operation.
- D. Location: Through hinged door in front of unit; isolated from conditioned air stream to allow service while system is operating.

2.17 MICROPROCESSOR CONTROL SYSTEM

- A. Logic Circuitry: Microprocessor shall continuously monitor operation of process cooling system; continuously digitally display room temperature and room relative humidity; sound alarm on system malfunction and simultaneously display problem. When more than one malfunction occurs, flash fault in sequence with room temperature, remember alarm even when malfunction cleared, and continue to flash fault until reset.
- B. Malfunctions: Power Loss, Loss of Air Flow, Clogged Air Filter, High Room Temperature, Low Room Temperature, High Humidity, Low Humidity, [Smoke/Fire,] Compressor No. 1 -Overload, Compressor No. 1 - Low Pressure, Compressor No. 1 - High Pressure, Compressor No. 2 - Overload, Compressor No.

2 - Low Pressure, Compressor No. 2 - High Pressure, [Water-Under-Floor,] and Supply Fan Overload.

- C. Light Emitting Diodes Display: Control Power On, System On, Humidification, De-humidification taking place, Compressor No. 1 operating, Compressor No. 2 operating, Heat or Reheat operating, Economy Cooling.
- D. Provide push buttons to STOP process cooling system, START process cooling system, SILENCE audible alarm, push-to-test LED indicators, and display room relative humidity.

2.18 PERFORMANCE

- A. Cooling Capacity: [] Btu/hr with [] cfm of air entering evaporator at [] degrees F DB and [] degrees F WB, leaving evaporator at [] degrees F DB and [] degrees F WB, with [one] [two] evaporator fan motors at [] hp.
- B. [Water] [Glycol] Cooled: [] gpm condenser water entering at [] degrees F, [one] [two] [] condenser fan motors at [] hp.
- C. Air Cooled: Air entering air cooled condensing unit at [] degrees F, [one] [two] [] condenser fan motors at [] hp.
- D. Reheat Capacity: [] Btu/hr when supplied with [] gpm water entering at [] degrees F and leaving at [] degrees F.
- E. Reheat Capacity: [] Btu/hr when supplied with [] lb/hr steam at [] psig.
- F. Reheat Capacity: [] Btu/hr.
- G. Glycol Cooling: Coil capacity of [] Btu/hr with air entering at [] degrees F DB and [] degrees F WB, leaving at [] degrees F DB and [] degrees F WB, when supplied with [] gpm glycol entering at [] degrees F, [one] [two] pumps at [] hp.
- A. Humidifier: Total capacity of [] lb/hr with [] W input.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that flooring system is ready to receive work and opening dimensions are as indicated on shop drawings.
- B. Verify that proper power supply is available.

3.02 INSTALLATION

- A. Install units in accordance with manufacturer's instructions.
- B. Coordinate installation of computer room air conditioning units with computer room raised floor installer.
- C. Provide adequate drainage connections for [water cooled units] [condensate] and humidifier flushing system.
- D. Provide shut-off valves in condenser water inlet and outlet piping on water cooled units.

3.03 SCHEDULE

Drawing Code CAC-1 CAC-2 CAC-3 CAC-4

Location
 Service
 Manufacturer
 Model Number
 Cooling Capacity
 Total
 Sensible
 Evaporator
 Air Flow
 Entering Air DB Temp
 Entering Air WB Temp
 Leaving Air DB Temp
 Leaving Air WB Temp
 Evaporator Fan Motors
 Condenser
 Water Flow
 Water Temp
 Ambient Air Temp
 Fan Motors
 Glycol Flow
 Glycol Temp
 Reheat

- Capacity
- Water Flow
- Entering Water Temp
- Leaving Water Temp
- Steam Flow
- Steam Pressure
- Glycol Cooling
 - Total Capacity
 - Entering Air DB Temp
 - Entering Air WB Temp
 - Leaving Air DB Temp
 - Leaving Air WB Temp
 - Glycol Flow
 - Entering Glycol Temp
- Glycol Pump Motors
- Humidifier
 - Capacity
 - Power Input

END OF SECTION

SECTION 23 81 23.A
COMPUTER ROOM AIR CONDITIONING UNITS - UNITARY COOLING

NOTE THAT THIS IS A NEW SPECIFICATION. IT IS INTENDED TO BE INCLUDED AS A "SHELL" FOR THE ENGINEER TO USE IN FUTURE PROJECTS. PLEASE SUBMIT COMMENTS AS MIGHT BE APPROPRIATE.

NOTE TO ENGINEER: WHEN USING THIS SECTION, IT WILL BE NECESSARY TO ADD A SPECIFICATION FOR AN OUTSIDE CONDENSING UNIT IF CHILLED WATER IS NOT USED AS A COOLING MEDIUM.

PART 1 GENERAL

1.00 The following sections are to be included as if written herein:

- A. Section 23 00 00 – Basic Mechanical Requirements
- B. Section 23 05 29 – Sleeves, Flashings, Supports and Anchors
- C. Section 23 05 53 – Mechanical Identification

1.01 SECTION INCLUDES

- A. Air Conditioning Units
- B. Controls

1.02 RELATED SECTIONS

- A. Section 23 09 99 – Controls and Instrumentation
- B. Section 26 05 19 - Cable, Wire and Connectors, 600 Volt: Electrical characteristics, cable, wire, materials
- C. Section 26 27 26 - Wiring Devices and Floor Boxes: Wiring connections

1.03 REFERENCES

- A. ANSI/ASME - Boiler and Pressure Vessels Code
- B. ANSI/NEMA 250 - Enclosures for Electrical Equipment (100 Volts Maximum)
- C. ASHRAE 52 - Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter

D. UL - Underwriters Laboratories

1.04 SUBMITTALS

- A. Submit under provisions of Section 23 00 00.
- B. Product Data: Provide manufacturer's literature and data indicating water, drain, and electrical rough-in connections.
- C. Manufacturer's Installation Instructions: Indicate procedures required for rigging and making service connections.

1.05 OPERATION AND MAINTENANCE DATA

- A. Submit under provisions of Section 23 00 00.
- B. Include manufacturer's descriptive literature, operating instructions, installation instructions, maintenance and repair data.

1.06 WARRANTY

- A. Provide five-year warranty under provisions of Section 23 00 00.
- B. Warranty: Include coverage of entire unit including the refrigeration compressor.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Leibert Model [_____]
- B. Compair Model [_____]
- C. [_____] Model [_____]
- D. Substitutions: Under provisions of Section 23 00 00

2.02 AIR CONDITIONING UNITS

- A. Description: Self contained [water] [air] cooled, factory assembled, pre-wired and pre-piped unit, consisting of cabinet, fan, filters, [humidifier,] controls.

- B. Assembly: For horizontal ceiling mounting to fit 24 x 48 inches T-bar ceiling opening.
- C. Cabinet: [10] [14] [_____] gauge welded steel with baked enamel finish, and lined with 1/2 inch thick acoustic duct liner.
- D. Evaporator Fan: Forward curved centrifugal, directly driven by two speed motor.
- E. Compressor: Hermetic with resilient suspension system, oil strainer, internal motor overload protection, low pressure switch, manual reset high pressure switch.
- F. Evaporator Coil: Direct expansion cooling coil of seamless copper tubes expanded into aluminum fins, with thermal expansion valve with external equalizer, liquid line filter-drier, service shutoff valves and charging valves. Mount coil assembly in stainless steel drain pan.
- G. Water Cooled Condenser: Coaxial counterflow tube-in-tube type with liquid line stop valve and head pressure actuated water regulating valve, sized for rated capacity with [_____] gpm water entering at [_____] degrees F.

***** [OR] *****

- G. Air Cooled Condenser: Integral copper tube aluminum fin coil sized for rated capacity at [95] [_____] degrees F with [fan driven by double shafted evaporator fan motor] [remote fan package].
- H. Filter: One inch thick disposable glass fiber media.
- I. Heating Coils: Nichrome wire electric elements with contactor, dehumidification relay, and high temperature limit switch.
- J. Atomizing Humidifier: Centrifugal atomizer with stainless steel pan, demister pad, and solenoid valve.

***** [OR] *****

- J. Evaporative Pad Humidifier: Evaporative, self-flushing type with disposable evaporation pad medium, stainless steel drain pan, solenoid valve control.

***** [OR] *****

- J. Evaporative Pan Type: Stainless steel pan and cover, with stainless steel or brass float valve mechanism, electric heating coil with low water cut-off switch, flush cycle timer and solenoid drain valve.

2.03 REMOTE GLYCOL COOLER

- A. Cooler: Corrosion resistant cabinet with copper tube aluminum fin coil, direct drive propeller fan with fan guards and [permanently lubricated ball bearing] single phase [] hp fan motors with internal overload protection.
- B. Pump: In-line type centrifugal pump with mechanical seal, [] hp motor, [] volt, [single] [three] phase, 60 Hz.
- C. Controls: Electrical control cabinet with starters, relays, and disconnects.
- D. Piping: Interconnecting piping, from suction to discharge with shut-off valves, flow switch, check valve in pump discharge and unions.
- E. Glycol: Inhibited [ethylene] [propylene] glycol and water solution mixed [50-50] [] suitable for operation temperature of [-40] [] degrees F.
- F. Expansion Tank: [Diaphragm] [Open] expansion tank and vent fitting with air separator, [automatic air vent,] and system charging connection.

2.04 CONTROL SYSTEM

- A. Unit Mounted: Main fan contactor, compressor [and condenser fan] contactor, compressor start capacitor, controls transformer with circuit breaker, solid state temperature [and humidity] control modules, [humidity contactor, time delay relay, reheat contactor, and high temperature thermostat].
- B. Controls: Solid state [wall] [unit] mounted with start/stop switch, adjustable temperature setpoint [, adjustable humidity setpoint].

2.05 PERFORMANCE

- A. Cooling Capacity: [] Btu/hr with [] cfm of air entering evaporator at [] degrees F DB and [] degrees F WB, leaving evaporator at [] degrees F DB and [] degrees F WB, with evaporator fan motor at [] hp.
- B. [Water] [Glycol] Cooled: [] gpm condenser water entering at [] degrees F, condenser fan motor at [] hp.
- C. Air Cooled: Air entering air cooled condensing unit at [] degrees F, condenser fan motors at [] hp.
- D. Reheat Capacity: [] Btu/hr.

- E. Humidifier: Total capacity of [_____] lb/hr with [_____] W input.
- F. Power Connection: [_____] volt, [single] [three] phase, 60 Hz.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that ceiling system is ready to receive work and opening dimensions are as indicated on shop drawings.
- B. Verify that proper power supply is available.

3.02 INSTALLATION

- A. Install units in accordance with manufacturer's instructions.
- B. Coordinate installation of air conditioning unit with computer room ceiling installer.
- C. Provide adequate drainage connections for [water cooled units] [condensate] and humidifier flushing system.
- D. Provide shut-off valves in condenser water inlet and outlet piping on [water] [glycol] cooled units.

3.03 SCHEDULE

Drawing Code CAC-1 CAC-2 CAC-3 CAC-4

Location
 Service
 Manufacturer
 Model Number
 Cooling Capacity
 Total
 Sensible
 Room DB Temp
 Room WB Temp
 Air Flow
 Fan Motor Size
 Condenser
 [Water] [Glycol] Flow
 [Water] [Glycol] Temp

Ambient Air Temp
Fan Motor Size
Glycol Pump Motor Size

Reheat

Capacity

Humidifier

Capacity

Power Input

Power Volt/Phase/Cycle

END OF SECTION

SECTION 23 82 16
AIR COILS

PART 1 - GENERAL

1.1 THE FOLLOWING SECTIONS ARE TO BE INCLUDED AS IF WRITTEN HEREIN:

- A. Section 23 00 00 – Basic Mechanical Requirements
- B. Section 23 05 29 – Sleeves, Flashings, Supports and Anchors
- C. Section 23 05 53 – Mechanical Identification

1.2 SECTION INCLUDES

- A. Water coils
- B. Glycol coils
- C. Steam coils
- D. Refrigerant coils
- E. Electric coils

1.3 RELATED SECTIONS

- A. Section 23 07 19 - Piping Insulation
- B. Section 23 06 20.13 - Hydronic Specialties
- C. Section 23 22 00.A - Steam and Steam Condensate Specialties
- D. Section 23 31 00 - Ductwork: Installation of duct coils
- E. Section 26 05 19 - Cable, Wire and Connectors, 600 Volt
- F. Section 26 27 26 - Wiring Devices and Floor Boxes

1.4 REFERENCES

- A. ANSI/ARI 410 - Forced-Circulation Air-Cooling and Air-Heating Coils
- B. ANSI/NFPA 70 - National Electrical Code
- C. ANSI/UL 1096 - Electric Central Air Heating Equipment
- D. SMACNA - HVAC Duct Construction Standards, Metal and Flexible

1.5 SUBMITTALS

- A. Submit shop drawings under provisions of Section 23 00 00.
- B. Submit shop drawings indicating coil and frame configurations, dimensions, materials, rows, connections, and rough-in dimensions.
- C. Submit product data under provisions of Section 23 00 00.
- D. Submit product data indicating:
 - 1. heat transfer quantities
 - 2. inlet and outlet conditions of air and heat transfer medium
 - 3. pressure drop and flow information
 - 4. minimum air flow (if applicable)
 - 5. minimum water flow (if applicable)
 - 6. velocity of heat transfer medium through coil
 - 7. wiring diagrams and control drawings for electrical heating coils
 - 8. materials, circuiting and configuration
- E. Submit manufacturer's installation instructions under provisions of Section 23 00 00.
- F. Submit manufacturer's certificate under provisions of Section 23 00 00 that coils are tested and rated in accordance with ANSI/ARI 410.

1.6 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing the products specified in this Section with minimum three years documented experience.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Deliver products to site under provisions of Section 23 00 00.
- B. Store and protect products under provisions of Section 23 00 00.
- C. Protect coil fins from crushing and bending by leaving in shipping cases until installation, and by storing indoors.
- D. Protect coils from entry of dirt and debris with pipe caps or plugs.

PART 2 - PRODUCTS

2.1 STEAM COILS:

- A. All steam coils shall be 5/8" O.D. seamless copper tubes having 0.035" minimum wall thickness. Coil shall have 0.008" thick aluminum fins (0.010" copper in Galveston and Austin) suitable for use with steam at a maximum temperature of 300 degrees F. and a maximum pressure of 200 psig. Coils shall vertical tube type. Coil headers shall be cast iron or I.P.S. brass or as specified hereinafter for chilled water coils. Coils shall have one row, and a maximum of 8 fins per inch. Frames and rails shall be hot dipped galvanized.

2.2 WATER COILS:

- A. Water coil capacities, pressure drops and selection procedures shall be certified for the capacity scheduled in accordance with ARI Standard 410. Non-certified coils will not be accepted.
- B. Chilled water, hot water, and glycol coils shall be of the extended surface type meeting all conditions and having the pressure drops scheduled on the Drawings, and shall have same-end supply and return connections unless otherwise indicated. Coils shall be constructed of copper tubes 5/8" O.D. with .035" thick minimum wall thickness and copper fins for chilled water and aluminum fins for heating water, permanently bonded to the tubes by mechanical expansion. Coils shall have a maximum of 8 fins per inch, and a maximum of 6 rows. If additional capacity is necessary, the additional capacity shall be provided by an additional coil, with an additional access section between the coils, and the coils shall be piped in series, counterflow to the direction of air flow. Copper fins on plate coils shall be .006" thick (.01 IN AUSTIN).
- C. Coil headers and connections shall be of I.P.S. brass or heavy gauge seamless hard drawn copper tubing with penetrations for connection of core tubing by die-formed intrusion process with resulting contact depth between the header wall and core tubing of not less than .090". Joints between core tubing and header shall be of recess swage design to allow a large mating area for build up of brazing materials to give increased strength to the joint. Supply and return connection of brass or copper shall be terminated with National Pipe Threads with wrench flats (FOR U.T. AUSTIN, THE HEADERS SHALL BE SCHEDULE 80 RED BRASS AND SHALL BE PROVIDED WITH SUPPLY AND RETURN CONNECTIONS AT BOTH THE TOP AND BOTTOM OF BOTH OF THE HEADERS, WITH SEPARATE VENT AND DRAIN OPENINGS).
- D. Coils shall be designed and certified by the manufacturer to operate as scheduled without moisture carry over. Each coil section shall be provided with a 316-L Stainless Steel frame/casing, including tube sheets, no lighter than 16 gauge. Frame members shall extend over the ends and edges of the coils and shall be constructed with formed holes for tubes, permitting free expansion and contraction of coil sections while supported by an extended surface of the frame. Intermediate tube support sheets of 316-L stainless steel shall be provided in all coils having tube lengths in excess of 48": on long coil sections the spacing of coil supports shall not exceed 48". All intermediate supports shall be welded to coil frame members and fabricated with formed tube holes to support the penetrating tubes.
- E. Pressure test all coils to 350 psi under water.

2.3 ELECTRIC COIL:

- A. Manufacturers:
 - 1. Subject to compliance with these specifications, provide electric heating coils by one of the following manufacturers:
 - a. Brasch
 - b. Chromalox
 - c. Indeeco
 - d. Warren
- B. Heaters shall be U.L. Listed for zero clearance and meet all the applicable requirements of the National Electrical Code.
- C. All resistance coil terminals and nuts shall be made of stainless steel, and terminal insulators and bracket bushings shall be made of high grade ceramic and securely positioned. Resistance wire shall be iron free, 80% nickel and 20% chromium. Bracket supports for the resistance wire shall be reinforced with stiffening ribs and gussets, and spaced no more than four inches apart. Heaters shall be tested dielectrically for 1000V plus twice the rated voltage or 2000V, whichever is higher. Manufacturer shall provide documentation of this test and supporting testing process documents.
- D. Heaters shall be furnished for volts and phases as scheduled. Three phase heaters shall be furnished with balanced three phase load. The control voltage shall be 120 volts or as scheduled and transformers with primary fuse protection shall be provided in the terminal box for each heater when the control voltage is not the same as the unit feeder voltage. .
- E. Heaters shall be supplied with overcurrent protection per NEC. Overcurrent protection shall consist of one built in automatic circuit. A disc type automatic reset thermal cutout shall be furnished for primary overheating protection. Secondary protection fusible links shall be provided to de-energize the elements in case the primary cutout fails. Both devices shall be serviceable through the terminal box without having to remove the heater from the duct or air handling unit. Provide factory mounted and wire pressure sensitive type air flow switch for each heater to allow the heater to be "on" only when sufficient air is blowing through the heater. Note that the minimum airflow velocity required for the heater to be on must be included in the submittal.
- F. Heaters and protection devices shall be arranged for single point connection.
- G. Duct Heaters: Electric duct heaters shall be of the flanged type and shall be suitable for mounting in a horizontal or vertical duct, and air flow through the heater in either direction. Heaters shall be made with galvanized steel frame. A terminal box shall be provided on the unit with solid cover.
 - 1. All duct heaters shall be sized to fit the duct in which they are installed and be located at least 48" (forty-eight inches) from any turn, transition, tap, damper, or other fittings in the duct run.

- H. Capacity Control: Furnish Heaters with contactors for each scheduled stage or SCR as scheduled

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install in ducts and casings in accordance with SMACNA HVAC Duct Construction Standards, Metal and Flexible.
- C. Support coil sections independent of piping on steel channel or double angle frames and secure to casings. Provide frames for maximum three coil sections. Arrange supports to avoid piercing drain pans. Provide airtight seal between coil and duct or casing.
- D. Protect coils to prevent damage to fins and flanges. Comb out bent fins.
- E. Make connections to coils with unions and flanges.
- F. On water [and glycol] heating coils, and chilled water cooling coils, connect water supply to leaving air side of coil (counterflow arrangement).
- G. Insulate headers located outside air flow as specified for piping. Refer to Section 23 07 19.
- H. Wire electric duct coils in accordance with ANSI/NFPA 70. Refer to Sections 26 05 19 and 26 27 26.

