Project Manual

for

The University of Texas MD Anderson Cancer Center
Houston, Texas

S1 Tunnel Washers and Floor Replacement

MD ANDERSON PROJECT: 18-0432 & 19-0630

A/E PROJECT: 219-024

PROJECT DELIVERY METHOD: Job Order Contract

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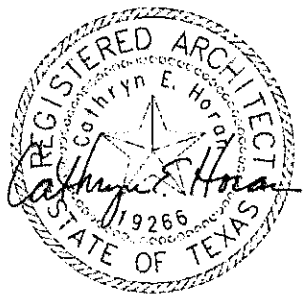
OWNER'S REPRESENTATIVE
Jason Sutton
Facilities, Planning, Design and Construction

PROJECT ARCHITECT
Cathryn Horan
PhiloWilke Partnership
11275 S. Sam Houston Pkwy W. Suite 200; Houston, Texas 77031
832-554-1130.

PROJECT MEP ENGINEER
Don Nye, PE
E&C Engineers and Consultants
1010 Lamar Street; Houston, Texas 77002
713-580-8800
TX Firm # F-003068



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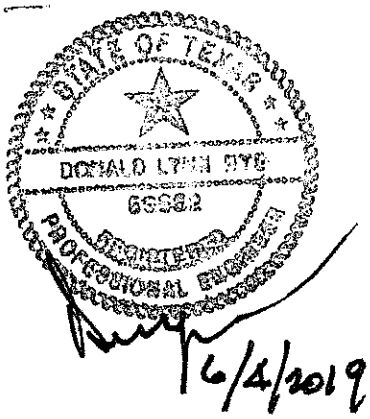

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SECTION 23 05 90 – CONTRACTOR COORDINATION WITH TESTING, ADJUSTING, AND BALANCING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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.

1.02 SUMMARY

A. Perform all Work required to prepare the building HVAC systems for testing, adjusting, and balancing (TAB) Work indicated by the Contract Documents, including the following:

1. Preparation of air systems for testing, adjusting and balancing.

2. Preparation of hydronic and steam systems for testing, adjusting and balancing.

3. Providing materials and labor to assist TAB Firm in meeting testing, adjusting and balancing requirements.

B. Testing, adjusting and balancing of the air conditioning systems and related ancillary equipment will be performed by a technically qualified TAB Firm. The preparation for and corrections necessary for the testing, adjusting and balancing of these systems, as described herein, are the responsibility of this Contractor.

C. Make any changes or replacements to the sheaves, belts, dampers and valves required for correct balance as advised by the TAB Firm, at no additional cost to the Owner.

1.03 REFERENCE STANDARDS

A. The latest published edition of a reference 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. AABC: National Standards for Testing and Balancing Heating, Ventilating and Air Conditioning Systems.

2. AABC: Testing and Balancing Procedures.

3. ASHRAE HVAC Applications Chapter 37: Testing, Adjusting and Balancing.

4. ANSI/ASHRAE Standard 111: Practices for Measurement, Testing, Adjusting and Balancing of Buildings, Heating, Ventilation, Air Conditioning and Refrigeration Systems.

1.04 QUALITY ASSURANCE

A. Provide and coordinate the services of qualified, responsible Subcontractors, suppliers and personnel as required to correct, repair, and/or replace any and all deficient items or conditions found during the course of this project, including during the testing, adjusting and balancing period.

B. In order that systems may be properly tested, adjusted, and balanced, the Contractor shall operate systems at Contractor's expense for the length of time necessary to properly verify the systems' completion and readiness for TAB.

C. Project Contract completion schedules shall allow for sufficient time to permit the completion of TAB services prior to Owner occupancy. Allow adequate time for the testing and balancing activities during the construction period and prior to Substantial Completion.

PART 2 - PRODUCTS

2.01 GENERAL

A. None used.

PART 3 - EXECUTION

3.01 PREPARATION

A. Contractor shall be responsible to prepare the building heating, ventilating, and air conditioning systems ready for TAB when scheduled.

B. Operational readiness requires that construction status of the building will permit the closing of doors, windows, ceilings installed, etc., to obtain simulated or projected operating conditions.

C. Notification of System Readiness:

1. Upon completion of the system installation Work, the Contractor shall notify the Owner and TAB Firm in writing, certifying that the Work has been accomplished and that the air conditioning systems are in operational readiness for testing, adjusting, and balancing.

2. TAB Firm shall notify the Contractor of TAB Firm's readiness for balancing.

3. Should the TAB Firm be notified as described above, and the TAB Work commenced and the systems are found NOT to be in readiness or a dispute occurs as to the readiness of the systems, the Contractor shall request an inspection be made by a duly appointed representative of the Owner, Architect, TAB Firm and the Contractor. This inspection will establish to the satisfaction of the represented parties whether or not the systems meet the basic requirements for TAB services. Should the inspection reveal the TAB services notification to have been premature, all cost of the inspection and wasted Work accomplished by the TAB Firm shall be the responsibility of the Contractor.

3.02 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. Allow sufficient time for the TAB Firm to perform TAB Firm's Work within the Project schedule. Complete installation Work by system or floor, whichever is the most efficient for scheduling. Develop the Project schedule in close coordination with the TAB Firm.

D. The Drawings and Specifications indicate valves, dampers and miscellaneous adjustment devices for the purpose of adjustment to obtain optimum operating conditions. Install these devices in a manner that will leave the devices accessible and readily able to be adjusted. Immediately correct any malfunction encountered that the TAB Firm reports so that the balancing Work can proceed with minimal delay.

E. Contractor shall promptly correct deficiencies of materials and workmanship identified as delaying completion of TAB Work.

3.03 SYSTEMS VERIFICATION

A. Air Distribution Systems:

1. Verify installation for conformity to the Contract Documents. All supply, return, and exhaust ducts shall be terminated and pressure tested for leakage as required by the Contract Documents.

2. All volume, smoke and fire/smoke dampers are properly located and functional. Dampers serving requirements of minimum and maximum outside, return, and relief air shall provide tight closure and full opening, smooth and free operation.

3. All supply, return, exhaust and transfer grilles, registers, diffusers and terminal devices are installed and airflow at each device shall be verified.

4. Air handling systems, units and associated apparatus, such as heating and cooling coils, filter sections, access doors, etc., shall be sealed or blanked-off to eliminate excessive uncontrolled bypass or leakage of air.

5. All fans (supply, return and exhaust) operating and verified for freedom from vibration, with proper fan rotation and belt tension. Heater elements in motor starters are of proper size and rating. Record motor amperage and voltage on each phase at Start-up and running, and verify they do not exceed nameplate ratings.

6. All single and/or double duct variable and constant volume terminal units ("mixing boxes") shall be installed and functional (i.e. controls functioning).

7. Duct systems and air handling units and coils are clean and free of debris.

8. Air systems are pressure independent and can be tested by floor, riser, system, etc. but once the all systems are installed, the total flows and system tracking will require final testing, adjusting and balancing.

B. Water Circulating Systems:

1. Check and verify pump alignment and rotation.

2. Open all valves to their full open position, close bypass stop valves. Set mixing valves to full-flow through systems components. After the system is flushed and checked for proper operation, remove and clean all strainers. Repeat the operation until circulating water is clean.

3. Record the amperage of each pump motor on each phase and voltage after reaching rated speed. Readings shall not exceed nameplate rating.

4. Verify that the electrical heater elements are of the proper size and rating.

5. All water circulating systems shall be full and free of air. Expansion tanks shall be set for proper water level and all air vents shall be installed at high points of systems and operating freely. Systems shall be cleaned and flushed. Chemicals shall be added to closed systems to treat piping and inhibit corrosion.

6. Check and set operating temperatures and other parameters of the heat exchangers and control devices to the design requirements.

7. Installation and system verification of condenser water, hot water, and chilled water systems must be 100 percent complete prior to balancing.

C. Building Automation System (BAS):

1. Verify that all control components are installed in accordance with the Contract Documents and that all control components are functional, including all electrical interlocks, damper sequences, air and water resets, fire and freeze stats, high and low temperature thermostats, safeties, etc.

2. Verify that all controlling instruments are calibrated and set for design operating conditions with the exception of room thermostats or sensors, which shall be calibrated at the completion of TAB services with cooperation between the TAB Firm and BAS Provider.

3. BAS Provider shall thoroughly check all controls, sensors, operators, sequences, etc. before notifying the TAB Firm that the building automation system is operational. The BAS Provider shall provide technical support, including technicians and necessary computers, to the TAB Firm for a complete check of these systems.

4. BAS Provider shall assist the Contractor with functional performance testing and point-to-point testing back to the main graphics.

5. BAS Provider, if requested by Owner, shall set-up controls on sample fan powered terminal units at TAB Firm’s office.

END OF SECTION 23 05 90

SECTION 23 05 93 – SYSTEM TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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.

1.02 SUMMARY

A. Testing, adjusting, and balancing (TAB) of the air conditioning systems and related ancillary equipment will be performed by a technically qualified TAB Firm.

B. TAB Firm shall be capable of performing the TAB services as specified in accordance with the Contract Documents, including the preparation and submittal of a detailed report of the actual TAB Work performed.

C. TAB Firm shall check, adjust, and balance components of the air conditioning system which will result in optimal noise, temperature, and airflow conditions in the conditioned spaces of the building while the system equipment is operating economically and efficiently. This is intended to be accomplished after the system components are installed and operating as specified in the Contract Documents. It is the responsibility of the Contractor to place the equipment into service. Variable air volume systems shall be balanced in accordance with AABC Standard, Latest Edition or NEBB Standards for Testing, Adjusting, Balancing of Environmental Systems (Latest Edition).

D. TAB Firm shall check, adjust, and balance all hydronic systems including pumps, water distribution systems, chillers, cooling towers, boilers, heat exchangers, coils, and related equipment.

E. Liaison and Early Field Inspection:

1. TAB Firm shall act as a liaison between the Owner, Architect and Contractor. TAB Firm shall perform the following reviews (observations) and tests:

a. During construction, review all HVAC submittals such as control diagrams, air handling devices, etc., that pertain to the ability to satisfactorily balance systems.

b. Test at least one or at least 10 percent of the single and fan-powered terminal units if the number of units are greater then twenty (20), for casing and damper leakage when the shipment arrives at the Project Site. All testing (except for the initial terminal units) shall be performed at the Project Site.

c. 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 inch increments until fully closed. Track the valves' response time in relation to sash movement and the lab differential.

2. During the balancing process, as the TAB Firm discovers abnormalities and malfunctions of equipment or components, the TAB Firm shall advise the Contractor in writing so that the condition can be corrected by the Contractor prior to finishing the TAB scope of Work. Data from malfunctioning equipment shall not be recorded in the final TAB report.

1.03 REFERENCE STANDARDS

A. The latest published edition of a reference 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. AABC - National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems.