END OF SECTION

SECTION 23 82 19
TERMINAL HEAT TRANSFER UNITS

PART 1 GENERAL

1.00 The following sections are to be included as if written herein:

A. Section 23 00 00 – Basic Mechanical Requirements

B. Section 23 05 29 – Sleeves, Flashings, Supports and Anchors

C. Section 23 05 53 – Mechanical Identification

1.01 SECTION INCLUDES

A. Unit Heaters

B. Cabinet Unit Heaters

C. Fan-coil Units

D. Unit Ventilators

1.02 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION

A. Section 23 09 00 - Controls and Instrumentation: Installation of Room Thermostats

B. Section 26 05 19 - Cable, Wire and Connectors, 600 Volt

C. Section 26 27 26 - Wiring Devices and Floor Boxes

1.03 RELATED SECTIONS

A. Section 23 05 13 - Motors

B. Section 23 21 00 - Hydronic Piping

C. Section 23 06 20.13 - Hydronic Specialties

D. Section 23 22 00 - Steam and Steam Condensate Piping

E. Section 23 22 00.A - Steam and Steam Condensate Specialties

F. Section 23 09 00 - Controls and Instrumentation

G. Section 26 05 19 - Cable, Wire and Connectors, 600 Volt

H. Section 26 27 26 - Wiring Devices and Floor Boxes

1.04 REFERENCES

A. ANSI/NFPA 70 - National Electrical Code

1.05 SUBMITTALS

A. Submit shop drawings under provisions of Section 23 00 00.

B. Submit shop drawings indicating cross section of cabinets, grille, bracing and reinforcing, and typical elevation.

C. Submit product data under provisions of Section 23 00 00.

D. Submit product data indicating typical catalog of information including arrangements.

E. Submit schedules of equipment and enclosures typically indicating length and number of pieces of element and enclosure, corner pieces, end caps, cap strips, access doors, pilaster covers, and comparison of specified heat required to actual heat output provided.

F. Indicate mechanical and electrical service locations and requirements, specifically indicating deviations from indicated products.

G. Submit samples under provisions of Section 23 00 00.

H. Submit manufacturer's installation instructions under provisions of Section 23 00 00.

I. FAN SUBMITTAL DATA:

1. Submittal data for approval for all fans of every description furnished under this section of these Specifications driven by 5 (five) HP and larger motors shall include the following:

2. Fan curves with recommended stable range of operation.

3. Data to substantiate that fans on double duct systems will operate in a stable range at 1/2" (one-half inch) S.P. above scheduled static pressure with motors sized accordingly.
4. Fans shall be selected to operate stably at the reduced loads specified by the Engineer by means of variable speed drives.

1.06 PROJECT RECORD DOCUMENTS

- A. Submit record documents under provisions of Section 23 00 00.
- B. Accurately record actual locations of access doors in radiation cabinets required for access or valving.

1.07 OPERATION AND MAINTENANCE DATA

- A. Submit operation and maintenance data under provisions of Section 23 00 00.
- B. Include manufacturer's descriptive literature, operating instructions, installation instructions, maintenance and repair data, and parts listings.

1.08 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing the products specified in this Section with minimum three years documented experience.

1.09 REGULATORY REQUIREMENTS

- A. Conform to ANSI/NFPA 70 code and Underwriters Laboratories, Inc. for internal wiring of factory wired equipment.

1.10 MOCKUP

- A. Provide mockup of typical exterior wall module under provisions of Section 23 00 00.
- B. If accepted, mockup will demonstrate minimum standard for the Work. Mockup may [not] remain as part of the Work.

1.11 DELIVERY, STORAGE AND HANDLING

- A. Deliver products to site under provisions of Section 23 00 00.
- B. Store and protect products under provisions of Section 23 00 00.

- C. Protect units from physical damage by storing in protected areas and leaving factory covers in place.

1.12 SEQUENCING AND SCHEDULING

- A. Sequence work under the provisions of Section 23 00 00.
- B. Schedule work under the provisions of Section 23 00 00.
- C. Install radiation, convectors, fan-coil units, unit ventilators and radiant heaters (equipment exposed to finished areas) after walls and ceiling are finished and painted. Avoid damage.

1.13 WARRANTY

- A. Provide five-year manufacturer's warranty under provisions of Section 23 00 00.
- B. Warranty: Include coverage of fan-coil unit, unit heater, and unit ventilator motors.

PART 2 PRODUCTS

2.01 UNIT HEATERS

- A. Coils: Seamless copper tubing, 0.025 inch minimum wall thickness, silver brazed to steel headers, and with evenly spaced aluminum fins mechanically bonded to tubing.
- B. Casing: 18 gauge steel with threaded pipe connections for hanger rods.
- C. Finish: Factory applied baked enamel of a color as selected by the Architect on visible surfaces of enclosure or cabinet.
- D. Fan: Direct drive propeller type, statically and dynamically balanced, with fan guard; horizontal models with permanently lubricated sleeve bearings; vertical models with grease lubricated ball bearings.
- E. Air Outlet: Adjustable pattern diffuser on projection models and [two] [four] way louvers on horizontal throw models.
- F. Motor: Refer to Section 23 05 13: horizontal models with permanently lubricated sleeve bearings, vertical models with grease-lubricated ball bearings.
- G. Control: Local [multi-speed] disconnect switch.

- H. Capacity: Based on 65 degree F entering air temperature, [180 degree F average water temperature.] [one psig steam.]

2.02 ROOM FAN COIL UNITS:

- A. The fan coil shall be as manufactured by McQuay, York or approved equal. The units shall be complete with coils, motors, drives, filters, 16 gauge front panels on vertical cabinet units, 18 gauge enclosures on vertical and horizontal cabinet units, internally insulated and corrosion resistant treated before final baked enamel finish is applied. Unit capacities shall be certified in accordance with ARI Standard 441-66. Unit sound data shall be rated in accordance with ARI Standard 443-66. The units shall bear an ARI (Air-Conditioning & Refrigeration Institute) stamp.
- B. Fan coil units shall be of the size and configuration as described on the Drawings.
 - 1. The unit shall be controlled with a control valve as indicated in the plans, furnished by temperature control supplier and installed in the field by the Mechanical Subcontractor.
 - 2. The unit (does not) (does) have a heating coil.
 - 3. The cooling coils shall be not less than two rows deep and constructed of 5/8" (five eighths inches) O.D. x .020" (twenty thousandths inch) wall thickness copper tubes. Units of 600 CFM capacity or less shall have a maximum of 14 aluminum fins per inch, .0075" (seven and one-half thousandths inch) thick minimum; over 600 CFM, a maximum of 9 fins per inch, .0088" (eight point eight thousandths inch) thick minimum. Provide manual air vent and drain plug for each coil. Units shall be provided with heavy duty, rust inhibited drain pans under the coil, with auxiliary drain pan under control valve piping package.
 - 4. The motors shall be of the permanent split capacitor type and wired for multiple speeds. The motors shall be controlled with easily accessible multispeed switches located within the unit housing on vertical units, wall mounted on horizontal. The motors shall have built-in thermal overload protection.
 - 5. See Temperature Control Section for control sequence.
 - 6. Each unit shall have a (steam, hot water, electric) coil installed.
 - 7. The unit shall have belt or direct drive fans and 1/2" (one half inch) (aluminum, steel, permanent, throw-away) filters.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that surfaces are ready to receive work and opening dimensions are as indicated on shop drawings.
- B. Verify that required utilities are available, in proper location, and ready for use.
- C. Beginning of installation means installer accepts existing surfaces.

3.02 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Hang unit heaters from building structure, with pipe hangers anchored to building, not from piping. Mount as high as possible to maintain greatest headroom unless otherwise indicated.
- C. Install fan-coil units as indicated. Coordinate to assure correct recess size for recessed units.
- D. Protect units with protective covers during balance of construction.
- E. Provide hydronic units with shut-off valve on supply and lock shield balancing valve on return piping. If not easily accessible, extend vent to exterior surface of cabinet for easy servicing. For cabinet unit heaters, fan coil units, and unit heaters, provide float operated automatic air vents with stop valve.
- F. Install electric heating equipment including devices furnished by manufacturer but not factory-mounted. Furnish copy of manufacturer's wiring diagram submittal. Verify that electrical wiring installation is in accordance with manufacturer's submittals and installation requirements of Division 26 sections.

3.03 CLEANING

- A. Clean work under provisions of 23 00 00.
- B. After construction is completed, including painting, clean exposed surfaces of units. Vacuum clean coils and inside of cabinets.

- C. Touch-up marred or scratched surfaces of factory-finished cabinets, using finish materials furnished by manufacturer.
- D. Install new filters after Substantial Completion.

NOTE TO SPECIFICATION WRITER: THE FOLLOWING SCHEDULES ARE INCLUDED FOR INFORMATION. JOB SCHEDULES ARE TO APPEAR ON THE DRAWINGS RATHER THAN IN THE SPECIFICATIONS.

3.04 UNIT HEATER SCHEDULE

<u>Drawing Code</u>	<u>UH-1</u>	<u>UH-2</u>	<u>UH-3</u>	<u>UH-4</u>
Location				
Service				
Manufacturer				
Model Number				
Heat Output				
Water Flow				
Motor (RPM)				
Motor (HP)				
Remarks				

3.05 FAN COIL UNIT SCHEDULE

<u>Drawing Code</u>	<u>FC-1</u>	<u>FC-2</u>	<u>FC-3</u>	<u>FC-4</u>
Location				
Service				
Manufacturer				
Model Number				
Supply Fan				
Air Flow				
Static Pressure				
Motor (HP)				
Cooling				
Sensible				
Total				
Entering DB Temp				
Entering WB Temp				
Leaving DB Temp				
Leaving WB Temp				
Nominal Capacity (tons):				
Remarks				

END OF SECTION

SECTION 23 82 20
FANS, AIR INTAKES AND RELIEF VENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

- A. The Conditions of the Contract and applicable requirements of Division 1, "General Requirements", and Section 23 01 00, "Mechanical General Provisions", govern this Section.

1.2 DESCRIPTION OF WORK:

- A. Work Included: Provide supply and exhaust fans, air intakes, and relief vents as scheduled and indicated.
- B. Types: The types of fans, outside intakes and relief vents required for the project include, but are not limited to, the following:
 - 1. Centrifugal roof exhaust fans.
 - 2. Centrifugal upblast roof exhaust fans.
 - 3. Sidewall propeller exhaust fans.
 - 4. **[In-line exhaust/transfer fans.] To be used on renovation projects only.**
 - 5. Utility exhaust fans.
 - 6. Upblast smoke exhaust fans.
 - 7. Vane axial supply/exhaust fans.
 - 8. Air intakes.
 - 9. Relief vents.

1.3 RELATED WORK

- A. Section 23 05 13 - Motors
- B. Section 23 05 48 - Vibration Isolation
- C. Section 23 07 13 - Ductwork Insulation
- D. Section 23 29 23 – Variable Speed Drives
- E. Section 23 31 00 - Ductwork
- F. Section 23 33 00 - Ductwork Accessories: Backdraft Dampers
- G. Section 26 05 19 - Cable, Wire and Connectors, 600 Volt
- H. Section 26 27 26 - Wiring Devices and Floor Boxes

1.4 QUALITY ASSURANCE:

- A. Manufacturers: Provide products complying with these specifications and produced by one of the following:
 - 1. Acme.
 - 2. Carnes Company, Inc.

3. Cooke.
4. Flakt Products, Inc.
5. Greenheck Fan Corporation.
6. Peerless.
7. Penn Ventilator Company.
8. Trane Company.
9. Woods Fan Division.

- B. AMCA Seals: Provide fans which are rated per AMCA standards and bear the AMCA-certified rating seal.
- C. Electrical Standards: Provide electric motors and products which have been listed and labeled by Underwriters' Laboratories, Inc. (UL) and comply with National Electrical Manufacturer's Association (NEMA) standards.

1.5 SUBMITTALS:

- A. Shop drawing submittals shall include, but not be limited to, the following:
 1. Cut sheets clearly indicating fans, air intake and relief vent construction, dimensions, ratings, capacities, and accessories.
 2. Cut sheets on roof curbs clearly indicating dimensions, required roof openings, and flashing details.
 3. Fan curves with fan selection point clearly indicated.
 4. Fan drive selection calculations.
 5. Motor data as required in Section 23 04 00, "Motors and Controllers".
 6. Additional information as required in Section 23 03 00.

1.6 PRODUCT DELIVERY, STORAGE AND HANDLING:

- A. Deliver fans, intakes, vents, and accessories carefully to avoid damage to material components, enclosure, and finish.
- B. Handle fans, intakes, vents, and accessories carefully to avoid damage to material components, enclosure and finish.
- C. Store fans, intakes, vents, and accessories in a clean, dry space, and protect from the weather.

PART 2 - PRODUCTS

[REFER TO TEXT AFTER END OF SECTION FOR ADDITIONAL FAN TYPES]

2.1 GENERAL FAN REQUIREMENTS:

- A. Ratings: Fans shall be licensed to bear the AMCA-certified ratings seal. Ratings of fans shall be not less than the values shown on the Drawings, based on 69.8°F and 29.92" of Hg atmospheric pressure.
- B. Construction: Fan construction shall be in accordance with AMCA classes of construction for the intended duty. Fan wheels, shafts, and drives shall be statically and dynamically balanced at the factory as a unit. Balancing shall be factory-certified.
- C. Motors: Fan motors shall be 1750 rpm open drip-proof (ODP) or totally-enclosed, fan-coded (TEFC) type as required for the application. Motors 1 hp and larger shall be energy efficient, high efficiency type. Motors shall be selected to be nonoverloading with the fan provided. Refer to Section 23 04 00 for additional motor requirements.
- D. Drives: Provide drives with a minimum belt horsepower capacity of 165% of the motor nameplate horsepower. All fans requiring 1-1/2 hp or larger motor shall include the fan drive selection calculations with the submittal. The selection calculations shall include the correction factor for arc of contact. The submittal data shall identify the source of the selection data.
- E. Motor Sheaves: Motor sheaves shall be Browning Type, MVP, or approved equal, adjustable type with double locking feature. Motor sheaves shall be selected for the rated fan rpm and shall be adjustable to as close as 10% above and below the rated fan speed. Provide fixed sheaves for all motors 3 hp and larger after proper speed has been determined during system balancing.
- F. Fan Sheaves: Provide nonadjustable sheaves with removable machined bushings. Sheaves shall be machined on all surfaces. Sheaves with over three grooves shall be dynamically balanced and the manufacturer shall so designate on each sheave. Fan sheaves with three grooves or less shall be statically balanced and weights required for balancing shall be welded to the sheaves. Manufacturers shall be Browning, Eaton, Yale and Towne, Dodge Manufacturing Company, or Fort Worth Steel and Machinery Company.
- G. Belts: Provide standard "V-groove" belts suitable for the service intended with the required capacities. The belts shall be closely matched and tagged prior to delivery to the job site. If the belts do not appear to be properly matched during operation, they shall be rechecked and, if necessary, replaced. Belts shall be as manufactured by Gates (Preferred UH product), Durkee-Atwood, Goodyear, Browning, or Uniroyal.
- H. Speed Control: All single phase direct drive fans shall be provided with compatible internally mounted solid state speed controllers, unless noted otherwise.
- I. Bearings: Provide SKF, Sealmaster, Timken or Fafnir, externally or internally-mounted, grease-lubricated, self-aligning ball bearings. Bearings shall have grease type Zerk fittings and shall be selected for a minimum B-10 life as defined by AFBMA of 200,000 hours, unless specified otherwise.
- J. Motor Mounts: Motors shall be mounted on an adjustable base rigidly supported on the fan and shall have extended shaft to accommodate the adjustable pitch sheave.

2.2 ROOF CURBS:

- A. General: Provide prefabricated, insulated aluminum roof curbs for all roof mounted fans. Curbs shall be of welded construction and roof-over-flashing type with build-in cant and a minimum overall height of 8" above roof surface, unless otherwise noted or required to meet code requirements. Roof curbs shall be Greenheck Model #GPS or approved equal for roof decks that are not surface insulated and Model #GPR or approved equal for roof decks that are surface insulated. Damper trays shall be provided to facilitate the mounting of the backdraft dampers, where specified or scheduled. Extended base curbs shall be provided when scheduled or required.

2.3 CENTRIFUGAL ROOF EXHAUST FANS:

- A. General: Provide Greenheck Model G, GB or approved equal ACME, Cook or Carnes centrifugal roof-mounted exhaust fans with capacities as scheduled.
- B. Construction: Fans shall be centrifugal, belt or direct driven as scheduled. Construction of the fan housing, fan wheel and inlet cone shall be aluminum. Wheels shall be aluminum, non-overloading backward curved, centrifugal type and shall be statically and dynamically balanced to assure smooth and vibration-free operation. The entire drive assembly shall be mounted on vibration isolators. Fans shall be constructed to withstand winds up to 150 mph.
- C. Drives: The wheel shaft on belt drive models shall be ground and polished shafting mounted in heavy duty sealed pillow block bearings. Drives shall be sized for a minimum of 165% of driven horsepower. Pulleys shall be fully machined cast iron type, keyed and securely attached to the wheel and motor shafts. An adjustable drive shall be used for balancing and then a fixed drive shall be provided.
- D. Motors: Motor and drives shall be isolated from the exhaust airstream and mounted on vibration isolators. Motors shall be of the heavy duty type with permanently lubricated, sealed ball bearings. **[Motors 1 hp and larger shall be of the high efficiency, energy efficient type.]**
- E. Certification: All fans shall bear the AMCA ratings seals for both air flow and sound performance with birdscreens in place.
- F. **[Coatings: Exhaust fans used for fume hood service shall have all fan parts exposed to the air stream coated with a high temperature acid resistant epoxy coating.]**
- G. Accessories: Provide all required accessories including, but not limited to: aluminum birdscreen, **[gravity] [motorized]** backdraft dampers **[with end switch]**, prefabricated insulated aluminum roof curb, factory-mounted and wired **[internal NEMA 1] [external NEMA 3R]** disconnect switch and solid state fan speed controllers (direct drive units only) with a conduit through the roof curb for field wiring.

2.4 DINING FACILITIES CENTRIFUGAL UPBLAST ROOF EXHAUST FANS:

- A. General: Provide a Greenheck Model CUBE, CUBE-HP, or approved equal ACME or Cook upblast centrifugal roof-mounted exhaust fans with capacities as scheduled.
- B. Construction: Fans shall be of belt or direct drive as scheduled, upblast vertical discharge type. Construction of housing shall be heavy gauge aluminum. The windband shall have a rolled bead and additional structural members for added strength.

- C. Wheels: The fan and wheel inlet cone shall be non-sparking aluminum and of the high performance, centrifugal blower type. Wheel shall be statically and dynamically balanced. Construction shall include a built in grease drain.
- D. Motors and Drives: Motors and drives shall be isolated from the exhaust air stream and mounted on vibration isolators. Motors shall be of the heavy duty type with permanently lubricated, sealed ball bearings. Air for cooling the motor shall be taken into the motor chamber by means of an air tube from a location free of discharge contaminants. The entire drive assembly and wheel, shall be mounted on vibration isolators as a unit and shall be removable through the support structure without dismantling the fan housing. The wheel shaft shall be mounted in heavy duty ball bearings. Drives shall be sized for 165% of driven horsepower. Pulleys shall be adjustable cast iron type, keyed to the fan and motor shafts. The entire drive assembly shall be mounted on rubber vibration isolators. Motors shall be 1750 rpm open dripproof (ODP) type of the horsepower and voltage scheduled. **[Motors 1 hp and larger shall be of the high efficiency, energy efficient type.]**
- E. Certification: All fans shall bear the AMCA Certified Ratings seal for both air and sound performance.
- F. Accessories: Provide all required accessories including, but not limited to: aluminum birdscreen, **[extended base to conform to NFPA 96 requirements for fan discharge a minimum of 40" above roof,]** fan UL-listed and labeled for grease removal (UL 762), **[grease drain connection and trap (for all kitchen hood exhaust fans),]** **[insulated motor heat baffle (for kitchen exhaust fans).]** **[gravity]** **[motorized]** backdraft dampers **[with end switch (for all fans except kitchen hood exhaust fans)]**, prefabricated insulated aluminum roof curb, factory-mounted and wired **[internal NEMA 1]** **[external NEMA 3R]** disconnect switch and solid state fan speed controllers on direct drive units.