2. NEBB - National Environmental Balancing Bureau, Procedural Standards for Testing, Adjusting, Balancing of Environmental Systems.

3. ASHRAE HVAC Applications Chapter 37: Testing, Adjusting and Balancing.

4. ANSI/ASHRAE Standard 111: Practices for Measurement, Testing, Adjusting and Balancing of Buildings, Heating, Ventilation, Air Conditioning and Refrigeration Systems.

5. CTI - Cooling Technology Institute CODE ATC-105.

1.04 QUALITY ASSURANCE

A. TAB Firm shall have operated a minimum of five (5) years under TAB Firm's current name and shall be in good standing with the State of Texas, Franchise Tax Board. TAB Firm shall submit full incorporated name, Charter Number, and Taxpayer's I.D. Number for proper verification of TAB Firm's status.

B. TAB Firm's personnel performing Work at the Project Site shall be either professional engineers or certified air and water balance technicians, who shall have been permanent, full time employees of the TAB Firm for a minimum of six (6) months prior to the start of Work for this Project.

C. TAB firm shall have a background record of at least five (5) years of specialized experience in the field of air and hydronic system balancing and shall possess properly calibrated instrumentation.

1.05 SUBMITTALS

A. The activities described in this Section shall culminate in a report to be provided in quadruplicate (4), individually bound and also provided electronically to the Contractor to be presented to the Owner. Neatly type and arrange data. Include with the data, the dates 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 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 report must have been made at the Project Site by the permanently employed technicians or engineers of the TAB Firm.

C. At the Owner’s option, all data sheets tabulated each day by TAB Firm personnel shall be submitted for review and sign-off by the Owner’s Construction Inspector. Those data sheets, as initialed by Owner’s Construction Inspector, shall be presented as a supplement to the final TAB report.

D. Submit reports on electronic forms approved by the Owner and Architect/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. 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 and location.

   b. Manufacturer.

   c. Model.

   d. Air flow, specified and actual.

   e. Total static pressure (total external), specified and actual.

   f. Inlet pressure.

   g. Discharge pressure.

   h. Fan RPM.

4. Air Handler Return Air/Outside Air Data (If fans are used, provide fan data as noted above):

   a. Identification and 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. Horsepower/brake horsepower.

   c. Phase, voltage, amperage, nameplate, actual.

   d. RPM.

   e. Service factor.

   f. Starter size, heater elements, rating.

6. V-Belt Drive:

a. Identification and 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.

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 and location.

b. System.

c. Size.

d. Area.

e. Design velocity.

f. Design air flow.

g. Test velocity.

h. Test air flow.

9. Variable or Constant Volume Terminal Unit Test Sheet:

a. Identification number.

b. Room number/location.

c. Terminal type (FP if fan powered) and / or (SDVV, SDCV, DDVV, DDCV), and (HWRH or ERH if reheat coil is used).

d. Terminal size.

e. Area factor.

f. Design velocity.

g. Design maximum and minimum air flow.

h. Test (final) velocity.

i. Test (final) maximum and minimum air flow.

j. For DDC instrumentation: Measure and record computer readout and calibration factor at the final measurement conditions.

k. Air dry bulb temperature at the discharge of the terminal unit.

10. Cooling Coil Data:

a. Identification number.

b. Location.

c. Service.

d. Manufacturer.

e. Entering air DB temperature, design and actual.

f. Entering air WB temperature, design and actual.

g. Leaving air DB temperature, design and actual.

h. Leaving air WB temperature, design and actual.

i. Water pressure flow, design and actual.

j. Water pressure drop, design and actual.

k. Pressure independent control valve water pressure drop, design and actual.

l. Entering water temperature, design and actual.

m. Leaving water temperature, design and actual.

n. Air quantity CFM design, and CFM actual.

o. Air pressure drop, design and actual.

p. Sensible Btu/hr design, and actual.

q. Total Btu/hr design, and actual.

11. Heating Coil Data:

a. Identification number.

b. Location.

c. Service.

d. Manufacturer.

e. Air flow, design and actual.

f. Water flow (gpm) or Steam mass flow rate (lbs per hour) design and actual.

g. Pressure drop water (feet w.g.) or steam (psid), design and actual.

h. Pressure independent control valve water pressure drop, design and actual.

i. Entering water or steam temperature, design and actual.

j. Leaving water or steam temperature, design and actual.

k. Entering air temperature, design and actual.

l. Leaving air temperature, design and actual.

m. Air quantity CFM design, and CFM actual.

n. Air pressure drop, design and actual.

o. Sensible Btu/hr design, and actual.

p. Electric heat kW, number of stages, kW per stage – specified and actual (if applicable).

12. Sound Level Report:

a. Location (Location established by the Engineer).

b. Baseline background NC curve for eight (8) bands – with equipment off.

c. Operating NC curve for eight (8) bands – with equipment on.

13. Vibration Test on equipment having 10 horsepower motors or greater:

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 outlet).

9) Duct after flexible connection (suction inlet).

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).

14. Control verification indicating date performed and any abnormalities identified:

a. Point Location/Description.

b. EMS Readout (Setpoint and Actual).

c. Actual Readout.

d. Interlocks.

e. Safeties:

1) VSD Normal Operation.

2) VSD Bypass Operation.

f. Alarms.

g. Sequences of Operation.

15. Include in the appendix all submittals for air handling units, pumps, fans, heat exchangers, energy recovery units control system, etc.

PART 2 - PRODUCTS

Not used.

PART 3 - EXECUTION

3.01 AIR BALANCE

A. When systems are installed and ready for operation, the TAB Firm shall perform an air balance for all air systems and record the results. The outside, supply, exhaust and return 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 percent 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 and the device opposed blade damper (OBD) for duct connected devices. 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.

B. The general scope of balancing by the TAB Firm shall include, but is not limited to, the following:

1. Filters: Check air filters and filter media and balance only systems with essentially clean filters and filter media. The 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 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 and recorded for this report at the furthest air device or terminal unit from the air handler supplying that device. 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 reheat coil at each VAV 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 HVAC VAV terminal unit and VAV air handling unit for design CFM.

8. Outlet Air Flow: Adjust each exhaust inlet and supply diffuser, register and grille to within + 5 percent 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 percent and supply to design - 5 percent. Positive areas will have opposite tolerances.

9. Pitot Tube Traverses: For use in future troubleshooting by Owner, all exhaust ducts, main supply ducts and return ducts shall have air velocity and volume measured and recorded by the traverse method. Locations of these traverse test stations shall be described on the sheet containing the data.

10. Maximum and minimum air flow on terminal units.

3.02 HYDRONIC SYSTEM BALANCE

A. When systems are installed and ready for operation, the TAB Firm shall perform water balance for each chilled and heating hot water system.

B. The general scope of balancing by the TAB Firm shall include, but not be limited to, the following:

1. Adjusted System Tests: Adjust pressure independent control valves at each coil and heat exchanger for design flow, +/- 5 percent, in accordance with valve manufacturer's published commissioning procedure. Pressure independent valve manufacturer will provide service tool and/or service software for use in this commissioning process, and provide training in its use. 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 design conditions. Provide final readings at all thermometer well locations.

3. Test cooling towers in accordance with CTI Code ATC – 105.

4. 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 pressure independent control valves, in accordance with valve manufacturer's published commissioning procedures until the rated pressure drops across each coil is obtained and total water flow is verified by flow measuring status. Verify required pressure drop across each pressure independent control valve. 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.

5. Ampere Readings: Reading and record full load amperes for each pump motor.

3.03 SOUND VIBRATION AND ALIGNMENT

A. Sound: Read and record sound levels at up to fifteen (15) locations per floor in the building as designated by the Architect/Engineer. All measurements shall be made using an Octave Band Analyzer. All tests shall be conducted when the building is quiet and in the presence of the Architect/Engineer, at the Architect/Engineer's option.

B. Vibration: Read and record vibration for all water circulating pumps, air handling units, and fans which have motors larger than 10 horsepower Include equipment vibration, bearing housing vibration, foundation vibration, building structure vibration, and other tests as directed by the Architect/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 one mil on fans and one mil on pumps unless otherwise specified. Equipment manufacturer shall rectify all systems exceeding vibration tolerances.

3.04 BUILDING AUTOMATION SYSTEMS

A. In the process of performing the TAB Work, the Contractor shall:

1. Work with the Building Automation System (BAS) Provider and Owner 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 the intended controllers operate all dampers, valves and other controlled devices.

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 all duct-mounted dampers, dampers in terminal units, and fire/smoke dampers.

6. Observe that all valves are properly installed in the piping system in relation to direction of flow and location. Observe that all pressure independent control valves are properly installed in accordance with manufacturer's published installation instructions.

7. Observe the calibration and operation 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. BAS Provider will relocate sensors as deemed necessary by the TAB Firm or Contractor.

11. Verify that the sequence of operation for any control mode is in accordance with approved Shop Drawings and Specifications. Verify that no demand for simultaneous heating and cooling occurs at the terminal units.

12. Verify that all controller setpoints meet the Contract Documents.

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 system components track with changes from full flow to minimum flow.

END OF SECTION 23 05 93

SECTION 23 07 13 – DUCTWORK INSULATION

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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.

1.02 SUMMARY

A. Perform all Work required to provide and install ductwork insulation and jackets indicated by the Contract Documents with supplementary items necessary for proper installation.

1.03 REFERENCE STANDARDS

A. The latest published edition of a reference 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. ASTM B209 - Aluminum and Aluminum-Alloy Sheet and Plate.

2. ASTM C168 - Terminology Relating to Thermal Insulation Materials.

3. ASTM C518 - Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus.

4. ASTM C553 - Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications.

5. ASTM C612 - Mineral Fiber Block and Board Thermal Insulation.

6. ASTM C1071 - Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material).

7. ASTM C1104 - Standard Test Method for Determining the Water Vapor Sorption of Unfaced Mineral Fiber Insulation.

8. ASTM C1290 - Standard Specification for Flexible Fibrous Glass Blanket Insulation Used to Externally Insulate HVAC Ducts.

9. ASTM C1136 - Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation.

10. ASTM C1338 - Standard Test Method for Determining Fungi Resistance of Insulation Materials and Facings.

11. ASTM E84 - Surface Burning Characteristics of Building Materials.

12. ASTM E96 - Water Vapor Transmission of Materials.

13. ASTM E119 - Standard Test Methods for Fire Tests of Building Construction and Materials.

14. ASTM G21 - Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi.

15. NFPA 255 - Surface Burning Characteristics of Building Materials.

16. SMACNA - HVAC Duct Construction Standards - Metal and Flexible.

17. UL 181 - Standard for Factory-Made Air Ducts and Air Connectors.

18. UL 723 - Surface Burning Characteristics of Building Materials.

19. ASTM E2336 - Standard for Grease Ducts.

20. ASTM D5590 - - Standard Test Method for Determining the Resistance of Paint Films and Related Coatings to Fungal Defacement by Accelerated Four-Week Agar Plate Assay

1.04 QUALITY ASSURANCE

A. All ductwork requiring insulation shall be insulated as specified herein and as required for a complete system. In each case, the insulation shall be equivalent to that specified and materials applied and finished as described in these Specifications.

B. 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.

C. Application Company Qualifications: Company performing the Work of this Section must have minimum three (3) years experience specializing in the trade.

D. All insulation shall be applied by mechanics skilled in this particular Work and regularly engaged in such occupation.

E. 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.

1.05 SUBMITTALS

A. Product Data:

1. Provide product description, list of materials, “k” value, “R” value, mean temperature range, and thickness for each service and location.

B. Record Documents:

1. Submit under provisions of Division 01.

C. Operation and Maintenance Data:

1. Samples: When requested, submit three (3) samples of any representative size illustrating each insulation type.

2. Manufacturer’s Installation Instructions: Indicate procedures that ensure acceptable standards will be achieved. Submit certificates to this effect.

1.06 DELIVERY, STORAGE AND HANDLING

A. Deliver, store, protect, and handle products to the Project Site under provisions of Division 01 and Division 20.

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.

D. Maintain ambient temperatures and conditions required by manufacturers of adhesives, mastics and insulation cements.

PART 2 - PRODUCTS

2.01 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.

2.02 MANUFACTURERS

A. CertainTeed Corporation.

B. Johns Manville Corporation.

C. Knauf Corporation.

D. Owens-Corning.

E. Armacell North America.

F. Unifrax 1 LLC. (FyreWrap)

G. 3M Fire Protection Products (Fire Barrier Duct Wrap 615+)

2.03 INSULATION MATERIALS

A. Type D1: Flexible glass fiber; ASTM C553 and ASTM C1290; commercial grade; 'k' value of 0.25 at 75 degrees F; 1.5 lb/cu ft minimum density; 0.002 inch foil scrim kraft facing for air ducts.

B. Type D2: Rigid glass fiber; ASTM C612, Class 1; 'k' value of 0.23 at 75 degrees F; 3.0 lb/cu ft minimum density; 0.002 inch foil scrim kraft facing for air ducts.

C. Type D3: Ductliner (to be used in return air sound boots only), flexible glass fiber; ASTM C1071; Type II, 'k' value of 0.23 at 75 degrees F; 3.0 lb/cu ft minimum density; coating air side for maximum 4,000 feet per minute air velocity. The airstream surface must be protected with a durable acrylic surface coating specifically formulated to:

1. Be no more corrosive than sterile cotton when tested in accordance with the test method for corrosiveness in ASTM C665.

2. Absorb no more than 3 percent by weight when tested in accordance with the test method for moisture vapor sorption in ASTM C1104.

3. Not support the growth of fungus or bacteria, when tested in accordance with the test method for fungi resistance in ASTM C1071, ASTM C1338, ASTM G21, and ASTM G22.

4. Show no signs of warpage, cracking, delaminating, flaming, smoking, glowing, or any other visibly negative changes when tested in accordance with the test method for temperature resistance in ASTM C411.

5. Have a flame spread rating of 25 or less and a smoke developed rating of 50 or less when tested in accordance with the test method for surface burning in ASTM E 84.

6. Meet the sound absorption requirements when tested in accordance with the test method for sound absorption in ASTM C423.

7. Show no evidence of continued erosion, cracking, flaking, peeling, or delamination when tested in accordance with the test method for erosion resistance in UL181.

D. Type D4: Fire Rated Grease Duct Insulation (High Temperature Flexible Blanket); 1-1/2-inch thick refractory grade fibrous fire barrier material with minimum service temperature design of 2,000 degrees F; aluminum foil laminated on both sides; with a minimum 'k' value of 0.25 and a minimum density of 6 lbs/cu ft; containing no asbestos. Listed by a nationally recognized testing laboratory (NRTL) UL to meet ASTM E 2336, ASTM E119, and with flame spread/smoke minimum rating of 25 / 50 when tested as per ASTM E84/UL 723.

E. Type D5: Outdoor Duct Insulation (Closed Cell Flexible Elastomeric Insulation); 1 inch thick material that has a service temperature range from –60 degrees F to 180 degrees F. This outdoor duct insulation meets ASTM C 177 or C 518 and shall have minimum 'k' value of 0.27 Btu-in. / hr-ft2- degrees F at minimum density measurement of 3 lb/cu ft. The insulation and outside surface must be protected with a white Thermo Plastic Rubber Membrane formulated to:

1. Be resistant to UV, and ozone, acid rain, and physical elements produced from outdoor weather per ASTM E 96 Procedure A.

2. Have aflame spread rating of 25 or less and a smoke developed rating of 50 or less when tested in accordance with the test method for surface burning in ASTM E 84.

3. Show no evidence of continued erosion, delaminating, cracking, flaking, or peeling when tested in accordance with the test method for erosion resistance in UL181. Be resistant to mold growth resistance, ASTM G 21/C 1338 resistant to fungi, and resistant to bacteria growth per ASTM G 22.

F. Type D6: Ductliner (to be used in return air sound boots only), flexible glass fiber; ASTM C1071; Type II, 'k' value of 0.23 at 75 degrees F; 3.0 lb/cu ft minimum density; coating air side for maximum 4,000 feet per minute air velocity. The airstream surface must be protected with a durable polyacrylate copolymer emulsion specifically formulated to:

1. Not support the growth of fungus or bacteria, when tested in accordance with the test method for fungi resistance in ASTM D 5590 with "0" growth rating.

2. Act as a fungicidal protective coating: water based, VOC < 50 g/l. Fungicidal coating must be EPA registered for use in HVAC duct systems. Manufacturer: H.B. Fuller Construction Products Inc., Foster 40-20 (white) or 40-30 (black) Fungicidal Protective Coating or approved equal. Coatings may also be used to repair damage to duct liner insulation.

2.04 INSULATION ACCESSORIES

A. Adhesives: Waterproof vapor barrier type, meeting requirements of ASTM C916; Childers CP-82 or Foster 85-20/85-60.

B. Weather Barrier: Breather Mastic:, Childers CP-10/CP-11 or Foster 46-50 White..

C. Vapor Barrier Coating: Permeance - ASTM E 96, Procedure B, 0.08 perm or less at 45-mil dry film thickness, tested at 100F and 50%RH; Foster 30-65 or Childers CP-34

1. When higher humidity levels may be of concern, only specify the following fungus/mold resistant coating: Foster 30-80 AF (anti fungal). Coating must meet ASTM D 5590 with 0 growth rating**

D. Reinforcing Mesh: 10x10 or 9x8 glass mesh; Foster Mast a Fab or Childers #10

E. Jacket: Pre-sized glass cloth, minimum 7.8 oz/sq yd.

F. Type D4 Insulation Adhesive: Fire resistive to ASTM E84, Childers CP-82 or Foster 85-20.

G. Impale Anchors: Galvanized steel, 12 gage self-adhesive pad.

H. Joint Tape: Glass fiber cloth, open mesh.

I. Tie Wire and Wire Mesh: Annealed steel, 16 gage.

J. Stainless Steel Banding: 3/4-inch wide, minimum 22 gage, 304 stainless.

K. Armaflex 520, 520 BLV, or Foster 85-75 contact adhesive.

L. Armatuff 25 white seal seam tape.

PART 3 - EXECUTION

3.01 PREPARATION

A. Verify that ductwork has been tested before applying insulation materials.

B. Verify that surfaces are clean, foreign material removed, and dry.

C. Maintain required ambient temperature during and after installation for a minimum period of 24 hours.

3.02 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. Extend duct insulation without interruption through walls, floors, and similar penetrations, except where otherwise indicated.

D. Provide external insulation on all round ductwork connectors to ceiling diffusers and on top of diffusers as indicated in the Ductwork Insulation Application and Thickness Schedule and the Drawings. Secure insulation to the top of ceiling diffusers with UL181B-FX listed polypropylene duct tape Do not insulate top of ceiling diffuser if it is used in ceiling return air plenum or in an open space with no ceiling.

E. Flexible and Rigid fiberglass insulation (Types D1 and D2) application for exterior of duct:

1. Secure flexible insulation jacket joints with vapor barrier adhesive, tape. Tape shall be UL181B-FX listed polypropylene duct tape.

2. Install without sag on underside of ductwork. Use 4-inch wide strips of adhesive on 8-inch centers and mechanical fasteners where necessary to prevent sagging. Seal vapor barrier penetrations by mechanical fasteners with vapor barrier adhesive. Stop and point insulation around access doors and damper operators to allow operation without disturbing wrapping.

3. Insulate standing seams and stiffeners that protrude through the insulation with 1-1/2 inch thick, unfaced, flexible blanket insulation. Cover with reinforcing mesh and coat with vapor barrier finish coating.

4. On circumferential joints, the 2-inch flange on the facing shall be secured with 9/16 inch outward clinch steel staples on 2-inch centers, and taped with minimum 3-inch wide strip of glass fabric and finish coating.

5. Vapor seal all seams, joints, pin penetrations and other breaks with vapor barrier coating reinforced with reinforcing mesh.

F. Duct Liner (Type D3 or D6) application for interior of return air sound boots:

1. Secure insulation with 100 percent coverage of duct liner adhesive, pins and clips not more than 18 inches on center.

2. Secure bottom of duct insulation using alternate single and double clips. The first pin will secure the insulation and the second clip will be used to secure the cladding. Isolate the exterior clip from the cladding by using two 1/8 inch closed cell neoprene (Armaflex) washers on either side of the cladding. Predrill holes in cladding and avoid contact with pin during installation.

3. For round duct, secure insulation with 100 percent coverage of duct liner adhesive. Secure cladding with 3/4 inch, 0.020 inch stainless steel bands on 12-inch centers.

4. For joints and overlaps, fold cladding to form a double thickness hem 2 inches minimum. Seal with a non-shrink, non-hardening sealing compound.

5. Type D6: Provide fungicidal coating in air handlers ten feet on either side, first ten feet downstream of cooling coils, ten feet downstream of mix boxes, in mechanical rooms or as otherwise specified in potentially high humidity areas in the duct system shall be coated with an fungicidal coating; EPA registered for use in HVAC duct systems at a coverage rate of 80 ft2/gallon.

G. All ductwork, accessories, and all plenums including metal and masonry construction, 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.

H. Flexible ductwork connections to equipment shall not be insulated.

I. 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.

J. Extreme care shall be taken in insulating high and medium pressure ductwork including all ductwork between the fan discharge and all mixing boxes to ensure 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.

K. Where canvas finish is specified use lagging adhesive/coating to prevent mildew in securing canvas. Do not use wheat paste.Use only anti fungal lagging adhesive that adheres to ASTM D 5590 with 0 growth rating. (Foster 30-36AF, Childers CP-137AF). In addition, cover all exterior canvas-covered insulation with a fire retardant weather barrier mastic.