2.5 SIDEWALL PROPELLER EXHAUST FANS:

- A. General: Provide Greenheck Model SDE, SDP, and SBP or approved equal ACME, Cook or Carnes sidewall propeller exhaust fans with capacities as scheduled.
- B. Construction: Fans shall be axial type, belt or direct driven as scheduled. Blades shall be die-formed and welded to a steel hub. A polished steel fan shaft shall be mounted in permanently-lubricated, sealed ball bearing pillow blocks. The drive frame assembly shall be formed steel. The fan panel shall have prepunched mounting holes, formed flanges with welded corners, and a deep formed venturi. Fans shall bear AMCA rating seals for air and sound performance.
- C. Motors: Motors shall be 1750 rpm open dripproof (ODP) type of the horsepower and voltage scheduled. **[Motors 1 hp and larger shall be of the high efficiency, energy efficient type.]**
- D. Accessories: Provide all required accessories including, but not limited to: mounting collar, factory-wired and mounted NEMA 1 disconnect switch, **[gravity]** **[motorized]** backdraft damper **[with end switch]**, and motor side fan guard (except on fans with reverse air flow).

2.6 IN-LINE EXHAUST/TRANSFER FANS:

- A. General: Provide Greenheck Model CSP, BCF, BSQ, BSQ-HP or DSQ or approved equal Acme or Cook in-line exhaust fans with capacities as scheduled.

- B. Construction: Fans shall be belt or direct driven in-line type with square heavy gauge galvanized steel housing with duct mounting collars shall have a galvanized or thermally fused epoxy finish. One or both sides shall be hinged and shall support the entire drive assembly and wheel allowing the assembly to swing out for cleaning, inspection, or service without dismantling the unit in any way. On belt drive models the motor shall be mounted on the hinged side exterior, isolated from the airstream. The motor shall be isolated from the airstream by a motor enclosure and shall draw cooling air from outside the fan housing.
- C. Wheels: The fan inlet shall be spun venturi throat overlapped by an aluminum backward inclined centrifugal wheel with spun cone for maximum performance. The fan wheel shall be statically and dynamically balanced.
- D. Insulation: The interior of the fan housing shall have one inch (1") thick, 3 PCF density internal sound absorbing fiberglass insulation to reduce operating noise levels.
- E. Drives: Motors shall be heavy duty type with permanently-lubricated, sealed ball bearings. The wheel shaft shall be ground and polished shafting mounted in heavy duty sealed pillow block bearings. Drives shall be sized for a minimum of 165% of driven horsepower. Pulleys shall be fully machined cast iron type, keyed and securely attached to the wheel and motor shafts. An adjustable drive shall be used for balancing and then a fixed drive shall be provided. Motors shall be 1750 rpm open dripproof (ODP) type of the horsepower and voltage scheduled. **[Motors 1 hp and larger shall be of the high efficiency, energy efficient type.]**
- F. Wiring: Flexible wiring leads shall be installed in conduit from the fan motor to an externally mounted junction box[, **motor speed controller (single phase units only)**] and disconnect switch, permitting access for service without disconnecting field wiring.
- G. Certification: All fans shall bear the AMCA-certified ratings seal for both air and sound performance.
- H. Accessories: Provide all required accessories including, but not limited to: Duct mounted automatic acting gravity type backdraft dampers of same size as fan housing, hanging support isolators with door side perpendicular to mounting surface, solid state fan speed controllers (direct drive units only) and belt guard for belt driven fans.

2.7 UTILITY EXHAUST FANS:

- A. General: Provide Greenheck Model SFD or approved equal Peerless or Trane utility exhaust fans with capacities as scheduled.
- B. Construction: Fans shall be belt or direct driven, single width, single inlet centrifugal blowers with discharge arrangement as shown on the drawings. The blower housing shall be of continuously welded construction which can be adjusted for discharge position. Housing supports shall have formed flanges and prepunched mounting holes. The blower wheel shall be steel of the forward curved type and shall be statically and dynamically balanced. A polished steel fan shaft shall be mounted in ball bearing pillow blocks. Bearings shall be grease lubricated.

- C. Finish: Entire exterior of the fan assembly shall be phosphatized, primed and finished with a baked enamel. **[Laboratory exhaust fans shall have a factory applied epoxy corrosion resistant coating applied to all surfaces exposed to the air stream.]**
- D. Motors: Motors for interior mounted fans shall be open dripproof (ODP) type and motors for exterior mounted fans shall be totally enclosed fan cooled (TEFC). Motors shall be 1750 rpm type of the horsepower and voltage scheduled. **[Motors 1 hp and larger shall be of the high efficiency, energy efficient type.]**
- E. Accessories: Provide all required accessories including, but not limited to: Vented weather hood with expanded metal outlet guard, access doors, shaft seals, factory-mounted and wired NEMA **[1] [3R]** disconnect switch, felt tipped automatic aluminum backdraft dampers, vibration isolators, belt guard, drain connections and weather hoods (where required).

2.8 UTILITY EXHAUST FANS:

- A. General: Provide Greenheck Model SFB, SWB, or approved equal Peerless or Trane exhaust fans with capacities and discharge arrangement as scheduled and shown on the Drawings.
- B. Configuration: Fans shall be a belt drive, single width, single inlet utility vent set with forward curved or backward inclined centrifugal fan wheel as scheduled.
- C. Housing: The fan housing and inlet cones shall be constructed of heavy gauge steel with lock-formed seams to prevent leakage. Housing supports and drive frame shall be constructed of welded steel members to prevent vibration and rigidly support the fan shaft and bearings.
- D. Wheels: Fan wheels shall be constructed of formed steel blades securely attached to the wheel backplate and cone. Each wheel and shaft shall be statically and dynamically balanced.
- E. Fan Shafts: Fan shafts shall be precision tuned, ground and polished steel shafts, sized so that the first critical speed is a minimum of 25% over the maximum operating speed. Fan shaft shall have pillow block bearings. All fan bearings shall be factory-lubricated and equipped with standard hydraulic grease fittings. Extended lube lines shall be furnished where bearings are not accessible and shall terminate on the outside of drive end of each unit including extension to allow greasing without removal of drive guard.
- F. Drives: V-belt fan drives with variable pitch motor sheave shall be selected for 150% of motor horsepower and anti-static belts shall be furnished. Drive guards shall have accessible opening to read rpm.
- G. Motors: Fan motors shall be ball bearing 1750 rpm open dripproof (ODP) type for indoor use and shall have electrical characteristics as scheduled. **[Motors 1 hp and larger shall be of the high efficiency, energy efficient type.]** Motor base shall be equipped with adjustable base rails.
- H. Finish: The entire fan assembly shall be phosphatized and painted with the manufacturers standard paint finish.
- I. Certification: Fan performance shall be based on tests conducted in accordance with AMCA Standard 210 test code for air moving devices. Fans shall be licensed to bear the AMCA Certified Rating Seal for air performance.

- J. Accessories: Provide all required accessories including, but not limited to, belt guard, access door, **[gravity] [motorized] backdraft damper [with end switch], [inlet] [discharge] guard, drain connection] and [a motor and drive weather load].**

2.9 UPBLAST SMOKE EXHAUST FANS:

- A. General: Provide Greenheck Model TAUB-HT or approved equal roof-mounted upblast tube axial smoke exhaust fans capable of operating for a minimum of 4 hours at an exhaust air temperature of 500°F.
- B. Construction: Fan housing shall be constructed of heavy gauge welded steel and shall be designed for curb mounting using a curb cap with an integral flanged venturi inlet. The fan housing shall have a reinforced steel windband and outlet screen from discharge damper protection. Bearing and motor supports shall be constructed of structural steel shapes and welded to the fan housing. A ventilated weatherproof motor cover shall be provided.
- C. Dampers: Provide spring-loaded steel butterfly damper on the fan discharge. Damper shall be gasketed in the closed position to minimize leakage and be provided with damper stops to maintain proper damper position when the fan is operating. The damper shall be held closed by a resettable McCabe type electrothermal link which shall open the damper at 165°F ambient temperature or upon a 120 volt signal on fan start-up.
- D. Fans: Propeller construction shall be fabricated steel, with the fan hub key locked to the fan shaft. Fans and shafts shall be statically and dynamically balanced.
- E. Fan Shafts: Fan shafts shall be precision tuned, ground and polished steel shafts, sized so that the first critical speed is a minimum of 25% over the maximum operating speed. Fan shaft shall have pillow block bearings. All fan bearings shall have a minimum B-10 life as defined by AFBMA of 25,000 hours, factory-lubricated and equipped with standard hydraulic grease fittings. Extended lube lines shall be furnished where bearings are not accessible and shall terminate on the outside of drive end of each unit including extension to allow greasing without removal of drive guard. Heat slingers shall be mounted on the fan shaft to dissipate heat from the fan shaft and draw cooling air over the bearings, shaft, and drive.
- F. Drives: V-belt fan drives with variable pitch motor sheave shall be selected for 150% of motor horsepower and anti-static belts shall be furnished. Drive guards shall have accessible opening to read rpm. Belt and bearing tubes shall be constructed of welded heavy gauge steel and provided with ventilation for proper cooling of belts, bearings, and drives.
- G. Motors: Fan motors shall be ball bearing 1750 rpm open dripproof (ODP) type for indoor use and shall have electrical characteristics as scheduled. Motor base shall be equipped with adjustable base rails.
- H. Finish: The entire fan assembly shall be phosphatized and painted with the manufacturers standard paint finish.
- I. Certification: Fan performance shall be based on tests conducted in accordance with AMCA Standard 210 test code for air moving devices. Fans shall be licensed to bear the AMCA Certified Rating Seal for air performance.

- J. Accessories: Provide all required accessories including, but not limited to, an outlet screen, bolted access door, and a factory-mounted and wired heavy duty NEMA 3R disconnect switch.

2.10 VANE AXIAL SUPPLY/EXHAUST FANS

- A. General: Provide Woods of Colchester Limited or approved equal belt or direct driven in-flight controllable pitch and manually adjustable fixed pitch vane axial type supply and exhaust fans of the type, size, and capacity scheduled.
- B. Ratings: The fan shall deliver the volume and pressure specified in the fan schedule when tested in accordance with AMCA Standard 210.
- C. Casings: The fan casing will consist of two sections, each 3/16" minimum thickness mild steel, joined with bolted flanges. The motor will be supported by the fabricated steel structure of 3/16" minimum thickness welded to one of the ducts. The other duct will be removable for access to the impeller. Drilled flanges will be provided for attachment of accessories or ductwork. The casing shall have an integral support frame and plate for mounting the motor on direct drive fans and internal bearing supports and an external motor mounts on belt drive fans. The casing and drilled flanges shall be hot dip galvanized.
- D. Fan Impellers: The impeller hub shall be cast in high strength heat-treated aluminum alloy precision-machined and balanced. Blades shall be of aerofoil section cast from silicon aluminum alloy and mounted on thrust bearings with grease retaining features such that the bearings shall be fully submersed in grease. All hub and blade materials shall be examined by X ray before machining. The manufacturer shall have available, laboratory evidence that impeller hubs and blades are suitable designed for normal running conditions and that fluctuating stresses in use are sufficiently low to ensure that no premature failure will occur due to metal fatigue.
- E. Fixed Adjustable Pitch Fans: The fan impeller pitch angle shall be manually adjustable in the field.
- F. In-flight Controllable Fans: The impeller blades shall be actuated in flight by an internal pneumatic actuator built into the hub and providing stepless control of the blade pitch angle. A pilot positioner shall be provided to ensure minimum control hysteresis. Where scheduled, the fan blades shall be reversible in-flight to reverse the airflow direction through the fan. A blade angle indicator shall be provided on the outside of the fan housing. The pneumatic operator shall be factory-adjustable to control fan blade angle from minimum to maximum pitch from a 3 to 15 psi pneumatic signal **[and for pitch reversing, where applicable]**.
- G. Balancing: After assembly the fan shall be dynamically balanced while on anti-vibration mountings giving over 90% isolation. The balance standard shall be in accordance with ISO 2372;1974 Quality Grade C for Class II machines. Maximum vibration velocity shall not exceed 0.14 in/sec r.m.s. on 60 Hz supplies over the full pitch angle range, when measured at the fan mounting feet.
- H. Certification: The fan manufacturer shall supply a test certificate for each fan showing the voltage, current, frequency, kilowatts input, degree of balance and control characteristic (actuator movement against control signal). The fan pitch angle for adjustable fixed pitch fans shall be adjusted at the factory to meet scheduled conditions.

- I. Characteristics: The aerodynamic design of the fan shall be such that the maximum power absorbed by the impeller occurs within the normal working range such that the fan has a non-overloading characteristic.
- J. Impeller Attachment: The impeller shall be secured to the motor or fan shaft by a key and keyway. Axial location shall be provided by a collar or a shoulder on the drive shaft together with a retaining washer and a screw fitted into a tapped hole in the end of the shaft. The screw shall be locked in position.
- K. Direct Drive Motors: Motors shall be totally enclosed fan cooled (TEFC) with Class F insulation and 1.15 service factor. Motor bearings shall be selected for a minimum L-10 life of 20,000 hours. Grease lubrication lines shall be brought to outside of the fan casing and labeled. Motor wiring shall be factory-extended to a junction box installed on the outside of the fan housing.
- L. Belt Drive Motors: Fan motors shall be ball bearing 1750 rpm open dripproof (ODP) type for indoor use and shall have electrical characteristics as scheduled. **[Motors 1 hp and larger shall be of the high efficiency, energy efficient type.]** Motor base shall be equipped with adjustable base rails.
- M. Belt Drives: V-belt fan drives with variable pitch motor sheave shall be selected for 150% of motor horsepower and anti-static belts shall be furnished. Drive guards shall have accessible opening to read rpm.
- N. Fan Shafts: Fan shafts shall be precision tuned, ground and polished steel shafts, sized so that the first critical speed is a minimum of 25% over the maximum operating speed. Fan shaft shall have pillow block bearings. All fan bearings shall be factory-lubricated and equipped with standard hydraulic grease fittings. Extended lube lines shall be furnished where bearings are not accessible and shall terminate on the outside of drive end of each unit including extension to allow greasing without removal of drive guard.
- O. Accessories: Provide all required accessories including, but not limited to:
 - 1. Inlet bell mouth fittings with guards.
 - 2. Outlet guard.
 - 3. Outlet cone.
 - 4. Inlet and outlet attenuators.
 - 5. Flange mounted flexible connections.
 - 6. Horizontal or vertical mounting brackets as required for isolated fan mounting.

2.11 AIR INTAKES & RELIEF VENTS (COMBINE REDUNDANT SECTIONS):

- A. General: Provide ACME or approved equal Greenheck, Cook or Carnes roof-mounted air intakes with capacities as scheduled.
- B. Construction: Construction of the housing shall be aluminum. Intakes shall be constructed to withstand winds up to 150 mph.

- C. Accessories: Provide all required accessories including, but not limited to: aluminum birdscreen, gravity or motorized (as scheduled) backdraft dampers and prefabricated insulated aluminum roof curb.

2.12 RELIEF VENTS:

- A. General: Provide ACME or approved equal Greenheck, Cook or Carnes roof-mounted air relief vents of the type and capacities as scheduled.
- B. Construction: Construction of the housing shall be aluminum. Vents shall be constructed to withstand winds up to 150 mph.
- C. Accessories: Provide all required accessories including, but not limited to: aluminum birdscreen, gravity or motorized (as scheduled) backdraft dampers and prefabricated insulated aluminum roof curb.

PART 3 - EXECUTION

3.1 INSPECTION:

- A. General: Installer shall examine conditions under which fans, outside intakes, and relief vents are to be installed and notify Contractor in writing of conditions detrimental to proper and timely completion of the Work. Do not proceed with the Work until unsatisfactory conditions have been corrected in a manner acceptable to Installer.

3.2 INSTALLATION:

- A. General: Install fans, outside intakes, and relief vents where shown, in accordance with manufacturer's written instructions and recognized industry practices to ensure that fans, outside intakes, and relief vents comply with requirements and serve intended purposes. Comply with NEMA standards and requirements of NEC.
- B. Curb-mounted Fans: All fans mounted on roof curbs shall be securely attached to the roof curb with appropriate fasteners located 8" on center with a minimum of two fasteners per side by this Contractor. The roof curb shall be securely attached to the building structure by the General Contractor.
- C. Insulation: Refer to Section 23 05 48 for fan insulation requirements.
- D. Housekeeping Pads/Vibration Isolation: Refer to Section 23 03 00 and Section 23 05 48 for applicable requirements.

3.3 COORDINATION:

- A. General: This Contractor shall be responsible for coordinating installation requirements and provisions with the work of other Divisions and the General Contractor.
- B. Coordinate all required fan motor horsepower, voltages and locations with Electrical Contractor prior to purchase.
- C. **All fans with 2000 cfm or greater airflow shall have a firestat with manual reset set to open at 50°F, above maximum system operating temperature to interrupt electric current to the fan motor in case of fire. Firestat shall be furnished and installed by [this**

Contractor with wiring of firestat by the Electrical Contractor.] [the Temperature Controls Subcontractor. Refer to Section 23 06 00 for control requirements].]

- D. Coordinate all roof mounted fan curb openings with General Contractor prior to roofing installation.

3.4 START-UP SERVICES:

- A. General: The fan supplier shall provide fan checkout, start-up, testing and adjusting of system components for the vane axial fan systems. The fan supplier shall also train the Owner's Engineer in the proper operation and maintenance of these fans.

3.5 TESTING:

- A. General: Test and adjust all installed fans to verify proper operation as specified herein and as recommended by the manufacturers. Where specified hereinabove, start-up, testing, and adjustment shall be provided by a representative of the equipment supplier.
- B. Refer to Section 23 05 93 for additional start-up, testing, and adjustment requirements.

3.6 IDENTIFICATION:

- A. Refer to Section 23 03 00, for applicable painting, nameplates, and labeling requirements.

END OF SECTION

UTILITY EXHAUST FANS

Furnish and install Greenheck Model SWB or approved equal ACME or Cook exhaust fans as scheduled.

Fan shall be a belt drive, single width, single inlet utility vent set with an aluminum backward inclined non-overloading centrifugal fan wheel. Fan shaft shall have pillow block bearings. All fan bearings shall be factory lubricated and equipped with standard hydraulic grease fittings. Extended lube lines shall be furnished where bearings are not accessible and shall terminate on the outside of drive end of each unit including extension to allow greasing without removal of drive guard.

V-belt fan drives with variable pitch motor sheave shall be selected for 150% of motor horsepower and anti-static belts shall be furnished. Drive guards shall have accessible opening to read rpm.

Fan housing and drive guard shall be minimum 16 gauge arc-welded steel. Housing shall have a 1" FPT coupling welded to bottom of housing with automatic trap drain provided and installed by Mechanical Contractor to automatically drain the fan housing. Fan motors shall be ball bearing 1750 rpm open dripproof (ODP) type for indoor use and shall have electrical characteristics as scheduled. **[Motors 5 hp and larger shall be of the high efficiency, energy efficient type (Refer to Section 23 03 00).]** Motor base shall be equipped with adjustable base of rails.

All parts of the fan that come into contact with the air-stream shall be coated with a high temperature acid resistant epoxy coating.