L. All supply ductwork in the Project shall be insulated; all exhaust and fume hood exhaust ductwork shall not be insulated, unless used for energy recovery purposes or noted on drawings.

M. Flexible round ducts shall be factory insulated.

3.03 INSPECTION

A. Visually inspect the completed insulation installation per manufacturers recommended materials, procedures and repair or replace any improperly sealed joints.

B. Where there is evidence of vapor barrier failure or “wet” insulation after installation, the damaged insulation shall be removed, duct surface shall be cleaned and dried and new insulation shall be installed.

3.04 DUCTWORK INSULATION APPLICATION AND THICKNESS SCHEDULE

Ductwork System	Application	Insulation Type	Insulation Thickness

Ductwork System	Application	Insulation Type	Insulation Thickness
Supply Air (Hot, Cold, Combination)	Outside of Mechanical Rooms	D1	2"
	Inside of Mechanical Rooms	D2	1-1/2"
Supply Air Diffusers	Top of Diffuser	D1	2"
Return Air Sound Boots/Elbows	All	D3	1"

END OF SECTION 23 07 13

SECTION 23 22 13 – STEAM AND STEAM CONDENSATE PIPING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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.

1.02 SUMMARY

A. Perform all Work required to provide and install steam and condensate pipe, valves and fittings indicated by the Contract Documents with supplementary items necessary for the proper installation of the steam and condensate piping systems.

1.03 REFERENCE STANDARDS

A. The latest published edition of a reference 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 and as noted in this Section:

1. ANSI/ASME SEC 9 - Welding and Brazing Qualifications.

2. ANSI/ASME SEC B31.9 - Building Services Piping.

3. ANSI/AWS D10.12 – Guide for Welding Mild Steel Pipe.

4. ASTM A234 – Pipe Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service.

5. ASME B36.1 – Standardization of dimensions of welded and seamless wrought steel pipe for high or low temperatures and pressures.

1.04 QUALITY ASSURANCE

A. Valve manufacturer’s name and pressure rating shall be marked on valve body.

B. All valves of the same type shall be provided from same manufacturer.

C. All fittings of the same type (threaded or welding) shall be provided from same manufacturer.

D. All flanges shall be from same manufacturer.

E. Welding Materials and Procedures: Conform to Chapter V, ANSI/ASME SEC B31.9 and applicable state labor regulations.

F. Welders Certification: In accordance with ANSI/AWS D10.12.

1.05 SUBMITTALS

A. Product Data:

1. Include data on pipe materials, pipe fittings, valves, and accessories.

B. Record Documents:

1. Include welder's certification of compliance with ANSI/AWS D10.12 and ANSI/ASME B31.9.

2. Submittal data for all fittings and flanges shall include a letter signed by an official of the manufacturing company certifying compliance with these Specifications.

PART 2 - PRODUCTS

2.01 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. Wall, Floor and Ceiling Plates:

1. Provide chrome-plated brass floor and ceiling plates.

C. Piping System Classification:

1. Piping systems designed for steam pressure below 25 psig are low-pressure steam systems. Piping systems designed for steam pressures from 25 psig up to and including 125 psig are medium-pressure steam. Systems 126 psig and above are high-pressure steam.

2. Distribution piping complying with Thermal Energy Cooperative (TECO) requirements is considered high-pressure steam.

D. Piping Materials:

1. Sizes as scheduled and shown on the Drawings are nominal pipe sizes unless otherwise indicated.

2. All pipe and fittings shall be manufactured by a domestic company.

3. All brass and bronze piping components shall have no more than 15 percent zinc content.

E. Threaded Fittings:

1. All threaded fittings shall be USA factory made wrought carbon or alloy steel threaded fittings conforming to ASTM A234 or malleable iron threaded fittings conforming to ASME/ANSI B16.3.

2. Manufacturers: Grinnell, Tube Turn, Weld Bend Hackney, Taylor Forge, Ladish Company.

3. Each fitting shall be stamped as specified by ANSI B16.3.

F. Welded Fittings:

1. All weld fittings shall be USA factory made wrought carbon steel, butt welded fittings conforming to ASTM A234 or ASME B16.9.

2. Manufacturers: Grinnell, Tube Turn, Weld Burn Hackney, Taylor Forge, Ladish Company.

3. Each fitting shall be stamped as specified by ANSI B31.9.

G. Flanges:

1. 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 A1-191 Grade I or II or A-105 as made by Tube Turn, Hackney or Ladish Company. Slip on flanges shall not be used. Complete test reports may be required for any fitting selected at random.

2. Flanges shall have the manufacturer's trademark permanently identified in accordance with MSS SP-25.

3. Bolts used shall be carbon steel bolts with semi-finished hexagon nuts of American Standard Heavy dimensions. All-thread rods are not an acceptable substitute for flange bolts. Bolts shall have a tensile strength of 60,000 psi and an elastic limit of 30,000 psi.

4. All flanges shall have gaskets. Place gasket between flanges of flanged joints. Gaskets shall fit within the bolt circle on raised face flanges and shall be full face on flat face flanges.

H. Gaskets:

1. Gaskets shall be placed between the flanges of all flange joints. Such gaskets shall be ring form gaskets fitting within the bolt circle of their respective flanges.

2. All gaskets used on steam system shall be Flexitallic Style CG, AP1061 spiral wound 30455 with Grafoil fill as manufactured by Garlock or approved equal, regardless of pipe size and pressure.

3. 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.

2.02 PIPE

A. High Pressure Steam and Trapped Condensate Piping:

1. Pipe 2 inches and smaller: Carbon steel, ASTM A53, Grade B, seamless, Schedule 80.

a. Fittings: Forged steel, ASTM A105, socket weld, 300 lb.

b. Joints: Socket weld.

c. Unions: Forged steel, ASTM A105, socket weld, 3000 lb., stainless steel seats.

d. Gaskets: Flexitallic Style CG, API 601 sprial wound 304SS with Grafoil Fill or accepted substitution.

e. Cathodic Protection Gaskets: 1/16 inch thick Sealon by Ameriflex. Specify OD and ID of pipe and flanges. Bolt holes to be ¼ inch oversized.

2. Pipe 2-1/2 inches and larger: Carbon steel, ASTM A53, Grade B, seamless; standard weight for steam, and ERW schedule 80 for condensate.

a. Fittings: Carbon steel, ASTM A234 WPB, seamless welding fittings, standard weight for steam, Schedule 80 for condensate.

b. Joints: Butt weld.

c. Flanges: 300 lb., ANSI forged carbon steel, ASTM A181 Class 70, weld neck raised face.

d. Gaskets: Flexitallic Style CG, API 601 spiral wound 304SS with Grafoil Fill or accepted substitution.

e. Cathodic Protection Gaskets: 1/8 inch thick Sealon by Ameriflex. Specify OD and ID of pipe and flanges. Bolt holes to be ¼ inch oversized.

B. Medium Pressure Steam and Trapped Condensate Piping:

1. Pipe 2 inches and smaller: Carbon steel, ASTM A53, Grade B, seamless, Schedule 80.

a. Fittings: 125 lb., cast iron, screwed, conforming to ANSI B16.4. Thread-o-lets may be used when the branch line is 1/3 the main size or less.

b. Joints: Screwed.

c. Unions: Class 300 malleable iron.

2. Pipe 2-1/2 inches and larger: Carbon steel, ASTM A53, Grade B, seamless, standard weight for steam, and ERW schedule 80 for condensate.

a. Fittings: ASTM A234, Grade WPB, ANSI B16.9; butt welding type, standard weight for steam, Schedule 80 for trapped condensate. Thread-o-lets may be used when the branch line is one-third the main size or less.

b. Joints: Butt weld.

c. Flanges: Class 150, ANSI B16.5, forged carbon steel, raised face. Materials in accord with ASTM A105, Grade II weld neck.

C. Low Pressure Steam and Trapped Condensate Piping:

1. Pipe 2 inches and smaller: Carbon steel, ASTM A53, Grade B seamless, Schedule 40 for steam, Schedule 80 for condensate.

a. Fittings: 125 pound black cast iron. Thread-o-lets may be used when the branch line is one-third the main size or less.

b. Joints: Threaded.

c. Unions: Class 300 malleable iron.

2. Pipe 2-1/2 inches and larger: Carbon steel, ASTM A53, Grade B, seamless, standard weight for steam, and ERW schedule 80 for condensate.

a. Fittings: Butt weld, conforming to ASTM A234, Grade WPB, ANSI B16.9, standard weight for steam, Schedule 80 for trapped condensate.

b. Joints: Butt weld.

c. Flanges: Class 150, ANSI B16.5, forged steel, raised face. Materials in accord with ASTM A105, Grade II, weld neck.

D. Condensate Piping (Building) – Return and Pumped Return:

1. All piping shall be ERW extra strong black steel piping.

2. Fittings on piping 2-1/2 inches and larger shall be extra heavy butt welding type. Flanges shall be 150 lb. welding neck type. Extra strong Weld-o-lets, Thread-o-lets or shaped nipples may be used only when takeoff is one-third or less nominal size of main.

3. Screwed fittings around traps and for piping 2 inches and smaller shall be 125 lb. black cast iron (300 lb. for unions).

E. TECO Condensate and Pumped Return Piping:

1. Pipe 2 inches and smaller: Carbon steel, ASTM A53, Grade B, seamless, Schedule 80.

a. Fittings: Forged steel, ASTM A105, socket weld.

b. Joints: Socket weld.

c. Flanges: 150 lb. ANSI forged carbon steel, ASTM A181, Class 70, socket weld with Flexitallic Style CG Gasket, API 601 spiral wound 304SS with Grafoil Fill or accepted substitution.

d. Cathodic Protection Gaskets: 1/8 inch thick Sealon by Ameriflex. Specify outside diameter (OD) and inside diameter (ID) of pipe and flanges. Bolt holes to be ¼ inch oversized.

2. Pipe 2-1/2 inches and larger: Carbon steel, ASTM A53, Grade B, ERW, Schedule 80.

a. Fittings: 150 lb. ANSI, forged carbon steel, ASTM A181, Class 70, weld neck.

b. Joints: Butt weld, beveled.

c. Flanges: 150 lb. ANSI, forged carbon steel, ASTM A181, Class 70, weld neck with Flexitallic Style CG gasket, API 601 sprial wound 304SS with Grafoil Fill or accepted substitution.

d. Cathodic Protection Gaskets: Ameriflex. Specify OD and ID of pipe and flanges. Bolt holes to be ¼ inch oversized.

F. Low and Medium Pressure Clean Untreated Steam (304 Stainless Steel):

1. Pipe 2 inches and smaller: ASTM A312, TP 304, Schedule 40, seamless stainless steel.

a. Fittings: ASTM A182, Gr. F304, ANSI B16.11, 3000 lb. socket-weld.

b. Unions: 3000 lb socket-weld, stainless steel ground joint.

2. Pipe 2-1/2 inches and larger: ASTM A312, TP 304, Schedule 40, seamless stainless steel.

a. Fittings: ASTM A403, Gr. WP304/ANSI 16.9, Butt-weld.

b. Unions: None

c. Flanges: ASTM A182, Gr. F304, ANSI B16.5, 150 lb. standard with 1/16 inch raised face, serrated face finish and welding neck.

d. Bolts: Stud bolts, ASTM A193, Gr. B7.

e. Nuts: ASTM A194, Gr. 2H.

G. Equipment Drain Piping:

1. All factory fabricated or field erected steam equipment or apparatus that require drains shall be connected with adequately sloped drain line routed to a floor drain.

2. All drain piping shall be one-inch minimum diameter or larger as indicated on the Drawings or required by equipment. Such piping shall be standard weight galvanized steel pipe with galvanized malleable iron screw tees at each change in direction; or Type K, hard drawn copper tubing with threaded joints and fittings.

3. Install screw plug in unused openings for access to rod and clean.

2.03 VALVES

A. General:

1. All valves used in 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 approval by the Owner must be secured for the use of alternative materials.

2. Manufacturers: NIBCO, Crane, Velan, Williams and Vogt.

3. All ductile Iron body valves shall have pressure containing parts constructed of ASTM A-395. Ductile iron stem material shall meet 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.

4. 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 inch to 6 inch. Sizes 8 inch 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 percent chromium A-182-F6 stainless. Handwheels shall be A47 Grade 35018 malleable iron or Ductile Iron ASTM A536.

5. 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.

6. 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 inches and larger which may have either malleable iron or ASTM A-126 Class B, gray iron hand wheels.

7. 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.

8. Valves 6 inches 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 bypass valve assembly.

9. Valve Operator: Provide valve chain operator type on all shutoff valves shown on the Drawings that are 7'-6" above finished floor and higher. Chain operator shall be chain wheel of cast iron or malleable iron and designed to provide positive grip on wheel. Provide chain guide to prevent chain from slipping or jumping on wheel. Employ rust-proof chain complete with closing link of sufficient length to operate at 6'-6" above floor level.

B. Gate Valves:

1. High Pressure Steam and Trapped Condensate:

   a. Socket Welded Pipe: 800 psig forged steel, welded bonnet, bolted gland, outside screw and yoke. Thread ends Vogt Ser. 2801 or socket weld Vogt 2801 SW.

   b. Welded Pipe: Class 300 OS&Y, bolted flexible wedge disc. Crane Fig. No. 33 welded and flanged.

2. Medium and Low Pressure Steam and Trapped Condensate:

   a. Threaded Pipe: 150 lb., screwed, bronze gate, rising stem, union bonnet, NIBCO T-134.

   b. Welded Pipe: 150 lb. flanged OS&Y gate valve ductile iron, NIBCO F-637-31.

3. Building Condensate Return and Pumped Return:

a. Threaded Pipe: 150 lb., screwed, bronze gate, rising stem, union bonnet, NIBCO T-134.

b. Welded Pipe: 125 lb. flanged OS&Y gate valve ductile iron, NIBCO F-637-31.

4. TECO Pumped Condensate Return:

a. Socket Welded Pipe: 800 lb. forged steel, socket weld, Vogt 2801 SW or threaded Vogt 2801.

b. Welded Pipe: 150 lb. carbon steel, butt welding ends (flanged ends where designated), OS&Y bolted bonnet, flexible wedge disc. Crane No. 47 ½ XU welded, 47 XU flanged.

5. Clean Steam:

a. Socket-welded Pipe: Stainless steel body, flanged, stainless steel solid wedge, stellite seats, rising stem, union bonnet, malleable iron handwheel impregnated Teflon packing, Class 150 (150 psi WP steam), Williams Figure S15F6-316.

b. Welded Pipe: Stainless steel body, flanged, stainless steel solid wedge, stellite seats, impregnated Teflon packing, Class 150 (150 psi WP steam), equal to Williams Figure S15F6-316.

c. Drain valves: Use gate valve as specified above with hose thread adapter. Provide ¾ inch minimum drain valve size except strainer blowdown valves to be blowdown connection size.

C. Globe Valves:

1. High Pressure Steam and Trapped Condensate:

a. Manufacturers: NIBCO, Crane, Williams, Vogt, Velan.

b. Socket Welded Pipe: 800 psig forged steel, welded bonnet, bolted gland, outside screw and yoke. Thread ends Vogt Ser. 2821 or socket weld Vogt 2821 SW.

2. Medium Pressure Steam and Trapped Condensate:

a. Threaded Pipe: 200 lb., screwed, bronze globe valve, rising stem, with 500 Brinnell hardness plug disc and seat ring. NIBCO T-256-AP.

b. Welded Pipe: 150 lb. Flanged OS&Y globe valve ductile iron, NIBCO F-738-31.

3. Low Pressure Steam and Trapped Condensate:

a. Threaded Pipe: 200 lb., screwed, bronze globe valve, rising stem, with 500 Brinnell hardness plug disc and seat ring. NIBCO T-256-AP.

b. Welded Pipe 150 lb flanged OS&Y globe valve Ductile Iron NIBCO F-738-31.

4. Building Condensate Return and Pumped Return:

a. Threaded Pipe: 200 lb., screwed, bronze globe valve, rising stem, with 500 Brinnell hardness plug disc and sear ring. NIBCO T-256-AP.

b. Welded Pipe: 150 lb. flanges OS&Y globe valve Ductile Iron NIBCO F-738-31.

5. Clean Steam:

a. Socket-welded Pipe: Stainless steel body, flanged, stainless steel disc, stellite seats, impregnated teflon packing, union or screw-over bonnet, malleable iron handwheel Class 150 (150 psi WP steam), Williams Figure S152F6-316.

b. Welded Pipe: Stainless steel body, flanged, stainless steel disc, stellite seats, Class 150, (150 psi WP steam), Williams Figure S152F6-316 approved equivalent model by listed manufacturers.

D. Check Valves:

1. High Pressure Steam and Trapped Condensate:

a. Socket Welded Pipe: 800 lb., forged steel, socket weld, stainless steel seat and disc, swing check. Crane No. 3682X or accepted substitution.

b. Welded Pipe: Class 300 carbon steel, bolted cover, weld end (flanged end where designated), stainless steel seat and disc, swing check, 147XU flanged.

c. Manufacturers: NIBCO, Crane, Williams, Velan, Vogt.

2. Medium Pressure Steam and Trapped Condensate:

a. Threaded Pipe: 150 lb., screwed, horizontal swing check valve with screwed cap. NIBCO T-433-B.

b. Welded Pipe: 150 lb. flanged horizontal, swing check valve, ductile iron with bolted cap. NIBCO F938-31.

3. Low Pressure Steam and Trapped Condensate, and Building Condensate Return, and Pumped Return:

a. Threaded Pipe: 150 lb., screwed, horizontal swing check valve with screwed cap NIBCO T-433-B.

b. Welded Pipe: 150 lb. flanged horizontal, swing check valve, ductile iron with bolted cap. NIBCO F938-31.

4. TECO Pumped Condensate Return:

a. Socket Welded Pipe: Class 600 steel body, stainless steel swing check. Crane 175-1/2XU.

b. Welded Pipe: Class 150 swing check, stainless steel trim. Crane 147-1/2 XU welded, Crane 147 flanged.

5. Clean Steam:

a. Socket-welded Pipe: Stainless steel body, flanged, stainless steel disc, Class 150 (150 psi WP steam), Williams, Powell or Velan equal to Williams Figure S151F6-316.

b. Welded Pipe: Stainless steel body, flanged, stainless steel disc, Class 150 (150 psi WP steam), Williams Figure S151F6-316.

E. Ball Valves:

1. Two-piece bronze body rated at 150 psi steam, TFE seats, stainless steel ball and stem. NIBCO T-585-70-66.

2. The following manufacturers are acceptable if they comply with the specification: NIBCO, Apollo, or Watts.

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. 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.

C. Prepare piping connections to equipment with flanges or unions.

D. After completion, fill, clean and treat systems.

3.02 WELDING OF STEAM SYSTEM PIPING

A. Steam and condensate piping and fittings shall be welded and fabricated in accordance with the latest edition of ASME/ANSI the latest editions of Standards B31.9 for all systems. Machine beveling in shop is preferred. Field beveling may be done by flame cutting to recognized standards.

B. Ensure complete penetration of deposited metal with base metal. Provide filler metal suitable for use with base metal. 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 is not permitted.

C. 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.

D. No weld shall project into 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.

E. Remove all split, bent, flattened or otherwise damaged piping from the Project Site.

F. Remove dirt, scale and other foreign matter from the inside of piping, by swabbing or flushing, prior to the connection of piping sections, fittings, valves or equipment.

G. Schedule 40 pipe shall be welded with not less than three passes including one stringer/root, one filter 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.

3.03 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. Pipe Installation:

1. Direct connection of a steam exhaust, blowoff or drip pipe shall not be made with the building drainage system. Discharge into the building drainage system shall be at a temperature not higher than 140 degrees F. When higher temperatures exist, approved cooling methods shall be provided.

2. All the various piping systems shall be made up straight and true and routed in an orderly manner, plumb and parallel to the building structure. Install piping to conserve building space. Coordinate location with other trades and do not interfere with use of space for other work.

3. Piping shall follow as closely as possible the routes shown on Drawings, which take into consideration conditions to be met at the Project Site.

4. Should any unforeseen conditions arise, lines shall be changed or rerouted after proper approval has been obtained.

5. All piping shall be installed with due regard to expansion and contraction and to prevent excessive strain and stress in the piping, in connections, or in equipment to which the lines are connected.

6. Group piping whenever practical at common elevations.

7. Slope piping and arrange system to drain at low points. Use eccentric reducers to maintain bottom of pipe level.

8. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welding.

9. Provide clearance for installation of insulation, and access to valves and fittings.

10. Prepare pipe, fittings, supports, and accessories for finish painting.

11. Procedure of Assembling Screw Pipe Fittings:

a. All screw joints shall be made with taper threads, properly cut.

b. Joints shall be made tight with Teflon-based compound appropriate to the medium, material, and temperature range of the system. Teflon tape is not permitted.

c. Compound shall be applied to the pipe threads only and not to fittings.

d. When threads are cut on pipes, the ends shall be carefully reamed to remove any burrs.

e. Before installing pipe that has been cut and threaded, lengths of pipe shall be upended and hammered to remove all shavings and foreign material.

D. Valve Installation:

1. Locate all valves 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 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 at a minimum 30 degree angle above the horizontal position. All valves must be true and straight at the time the system is tested and inspected for final acceptance. Install valves as nearly as possible to the locations indicated in the Drawings. Any change in valve location must be so indicated on the Record Drawings.