Fan accessories shall include belt guard, heat slinger wheel, high temperature drive belts, high temperature wheel bearings and bearing grease, access door, gravity backdraft damper, discharge guard and factory installed disconnect switch.

SMOKE REMOVAL FANS

Furnish and install Flakt Products, Inc. Model AV or approved equal belt driven fixed pitch axial flow type smoke removal fans of the size and capacity scheduled.

Fans shall be Arrangement 9 V-belt drive with fan rotor mounted on separate shaft and bearings in an enclosed tube with fixed pitch belt drive with a 1.5 safety factor.

Fan casings shall be welded of hot-rolled steel plate .135" in small sizes up to 28" with continuously welded flanges. The next fan sizes up to 50" shall be 3/16" thick with flanges rolled at inlet and outlet. Sizes of 50" or greater diameter shall be of 1/4" plate steel with rolled flanges at inlet and outlet. Concentricity of fan casings shall be insured through the use of welding jigs and fixtures. A fabricated adjustable steel motor support of plate steel shall be supported by adjustable rods welded to a base on the outside of the fan casing.

Fan casings shall be fitted with mounting legs or hanging clips as shown on the drawings. Fan mounting legs shall be fabricated from minimum 3/16" steel plate suitably braced to insure stability and rigidity. Clips for horizontal suspension shall be of minimum 3/8" steel plate mounted at fan center line. Clips for vertical suspension shall be mounted at center of moment of inertia of fan assembly.

Fan rotor shall be of fabricated steel. Fan blades shall be designed for maximum efficiency and be air-foil shaped, varying in twist and width from base to tip. Blade tip clearance shall be within tolerance to meet certified performance of fan.

The fan rotor assembly shall be statically and dynamically balanced. Belt drive rotors shall be installed on their fan shafts for balancing to tolerances as listed below in mils double amplitude:

FAN RPM RANGE	MILS PK-PK
2400 - 3600	0.4
1800 - 2400	0.6
1200 - 1800	0.8
900 - 1200	1.2
LESS THAN 900	1.6

The fan rotor shall be secured on the fan shaft by a key and keyway, and by locking hardware threaded on the end of the shaft.

Fan motors shall be foot-mounted NEMA standard [**open dripproof (ODP)**] [**totally enclosed fan cooled (TEFC)**] continuous duty, ball bearing, with Class "B" insulation. Motor leads shall terminate in the conduit box mounted on the exterior of the motor. External grease fittings with extended grease leads shall be supplied for lubrication of the fan shaft bearings.

After fabrication, fans shall be prime coated and finish painted. Zinc chromate epoxy primer shall be applied after surfaces are cleaned and degreased. Finish coat shall be air dry acrylic enamel.

All fan bearings shall have a B-10 life as defined by AFBMA of at least 25,000 hours.

Fans shall be furnished with high temperature belts, high temperature grease, heat slinger, shall be all steel construction per City of Houston High Rise Code requirements and shall be suitable for continuous operation with 500_o_F exhaust air.

SMOKE REMOVAL FANS

Furnish and install Industrial Air, Inc. Series 047 or approved equal smoke removal fans of the size and capacity scheduled.

Fan shall be of a bifurcated vane axial design with an insulated motor well and heat slinger induced air cooling and shall be suitable for use with exhaust air temperatures up to 500_o_F. Cooling air intakes shall have louvered covers.

Fan shall be direct drive type with high temperature aluminum alloy blades. Blades shall be manually adjustable from the front of the wheel.

Fan shall be designed for duct inlet and outlet.

Fan motor shall be factory installed and aligned and to entire rotating assembly shall be statically and dynamically, balanced.

SMOKE REMOVAL FANS

Fan shall be an up-blast propeller type constructed to meet The City of Houston High Rise Code for smoke exhaust and shall be of the size and capacity as indicated on the drawings.

Construction features shall include:

- Painted Steel curb
- Heavy duty painted steel curb cover
- Painted steel weather cover over motor
- Butterfly dampers with rubber weather seal
- Sheaves and belts out of the air stream
- Welded drum assembly welded to curb cap

Fan shall be a Cincinnati model RA or approved equal.

HOOD EXHAUST FANS

Furnish and install Dual Industries Model [????] or approved equal utility fans of the size and capacities scheduled.

Fan shall be belt driven, single width, single inlet, centrifugal blower with vertical discharge. The blower housing shall be PVC with PVC inlet and outlet angle flanges and PVC drain. Frame shall be phenolic coated steel. Fan wheel shall be PVC coated steel. Motor shall be totally enclosed, fan cooled, ball bearing type.

Other features to include: heavy angle iron bracing, over capacity shaft and oil-type, pillow block ball bearings, formed PVC venturi inlet, 155_o_F operating temperature, OSHA belt and shaft guards and ventilated weatherproof PVC motor and drive housing.

The fan and wheel inlet cone shall be non-sparking aluminum and of the high performance, centrifugal blower type. Wheel shall be statically and dynamically balanced.

Motor and drives shall be isolated from the exhaust airstream. Motors shall be of the heavy duty type with permanently lubricated, sealed ball bearings. Air for cooling the motor shall be taken into the motor chamber by means of an air tube from a location free of discharge contaminants.

The entire drive assembly and wheel, as a unit, shall be removable through the support structure without dismantling fan housing. The wheel shaft shall be mounted in heavy duty ball bearings.

Drives shall be sized for 165% of driven horsepower. Pulleys shall be adjustable cast iron type keyed to the fan and motor shafts. The entire drive assembly shall be mounted on rubber vibration isolators. Motors shall be 1750 RPM open dripproof (ODP) type for indoor use and totally enclosed fan cooled (TEFC) type for exterior use and shall be of the horsepower and voltage scheduled. **[Motors 5 hp and larger shall be of the high efficiency, energy efficient type (Refer to Section 23 03 00).]**

Fan accessories shall include: 1/2" mesh aluminum birdscreen, gravity backdraft damper, disconnect switch and weather hood (where applicable).

FUME HOOD EXHAUST FAN

Furnish and install Greenheck Model SWB or approved equal ACME or Cook exhaust fans as scheduled.

Fan shall be a belt drive, single width, single inlet utility vent set with an aluminum backward inclined non-overloading centrifugal fan wheel. Fan shaft shall have pillow block bearings. All fan bearings shall be factory lubricated and equipped with standard hydraulic grease fittings. Extended lube lines shall be furnished where bearings are not accessible and shall terminate on the outside of drive end of each unit including extension to allow greasing without removal of drive guard.

V-belt fan drives with variable pitch motor sheave shall be selected for 150% of motor horsepower and anti-static belts shall be furnished. Drive guards shall have accessible opening to read RPM.

Fan housing and drive guard shall be minimum 16 gauge arc-welded steel. Housing shall have a 1" FPT coupling welded to bottom of housing with automatic trap drain provided and installed by Mechanical Contractor to automatically drain the fan housing. Fan motors shall be ball bearing 1750 RPM open dripproof (ODP) type for indoor use and totally enclosed fan cooled (TEFC) for exterior use and shall have electrical characteristics as scheduled. **[Motors 5 hp and larger shall be of the high efficiency, energy efficient type (Refer to Section 23 04 00).]** Motor base shall be equipped with adjustable base of rails.

All parts of the fan that come into contact with the air-stream shall be coated with a high temperature acid resistant epoxy coating.

Fan accessories shall include belt guard, weatherhood, access door, gravity backdraft damper and discharge guard.

FILTERED DOWNBLAST ROOF MOUNTED FAN

Furnish and install a Greenheck Model RSF or approved equal roof mounted supply air fans with capacities as scheduled.

Fans shall be a belt drive, double width, double inlet, forward curved centrifugal blower type with the blower assembly mounted on suitable vibration isolators. Drive shall be designed for a minimum of 165% of driven horsepower and shall be furnished with cast iron, adjustable type drive sheaves.

Motors shall be 1750 RPM open drip proof type of the horsepower and voltage scheduled. **[Motors 5 hp and larger shall be of the high efficiency, energy efficient type (Refer to Section 23 04 00).]**

The motor and blower shall have permanently lubricated, sealed ball bearings.

The fan housing shall be heavy gauge galvanized steel **[and the unit shall be designed to elevate the air intake a minimum of 3 feet above the roof.]** The unit wind band shall be adequate to prevent moisture from entering the building. The fan cover shall be insulated and shall be securely held in place.

Reusable 1" permanent aluminum filters shall be provided. Fan accessories shall include a duct adapter, an extended insulated base roof curb **[to provide the minimum 3' intake height]**, a disconnect switch and a **[gravity] [pneumatic]** backdraft damper. **[Refer to Section 23 06 00 for damper operators and controls.]**

The fan unit shall bear the AMCA certified ratings seal for air performance with filters in place.

UNFILTERED DOWNBLAST ROOF MOUNTED FAN

Furnish and install a Greenheck FFS Series or approved equal power roof ventilator with capacities as scheduled.

Ventilator housing shall be heavy duty aluminum with rolled interlocking seams for reinforcement.

The hood top shall be hinged for easy access to the fan.

Drives shall be adjustable and shall be sized for 165% of driven horsepower and shall be mounted on vibration isolators. The fan shall be axial propeller type with sealed ball bearing and cast iron drive sheaves. Motors shall be 1750 open dripproof (ODP) type of the horsepower and voltage scheduled.

[Motors 5 hp and larger shall be of the high efficiency, energy efficient type. (Refer to Section 23 04 00).] The motor and blower shall have permanently lubricated, sealed ball bearings.

Accessories shall include an expanded aluminum birdscreen, duct adapter, an insulated aluminum roof curb and a disconnect switch.

The fan unit shall bear AMCA seals for sound and air with the birdscreen in place.

ROOF MOUNTED PROPELLER SUPPLY FANS

Furnish and install Greenheck Model PBS, PDS or approved equal ACME, Cook or Carnes roof mounted propeller fans with capacities as scheduled.

Fans shall be axial type, belt or direct driven as scheduled. Blades shall be die formed and welded to a steel hub. A polished steel fan shaft shall be mounted in permanently lubricated, sealed ball bearing pillow blocks. The drive frame assembly shall be formed steel. The fan panel shall have prepunched mounting holes, formed flanges with welded corners, and a deep formed venturi. A special arrangement for supply air shall be used with the fan panel reversed so that air flows through the panel

in the proper direction in respect to the inlet venturi. Fans shall bear AMCA ratings seals for air and sound performance.

Round low profile discharge hood shall be fastened to roof curbs with heavy duty full length piano hinge. Fan motor brackets shall mount down inside roof curb to keep overall unit height as low as possible.

Motor shall be 1750 RPM open dripproof (ODP) type of the horsepower and voltage scheduled.

[Motors 5 hp and larger shall be of the high efficiency, energy efficient type (Refer to Section 23 04 00).]

Accessories shall include 1/2" mesh birdscreen, prefabricated insulated aluminum roof curb, damper tray, disconnect switch, gravity backdraft damper. Refer to Section 23 06 00 for controls.

SIDEWALL PROPELLER SUPPLY FANS

Furnish and install Greenheck Model SDE, SBPS or approved equal ACME, Cook or Carnes sidewall propeller fans with capacities as scheduled.

Fans shall be axial type, belt or direct driven as scheduled. Blades shall be die formed and welded to a steel hub. A polished steel fan shaft shall be mounted in permanently lubricated, sealed ball bearing pillow blocks. The drive frame assembly shall be formed steel. The fan panel shall have prepunched mounting holes, formed flanges with welded corners, and a deep formed venturi. A special arrangement for supply air shall be used with the fan panel reversed so that air flows through the panel in the proper direction in respect to the inlet venturi. Fans shall bear AMCA ratings seals for air and sound performance.

Accessories shall include mounting collar, disconnect switch, pneumatic backdraft damper with end switch and motor side fan guard. Refer to Section 23 06 00 for damper operators and controls.

SIDEWALL MOUNTED PROPELLER SUPPLY FANS

Furnish and install Greenheck Model SPN or approved equal ACME, Cook or Carnes sidewall mounted propeller fans with capacities as scheduled.

Fans shall be axial type, belt or direct driven as scheduled. Blades shall be die formed and welded to a steel hub. A polished steel fan shaft shall be mounted in permanently lubricated, sealed ball bearing pillow blocks. The drive frame assembly shall be formed steel. The fan panel shall have prepunched mounting holes, formed flanges with welded corners, and a deep formed venturi. A special arrangement for supply air shall be used with the fan panel reversed so that air flows through the panel in the proper direction in respect to the inlet venturi. Fans shall bear AMCA ratings seals for air and sound performance.

Motors shall be 1750 RPM open dripproof (ODP) type of the horsepower and voltage scheduled.

[Motors 5 hp and larger shall be of the high efficiency, energy efficient type (Refer to Section 23 04 00).]

Accessories shall include mounting collar, disconnect switch, pneumatic control damper with end switch and motor side fan guard. Refer to Section 23 06 00 for damper operators and controls.

IN-LINE SUPPLY FANS

Furnish and install Greenheck Model [????] or approved equal ACME, Cook or Carnes in-line supply fans with capacities as scheduled.

Fans shall be belt or direct driven in-line type with square heavy gauge galvanized steel housing which shall have a thermally fused epoxy finish. One of the sides shall be hinged and shall support the entire drive assembly and wheel allowing the assembly to swing out for cleaning, inspection, or service without dismantling the unit in any way. On belt drive models the motor shall be mounted on the hinged side exterior isolated from the airstream.

The belt and pillow block ball bearings shall be protected from the airstream by an enclosure. The shaft shall be keyed to both the wheel and pulley. On direct drive models the motor shall be isolated from the airstream by a motor enclosure and shall draw cooling air from outside the fan housing. The fan inlet shall be spun venturi throat overlapped by a backward curved centrifugal wheel with spun cone for maximum performance.

The interior of all in-line fan housing shall have 1" thick, 3 P.C.F. density internal sound absorbing fiberglass insulation to reduce operating noise levels.

Motors shall be 1750 RPM open dripproof (ODP) type of the horsepower and voltage scheduled.

[Motors 5 hp and larger shall be of the high efficiency, energy efficient type (Refer to Section 23 04 00).]

Fan accessories shall be as follows: Duct mounted automatic acting gravity type backdraft dampers of same size as fan housing, hanging support isolators with door side perpendicular to mounting surface and belt guard for belt driven fans.

UTILITY SUPPLY FANS

Furnish and install Greenheck Model AFSW or approved equal Peerless or Trane utility supply fans with capacities as scheduled.

Fans shall be of the centrifugal type with airfoil wheels.

The housing shall be constructed of continuously welded heavy-gauge steel to assure no air leakage.

The housing and bearing support shall be constructed of structural steel members to prevent vibration and rigidly support the shaft and bearings.

All structural parts shall be phosphatized, primed and coated with a baked enamel finish.

Non-overloading single and double width wheels shall be constructed of heavy gauge, airfoil blades securely welded to the wheel cone and a heavy gauge backplate. The wheel cone and unit inlet cone shall be carefully matched and have precise running tolerances to provide for maximum efficiency.

Each fan wheel shall be statically and dynamically balanced before being assembled into the fan.

Turned, precision ground and polished steel shafts shall be sized so the first critical speed is at least 25% over the maximum operating speed for each pressure class. Close tolerances shall be maintained where the shaft makes contact with the bearing. Bearings shall be heavy duty grease lubricated, self aligning ball bearing or roller pillow block type. Bearings shall be selected for a minimum of 400,000 hours life at maximum operating speed for each pressure class.

Inlet flanges welded to the inlet collar and outlet flanges welded to the fan outlet shall be provided flanged duct connections.

A 1" threaded drain connection with a plug shall be provided to drain moisture from the bottom of the fan housing.

A totally enclosed belt guard with provisions for measuring fan RPM without removing the guard shall be provided.

A motorized parallel blade backdraft damper with galvanized steel frame, aluminum blades, felt edge seals and steel end seals shall be provided mounted to each fan. Refer to Section 23 06 00 for pneumatic operators and controls.

Fan performance shall be based on tests conducted in accordance with AMCA Standard 210 test code for air moving devices and fans shall be licensed to bear the AMCA Certified Ratings Seal.

After assembly each fan shall be given a final balance test at the specified operating RPM to insure smooth vibration free operation.

Outside air fans shall be externally insulated in the field.

Motors for interior mounted fans shall be open dripproof (ODP) type and motors for exterior mounted fans shall be totally enclosed fan cooled (TEFC). Motors shall be 1750 RPM type of the horsepower and voltage scheduled. **[Motors 5 hp and larger shall be of the high efficiency, energy efficient type (Refer to Section 23 04 00).]**

Accessories shall include **[vented weather hood with]** expanded metal inlet guard, factory mounted disconnect switch, felt tipped automatic aluminum backdraft dampers, vibration isolators and drain connections.

STAIRWELL PRESSURIZATION FANS

Furnish and install Flakt Products, Inc. Series [????] or approved equal in-flight adjustable vaneaxial stairwell pressurization fans as scheduled.

[Fans shall be Arrangement 4, Type 2 with the fan rotor mounted directly on the drive motor shaft and the motor enclosed entirely within the fan casing. Fans shall be designed for horizontal or vertical mounting as scheduled and shall be of a weatherproof design when indicated or required.]

[Fans shall be Arrangement 4, Type 3 having the fan rotor mounted directly on the drive motor shaft, with the drive motor supported on a structural steel base upstream of the fan rotor and external to the fan casing. The inlet bell and fan casing shall also be supported from the structural steel base. A protective wire cage shall be supplied at the fan inlet covering drive motor and inlet bell.]

Fans shall consist of a fan casing followed by a separate removable guide vane section. Fan casings shall be welded of hot-rolled steel plate 3/16" thick in sizes through 50" diameter with 3/16" thick flanges continuously welded at inlet and outlet. Sizes greater than 50" diameter shall be of 1/4" thick steel with 1/4" thick flanges. Concentricity of fan casings shall be insured through the use of welding jigs and fixtures. A fabricated steel motor support shall be welded into the inlet end of the fan casing. Guide vane sections shall be welded of 12 gauge steel and shall be fitted with a removable panel for access to fan rotor and control section. The guide vane section shall be arranged for attachment of a flexible connection at the discharge.

Fan casings shall be fitted with mounting legs or hanging clips as shown on the drawings. Fan mounting legs shall be fabricated from steel plate suitably braced to insure stability and rigidity. Clips for vertical support shall be mounted at center of moment of inertia of fan assembly.

Fan blades and hub shall be aluminum castings. Hub shall be heat treated alloy 356-T6 and blades shall be alloy 356. Fan blades shall be designed for maximum efficiency and be air-foil shaped, varying in twist and width from base to tip. Blade tip clearances shall be within tolerance to meet certified performance of fan.

The center of the hub shall be equipped with a blade operating mechanism. An **[electronic]** **[pneumatic]** operator shall be furnished with linkage to operate the fan blades. The fan blade angle shall be variable from zero to maximum angle. Mechanical adjustable stops shall be furnished for maximum angle. The **[electronic]** **[pneumatic]** operator shall be factory installed, complete with **[wiring]** **[piping]** and linkage to a positioning device mounted external to the vane section. **[Power shall be supplied to the electronic activator at the required voltage by the Division 26 Contractor.] [Control air shall be supplied to the pneumatic operator by the Temperature Controls Subcontractor at the required pressure.] [Air pressure to the pneumatic operator shall be 65 PSIG. The positioning device shall operate with a 3-15 PSIG control signal from a sensing device and controller furnished and mounted by the control manufacturer as specified elsewhere. The positioning device shall be reverse acting wherein the 3 PSIG control signal requests maximum blade angle and the 15 PSIG control signal requests minimum blade angle.]** Operation of the control system shall be such that the fan blades on the lower fans go to the maximum angle upon loss of control **[power]** **[air]** and the upper fans go to the zero angle upon loss of control **[power]** **[air]**.