2. Equipment, valves, expansion joints, relief devices, strainers, etc., must be removed or isolated during the test if the pressure/force ratings of the devices are not as high as that specified for the test. Piping shall be drained and protected any time ambient temperature is below freezing.

3. 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.

4. Provide access where valves and fittings are not exposed. Coordinate size and location of access doors with architectural drawings.

5. At the end of one year, period spot checks will be made and should the valve packing show signs of hardening or causing stem corrosion, 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.

3.04 CLEANING AND FLUSHING OF STEAM SYSTEMS

A. General:

1. Thoroughly clean steam and condensate systems before placing into operation to rid systems of rust, dirt, piping compound, mill scale, oil, grease, any and all other material foreign to water being circulated.

2. Exercise extreme care during construction to prevent dirt and other foreign matter from entering 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.

3. 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. Provide only chemical products that are acceptable under State and local pollution control regulations.

4. Add a temporary line with drain and isolate the building steam and condensate piping from the campus/building distribution piping to allow for proper circulation and cleaning of new piping in the new or modified building system.

5. Clean systems with a chemical compound specifically formulated for the purpose 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.

6. Final connection shall not be made to the campus/building loop system until the Chemical Contractor has filed with the Owner's representatives, a report stating that the systems are clean.

B. MD ANDERSON Systems:

1. Clean piping systems thoroughly. Purge pipe of construction debris and contamination before placing the systems in service. Provide whatever temporary connections are required for cleaning, purging and circulating.

2. Install temporary strainers in front of pumps, tanks, water still, solenoid valves, control valves and other equipment where permanent strainers are not indicated. Where permanent strainers are indicated, assure that the strainers are installed and screens are in place and are cleaned. Keep temporary strainers in service until the equipment has been tested, then replace straining element with a new strainer and clean and deliver the old straining elements to Owner. Fit strainers with a line size blow-off valve.

3. Circulate a chemical cleaner in steam and condensate piping system to remove mill scale, grease, oil and silt. Circulate chemical cleaner for 48 hours, flush system and replace with clean water. Dispose of chemical solution in accordance with local codes. When the chemical cleaning is complete, remove, clean and reinstall all permanent screens. Notify Owner so that the reinstallation of clean strainer screens may be witnessed.

3.05 TESTING

A. Weldings:

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. Contractor shall be responsible for all labor, material and travel expenses involved in the re-inspection and retesting of any welds found to be unacceptable. In addition, Contractor shall be responsible for the costs involved in any and all additional testing required or recommended by ASME/ANSI Standards 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.

B. Pipe Pressure:

1. Equipment, valves, vents, expansion joints, pressure reducing stations, etc., must be removed or isolated from test pressure and/or forces if the devices are not rated for the test pressures. All water must be drained from all steam system piping and devices after test completion. Piping shall be drained and protected any time the ambient is below freezing.

2. The following lines shall be tested at the stated pressure for the length of time noted:

Line	Testing Medium	Testing Pressure (psig)	Time in Hours
Steam M.P. & L.P.	Water	150	24
Steam Condensate M.P.	Water	150	24
Steam Condensate H.P.	Water	150	24
Pumped Condensate Return	Water	150	24

3. Where leaks occur, repair pipe and repeat tests. No leaks shall be corrected by peening. Remove and replace defective piping and joints.

4. Condensate Return to TECO:

a. Dump condensate until acceptable to TECO. Fifteen (15) micromhos or less conductivity for the TECO Main Central Plant and 200 micromhos or less conductivity for the TECO South Main Plant is acceptable to TECO. TECO will test condensate samples and will notify Contractor when condensate is acceptable to return.

b. Each time the steam system is cycled, the condensate must again be tested.

c. After the above requirements have been met, the building will be scheduled to have steam services turned on.

d. Unnecessary cycling or intermittent use of thermal systems will not be permitted.

END OF SECTION 23 22 13

SECTION 23 22 30 – STEAM AND STEAM CONDENSATE SPECIALTIES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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.

1.02 SUMMARY

A. Perform all Work required to provide and install the following steam specialties indicated by the Contract Documents with supplementary items necessary for their proper installation.

1. Steam traps.
2. Flash tanks.
3. Condensate return pumping units.
4. Steam pressure-reducing valves.
5. Steam relief valves.
6. Steam safety valve discharge elbows.
7. Steam muffler attachments.
8. Steam pipe anchors.
9. Steam pipe guides.
10. Drip traps.
11. Sediment strainers.
12. Automatic air vents.
13. Gauges and gauge connections.
14. Thermometer and thermometer wells.
15. Steam orifice meters.
16. Steam integrating (condensate) meters.

1.03 REFERENCE STANDARDS

A. The latest published edition of a reference 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. ASTM A105 - Forgings, Carbon Steel, for Piping Components.

2. ASTM A216 - Steel Casings, Carbon, Suitable for Fusion Welding, for High Temperature Service.

3. ASTM A395 - Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures.

4. ASME B31.9 - Building Services Piping.

1.04 QUALITY ASSURANCE

A. All specialties of the same type shall be provided from the same manufacturer.

B. Manufacturer’s name and pressure rating marked on body of each device.

1.05 SUBMITTALS

A. Product Data:

1. Submit Shop Drawings, wiring diagrams and product data on all steam specialties.

B. Record Documents:

1. Shop Drawing submittal of traps shall contain an itemized list with a tabulation of the load, trap type and trap size.

PART 2 - PRODUCTS

2.01 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.

2.02 MANUFACTURERS

A. Steam Traps:

1. Armstrong.

2. Spirax Sarco.

3. Spence.

B. Flash Tanks:

1. Penn Separator.

2. Wendland.
3. Wilson.

C. Condensate Pumping Units:
1. Skidmore.
2. Aurora.
3. Mepco.
4. Spirax Sarco

D. Pressure Powered Condensate Pumps:
1. Armstrong.
2. Spriax Sarco.
3. Spence

E. Steam Pressure Reducing Valves:
1. Leslie.
2. Spence.
3. Spirax Sarco.
4. Fisher.

F. Steam Relief Valves:
1. Consolidated Type 1511.
2. Spirax Sarco 211S or SV Series.
3. Spence Engineering 41.
4. Crane 2501.

G. Steam Discharge Pan Elbows:
1. Grinnell Fig. No. 1538F.
2. Spirax Sarco DPE.
3. Spence Engineering DPE.

H. Steam Muffler Attachment:
1. Consolidated Type 1441.
2. Wright Austin 40EHC.

I. Automatic Air Vents:

1. Spirax Sarco 13W

2. Spence Engineering.

J. Sediment Strainers:

1. Muller Steam Specialty.

2. Keckley.

3. Spirax Sarco

K. Gauges:

1. Ashcroft No. 1279-R Duragauge.

L. Thermometer and Wells:

1. Weksler Industrial Thermometers.

2. Ashcroft 1279-R.

3. Conbraco 20-150.

M. Steam Condensate Integrating Meters:

1. Daniel Model CRA turbine meter.

2. Winters.

N. Vacuum Breakers:

1. Spirax Sarco VB

2. Kadent Johnson VB

2.03 INVERTED BUCKET TRAPS

A. Cast iron or semi-steel body and bolted cover for 250 psig working steam pressure (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.

2.04 FLOAT AND THERMOSTATIC TRAPS

A. ASTM A126, cast iron or semi-steel body and bolted cover for 125 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.

B. Float and thermostatic traps for clean steam service shall have Type 316L stainless steel bodies, covers, and all internal components.

2.05 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, and ¼ inch blow down valve.

D. Clean steam thermostatic traps for non-critical process areas shall be self-adjusting balanced pressure type capable of operating close to saturated steam temperature. All wetted parts shall be manufactured from Type 316L stainless steel. Traps shall be maintainable, of sealed construction, and shall be completely self-draining when installed in vertical pipeline.

2.06 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.

2.07 CONDENSATE PUMPING UNITS

A. Condensate pumping units shall be duplex horizontal type to include receiver, interstrainer, duplex pumps, float switches, control panel and accessories. Pumps shall be single-stage centrifugal type with head capabilities and flow rates as scheduled. Pumps shall be capable of pumping 212 degrees F condensate at the controlled water level.

B. Unit shall be complete with 3/16 inch thick steel receiver with rust resistant coating and shall have magnesium anode protection.

C. Each motor shall be provided with safety switch and a magnetic starter with current overload relays providing overload and undervoltage protection. These magnetic starters shall be provided with three-pole overload protection.

D. Pumps shall be bronze fitted throughout. Bearings shall be such as to protect them from dust and corrosion.

E. Each unit shall have fully automatic control by a float and float switch. An alternator switch shall be provided as a part of the unit to automatically alternate pumps at the end of each pump operation.

F. All accessories and auxiliaries, such as pressure gauges, water gauge glasses, etc., shall be installed complete.

G. Electrical wiring and controls shall be complete so 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 shall be mechanical type. If electrical alternator is used, it shall be Allen Bradley.

H. Each pump shall have stainless steel shafts. Furnish an extra set of Viton seals. Each duplex pump shall have two-point power connections (not a single point) and integral shut-off valves upstream and downstream of each pump.

I. Capacities and electrical characteristics shall be as scheduled on Drawings.

J. Provide high level alarm switch complete with transformer, bell and one set of 120 volt AC rated, normally open contacts for connection to the building automation system (BAS).

K. Control Cabinet: NEMA II enclosure, UL listed, with piano hinged door, grounding lug, combination magnetic starters with overload relays, circuit breakers and cover interlock, electric alternator, AUTO-OFF switch, test button, terminal strip, high level alarm light, acknowledge button, alarm horn and fusible control circuit transformer. Provide a normally open auxiliary alarm contact for connection to the BAS.

2.08 PRESSURE POWERED CONDENSATE PUMPS (PUMPING TRAP)

A. Pressure powered condensate pump (pumping trap) operated by steam, compressed air, or other pressurized gas, which does not require any electrical energy, and is safe for use in explosive atmospheres. Spring assisted float mechanism with no external seals or packing.

B. Stainless steel float and operating mechanism, inconel or stainless steel springs, and stainless steel trim.

C. Cast iron or fabricated steel bodies shall be S150 psi ASME rated and steel bodies shall be stamped.

D. Provide with factory-attached stainless steel swing type check valves on inlet. and stainless steel spring type check, Durable type SCV, on discharge.

2.09 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 steam pressure fluctuations.

B. Valve bodies shall be cast steel for high-pressure service and cast iron for medium and low-pressure service. Stations having a total steam capacity less than 3000 pounds per hour shall consist of one PRV with a minimum rangeability of 20:1. Discharge pressure shall be adjustable to any value between 10 percent and 75 percent of the supply pressure. Stations having a total steam capacity greater than 3000 pounds per hour shall consist of two PRV’s sized with a 1/3, 2/3 or 50 – 50 percent capacity split as indicated by the Drawings, and each capable of a minimum control ranageability of 20:1.