The fan rotor assembly shall be statically and dynamically balanced. Direct drive rotors shall be balanced on their motor shafts to tolerances as listed below in mils double amplitude:

FAN RPM	MILS PK-PK
1760	0.8
1180	1.2
880	1.6

[Fan Motors shall be totally enclosed air over (TEAO), continuous duty, ball bearing, with class "B" insulation. Motor leads shall be extended through an air tight conduit to a suitably sized conduit box on the side of the fan casing. Provide with external grease fittings and extended grease leads.]

[Fan motors shall be foot-mounted NEMA standard open drip proof (ODP) continuous duty, ball bearing, with Class "B" insulation. Motor leads shall be extended through an air tight conduit to a suitably sized conduit box mounted on the exterior of the fan casing. External grease fittings with extended grease leads shall be supplied for lubrication of the motor bearings.]

After fabrication, fans shall be prime coated and finish painted. Zinc chromate epoxy primer shall be applied after surfaces are cleaned and de-greased. Finish coat shall be air dry acrylic enamel.

Fan performance data shall be the result of test data obtained in an AMCA approved laboratory using applicable portions of AMCA Standard 210 for flow and Standard 300 for sound power levels.

ELEVATOR HOISTWAY PRESSURIZATION FANS

Furnish and install Flakt Products, Inc. Series [????] or approved equal manual (fan stopped) adjustable vane axial elevator hoistway pressurization fans as scheduled.

Fans shall be Arrangement 4, Type 2 having the fan rotor mounted directly on the motor shaft with the assembly enclosed entirely within the fan casing.

Fan casings shall be welded of hot-rolled steel plate 3/16" thick with 3/16" thick flanges continuously welded at inlet and outlet. Concentricity of fan casings shall be insured through the use of welding jigs and fixtures. A fabricated steel motor support of not less than 1/4" plate steel shall be welded into the inlet end of the fan casing.

Fan casings shall be fitted with mounting legs or handing clips as shown on the drawings. Fan mounting legs shall be fabricated from minimum 3/16" steel plate suitably braced to insure stability and rigidity. Clips for horizontal suspension shall be of minimum 3/8" steel plate mounted at fan center line clips for vertical suspension shall be mounted at center of moment of inertia of fan assembly.

Fan casing shall be fitted with an access panel for external adjustment of blade pitch angle. Access panel shall provide unimpeded accessibility for adjusting blade angle.

Fan blades and hubs shall be aluminum castings, alloy 356. Fan blades shall be designed for maximum efficiency and be air-foil shaped, varying in twist and width from base to tip. Blade tip clearance shall be within tolerance to meet certified performance of fan. Fan hub shall be a one piece aluminum casting and shall have a vernier scale to indicate blade position for each blade.

Fan blade pitch angle shall be individually manually externally adjustable through an access panel of the fan casing. External adjustment of blade angle shall be accomplished without disturbing the installation of removing fan from ductwork.

The fan rotor assembly shall be statically and dynamically balanced. Direct drive rotors shall be installed on their motor shafts to tolerances as listed below in mils double amplitude:

<u>FAN RPM</u>	<u>MILS PK-PK</u>
3550	0.4
1760	0.8
1180	1.2
880	1.6

The fan rotor shall be secured on the motor shaft by a key and keyway, and by a locking bolt threaded into the motor shaft.

Fan motors shall be foot-mounted NEMA standard open drop proof (ODP) continuous duty, ball bearing, with Class "B" insulation. Motor leads shall be extended through an air tight conduit to a suitable sized conduit box mounted on the exterior of the fan casing. External grease fittings with extended grease leads shall be supplied for lubrication of the motor bearings.

After fabrication, fans shall be prime coated and finish painted. Zinc chromate epoxy primer shall be applied after surfaces are cleaned and de-greased. Finish coat shall be air dry acrylic enamel.

Fan performance data shall be the result of test data obtained in an AMCA approved laboratory using applicable portions of AMCA standard 210 for flow and Standard 300 for sound power levels.

Return Air Fans

Furnish and install Trane or an approved equal centrifugal return air fans with capacities as scheduled. Fans shall include housing, wheel, fan shaft, bearings and side support structure as a factory assembled unit. All sheet metal parts shall be cleaned, conditioned and painted with enamel primer finish prior to final assembly. A final coat of gray enamel is applied to all exterior surfaces after assembly.

Fans shall have curved scroll housings with lockseam or spot welded construction with discharge configuration as shown on the Drawings. All housings are reinforced with rigid bracing to increase structural integrity. Bearing support brackets are positioned to directly oppose belt tension forces.

Inlet collars on all single width fans extend beyond the fan housing to provide an uninterrupted duct connection. Slip joint discharge duct connections shall be provided.

Precisely positioned cutoffs and aerodynamically spun inlet cones shall provide smooth air flow through the fan and minimum turbulence.

Fan wheels shall non-power-overloading with forward curved, backwardly inclined air foil blades or backwardly inclined, plate type blades.

Blades on all sizes shall be securely welded to the spun rim and to the hub plate. Hubs shall be close grained cast iron. All wheels shall be carefully trued after assembly and dynamically balanced.

Wheels shall be keyed to the shaft.

Fan shafts shall be solid AISI C-1040 or 1045 hot rolled steel accurately turned and polished. Close tolerances shall be maintained where the shaft makes contact with the bearings.

Bearings shall be grease lubricated, precision anti-friction extra heavy duty, split pillow block type with tapered, double spherical rollers selected for a minimum average life (AFBMA L-50) in excess of 400,000 hours operation at maximum cataloged operating conditions. Extended grease lines shall be provided as required.

Motors shall be 1750 RPM open dripproof (ODP) type of the horsepower and voltage scheduled.

[Motors 5 hp and larger shall be of the high efficiency, energy efficient type (Refer to Section 23 04 00).]

Fans shall be tested and rated in accordance with AMCA Standard 210 and the Certified Ratings Program and shall be licensed to bear the AMCA Certified Ratings Seal.

BUILT-UP AIR HANDLING UNIT SUPPLY FAN

Furnish and install Peerless Electric or approved equal supply fans of the size and capacity scheduled. Fans shall be of the belt driven, single width, backward incline, non-overloading air foil blade, centrifugal type.

Fans shall be Arrangement 3 V-belt drive. Backward inclined airfoil blades shall be continuously seam welded to backplate and wheel cove. Fan shaft shall have pillow block bearings.

Fan shall be tested in accordance with the latest AMCA fan test procedures and shall bear an AMCA seal.

Fan casings shall be fitted with heavy angle or channel frame suitable for mounting on concrete pad. Fan mounting shall be fabricated from minimum 3/16" steel plate suitably braced to insure stability and rigidity. Provide belt guard.

The fan assembly shall be certified to be statically and dynamically balanced at the factory.

Fan motors shall be foot-mounted NEMA standard open dripproof (ODP) continuous duty, ball bearing, with Class "B" insulation. **[Motors 5 hp and larger shall be of the high efficiency, energy efficient type (Refer to Section 23 04 00).]** Motor leads shall terminate in the conduit box mounted on the exterior of the motor. External grease fittings with extended grease leads shall be supplied for lubrication of the fan shaft bearings.

After fabrication, fans shall be prime coated and finish painted. Zinc chromate epoxy primer shall be applied after surfaces are cleaned and degreased. Finish coat shall be air dry acrylic enamel.

ROOF MOUNTED PROPELLER EXHAUST FANS

Furnish and install Greenheck Model PBE and PDE or approved equal ACME, Cook or Carnes roof mounted propeller exhaust fans with capacities as scheduled.

Fans shall be axial type, belt or direct driven as scheduled. Blades shall be die formed and welded to a steel hub. A polished steel fan shaft shall be mounted in permanently lubricated, sealed ball bearing pillow blocks. The drive frame assembly shall be formed steel. The fan panel shall have prepunched

mounting holes, formed flanges with welded corners, and a deep formed venturi. Fans shall bear AMCA ratings seals for air and sound performance.

Round low profile discharge hood shall be fastened to curb with heavy duty full length piano hinge. Fan motor brackets shall mounted down inside roof curb to keep overall unit height as low as possible.

Motors shall be 1750 RPM open dripproof (ODP) type of the horsepower and voltage scheduled.

[Motors 5 hp and larger shall be of the high efficiency, energy efficient type (Refer to Section 23 04 00).]

Accessories shall include 1/2" mesh birdscreen, prefabricated, insulated, aluminum roof curb, damper tray, disconnect switch, gravity backdraft damper.

CENTRIFUGAL FANS:

- A. General: Provide centrifugal fans of the single-width, single-inlet type with either forward or backward curved fan blades and adjustable belt drives.
- B. Motors: Provide standard dripproof motors. Provide cast iron housings for motors larger than 10 hp, riveted or spot-weld wheels with steel rims and hub plates.
- C. Fan: Blades shall be die cut and die-formed and hubs shall be machined close-grained cast iron. Steel housings shall have lock-seam construction with discharge reinforcement and shall be adjustable with continuous inlet collars. Provide weatherproof enclosure for motors and drive, if units are exposed to weather.
- D. Manufacturer: The equipment scheduled on the Drawings shall establish design requirements. Equipment that meets or exceeds these standards, manufactured by Buffalo Forge, Carrier, Sturtevant, American Blower, Chicago, Trane, Barry, York, or Clarage will be acceptable.

AXIAL FANS:

- A. General: Provide vane-axial and tube-axial fans constructed of heavy gauge welded steel, hot-dipped galvanized after fabrication. Direct drive fans shall have motor support systems acceptable to the Engineer. Lubricated fittings shall be extended to the outside of the fan casing.
- B. Fan: Fan blades shall be individually adjustable or controllable pitch. Each fan and fan wheel shall be statically and dynamically balanced and shall be so certified. Fans handling untreated air shall be capable of operating satisfactorily at 0 and 100°F across the fan.
- C. Motors: Provide motors having totally-enclosed air over (TEAO) type, a service factor of 1.0, with Class F epoxy-enameled copper windings.
- D. Accessories: Provide welded steel inlet and outlet cones, hot-dipped galvanized, and painted after fabrication, for each fan. Where fans are indicated to be controlled pitch, provide pneumatic actuators designed to operate with standard building control air.
- E. Manufacturer: The equipment scheduled on the Drawings shall establish the design requirements. Equipment which meets or exceeds these requirements and as manufactured by Buffalo, Sturtevant, Trane, Joy, Woods, or Flakt shall be acceptable.

CEILING EXHAUST FANS:

- A. General: Provide direct driven ceiling exhaust fans as scheduled on the Drawings. Fan shall be acoustically insulated and have a maximum sound level rating of 3.6 sones.

B. Motor: Motor shall be suitably grounded and mounted on rubber-in-shear vibration isolators and speeds shall not exceed 1050 rpm.

C. Accessories:

1. Provide totally noise-free, integral backdraft damper, with no metal-to-metal contact.
2. Inlet grille shall be white molded plastic with eggcrate shape and provide 85% free open area.
3. Provide terminal box on the housing with cord, plug, and receptacle inside the housing.

SECTION 23 84 13
STEAM GRID HUMIDIFIERS

PART 1 GENERAL

1.00 The following sections are to be included as if written herein:

- A. Section 23 00 00 – Basic Mechanical Requirements
- B. Section 23 05 29 – Sleeves, Flashings, Supports and Anchors
- C. Section 23 05 53 – Mechanical Identification

1.01 SECTION INCLUDES

- A. Dry Steam Humidifiers
- B. Steam Jacketed Distribution Manifolds

1.02 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION

- A. Section 23 09 00 - Controls and Instrumentation: Installation of Humidistat
- B. Section 26 05 19 - Cable, Wire and Connectors, 600 Volt
- C. Section 26 27 26 - Wiring Devices and Floor Boxes

1.03 RELATED SECTIONS

- A. Section 22 13 16 - Plumbing Piping: Connecting of Water and Drain Services
- B. Section 23 22 00 - Steam and Steam Condensate Piping: Connection of Steam
- C. Section 23 09 00 - Controls and Instrumentation: Installation of Humidistats
- D. Section 26 05 19 - Cable, Wire and Connectors, 600 Volt
- E. Section 26 27 26 - Wiring Devices and Floor Boxes

1.04 REFERENCES

- A. ARI 610 - Central System Humidifiers
- B. ARI 630 - Selection, Installation and Servicing of Humidifiers

1.05 SUBMITTALS

- A. Submit shop drawings under provisions of Section 23 00 00.
- B. Product Data: Provide catalog data indicating rated capacity, dimensions, duct and service connections, electric nameplate data and wiring diagrams.

1.06 OPERATION AND MAINTENANCE DATA

- A. Submit operation data under provisions of Section 23 00 00.
- B. Include manufacturer's descriptive literature, operating instructions, installation instructions, maintenance and repair data, and parts listing.

1.07 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing the products specified in this Section with minimum three years documented experience.

1.08 WARRANTY

- A. Provide two-year warranty under provisions of Section 23 00 00.
- B. Warranty: Include coverage for humidifier unit except the cylinder.

1.09 EXTRA MATERIALS

- A. Submit maintenance materials under provisions of Section 23 00 00.
- B. Provide two of humidifier cylinders under provisions of Section 23 00 00.

PART 2 PRODUCTS

2.01 STEAM HUMIDIFIERS:

- A. Furnish and install steam humidifiers of the sizes and capacities shown on the Drawings and listed in the equipment schedule. Humidifiers shall be of the multiple dispersion tube, steam injection, dry type wherein entrained condensate is removed from the steam by means of 304 stainless steel, centrifugal type, and water/steam separators. Humidifiers shall be designed and catalogued to accomplish 100% absorption within 3' (three feet) downstream of the humidifier when the air is at 95% relative humidity. Humidifiers shall be as manufactured by Dri-Steam Humidifier Company, P.O. Box 621, Hopkins, MN 55343, or approved equal.

- B. Steam shall be introduced into the moving air stream by means of 304 stainless steel, steam jacketed (and insulated) dispersion tubes of the quantity, size and length indicated in the schedule. The interconnecting manifold piping shall be furnished and field installed by this contractor. (The fiberglass insulation on the dispersion tubes shall be factory encased in a 22 gauge, 304 stainless steel jacket.) The tubes shall be installed so that they are on approximately 8" (eight inch) centers with the upper and lower tubes no closer than 5" (five inches) from the top and bottom of the duct, respectively.
- C. Each dispersion tube shall be provided with discharge openings located at 1-1/2" (one and one-half inch) centers along the entire length of the tube. The openings shall be pierced, drawn and tapped with each tapping containing a minimum of 3 (three) threads. Brass inserts, properly drilled by the manufacturer to match the specified design capacity of each humidifier, shall then be factory installed in each opening. Each pair of openings adjacent to each end of the dispersion tubes shall be sized for a lesser steam flow than the other openings because of the reduced air flow which takes place next to the vertical walls of the duct.
- D. The steam metering valves shall be of the (pneumatic) (electronic) normally closed type having linear flow characteristics and designed to close against the flow of steam. The maximum valve capacity shall be as called for in the schedule. The valve motor and humidity controller shall be furnished and installed by the Automatic Temperature Control subcontractor. The valve shall be furnished by the (humidifier manufacturer) (Automatic Temperature Control subcontractor, with a Cv factor as specified by the humidifier manufacturer).
- E. Accessories to be supplied for each humidifier by the manufacturer include a pair of float and thermostatic steam traps, one to drain condensate from the separator and the other for the manifold, a pipe line strainer, and for each dispersion tube, an escutcheon plate to seal the duct opening.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install to ARI 630.
- C. Provide galvanized steel rods to support distribution manifolds and mount in air system plenums.

- D. Connect dry steam humidifiers to steam supply and to condensate piping. Provide gate valve, inlet strainer, and inverted bucket steam trap. Refer to Section 23 22 00 and Section 23 22 00.A.

NOTE TO SPECIFICATION WRITER: THE FOLLOWING SCHEDULES ARE INCLUDED FOR INFORMATION. JOB SCHEDULES ARE TO APPEAR ON THE DRAWINGS RATHER THAN IN THE SPECIFICATIONS.

3.02 SCHEDULES

<u>Drawing Code</u>	<u>HU-1</u>	<u>HU-2</u>	<u>HU-3</u>	<u>HU-4</u>
Location				
Service				
Manufacturer				
Model Number				
Capacity				
Input				
Orifice Size				

END OF SECTION

SECTION 28 08 00
COMMISSIONING OF FIRE ALARM SYSTEMS

PART 1 – GENERAL

1.1 SUMMARY

- A. This Section includes commissioning process requirements for Fire Alarm/Notification systems, assemblies, controls, and equipment.
- B. This project will have selected building systems commissioned. The equipment and systems to be commissioned are specified “SECTION 01 91 00 - GENERAL COMMISSIONING REQUIREMENTS”.

1.2 RELATED SECTIONS

- A. SECTION 01 91 00 – GENERAL COMMISSIONING REQUIREMENTS
- B. SECTION 22 08 00 – COMMISSIONING OF FIRE PROTECTION SYSTEMS
- C. SECTION 22 08 00 – COMMISSIONING OF PLUMBING SYSTEMS
- D. SECTION 23 08 00 – COMMISSIONING OF HVAC SYSTEMS
- E. SECTION 26 08 00 – COMMISSIONING OF ELECTRICAL SYSTEMS

1.3 DEFINITIONS

- A. Refer to Section 01 91 00 - GENERAL COMMISSIONING REQUIREMENTS

1.4 SUBMITTALS

- A. Certificate of Readiness, signed by the Contractor, certifying that systems, assemblies, equipment, components, and associated controls are ready for testing.
- B. Manufacturer’s completed start-up reports for equipment and systems.

1.5 CONTRACTOR'S RESPONSIBILITIES

- A. Reference Project Specification Section 01 91 00 - GENERAL COMMISSIONING REQUIREMENTS for details of contractor’s responsibilities related to commissioning.
- B. Perform commissioning tests at the direction of the CxA.
- C. Attend commissioning meetings.
- D. Provide information requested by the CxA for functional testing and for final commissioning documentation.

- E. Provide measuring instruments and logging devices to record test data, and provide data acquisition equipment to record data for the complete range of testing for the required test period.
- F. Functional testing of systems will be carried out solely by contractor's personnel, under the direction of CxA. Provide experienced personnel, familiar with the systems being installed under this project.

1.6 CxA'S RESPONSIBILITIES

- A. Reference Project Specification Section 01 91 00 - GENERAL COMMISSIONING REQUIREMENTS.
- B. CxA will direct commissioning testing.

PART 2 – PRODUCTS (Not Used)

PART 3 – EXECUTION

3.1 GENERAL TESTING REQUIREMENTS

- A. Equipment Testing and Acceptance Procedures: Testing requirements are specified in Division 28 Sections. Provide submittals, test data, inspector record, and certification to the CxA.
- B. Reference Project Specification Section 01 91 00 - GENERAL COMMISSIONING REQUIREMENTS for detailed requirements of commissioning of Mechanical systems.
- C. Provide technicians, instrumentation, and tools to perform commissioning test at the direction of the CxA.
- D. Test all operating modes, interlocks, control responses, and responses to normal, abnormal, and emergency conditions, and verify proper response of building automation system controllers and sensors.
- E. Tests will be performed using design conditions whenever possible.

3.2 SYSTEM START-UP

- A. Contractor is solely responsible for system start-up. CxA may, at his discretion, witness start up procedures, but will not perform any Functional Testing of systems until Contractor has completed start-up and resolved all operating deficiencies, and has so certified.

3.3 TESTING PREPARATION

- A. Certify that Fire Alarm/Notification systems, subsystems, and equipment have been installed, calibrated, and started and are operating according to the Contract Documents.

- B. Certify that testing procedures for Fire Alarm systems have been completed and submitted, discrepancies corrected, and corrective work approved.
- C. Set systems, subsystems, and equipment into operating mode to be tested (e.g., normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).
- D. Inspect and verify the position of each device and interlock identified on checklists.
- E. Check safety cutouts, alarms, and interlocks with life-safety systems during each mode of operation.