C. High-pressure PRV's shall be pneumatically actuated rotary control valves. The valve bodies shall be cast carbon steel with integral 300-pound ANSI flanged ends. Valve plug design shall be eccentric rotary action offset to the shaft centerline. Seat ring shall be available in full port as well as 60 percent, 40 percent and 20 percent reduced port. Plug and seat ring shall be 316 stainless steel with satellite overlay. Stem packing shall be carbon graphite. Valve actuators shall be suitable for 60 psi control air and shall be selected to provide tight shut-off without air assist. Each actuator shall be provided with an electro-pneumatic valve positioner with gauges, control air regulator and 3-way 120VAC solenoid valve. The positioner, air regulator and 3-way solenoid valve shall be factory installed and connected with 3/8 inch outside diameter (OD) stainless steel tubing. The 3-way solenoid valve shall be rated for continuous duty and shall be connected to vent on loss of power.

D. When necessary to achieve required noise attenuation, high-pressure PRV's shall be provided with silencing orifice plates for noise attenuation. The high-pressure valves and orifice plates shall be sized and selected so as to minimize noise generation, including pipe insulation, to 85 dBA or less at three (3) feet from the valve. The silencing orifice shall be of 300 series stainless steel and shall be designed to install between two 300-pound ANSI flanges in the expanded section of pipe downstream of the PRV.

E. Each high-pressure PRV station shall be supplied with an electronic pressure controller and pressure transducer. The pressure transducer shall be mounted with a block valve and coil siphon in the common downstream header of the PRV station, and shall be wired by the BAS Provider back to the electronic pressure controller with shielded cable. The electronic controller shall be mounted in a NEMA 4X fiberglass enclosure. The enclosure shall include a 120 VAC circuit breaker, 24 VDC power supply and all other control relays necessary to provide the control requirements. The electronic controller shall provide a 4-20mA signal to the electro-pneumatic valve positioner(s) to modulate the control valves to maintain the system pressure. The controller shall be configured to accept a 4-20mA input for remote set point. The controller enclosure shall provide 120VAC to the 3-way solenoid valve(s). The controller shall have a high pressure limit that will interrupt the control signal to the valve(s) and de-energize the 3–way solenoid valve(s). Provide a normally open auxiliary high pressure alarm contact for connection to the BAS. Provide terminal points for all connections.

F. Medium and low-pressure PRVs shall be single-seated, pilot-operated valves with 250-pound cast iron bodies, stainless steel trim with renewable valve plugs and seats.

G. All pressure regulators 2-½ inches and larger shall have flanged connections. Pressure regulators 2 inches and smaller may have screwed connections. Unions shall be installed on each side of any screwed pattern regulators installed.

H. Each reducing valve shall be preceded by a sediment strainer complete with a full-sized blowoff valve with threaded end for hose connection.

2.10 STEAM RELIEF VALVES

A. Relief valves 2 inches and smaller shall have brass bodies and arranged for screwed connections. Such relief valves shall be Spence Type 41 or Spirax Sarco 211 Series safety valves for steam. Bushings shall not be used.

B. Relief valves 2-1/2 inches and larger for all medium and low pressure steam piping systems be arranged for flanged inlet and screwed outlet connections. Such relief valves shall be Spence Type 41 or Spirax Sarco SV Series, ASME Standard Cast Iron Safety Valves.

C. The pressure at which each relief valve shall open is designated on the Drawings. Specify the pressure at which each relief valve must be set. Each valve shall have a metal tag attached stamped with the valve identification plus the pressure setting. Each valve shall be sized at full steam flow through the PRV and discharge piping must be equal or greater than the steam relief valve outlet size.

D. Safety relief valve shall comply with ASME Section 1 or 8 as applicable. Provide Certificate of Conformance per ASME standard.

2.11 DRIP TRAPS

A. Traps shall be 3/4 inch traps unless specifically shown to the contrary, i.e., they shall have 3/4 inch inlet and outlet connections.

B. High-pressure drip traps shall have steel or 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, No. 300 Armstrong Traps, manufactured by Armstrong Machine Works. Capacity for discharging at least 3,500 pounds of condensate per hour when operating at a pressure of 250 pounds per square inch.

C. All drip traps used in medium pressure steam piping systems shall be 3/4 inch Armstrong No. 811 inverted bucket traps, with cast iron bodies and stainless steel trim.

D. Low-pressure traps shall be equal to Armstrong “A” or “B” series sized to handle 200 percent of the load with an operating differential pressure equal to 50 percent of the inlet steam pressure.

2.12 SEDIMENT STRAINERS

A. Sediment strainers in high pressure steam piping shall be cast steel 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.

B. For pipe sizes 2-1/2 inches and larger, flanged pattern sediment strainers shall be used. For pipe smaller than 2-1/2 inches, screwed pattern shall be used.

C. 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 inches and larger shall be flanged iron body strainers having bolted covers. These strainers shall be suitable for operating pressures as high as 125 psig.

E. Sediment strainers in low and medium pressure steam piping systems 2 inches and smaller shall be arranged for screwed pipe connections.

2.13 GAUGES AND GAUGE CONNECTIONS

A. Pressure gauges for interior steam systems shall be 4-1/2 inches with back connection when used on a panel; otherwise they shall have bottom connections. Each gauge shall be provided with Ashcroft carbon steel needle valve and a siphon rated for the steam pressure and temperature. The arrangement of the mechanisms shall conform to pressure ranges and details shown on the Drawings.

B. The dial graduation shall be 1.5 times the highest working pressure of the steam that the gauge is serving.

2.14 THERMOMETER AND THERMOMETER WELLS

A. Furnish and install thermometers of not less than 9 inch 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.

B. Thermometers shall be provided with range of 0 to 220 degrees F at hot water heat exchangers. The sensing element of the thermometer shall be at least one inch into the pipe.

C. Thermometer test wells shall be ¾ inch Weksler thermal wells, brass with stem of minimum length to extend beyond the mid-diameter of the pipe, 2-½ inch extension neck and brass screw plug. Wells shall be suitable for use of industrial type thermometers.

D. Indicating thermometers shall be Weksler industrial thermometers having stainless steel separable sockets and scales of the range suitable for steam pressures indicated on flow sheets.

2.15 STEAM CONDENSATE INTEGRATING METERS

A. Furnish and install turbine meter in the condensate return system as indicated on Drawings. Turbine meter to be installed to read GPM from all pumps.

B. Meter shall be constructed of stainless steel with stainless steel internal parts and tungsten carbide bearings:

1. Maximum Operating Range: 210 degrees F.

2. Pressure Range: 0 to 100 psig.

3. Maximum pressure drop: 4 psig.

4. Condensate Flow Rate: Engineer shall complete.

5. Output: 12 VDC.

6. Maximum Accuracy ± 0.05 percent over linear flow range.

7. Power Available: 12 VDC.

2.16 FINNED TUBE RADIATION

A. General: Supply and install finned tube radiation of the type, length and dimensions as shown on the Contract Documents. Finned tube radiation shall be the product of Engineered Air. All finned tube radiation components shall be cleaned and phosphatized to prevent corrosion. They shall be finished with a baked cactus gray enamel primer.

B. Copper-Aluminum Element: Tubing shall be 1-¼ inch nominal ID (1-3/8 inch OD) seamless copper. Fins shall be aluminum, 4-¼ inch x 4 inch, 0.015-inch thick with a stamped pattern for strength and rigidity. Fins shall have integral collars to provide even spacing and maximum heat transfer. Fins shall be firmly bonded to the tube by mechanical expansion. All copper-aluminum elements shall have 50 fins/foot. Tube ends shall be suitable for connecting with sweat fittings.

C. Element Brackets: Element brackets shall consist of a steel cradle mounted on a roller bearing, which will allow free and quiet element expansion. Element brackets shall be securely fastened to wall brackets or wall, on not more than 4-foot centers.

D. Dampers: Dampers shall be knob operated and have a screw-type control with a channel-type damper blade located behind the outlet grille. Damper mechanism shall provide complete adjustment between fully opened and fully closed positions.

E. Access Doors: Provide access doors where shown on Drawings. They shall consist of a surface-mounted 7 inch x 7 inch frame with a 6 inch x 6 inch continuous hinged door fitted with a slot operated cam lock. Flush-mounted factory-installed access doors are also acceptable.

F. Protective Covers: ½-inch diamond mesh, 18-gage expanded steel cover (Type WF-7) shall be provided. Covers should not contact element and shall be supported by combination bracket.

2.17 VACUUM BREAKERS

A. Vacuum breakers shall be used on all modulating or on/off heat exchangers and coils, except in vacuum return systems.

B. Vacuum breakers shall be of hardened ball check valve design with all working parts manufactured from stainless steel.

C. Bodies shall be made of brass or stainless steel and shall be suitable for operating conditions of 300 psig saturated steam.

PART 3 - EXECUTION

3.01 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. Install specialties in accordance with manufacturer’s instructions.

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 at an operating differential pressure equal to 50 percent of the inlet steam pressure unless noted otherwise.

E. Install thermostatic steam traps to drain condensate from steam radiation units, converters, and other similar terminal heating units.

F. Size steam traps to handle minimum of two times maximum condensate load of apparatus served.

G. Traps used on steam mains and branches shall be minimum 3/4-inch (20 mm) size.

H. Install steam traps with union or flanged connections at both ends.

I. Provide gate valve and strainer at inlet and gate valve at discharge of steam traps.

J. Provide minimum 10-inch (250 mm) long dirt pocket of same pipe sizes as apparatus return connection between apparatus and steam trap.

K. Remove thermostatic elements from steam traps or valve out during temporary and trial usage and until system has been operated and dirt pockets cleaned of sediment and scale.

L. 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.

M. Pressure reducing station shall be [one] [two] stage to produce flat reduced pressure curve over range of capacity.

N. Rate relief valves for pressure upstream of pressure reducing station, for full operating capacity. Set relief at maximum 20 percent above reduced pressure.

O. Terminate relief valves to outdoors. Provide drip pan elbow with drain connection to nearest floor drain.

P. When several relief valve vents are connected to a common header, header cross sectional area shall equal sum of individual vent outlet areas.

Q. Steam Safety Valve Discharge Elbows:

1. 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 effectively drain all condensate from the discharge side of all relief valves. No force shall be exerted on the safety valve by the discharge piping.

2. Provide temperature sensor mounted in steam safety valve piping in close proximity to steam pressure relief valve. Coordinate with Division 25 such that an alarm is initiated at the BAS upon a rise in temperature.

R. Steam Muffler Attachments:

1. At the point at which vent lines from safety valve discharge elbows terminate, a muffler attachment of the proper size shall be installed.

2. These muffler attachments shall be screwed pattern members.

S. Steam Pipe Anchors:

1. 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.