3.4 FUNCTIONAL TESTING / GENERAL

- A. Reference Project Specification Section 01 91 00 - GENERAL COMMISSIONING REQUIREMENTS for detailed requirements of commissioning of Plumbing systems.
- B. Provide measuring instruments to record test data as directed by the CxA.

3.5 RE-TESTING

- A. Reference Project Specification Section 01 91 00 - GENERAL COMMISSIONING REQUIREMENTS for detailed requirements of re-testing of Fire Alarm systems.

3.6 SYSTEMS TO BE COMMISSIONED

- A. Reference Project Specification Section 01 91 00 - GENERAL COMMISSIONING REQUIREMENTS for Fire Alarm systems to be commissioned.

END OF SECTION

SECTION 28 31 00
FIRE ALARM AND SMOKE DETECTION SYSTEM

PART 1 - GENERAL

1.1 WORK INCLUDED

A. This Section specifies the requirements for furnishing and commissioning a fully functional addressable fire alarm and voice evacuation system with full interface with other related systems. Work shall include, but not limited to, the following.

1. Fire alarm control and annunciator panels
2. Manual fire alarm stations
3. Automatic fire, smoke, and heat detection devices
4. Audible and visual alarm notification devices
5. Required batteries, battery panels, and associated accessories
6. Fire door control, security door control
7. Air handler duct smoke detection, and shutdown
8. Sprinkler system PIVs, OS&Y valves, and tamper switch monitoring
9. Sprinkler systems water flow and/or pressure switch monitoring
10. Monitoring of fire pump controls
11. Fire/smoke damper control
12. Smoke purge controls
13. Activation of deluge and pre-action sprinkler systems
14. Elevator recall and power shutdown
15. System acceptance testing and commissioning
16. Firefighters' two-way voice communication system

1.2 REFERENCES

- A. NFPA 101 - Safety to Life from Fire in Buildings and Structures
- B. NFPA 13 - Installation of Sprinkler Systems

- C. NFPA 20 – Installation of Stationary Pumps
- D. NFPA 70 - National Electric Code
- E. NFPA 72 - National Fire Alarm Code
- F. NFPA 90A – Installation of Air-Conditioning and Ventilating Systems
- G. NFPA 92A – Smoke- Control Systems
- H. UL 864 - Control Units for Fire Protective Signaling Systems
- I. ADA Accessibility Guidelines (ADAAG)
- J. Texas State Insurance Code
- K. Texas Accessibility Standards (TAS)
- L. Local-city Ordinances
- M. International Building Code
- N. All electronic equipment shall comply with all FCC limits governing radio frequency electromagnetic interference and be so labeled.
- O. None of the terms or provisions of this specification shall be constructed as waiving any of the rules, regulations or requirements of Codes.

1.3 SYSTEM DESCRIPTION

- A. The automatic fire detection and alarm system shall consist of a main fire alarm control panel, local control panel nodes, operator workstation, graphics terminal, audio control panel, printer, remote annunciator, detection devices, audible and visual notification devices, remote devices, and manual stations wired in accordance with the schedule on the Drawings and shall function as specified herein. The system shall use supervised multiplex data communications circuits, close loop initiation circuits, individual zone supervision, and individual audible and visual alarm circuit supervision.
- B. The system shall have sufficient capacity to incorporate all equipment and perform all functions as per intent of the specifications and Drawings. The system shall have an overall 20 percent spare capacity that includes but not limited to communication network, terminal strips, amplifier, batteries, etc., reserved for future expansion.
- C. The system shall be capable of being programmed on site for downloading, uploading or editing operating sequence or programming to accommodate and facilitate building parameter changes or changes as required by codes.
- D. A data communications network transmitting multiplexed input and output signals, which shall be electronically supervised, shall connect all control panel nodes. The

communication network shall consist of a communication cable transmitting all system operations in a digitally encoded format, an audible signaling bus serving all remote amplifiers, and a two-way phone communications bus serving all individually controlled fire phone circuits.

- E. The fire alarm control panels shall provide power, annunciation, supervision, and control for the fire detection and alarm system. Fire alarm control panels shall be distributed per floor or per zone as practical, such that each fire alarm control panel shall operate as a local stand-alone system with communication network connection to peers and main fire alarm control panel that normally resides in Fire Command Center. The Main Fire Control Panel in Fire Command Center shall monitor and annunciate all alarms and troubles of each Fire Alarm Control Panel in the fire alarm network system scattered throughout the building. All data communication wiring between the controls panels shall be supervised for open circuit, short circuit and ground fault.
- F. Data communication transmission shall use a peer-to-peer network communication channel with token-ring communication protocol as follows.
 - 1. Each node shall communicate to the next node in a peer-to-peer token-ring configuration.
 - 2. In the event that the path to the next node on the ring has experienced a communication failure, the node with possession of the token shall transmit it back in the direction from which it came to attempt to reach the next node by going around the ring in the opposite direction. At the same time the status of non-communication node shall be added into the content of transmission.
 - 3. In the event of communication break down and a group of nodes become isolated from the network, that group shall form a sub-network with all common interaction of monitoring and control remaining intact. The network shall be notified with the exact details of the lost communications.
 - 4. In the event that a single node becomes unable to handle the network token, the network interface card shall continue communications to the rest of the network. The off-line node is reported as such to the network and is periodically interrogated to determine if it is ready to be brought back online with the rest of the network.
- G. Fire detection initiation devices and audible visual alarm devices shall be wired to the fire alarm control panel on the same floor or with the same zone as practical. Smoke or heat alarm initiation devices shall be individually configurable on site to function desirable selective alarm, general alarm, evacuation, alert, test, fire/smoke damper operation, fire door/security door release, smoke control operation, HVAC interface or trouble warning.
- H. The system shall be designed such that alarm indications override trouble conditions. There shall be no limit, other than maximum system capacity, as to the number of addressable devices and/or zones, which may be in alarm simultaneously. The panel shall be capable of measuring the sensitivity of the addressable ionization and photoelectric detectors connected to it.

- I. The system shall initiate the following system outputs when any area or duct detector, manual station, or water flow switch operates in accordance with the fire alarm functional matrix:
 - 1. Audible devices - speakers.
 - 2. Visual devices – strobes and/or beacons.
 - 3. Automatically notify fire department, central station, and/or command center.
 - 4. Display individual detector and/or zone number on alphanumeric display with optional user-defined message.
 - 5. Light an indicating lamp on the device initiating the alarm.
 - 6. Shut down the associated HVAC system and operate dampers per drawing.
 - 7. Activate the elevator recall.
 - 8. Release all magnetic fire door holders.
 - 9. Activate deluge or pre-action sprinklers.
- J. The fire alarm and smoke detection system shall be used to monitor tamper switches and water flow switches on sprinkler and fire suppression systems.
- K. Fire alarm and smoke detection system shall release fire doors that are held open and security access controlled doors that are held close if desired.
- L. Fire pumps shall be monitored by the fire alarm and smoke detection system.
- M. Fire alarm and smoke detection system shall include the installation of duct-mounted smoke detectors, interface with HVAC damper control, and air-handler shutdown.
- N. Type and quantity of signals, which are expected to be transferred and monitored by existing campus command/dispatch center, shall be verified during design phase. Compatibility issue also needs to be addressed.
- O. [Provide all modules and interfacing necessary for implementation of mass notification system.]
- P. Provide all interfacing to generate the alarm and activate the proper alarm output to the building speakers, strobes etc.
- Q. Design speaker placement to ensure intelligibility of speech (as defined by NFPA 72 Year 2010) throughout the building and per current codes and regulations.

1.4 QUALITY ASSURANCE

- A. The system shall be installed by competent mechanics, regularly employed by a Fire Alarm contractor with full responsibility for proper operation of the system including debugging and proper calibration of each component in the entire system. The Contractor shall be with 3 years or more experience with installation of this type. The fire alarm technician shall be licensed by State Fire Marshal in order to install, certify and service the fire alarm system. Supplier shall be licensed by State Fire Marshal in order to sell fire alarm product, and shall have an in-place support facility within 50 miles of the site with technical staff, spare parts inventory and all necessary test and diagnostic equipment.
- B. The complete Fire Alarm and Smoke Detection System installation shall be in strict accordance to the national and local electrical codes and the electrical Section of these specifications. The equipment shall be manufactured by a manufacturer who has been engaged in this type of production (both hardware and software) for at least ten years. The product shall be UL listed under standards 864 (Control Units for Fire Protective Signaling Systems).

1.5 SUBMITTALS

1. The contractor shall include the following information in the equipment submittal:
 - a. Power calculations.
 - 1) Battery capacity calculations. Battery size shall be a minimum of 150% of the calculated requirement.
 - 2) Supervisory power requirements for all equipment.
 - 3) Alarm power requirements for all equipment.
 - 4) Power supply rating justification showing power requirements for each of the system power supplies. Power supplies shall be sized to furnish the total connected load in a worst case condition.
 - 5) Justification showing power requirements of the system amplifiers.
 - 6) Voltage drop calculations for wiring runs demonstrating worst case condition.
 - b. Complete manufacturer's catalog data including supervisory power usage, alarm power usage, physical dimensions, finish and mounting requirements.
 - c. Submit panel configuration and interconnection of modules and all other data as required to make an informed judgment regarding product suitability. At a minimum, data shall be submitted on the following:

- 1) Master system CPU including all fire detection, voice/audio and visual evacuation alarm control modules, and supervised power amplifiers with the required back up modules.
 - 2) Circuit interface panels including all modules.
 - 3) Power supplies, batteries and battery chargers.
 - 4) Pre-amplifiers, amplifiers, tone generators, master microphone and master telephone.
 - 5) Equipment enclosures, including dimensions and weights of completed units.
 - 6) Intelligent addressable manual pull stations, heat detectors, analog smoke detectors, alarm monitoring modules, and supervised control modules.
 - 7) Annunciator panel and printer.
 - 8) Audible and visual evacuation signals and devices.
 - 9) Software and firmware as required to provide a complete functioning system.
 - 10) Circuiting, including conduit and wire sizes.
- d. Data describing more than one type of item shall be clearly marked to indicate the type the contractor intends to provide for options not crossed out in submittal material will be furnished for the project. All submittal material shall be complete. Partial submittal will not be evaluated and will be rejected without comment. The contractor shall submit copies of UL listing or FM approval data showing compatibility of the proposed device or appliance and the panel being provided.
- e. Complete drawings covering the following shall be submitted by the contractor for the proposed system:
- 1) Floor plans showing all communicating, initiating, end of line, supervisory, indicating appliances, and output control devices; including circuit interface panels, message digitizers, amplifiers, annunciators, printers, video display terminals, color graphic displays, transponders and the main CPU locations. Raceways shall be shown, marked for size, conductor count with type and size, showing the percentage of allowable National Electric Code fill used. Drawings shall indicate ambient sound levels used by the system installer for sound level calculations and mathematical justification for signal placement to meet the code required 15dBA above ambient for audible warning signals.

- 2) Wiring diagrams showing points of connection and terminals used for all electrical connections to the system devices and panels.
 - f. A complete proposed system database including a description of all logic strings, control by event programming and point identification labels on a 3.5" high density floppy disk or CD ROM and in a formatted printed form, as required for off site editing, uploading and downloading shall be submitted for evaluation by the owner. A programming manual shall accompany the submitted program and shall be adequate to allow understanding, operation and editing by the system owner.
 - g. Statements shall be included, with copies of required licensing, verifying the qualifications of the installer as specified.
 - h. The fire alarm system subcontractor or manufacturer shall offer, for the owner's consideration at the time of system submittal, a priced inspection, maintenance, testing and repair contract in full compliance with the requirements of NFPA 72.
2. For use in system test, a complete operation and maintenance manual with two sets of proposed installation drawings shall be submitted.
 - a. The following information shall be inscribed on the cover:
 - 1) "OPERATION AND MAINTENANCE MANUAL"
 - 2) Building location.
 - 3) The name of the contractor, system manufacturer and system subcontractor.
 - 4) The name and phone number of the fire department required to respond to alarms at the project location.
 - b. The manual shall be legible and easily read with large drawings folded and contained in pockets. Included in the manual shall be circuit drawings, wiring and control diagrams with data to explain detailed operation and control of each item of equipment and a control sequence describing start up instructions. Included shall be installation instructions, maintenance instructions, safety precautions, test procedures, performance data, and software documentation.
 3. Upon completion of the installation, record drawings shall be submitted on each system before final acceptance of the work. The contractor shall furnish to the Owner a set of record drawings including system diagrams for each system. The record drawings masters shall be on reproducible mylar film, uniformly sized as required for legibility and reproduction and on high density floppy disks or CD ROM in an AutoCAD DXF format.

1.6 DELIVERY, STORAGE AND HANDLING

- A. Deliver fire alarm system components in factory-fabricated containers.
- B. Store in a clean, dry space and protected from the weather.
- C. Handle control and annunciator panels carefully to avoid damage to material components, enclosure and finish.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

- A. Simplex
- B. Edwards
- C. Siemens Fire Systems (cerberus Pyrotonics) type MXL
- D. Other manufacturers equal in design and function will be considered upon A/E approval following substitution procedure in Section 26 00 00 and Division 01 for substitution requirement.
- E. Manufacturers listed above must comply with entirety of specification and must be compatible with any existing campus fire alarm systems and must comply with any and all campus standards.

2.2 FIRE COMMAND CENTER OPERATOR WORKSTATION

- A. Operator Workstation Hardware
 - 1. The operator workstation personal computer shall be a central network processing unit providing alarm signals, annunciation, status display, software programming and controls for network functions using a Windows based graphic interface with a high resolution, touch-screen or mouse operated color monitor. The PC workstation shall provide control up to 50,000 points allowing future expansion without hardware additions.
 - 2. The operator workstation shall provide color graphic-based display of alarms, troubles, and system activity. Terminal shall provide complete operator control over fire alarm system, including acknowledging events, silencing audible alarms, reset control panels, disarming points, and generating alarm reports and diagnostic reports. Terminal shall be UL listed for fire alarm use.
 - a. Computer: minimum Pentium III, 800MHz, 128 Mb RAM, 20 Gb hard disk.
 - b. Interface: touch-screen or mouse operated.

- c. Monitor: 15 inch SVGA monitor.
 - d. Operating system: Microsoft Windows NT.
 - e. Password protection: 10 levels of password protection.
 - f. Drawing input: AutoCAD drawing imported.
 - g. Screen library: 5,000 custom screen capacities.
 - h. Zoom levels: 32 zoom levels per drawing.
 - i. Historical logging: 20,000 events minimum.
 - j. Fire alarm interface: RS-232 or RS-485
 - k. Network interface: Ethernet network card included.
 - l. Printer connection: two RS-232 ports, minimum.
 - m. System power: 120 Vac, 60 Hz, and single phase with integral UPS capable for 4-hour operation.
 - n. Clock: Real time clock.
 - o. Calendar: Electronic appointment calendar, with auto alarm.
 - p. Calculator: Basic arithmetic calculation functions (add, subtract, multiply, divide, percent, square root)
 - q. Control panel: Basic PC operating characteristic control; cursor blink rate, mouse sensitivity, screen color control, etc.
 - r. Note pad: Archive for miscellaneous notes.
3. The system provided must be capable of running standard off-the-shelf MS DOS compatible software packages concurrently with the real time system. Fully tested and qualified integrated third party software packages including spreadsheet, data base manager, and word processing shall be provided capable of running under MS DOS is to be identified as system compatible and listed in the submittal.
- a. The base system software shall include a CRT "windowing" feature to allow the operator to monitor the real time system and use third party software simultaneously.
 - b. All third party software packages identified shall have access to the system historical database previously specified.

B. Operator Workstation Software

1. Operator workstation software shall include as a minimum the Operating System (OS), Database Manager, Communications Control, Operator Interface (OI), Trend and History Files, Report Generator, Support Utilities, Scheduler, Time and Event Programs.
2. Real time operating system shall provide true multitasking providing concurrent execution of multiple real time programs and custom program development.
3. Database manager is to manage all data on an integrated and non-redundant basis. It shall allow additions and deletions to the database without any detriment to the existing data. Cross linkages are to be provided such that no data required by a software program may be deleted by the operator until that data has been deleted from its respective program.
4. Communications control, scheduler, trend files, reports, operator interface, and utilities shall be as specified hereinafter.
5. Provide a hierarchical linked dynamic graphic operator interface for accessing and displaying system data and commanding and modifying equipment operation. The interface shall utilize the mouse to provide "heads up operation" with pull-down menus, dialog boxes, zoom, coloration and animation to facilitate operator understanding of the system. A minimum of twenty (20) levels of graphic penetration shall be provided with the hierarchy operator assignable (for example, area, building, wing, floor, and sequence of operation pages, dynamic program display, and I/O point group). Dynamic system data points shall be assignable to each penetration level. Descriptors for graphics, points, alarms, etc. shall be modified through the operator's station under password control.
6. Operator access to the system is to be under personal ID and password control for up to 100 unique operators. Up to 12 alphanumeric characters for personal ID and up to 12 alphanumeric characters for password shall be assignable to each operator via the operator station. The operator shall be able to access the system from any operator station in the system by entry of the proper ID and password. The operators shall be permitted to change their own password without permitting access to any other password. Sign-off from a station shall be a manual operation via pull-down menu or, if no mouse or keyboard activity takes place within an assignable time period, shall be automatic. Automatic sign-off period shall be selectable from ten minutes to 120 minutes for each operator or may be disabled on a per operator basis. All sign-on/sign-off activity shall be automatically archived on the operator station disk for subsequent display or printout as desired.
7. Operator access to system points shall be controlled by individual operator-assigned graphic hierarchy and by privileges. The hierarchy shall permit access to an operator-assigned initial graphic and to all graphics linked to and below the initial graphic. The operator shall not have access to graphics in another hierarchical graphic "tree".

8. Data to be displayed within a unique graphic shall be assignable regardless of physical hardware address, communication channel or point type. Graphics are to be on-line programmable and under ID and password control. Points may be assignable to multiple graphics where necessary to facilitate operator understanding of system operation and where specified. Graphics shall also contain calculated or pseudo points. Each physical point and each point assigned to a graphic shall be assigned a descriptor for use in reports.
9. Penetration within a graphic hierarchy shall display each graphic name as graphics are selected to facilitate operator understanding. The "back trace" shall permit the operator to move upward in the hierarchy by mouse click on the back trace. The back trace shall show at least the previous four penetration levels. The operator shall be provided the option of showing each graphic full screen size with the back trace as the horizontal header or by showing a "stack" of graphics, each with a back trace.
10. All operator accessible data shall be displayed on the color monitor. The operator shall select further penetration via mouse click on an area, building, floor, etc. The defined linked graphic below that selection shall then be displayed. Dynamic data shall be assignable to any and all graphics.
11. The operator shall be provided with a means to directly access any graphic or any point without going through the penetration path.
12. Direct access to graphics shall be menu selectable wherein the operator may optionally enter the name of the graphic system desired or select the desired graphic via cursor positioning on a scroll bar listing of all graphics, or may be selected via keyboard entry.
13. Points (physical and pseudo) shall be displayed with dynamic data provided by the system with appropriate text descriptors, status or value, and engineering unit. Coloration shall be used to denote status and alarm states. Coloration conventions shall be variable for each class of points, as chosen by the owner. In addition, animation shall be used to confirm latest status. All points shall be dynamic with update rates user adjustable on a per point basis from 20 seconds to 120 seconds, depending upon the process dynamics.
14. An operator shall be permitted to split or resize the viewing screen to show one graphic on the left half of the screen and another graphic, spreadsheet, bar chart, word processing, curve plot, etc., on the right half screen. This will allow real time monitoring of one part of the system while displaying other parts of the system or data from the system to facilitate system operation.
15. An on-line context-sensitive "help" utility shall be provided to facilitate operator training and understanding. The help feature shall be a hypertext document with the ability to bridge to further explanation of selected keywords. The document shall contain text and graphics to clarify system operation. At a minimum, help shall be available for every menu item and dialog box. If the help utility does not have this

ability to bridge on keywords for more information, four complete sets of user manuals shall be provided with quarterly updates and additional training as hereinafter described.

C. Site Specific Fire Alarm Software

1. Provide software that will allow the user to modify and tailor the Fire Alarm System to the specific and unique requirements of the equipment installed, the programs implemented, and to staffing and operational practices. On-line modification of system configuration, program parameters, and database shall be provided via menu selection and keyboard entry of data into preformatted self-prompting templates. As a minimum, the following modification capability shall be provided.
 - a. Operator assignment capability shall include designation of operator ID, passwords, privilege(s), starting graphic and auto sign off duration.
 - b. Peripheral assignment capability shall include assignment of segregation groups to consoles and printers, and designation of backup printers.
 - c. System configuration/diagnostic capability shall include communications and peripheral port assignments, assignment of command trace to points and initiation of diagnostics.
 - d. System text add/change capability shall include action messages for alarms, supervisory, and trouble condition messages.
 - e. Time/Schedule change capability shall include time/date set, time/occupancy schedules, holiday schedules, and daylight savings time schedules. All time and calendar scheduling and schedule modification shall be accomplished graphically via color bars and calendars in a hardware independent manner.
 - f. Points shall be uniquely definable as to coloration, animation, audible rate and duration, point descriptors, operator messages (480 characters minimum), printer options, alarm archival option, alarm and warning limits, and engineering units. All messages specified and all physical and pseudo point descriptors shall be entered by the vendor.
 - g. Point related change capability shall include system/point enable/disable; assignment of points to point classes, analog value offset, and setting a fixed input value or output status.
2. Graphic creation. An on-line graphic development facility shall be provided to allow the user to develop or modify graphic displays and assign and position any array of points within each graphic.
 - a. All graphic displays shall be on-line created via operator station graphics package. It shall not require taking the operator station off-line or interfere with point archiving and alarms. Graphics shall be created via mouse and

keyboard selection of graphic library stored symbols and system profiles. Provide, in addition, the capability to create custom symbols, system profiles, floor plans, buildings, etc., and to store them in the graphic library.

- D. Alarm handler software shall be provided to respond to alarm conditions sensed and transmitted from fire alarm control panels. First in, first out handling of alarms in accordance with alarm priority ranking is required in case of simultaneous multiple alarms. There shall be no limitation of handling the amount of alarms, which may be activated simultaneously. Alarm handler shall be active in both the Signed On and Signed Off modes to assure that alarms will be processed even though an operator is not currently signed on.
1. Alarms shall be displayed in a dialog box of the color monitor. Display shall include as a minimum:
 - a. Indication of alarm condition; i.e., ABNORMAL OFF, HI ALARM/LO ALARM, analog value or status, point identification.
 2. Alarms are to be directed to appropriate operators, operator stations, and printers for segregation assignments as specified in previous Sections of this specification.
 3. Alarm silence shall be by selecting the "silence" button or by authorized operator's acknowledgment. In all cases, alarm acknowledgment shall only be allowed by operators authorized to acknowledge a point in alarm.
 4. Each point shall be assigned to an alarm class, with no limit to the quantity of alarm classes. Each alarm class shall be uniquely assignable to any combination of the following alarm processing attributes:
 - a. Audible beep duration (none, 10 seconds, 20 seconds, continuous)
 - b. Audible beep rate (slow-medium-fast)
 - c. Alarm historically archived (yes or no)
 - d. Alarm printed, with printer ID
 - e. Associated coloration with any of 256 colors, with separate brightness control, assignable to each alarm state (high alarm, high warning, normal, low warning, low alarm). Digital points shall similarly be distinguished with different colors for each possible state.
 5. Alarms shall be displayed and/or printed at each peripheral to which its segregation allows, but only those operators having proper privilege level will be allowed to acknowledge alarms.
 6. An unacknowledged alarm indicator shall be provided on the color monitor display to alert the operator that there are unacknowledged alarms in the system.

7. Symbols for points in a graphic display that are in an unacknowledged alarm state shall flash red; when in an acknowledged state, the symbol shall be non-flashing-red.
 8. Run time limit messages shall be presented and processed as alarm messages except the action message shall be of a maintenance directive nature.
- E. Standard reports shall be provided, which shall be operator selectable to appear on the operator station, any selected printer or both. A "terminate report" command shall be available to allow the operator to stop any report in the process of being printed. In the event of failure of any printer, subsequent reports directed to that printer shall be automatically redirected to an operator pre-assigned backup printer located at the operator station. The following standard pre-formatted reports to be provided shall include:
1. Point summary reports may be requested at any penetration level (facility, building, area, system) and shall include only points at and below that level. Point summary reports shall include the current value/status and condition, system and point descriptors for all points. Point summary reports shall be selectable for all points, only those points in alarm, fixed points, disabled points locked out points, locked out and in alarm points, analog input or output points, digital input or output points. All reports shall be capable of being scheduled to run at a specific time and/or interval via an operator function supported by necessary data entry templates and interactive prompts.
 2. Dynamic trends shall provide up to six points and show real time activity of the associated points. This information shall be printed and/or displayed in numeric, bar chart, curve plot, pie chart, etc., as selected by the operator. Graphic plots shall allow a unique color for each point. As new point values are sampled, they shall be processed, scaled, and dynamically appended to any plot being displayed. Sample interval of points selected for dynamic trend shall be user selectable from five seconds to sixty minutes.
 3. Alarm and run time reports shall be automatically issued to assigned printers immediately upon occurrence, and shall consist of the point descriptor, the status or value of the point with engineering unit, the time and date, and an action taking alarm message.
 4. The user shall be provided with a command trace feature selectable on a per point basis allowing the archiving of all commands issued to each point. The archived trace shall include the command, the command source, the point ID, and the time and date. Command trace reports shall be output upon operator demand.
 5. A custom report capability shall be provided to allow the user to format reports of any mix of text, points with status/value and descriptors, and points with status/value only. Custom reports may be scheduled or requested manually. A spreadsheet program similar to Microsoft Excel shall be provided fully integrated with the Fire Alarm System data base, and available to the user. Spreadsheet packages that

require off-line execution or manual translation of data files from one program format to another are not acceptable.

- F. Digital System Management. The operator workstation shall provide complete utilities necessary for management of the network of digital controllers and devices.
 - 1. Provide a multi-page set of dynamic graphic architectural displays showing each digital module including each remote panel, PC, peripheral, and communication links. Clicking on any device shall start an interactive dialog allowing the user to observe the device status and to select device management options. Each device shall also be provided with a descriptor. Digital devices in a failed or non-responsive mode shall show up distinctly red in digital system graphics.
- G. The software shall be designed specifically for fire alarm applications and shall provide for polling and demand requests to monitor status; processing alarms according to priorities; executing event-initiating programs; controlling/processing communications with operator peripherals; and synchronizing all systems activity. For reasons of reliability and preventing inadvertent changes, system software (operating system and data file) shall be maintained in non-volatile memory. System shall permit reprogramming by authorized personnel.

2.3 FIRE ALARM CONTROL PANELS

- A. Control panel enclosure shall consist of a floor-standing or surface-mounted back-box, hinged door, keyed lock, and tamper switch. Tamper switch shall put control panel into a trouble mode when door is opened. Back-box shall be sized to accommodate batteries, battery charger, power supply, control panel, indicating, initiating, communications, relays, and switch modules.
- B. The control panel power connections (whether ac or dc) shall be separately fused within the control panel. The system power supply shall be provided with an integral uninterruptible power source (UPS). This UPS shall provide continuous power to the system in the event of a commercial power failure. Transfer from commercial power shall be instantaneous to ensure proper processor operation and indicated by flashing the system power long-life light-emitting diode (LED).
 - 1. Loss of commercial power shall be annunciated as a system trouble. System trouble shall be indicated for over-voltage or under-voltage conditions, blown fuses, or disconnected batteries.
 - 2. The system shall visually and audibly indicate operation from standby power. The system shall automatically restart upon the return of power. No operator intervention shall be required.
 - 3. A dual-rate battery charger shall be provided, which is capable of recharging the batteries to 80 percent capacity in 12 hours.

4. Batteries shall be sized to provide 24 hours of standby operation followed by 5 minutes of operation of alarm notification appliances and 15 minutes of voice/alarm communication [mass notification] systems.
- C. The control panel shall be modular with solid-state electronics and microprocessor. The control panel shall provide power, annunciation, supervision, and control for the detection and alarm system. The system shall be capable of reading and displaying at the control panel the sensitivity of remote addressable ionization and photoelectric detection devices. The detection system shall remain 100 percent operational and capable of responding to an alarm condition while in the routine maintenance mode. Addressable detection devices shall be individually identified by the system, and any quantity of addressable detection devices shall be in alarm at any time up to the total number connected to the system.
1. The control panel shall be capable of supporting addressable detection devices.
 2. The panel annunciator shall be an alphanumeric display, which shall provide an optional user-definable message associated with each detection device or zone.
 3. Dynamic supervision of system electronics, wiring, detection devices, and software shall be provided by the control system. Failure of system hardware or wiring shall be indicated by type and location on the alphanumeric annunciator. The system shall provide fail-safe operation, i.e., incoming alarms shall automatically override all other modes of operation, and the panel shall automatically return to normal operating mode from any operator-initiated mode.
 4. Ground fault detection shall be provided for all initiating and audible circuits. Lamp test capability shall be provided to test all visual panel indicators and associated software.
 5. The system alarm lamp shall flash and an integral trouble buzzer shall sound upon receipt of any alarm condition. Acknowledgment of the alarm by operation of the silence switch shall silence the audible alarm and cause the alarm lamp to light steadily. Receipt of subsequent alarms shall cause the alarm buzzer to resound and the alarm lamp to flash.
 6. The system trouble lamp shall flash and an integral trouble buzzer shall sound upon the occurrence of any trouble condition. Acknowledgment of the trouble condition by operation of the silence switch shall silence the audible alarm and cause the trouble lamp to light steadily. Receipt of subsequent troubles shall cause the trouble buzzer to resound and the trouble lamp to flash.
 7. The service mode shall permit the arming and disarming of individual detection or output devices, as well as manually operating output devices. Status of these devices shall be displayed upon command from the control panel. The panel shall automatically return to normal mode in the event the panel remains unattended in the

service mode. The panel shall be capable of receiving and processing alarms even when in the service mode.

8. The control panel shall report, by specific device number, any device removed from an addressable initiating circuit, and all other devices shall continue to function.
9. The control panel shall have the ability to support an optional printer terminal.
10. No alarm or trouble indication shall be resettable until it has been acknowledged. It shall not be possible to reset the system until all alarms have been acknowledged and devices cleared.
11. The control panel shall have the ability to support a drill function on the panel that is easily identifiable and only initiates notification appliances on all floors.
12. Each panel shall have the following capacity:
 - a. Sensor Points: 275 addressable analog sensor points.
 - b. Module Points: 275 addressable monitoring and control module points, including 50 points as follows:
 - 1) Onboard Strobe Circuits: 10 circuits rated for 2 amps each at 24 Vdc.
 - 2) Onboard Speaker Circuits: 10 circuits rated for 25 watts each at 70.7 VRMS.
 - 3) Onboard Telephone Circuits: 10 fireman's telephone circuits.
 - 4) Onboard Auxiliary Relay Circuits: 10 general input circuits, 10 general output circuits.
 - c. Amplification: 500 watts, 70.7 VRMS, distributed, with one 500 watt backup amplifier every three panels.
 - d. Audio Channels: two.
 - e. Power Supply: 20 amps, 24 Vdc.
 - f. Battery Backup: 140 ampere-hour backups at 24 Vdc.
 - g. Mounting: NEMA 12 wall- or floor-mounted enclosure.
 - h. System Power: 120 Vac, 60 Hz, and single phase.
13. The following primary controls shall be visible through a front control panel.
 - a. 80-character liquid crystal display.

- b. Individual red fire alarm LED.
 - c. Individual red priority 2 alarms LED.
 - d. Individual yellow supervisory service LED.
 - e. Individual yellow trouble LED.
 - f. Green “power on” LED.
 - g. Yellow signals silenced LED.
 - h. Fire alarm acknowledge key.
 - i. Priority 2 alarm acknowledge key.
 - j. Supervisory service acknowledge key.
 - k. Trouble acknowledge key.
 - l. Alarm silence key.
 - m. System reset key.
 - n. Speaker circuit selection switches with LEDs.
 - o. Master audio control microphone.
 - p. Master fire fighters phone.
 - q. Phone circuit selection switches with LEDs.
14. The following functions shall be provided by operating the front control panel.
- a. LED testing.
 - b. Alarm, trouble, and abnormal condition listing.
 - c. Enabling and disabling of each monitor point separately.
 - d. Activation and deactivation of each control point separately.
 - e. One-person test/drill enable.
 - f. Running self-diagnostic.
 - g. Display historic logs.
 - h. Point listing.

15. Scrolling through menu options or lists shall be accomplished in a self-directing manner in which prompting messages shall direct the user. These controls shall be located behind an access door.
 16. Under normal conditions the front display panel shall display a "System Normal" message and the current time and date. Should an abnormal condition be detected the appropriate LED (Alarm, Supervisory or Trouble) shall flash. The unit audible signal shall pulse for alarm conditions and sound steady for supervisory and trouble conditions. The LCD shall display the following information relative to the abnormal condition of a point in the system.
 - a. 40 character custom location label
 - b. Type of device (i.e., smoke, pull station, water flow)
 - c. Point status (i.e., alarm, trouble)
- D. Fire alarm audio control panel shall provide complete voice annunciation control of the fire alarm system. Panel shall include ability to select paging zone by area or all call. Panel shall include master fireman's telephone handset, and interface shall be integral to panel. Panel shall support both live paging and prerecorded digital messages.
- Performance:
1. Audio Channels: two simultaneous 70.7 VRMS channels, minimum.
 2. Phone Risers: two fireman's telephone risers, minimum.
 3. Audio Levels: VU meter for audio level monitoring.
 4. Digital Message Length: 10 messages, 30 seconds each, minimum.
 5. Preamp Supervision and Automatic Changeover: yes.
 6. Amplification: supports 10 distributed- or central bank amplifiers.
 7. Backup Amplification: supports four backup amplifiers.
 8. Degrade Mode: degrade mode reverts to tone generation.
 9. Mounting: NEMA 12 wall- or floor-mounted enclosure.
 10. System Power: 120 Vac, 60 Hz, single phase.
- E. Line printer shall provide hard copy written record of alarms, troubles, and system activity. Printer shall be UL listed for fire alarm use. Performance:
1. Serial or parallel printer.
 2. 24 pin, dot matrix, wide-carriage type.

3. Paper out, offline, paper jam, and power off alarm supervision.
 4. Power Supply: 120 Vac, 60 Hz, single phase. Note: System must have integral or plant uninterruptible power supply unit capable of 15-minute operation in conjunction with Secondary Power Supply defined by NPFA 72.
- F. Initiating circuit modules shall maintain complete reporting of device status while in trouble due to any addressable device having its active transmitting component fail, open, or shorted. The initiating circuit modules shall detect a line break and provide information to the control panel, allowing the user to determine between which two devices the break has occurred.
 - G. Detection line circuit monitoring shall be provided by a zone input module. Each circuit shall be capable of Class A or B wiring. With Class B wiring, a capacitive end-of-line device shall be required. Each zone shall accommodate up to 96 ionization or photoelectric detectors, or 96 flame detectors, as well as any quantity of shorting-type contact devices. Upon actuation of any detector or device installed on a zone circuit, that particular zone shall lock into alarm and the zone identification and location shall be annunciated at the control unit. Zone troubles, such as opens, shall be annunciated at the control unit giving zone identification and trouble description. Alarm information and transmission shall have priority over trouble.
 - H. An output circuit indicating operation of dc audible devices, leased line or city tie shall be provided by an indicating module. Upon command by the control unit the output circuits will respond as configured. Leased line or city circuits shall be limited energy outputs. All signal circuits shall require and be fitted with an appropriate end-of-line resistor (EOLR). Each circuit shall be fused separately. The module shall be supervised by the control unit for open and shorted circuits. Open circuits shall report trouble only and respond with circuit identification. A shorted circuit shall respond in a similar manner. Each output circuit shall be individually fused with replaceable fuses.
 - I. For control of air-handling units, elevators, and beacon lights, relay modules shall be provided. The module shall be system interconnected and shall be operable by the control unit or manually. It shall contain eight independent relays, fitted with Form C contacts, rated at 120 Vac, 10 amps, minimum, inductive.

2.4 PERIPHERAL DEVICES

- A. All detection devices shall contain an integral alarm LED. All addressable detectors shall be individually identifiable by zone. Mounting bases shall be provided by life safety contractor, included with detector as a complete assembly.
- B. The addressable ionization detector shall be a plug in, twist/lock unit, which shall be capable of removal from or installation into its base with one hand.
 1. The detector shall contain two ionization chambers and solid-state indicator lamp. The reference chamber shall compensate against sensitivity changes due to changes in environmental temperature, humidity, and barometric pressure. The sensing

chamber shall be open to the outside elements through a protective cover, which will permit product of combustion to enter while preventing foreign matter from entering and causing unwanted alarms.

2. The detector shall be dynamically supervised, indicating a trouble condition at the control panel when the detector is unable to sense a fire condition due to either internal and external operation conditions or malfunctions.
- C. The addressable photoelectric smoke detector shall contain an LED as its light source and photodiode as a light receiver. An automatic gain control circuit shall be provided to maintain correct sensitivity by compensating for detector aging and dirt accumulation. The detector shall be a plug in twist/lock unit, which allows for easy connection to its mounting base. The detector shall provide complete supervision of the detector optics. The detector shall be supervised for complete failure of the LED light source or a critical reduction in the light output of the LED caused by excessive dirt, which could not normally be compensated for by the automatic-gain control circuit.
 - D. The addressable thermal detector shall be of the rate-compensated, fixed-temperature type. The detector shall be individually annunciated on the control panel. The detectors shall contain an integral alarm lamp.
 - E. The addressable programmable interface module is designed to provide an interface for direct-shorting contact devices. The unit is used with water flow switches, pressure switches, tamper switches on OS&Y valves, and other contact closure devices. The unit shall electrically supervise wiring to contacts via EOLR provided by life safety contractor.
 - F. The addressable manual pull station shall operate on any addressable detection circuit. The addressable manual pull station shall be individually annunciated on the control panel. The unit shall be double-action initiated, having latching relays.
 - G. The air duct smoke detector shall operate on a cross-sectional air-sampling principle to overcome stratification and skin effect. The air duct detector shall consist of a standard addressable photoelectric detector mounted in an air duct sampling assembly and sampling tube that protrudes across the duct of the ventilating system. The air duct detector shall retain the features of the addressable photoelectric detector, and be installed in the ventilating duct as indicated in the manufacturer's instructions. The air duct smoke detector shall come with appropriate addressable detector and base, remote test station, and inlet sampling tubes.
 - H. The detector mounting base shall be of the twist/lock type with screw terminals. Pigtailed or in line connectors shall not be permitted. It shall be possible to secure the detector in the base. The detector mounting base shall be universal for addressable photoelectric detectors.
 - I. Alarm bells shall be of the polarized 24 Vdc type. The mechanisms shall be fully enclosed and dust-proof. They shall be designed to be mounted on a wall, ceiling, or other suitable rigid surface that is free from vibration.

J. Alarm horns shall be of the polarized 24 Vdc type. The mechanisms shall contain an aerospace-grade aluminum diaphragm; blued, tempered, and polished armature, and tungsten contact points, all housed in a die-cast frame-and-grill assembly. They shall be designed to be mounted on a wall, ceiling, or other suitable rigid surface and capable of being surface, semi flush, or flush mounted.

K. EVACUATION SIGNALS

1. Speakers:

a. General

- 1) Shall be of the polarized 24-Vdc type. Speaker shall be UL listed for fire alarm voice evacuation use. Speakers shall be designed to be mounted on a wall, ceiling or other suitable rigid surface and shall be capable of being surface, semi flush, or flush mounted. Speakers shall be multi-tap. Minimum tap settings shall be 1/16, 1/8, 1/4, 1/2, 1, 2 or 4 or 8 watts.

b. Non-Ceiling Mounted

- 1) The speaker shall have 70.7 VRMS inputs and have field-selectable power taps from 1/8 watt to 8 watts. Speaker shall have frequency response of 400 to 4,000 Hz and be UL listed for fire alarm voice evacuation use. Speaker shall have vandal-resistant red grill faceplate. Speakers shall be designed to be mounted on a wall or other suitable rigid surface and shall be capable of being surface, semi flush, or flush mounted.

c. Ceiling Mounted – Preferred where possible

- 1) The speaker shall have 70.7 VRMS inputs and have field selectable power taps from 1/8 watt to 8 watts. Speaker shall have frequency response of 400 to 4,000 Hz and be UL listed for fire alarm voice evacuation use. Speaker shall have 4 inch cone and shall have 7.25 inch-diameter circular metal faceplate with white enamel finish. Speakers shall be designed to be mounted on a wall, ceiling, or other suitable rigid surface and be capable of being flush mounted.

d. Extra loud

- 1) The speaker shall have 70.7 VRMS inputs and have field-selectable power taps from 0.9 watt to 15 watts. Speakers shall have frequency response of 400 to 4,000 Hz and be UL listed for fire alarm voice evacuation use. Peak speaker output shall be 121 dB at 4 feet, 15 watt or 111 dB at 10 feet, 15 watt. Speaker shall have high-efficiency compression driver with re-entrant horn, and shall have a baked gray epoxy finish. Speakers shall be designed to be mounted on a wall,

ceiling, or other suitable rigid surface, and be capable of being surface mounted.

2. Strobe Light: ADA visual notification appliances shall be comprised of a xenon flashtube and be entirely solid state. These devices shall be UL listed and be capable of either ceiling or wall mounting. Provide a unit that is ADA compliant with an output no less than 15 candela. The Lexan lens shall be pyramidal in shape to allow better visibility. Provide a red lens on selected strobes where indicated on plans. Strobe light candela ratings have been shown on the plans. However, contractor is responsible for sizing strobes per NFPA 72 based on room size and device location. Units shall be installed 80" above finished floor. All strobes within the same line of site shall be synchronized. Candela ratings have been shown on the plans. These ratings shall be verified based on the room size and NFPA requirements. Where there are discrepancies The NFPA requirements for candela rating shall take precedence over the values shown on the plans. Provide multi-tap strobes to allow for a full range of candela settings. Settings shall be 15/75, 30/75, 75 or 110 candela. Circuits for strobes shall allow for capacity to increase strobe intensities one setting for all strobes. Provide spare devices equal to 1% of the total number of new devices provided for this project.

- a. Rated voltage shall range from 18 to 31.2 volts for nominal 24 Vdc models.

- b. The xenon flash tube and associated circuitry shall be enclosed in a translucent white polycarbonate lens with "fire" inscribed on the lens. Plate color shall be red.

****SPEC WRITER NOTE-USE BELOW FOR MASS NOTIFICATION SYSTEMS****

- c. The xenon flash tube and associated circuitry shall be enclosed in a translucent white polycarbonate lens with graphics appropriate for mass notification inscribed on the lens. Plate color shall be red. Device shall not include the word "FIRE" on device.

3. Speaker/Strobe combination: Standard, ADA Audio/Visual units shall provide a common enclosure for the fire alarm audible and visual alarm devices. The housing shall be designed to accommodate either horns, bells, chimes or speakers. The unit shall be complete with a tamper resistant, Pyramidal shaped lexan lens with Fire lettering visible from a 180-degree field of view. The front panel or bezel that is constructed of UL Listed Noryl, may be inverted so that the lens is below the audible device. Integral Xenon strobe shall provide 8000 peak candlepower and be adjustable from 1 to 3 flashes per second. Provide a unit approved for ADA compliance. Strobe shall be multi-tap type to allow for a full range of candela settings as indicated in paragraph G. Xenon strobe shall provide 4-wire connection to insure properly supervised in/out system connection. Unit shall be complete with all mounting hardware including backbox. Audio/visual unit shall be UL listed for its intended purpose. Speaker shall be multi-tap type to allow for different audio settings

as indicated in paragraph F. Provide spare devices equal to 1% of the total number of new devices provided for this project.

4. The evacuation signals shall be available in flush, semi-flush, or surface versions as required for signal locations shown on the contract documents. Signals shall be mounted using a listed outlet box, and as required, tile bridges. Signals shall be available in visual only and combination to satisfy all required project applications. Visual only and combination audio/visual alarms shall be white with red "FIRE" lettering.
- L. Water flow switches: Flow switches shall be UL listed for its intended purpose; furnished under Division 23 and electrically connected under Division 26. Individual addressable modules shall be provided on each switch.
 - M. Sprinkler Valve Tamper Switches: Switch shall be provided with either one or two sets of SPDT micro switches as required. Tamper switch shall be UL listed for its intended purpose, furnished under Division 23 and electrically connected by Division 26. Individual addressable modules shall be provided on each switch.
 - N. Firefighter's emergency telephone shall include handset, cradle with switch hook and heavy gauge steel enclosure. Handset shall be red, high-impact plastic with retractable coil cord. Telephone assembly shall permit two-way communication from fire alarm audio control panel and shall produce a distinct zone or call-in signal when the handset is removed from its cradle. Enclosure shall be finished in baked, red enamel and shall bear a silk-screened handset symbol and the words "emergency telephone". Enclosure shall be suitable for flush or surface mounting. Anticipated enclosure size shall be 5 1/8 inches wide by 8 1/8 inches high by 3 inches deep.
 - O. SPARE BOX
 1. Provide a separate box located adjacent to the main fire alarm panel. The box shall be sufficiently sized (16" X 16" C 6" minimum) to hold all spare detectors and paperwork. This box shall match the main fire alarm panel in appearance and be keyed the same.
 - P. REMOTE CIRCUIT INTERFACE PANELS
 1. Remote circuit interface panels shall consist of an enclosure, a remote power supply, digital communications circuitry, mother boards, batteries and hardware, modules and circuitry described for inclusion in the fire alarm control panel as required to function as specified.
 - a. Circuit interface panels, when required, include conventional zone module, analog loop drivers, indicating appliance circuits, output circuitry to perform actions, speaker supervisory and distribution circuits. All fire detection, alarm and indicating devices supported by the circuit interface panel shall function as a self standing system in the failsafe mode upon loss of the central fire alarm

control panel processing, communications or the communications wiring between them.

- b. Smoke detectors shall alarm at their programmed sensitivity settings and shall not revert to a common default setting when their operating system segment is in the default mode.
- c. Circuit interface panels shall support remote system displays, annunciators and printers. Test procedures shall be capable of initiation at the main fire control panel, any remote LCD annunciator or any remote interface panel equipped with a keypad.

Q. MAGNETIC HOLD OPEN DEVICE

- 1. Provide 120VAC [24VDC] magnetic hold open devices where indicated on plans and where required by Code. Devices shall close on an alarm.

R. FIRE SPRINKLER SYSTEM DETECTION AND SUPERVISION

- 1. Furnish sensors for installation by the fire sprinkler system contractor and provide system interconnection for the following functions.
 - a. Waterflow switches, vane type, with adjustable pneumatic retard of 0 - 75 seconds, single pole double throw switch calibrated for actuation when flow rate equals 10 GPM or greater.
 - b. Outside screw and yoke valve supervisory switches in sizes as required for monitoring valves. The single pole double throw supervisory switch shall activate an off normal report within one half turn of the valve.

S. INTELLIGENT SUPERVISED CONTROL MODULE

- 1. Furnish and install for the control of supervised relays, contactors, audible signal circuits, visual signal circuits, distributed speaker circuits and two way fire fighters communication circuits, intelligent supervisory and control modules including features as follows:
 - a. The modules shall be suitable for two wire operation and communications on intelligent analog alarm detection loops. Address assignments shall be accomplished electronically. Devices requiring dip switches, rotary switches, staples and/or jumpers are not acceptable.
 - b. The module shall display a steady LED in the normal power or standby power condition, when in the activated state.
 - c. The module shall be suitable for semi-flush or surface mounting in a 2" deep, 4" square or double gang electrical outlet box having a depth of 3 1/2".

2. Modules shall be available to supervise reverse polarity supervised indicating circuits utilizing 24VDC, two way supervised fireman's communication circuits or audio circuits utilizing 25VRMS or 70.7VRMS. It shall be possible to configure the module for control of motor contractors and AC voltages to 115VAC.
 - a. All connected field wiring shall be supervised for opens, short circuits and grounded circuits.
 - b. All controlled circuits shall be power limited at 1.5A, produced by self restoring thermal components. Units requiring circuit replacement for restoration of outputs are not acceptable.
 - 1) Signal outputs shall be supported in either Style "Y" or Style "Z" configuration.
 - 2) The module shall report a trouble condition in the event of loss of the 24VDC signal operating supply voltage.

T. SECURITY INTERFACE TERMINAL BOX

1. The interface terminal box shall be a lockable continuous hinge cover NEMA Type 4 enclosure. The cover of the enclosure shall be labeled to identify its function.
2. Dual screw barrier type terminal strips shall be provided within the interface terminal box. Terminals shall be provided for each interface output from the fire alarm system and the manual unlock keyswitch. All terminals shall be labeled to identify their function.
3. The output contacts from the fire alarm system shall be rated for 1A at 120V.

U. MANUAL UNLOCK SWITCH FOR SECURITY SYSTEM

1. The manual unlock switch shall be a maintained DPDT contact toggle switch. The contacts shall be rated for 1 A at 120V.
2. The switch shall be mounted on a single gang plate with a guard to prevent the switch from inadvertently being activated.
3. The switch shall be labeled to identify its function, the locked position, and the unlocked position.

2.5 ***SPEC WRITER NOTE – FOR MASS NOTIFICATION SYSTEMS***MASS NOTIFICATION PANEL**

- A. Provide and install a new EST3 FACP/Mass Notification system consisting of:
 1. Building command center.
 2. LCD annunciator.

3. Multi-channel one-way voice communication system.
4. Audible appliances
5. Synchronized visual appliances.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Contractor shall examine the areas and conditions under which the fire alarm system is to be installed and notify the Contractor in writing of conditions detrimental to the proper and timely completion of the work. Do not proceed until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install system and materials in accordance with the manufacturer's written instructions, drawing set, and details, the applicable requirements of the NEC and NFPA 72, and specifications in Division 26.
- B. Junction boxes used as back boxes for fire alarm system field devices shall be 4-inch square with 2 1/8-inch minimums in depth. Install adapter plates and extension rings where required. Junction boxes for concealed conduit system shall be flush mounted.
- C. Mount outlet box for electric door holder to withstand 80 pound-pulling force.
- D. Upon initial installation, all fire alarm detection devices shall have the original plastic dust covers installed. Dust covers shall not be removed until installation is completed and the system is ready for test.
- E. Each conductor shall be identified as shown on the shop drawings by attaching permanent alphanumeric wire markers within 2 inches of the wire termination at both ends. Marker legends shall be visible. Junction box and pull box covers shall be painted yellow or have embossed adhesive tape labeling that is minimum 1/4 inch white letters over a yellow background with text "Fire Alarm". Install end of line device in box with text "End-of-Line" or "EOL". Number-code or color-code conductors, appropriately and permanently for identification and servicing of system.
- F. Splices shall only be made on terminal strips. All fire alarm wiring shall be installed in raceways as per drawing. All external wiring shall be color-coded and shall not be installed in the same outlet box, junction box, or conduit with conductors of lighting or power systems.

- G. Locate and install the detector assembly for optimum response time and easy accessibility. Identify device point number with ½” lettering. Use minimum of 1” lettering to identify detectors mounted on ceilings higher than 10 feet ensuring visibility from floor level.
- H. Provide manual pull stations at every identified egress and installed in compliance with the maximum distance from the operable egress door per NFPA 72.
- I. Provide a drawing mounted near exit of all mechanical rooms clearly identifying the location and type of device located in room.

3.3 TESTING

- A. The entire fire alarm system shall be field tested in accordance with NFPA standards and other applicable standards in the presence of the Construction Inspector. Inspection and test method shall be in compliance with NFPA 72. Inspection and test record forms that are recommended by NFPA 72 shall be utilized. Results of such testing shall be recorded on forms approved for the purpose, certified and submitted to the Construction Inspector prior to final acceptance.
- B. All test equipment; instruments, tools, and labor that required conducting the system tests shall be provided by the Contractor. The following equipment, but not limited to, shall be a minimum for conducting such tests.
 - 1. Ladders and scaffolds as required for access all field devices.
 - 2. Multi-meter for reading voltage, current and resistance.
 - 3. Intelligent device programmer/tester.
 - 4. Laptop computer with programming software for any required program revisions.
 - 5. Two-way radios, flashlights, smoke generation devices and supplies.
 - 6. Spare printer paper.
 - 7. Decibel meter.
- C. Perform all electrical and mechanical tests required by the equipment manufacturer's certification form. In addition, measure and adjust each of the ionization detectors to the maximum stable sensitivity setting. This must be performed with the detector at its operational environmental conditions in the area. Bench settings are not acceptable. All test and report costs shall be in the contract price. A checkout report shall be prepared by the installation technicians and submitted in triplicate, of which one copy will be registered with the equipment manufacturer. The report shall include, but not be limited to:
 - 1. A complete list of equipment installed and wired.

2. Indication that all equipment is properly installed and functions and conforms to these Specifications.
 3. Serial numbers, locations by zone and model number for each installed detector. All intelligent devices shall be tested and logged for correct address and sensitivity using test equipment specifically designed for that purpose. Sensitivity settings for each ionization and photoelectric detector as measured in place with the HVAC system operating.
 4. Wiring runs shall be tested for continuity, short circuits and ground before system is energized. Resistance, current and voltage reading shall be made as work progresses.
 - a. A systematic record shall be maintained for all readings using schedules or charts of tests and measurements. Areas shall be provided on the logging form for readings, dates, and witnesses.
 - b. The Owner shall be notified before the start of the required tests. All items found at variance with the applicable drawings and/or specifications during testing and inspection by the Owner, shall be corrected by Contractor at no additional cost to the Owner.
 - c. Test reports shall be delivered to the Owner when completed.
 5. Test of individual zones as applicable.
 6. Duct detector cfm readings with HVAC system operating.
 7. HVAC shutdown response upon smoke detection.
 8. Water flow alarm response upon water flow or tamper switch activation.
 9. Elevator recall, alternate floor recall, and power shutdown response.
 10. Firefighter's emergency telephone response time.
 11. Response time on thermostats and flame detectors (if used).
 12. Technician's name, certificate number, and date.
- D. Final Acceptance Test (FAT)
1. The FAT shall be conducted in the presence of the Owner and under the supervision of the Manufacturer. Prior to FAT, the Owner shall be provided drawings showing the correct address for all addressable alarm initiation devices. The address shall be shown in their respective locations for the device on drawings. Signals shall be sequentially numbered as the address of the controlling module.

2. System wiring shall be tested to demonstrate correct system response and correct subsequent system operation in the event of:
 - a. Open, short, and ground fault for intelligent analog signaling circuit.
 - b. Open, short, and ground fault for intelligent digital signaling circuit.
 - c. Open, short, and ground fault for network signaling circuit.
 - d. Intelligent device removal.
 - e. Primary power or battery disconnected.
 - f. Type of device miss-match the address ID.
 - g. Polarity check.
 - h. Printer trouble, off line or out of paper.
3. System indications shall be demonstrated as follows.
 - a. Correct message display for each alarm input at the remote control panel, central control panel and operator's workstation graphic display.
 - 1) Correct annunciator light for each alarm input at each annunciator and color graphic of operator's workstation.
 - 2) Correct printer logging for all system activity.
 - b. Secondary power capacities shall be demonstrated as follows.
 - 1) System primary power shall be disconnected for a period of 8 hours. At the end of that period, an alarm condition shall be created and the system shall perform as specified for a period of 5 [15] minutes.
 - 2) System primary power shall be restored 48 hours and system charging current shall be normal trickle charge for a fully charges battery pack.
 - 3) System battery voltages and charging currents shall be checked at the fire alarm control panel using the test code and displayed on the LCD display.
 - c. Firefighter's HVAC override system functions shall be demonstrated as following.
 - 1) On/off control of each controlled element and test for interaction of others automatic and manual control functions while in the override mode.
 - 2) Correct status display of monitored elements.

- 3) Correct logging of activity to printer and historical memory as programmed.
4. The entire system needs to be tested in compliance with the building emergency operation sequence specified by contract document. The tests are included, but not limited to, fire door control, security door control interface, air handler duct smoke detection shutdown interface, sprinkler system PIVs, OS&Y valves, and tamper switch monitoring, sprinkler systems water flow and/or pressure switch monitoring, monitoring of fire pump controls, fire/smoke damper control, smoke purge control interface, activation of deluge or pre-action sprinkler systems, and elevator recall power shutdown.
5. In the event of system failure to perform as specified and programmed during the FAT, the test shall be terminated at the discretion of the Owner.
 - a. The Contractor shall retest the system correcting all deficiencies and providing test documentation to the Owner without additional cost to the Owner.
 - b. In the event that software changes are required during the FAT, a utility program shall be provided by the system manufacturer to compare the edited program with the original. The utility shall field a printed list of the changes and all system functions, inputs and outputs affected by the changes. The items listed by the program shall be the minimum acceptable to be retested before calling for resumption of the FAT. The printed list and the printer log of the retesting shall be submitted before scheduling of the FAT.
 - c. The Owner may elect to require the complete FAT to be performed again if, in their opinion, modifications to the system hardware or software warrant complete retesting.
6. Verify, test, and demonstrate all Mass Notification system communication and operation with the control from origin of Mass Notification System.
7. Verify, test and demonstrate the interface between the local Fire Alarm System and the local Mass Notification system

3.4 WARRANTY AND SERVICES

- A. The Contractor shall warrant the entire system against mechanical and electrical defects for a period of 18 months. This period shall begin upon completed certification and test of the system.
- B. During the warranty period, provide at no additional charge the inspection, parts, maintenance, testing and repair in full compliance with the requirements of NFPA 72. The contractor performing the contract services shall be qualified and listed to maintain ongoing certification of the completed system to the UL for specific installed system listing.

3.5 MANUFACTURER'S FIELD SERVICES

- A. Include services of factory-certified technicians to supervise installation, adjustments, calibrations, final connections, and system testing. A representative of the manufacturer shall instruct the Owner and demonstrate the system after the Owner has occupied the building.
- B. Formal training for the operation and maintenance of fire alarm equipment and the systems specified herein shall be provided by manufacturer trained and certified personnel. The formal training shall consist of a minimum of five-day eight-hour training sessions or the number of hours as indicated per contract document. The timing of the training shall coincide with the schedule for the manufacturer's representatives to be on site for testing and start-up of each building fire alarm system. The formal training shall be provided at a location designated or provided by the Owner for number of personnel selected by the Owner, in addition to any informal on-site orientation and training.
- C. A formal training proposal shall be submitted with curriculum material, schedule, instructor's qualification for the Owner's approval at least 60 days prior to formal training. The trainer shall provide approved training material manus at the time of training with quantity of copies per Owner's instruction.
- D. As-built drawings shall be provided upon acceptance of the system with quantities per contract document.

END OF SECTION