T. Steam Pipe Guides:

1. All steam piping systems shall be properly guided.

U. Drip Traps:

1. High-pressure drip trap assemblies shall be provided per the Contract Documents and where required to keep piping systems completely drained of condensate.

2. Where drip taps are installed in conjunction with 3 inch 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. The diameter of the drip pocket shall be the same size as the distribution line up to 4 inches in diameter. The diameter shall be half the size of the distribution line over 4 inches but never less than 4 inches.

3. 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. Each trap shall be provided with a valved test line and shall be preceded by a sediment strainer.

4. Condensate traps from coils, convertors, hot water generators, and all other devices where modulating steam valves are employed shall be of the float and thermostatic type. Installed traps with less than 12 inch of height between equipment outlet and trap inlet shall be sized for not less than 300 percent of the load. Each trap shall be provide with a ½ inch valve test line and shall be preceded by a sediment strainer. A vacuum breaker shall be supplied for these applications and it can be integral to the trap. Under no circumstances shall a float and thermostatic trap be installed in a manner to lift condensate up in a return line.

V. Sediment Strainers:

1. 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.

2. 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.

3. 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.

W. Automatic Air Vents:

1. Provide auto air vents with a pressure rating that is equal to system classification but not less than 125 psig. Provide shut-off valve to facilitate maintenance of air vent.

2. Locate all air vents and their discharge lines in accessible locations, preferably clustered.

X. Thermometer and Thermometer Wells:

1. 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. When installed in horizontal pipes, thermometers shall be installed in the side and not on top of the pipe.

2. Thermometer wells and thermometers shall be located where noted on the Drawings and where called for in other Specification Sections. Thermometer test wells shall only be installed in a vertical position in horizontal lines and at 45 degrees in vertical lines to hold a fluid in the well.

Y. Condensate Integrating Meters:

1. Meters 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.

Z. Condensate Pumping:

1. Install condensate pumping units on a housekeeping pad.

2. Install vent and overflow piping as detailed in the Drawings. Route the overflow pipe to a floor drain. Provide and pipe a receiver drain valve and pipe to the nearest floor drain.

3. Install spring assisted check valves in the discharge of each pump. Install globe valves for pump balancing in the discharge of each pump. Install gate valves downstream of the globe valves.

4. Pump discharge lines 1-1/2 inches and larger shall be piped to the condensate return piping with stainless steel flex connectors.

AA. Pressure Powered Condensate Pumps (Pumping Trap):

1. Do not install pumping traps on housekeeping pads (housekeeping pads reduce the filling head to the pump). Install the pump at the lowest possible point below the equipment that is being drained.

2. Where specified, provide an inlet condensate receiver. The receiver shall be an ASME vessel as shown on the Drawings. Install and support the receiver above the pumping trap unit. Route all condensate to be drain to the top on the receiver. The receiver shall be vented to atmosphere and shall also be supplied with a drain connection and drain valve.

3. The pumping trap body shall be provided with a gauge glass assembly.

4. When motive gas pressure is greater than 20 psig over the required discharge head, provide a PRV assembly to regulate motive gas pressure. The PRV assembly shall include an inlet block valve, y-strainer, PRV and pressure gauge assembly. When motive gas is steam, install a drip trap assembly upstream of the PRV. When motive gas is air or nitrogen, provide a spring loaded check valve downstream of the PRV.

5. Route the exhaust vent pipe of the pumping trap, and the receiver vent (when receiver is installed), to an atmospheric vent line, or, it may be routed 8 to 10 feet up and piped back down a minimum of 6 inches. Install a drain valve and drain line off the pumping trap unit and route to the nearest floor drain.

BB. Vacuum Breakers:

1. Vacuum breakers shall be installed in the supply side between the control valve and equipment.

2. Install in a vertical position with cap at top.

3. Mount the vacuum breaker on the highest point of the circuit.

4. Large coils or equipment may require more than one vacuum breaker to be fitted.

END OF SECTION 23 22 30

SECTION 23 31 00 – DUCTWORK

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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.

1.02 SUMMARY

A. Provide materials and installation for complete first class HVAC systems; install ductwork, flexible duct, hangers, supports, sleeves, flashings, vent flues, and all necessary accessories as indicated in the Contract Documents. Provide any supplementary items necessary for proper installation that make the systems operable, code compliant and acceptable to the authorities having jurisdiction.

1.03 REFERENCE STANDARDS

A. The latest published edition of a reference 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. ASHRAE - Handbook of Fundamentals; Duct Design.

2. ASHRAE - Handbook of HVAC Systems and Equipment; Duct Construction.

3. ASTM A 90 - Weight of Coating on Zinc-Coated (Galvanized) Iron or Steel Articles.

4. ASTM E 96 - Standard Test Methods for Water Vapor Transmission of Materials.

5. ASTM A 167 - Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.

6. ASTM A 525 - General Requirements for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process.

7. ASTM A 527 - Steel Sheet, Zinc-Coated (Galvanized) by Hot-Dip Process, Lock Forming Quality.

8. ASTM B209 - Aluminum and Aluminum Alloy Sheet and Plate.

9. NFPA 90A - Installation of Air Conditioning and Ventilating Systems.

10. NFPA 90B - Installation of Warm Air Heating and Air Conditioning Systems.

11. NFPA 96 - Installation of Equipment for the Removal of Smoke and Grease-Laden Vapors from Commercial Cooling Equipment.
12. NFPA 45 – Laboratory Ventilating Systems and Hood Requirements.
13. SMACNA – HVAC Duct Construction Standards.
14. SMACNA – Rectangular Industrial Duct Construction Standards.
15. SMACNA – Round Industrial Duct Construction Standards.
16. SMACNA – HVAC Air Duct Leakage Test Manual.
17. UL 181 - Factory-Made Air Ducts and Connectors.
18. Engineering Design Manual for Air Handling Systems, United McGill Corporation (UMC).
19. Assembly and Installation of Spiral Ducts and Fittings, UMC.
20. Engineering Report No. 132 (Spacing of Duct Hangers), UMC.
21. AWSD1.1 American Welding Society Structural Welding Code.

1.04 INSTALLER QUALIFICATIONS:

A. Company shall have minimum three years documented experience specializing in performing the work of this section.

B. Installation of HVAC systems shall be performed by qualified Journeyman.

1.05 DEFINITIONS

A. Low Pressure

1. 2 inch W.G. Pressure Class: Ductwork systems up to 2 inch w.g. positive or negative static pressure with velocities less than or equal to 1500 fpm.

B. Medium Pressure

1. 3 inch W.G. Pressure Class: Ductwork systems over 2 inch w.g. and up to 3 inch w.g. positive or negative static pressure with velocities less than or equal to 2500 fpm.
2. 4 inch W.G. Pressure Class: Ductwork systems over 3 inch w.g. and up to 4 inch w.g. positive or negative static pressure with velocities less than or equal to 2500 fpm.
3. 6 inch W.G. Pressure Class: Ductwork systems over 4 inch w.g. and up to 6 inch w.g. positive or negative static pressure with velocities less than or equal to 2500 fpm.

C. High Pressure

1. 10 inch W.G. Pressure Class: Ductwork systems over 6 inch w.g. and up to 10 inch w.g. positive or negative static pressure with velocities greater than 2500 fpm.

1.06 SUBMITTALS

A. Product Data:

1. Provide the following information for each sheet metal system furnished on the Project:

a. System name and type.

b. Duct system design pressure.

c. Duct material.

d. Duct gage.

e. Transverse joint methods.

f. Longitudinal seam type.

g. Sealant type.

h. SMACNA rectangular reinforcement type.

i. SMACNA intermediate reinforcement type.

j. SMACNA transverse reinforcement type.

B. Record Documents:

1. Submit Shop Drawings on all items of ductwork, plenums, and casings including construction details and accessories specified herein in accordance with Division 01. Ductwork construction details and materials used for duct sealant, flexible connections, etc. shall be submitted and approved prior to the fabrication of any ductwork.

2. [Option if no Shop Drawings are required: Prepare Shop Drawings for the purpose of coordination with other trades including structural, piping, plumbing, electrical, lighting, and architectural. When Shop Drawings are not required to be submitted for the Project, field sketches and shop tickets must be available to the Owner upon request. Changes required during construction to accommodate coordination issues will be performed at no additional cost to the Owner.]

3. Draw ductwork Shop Drawings on minimum 1/4 inch equal to one foot scale building floor plans and shall indicate duct sizes, material, insulation type, locations of transverse joints, fittings, ductwork bottom elevation, offsets, ductwork specialties, fire and fire/smoke dampers, and other information required for coordination with other trades. Clearly designate the following on the Shop Drawings:

a. Clearance dimensions between ducts and or location dimensions from walls, floors, columns, beams and large bore piping.

b. Duct materials i.e., stainless steel, galvanized steel, prefabricated fire rated ductwork pressure class ratings of ducts as defined within this specification.

c. Duct materials i.e., stainless steel, galvanized steel, prefabricated fire rated ductwork.

d. Fire and fire/smoke partitions.

4. Detail Drawings for mechanical rooms and air handling unit locations shall be submitted at a minimum scale of 1/4 inch equal to one foot shall also be included within the Shop Drawings.

5. Coordinate with all other trades and building construction prior to submitting Shop Drawings for review. Indicate location of all supply, return, exhaust, and light fixtures from approved reflected ceiling plans on Shop Drawings.

1.07 DELIVERY, STORAGE AND HANDLING

A. Deliver products to the Project Site and store and protect products under provisions of Division 01 and Division 20.

B. Protect materials from rust both before and after installation.

1.08 WARRANTY

A. All ductwork shown on the Drawings, specified or required for the air conditioning and ventilating systems shall be constructed and erected in a first class workmanlike manner.

B. The Work shall be guaranteed for a period of one (1) year from the Project Substantial Completion date 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 Owner at Contractor's expense.

PART 2 - PRODUCTS

2.01 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.

2.02 APPLICATION

A. Ductwork systems shall be constructed in accordance with the following Materials as a minimum standard. Refer to Drawings for any deviation from this Table.

AIR SYSTEM	**MATERIAL**	**MINIMUM PRESSURE CLASSIFICATION (1)**
Supply and Return Systems:		
Untreated Outside Air Intake (Louver) to AHU Plenum	304 Stainless Steel	Low Pressure
Treated Outside Air to AHU	Galvanized Steel	Medium Pressure
Single Zone FCU Supply	Galvanized Steel	Low Pressure
Single Zone AHU Supply	Galvanized Steel	Medium Pressure
Mixed Air (AHU Plenum)	Galvanized Steel	Medium Pressure
AHU Discharge/Vertical Supply Riser	Galvanized Steel	Medium Pressure
Vertical Supply Riser to Terminal Unit	Galvanized Steel	Medium Pressure
Terminal Unit Connection	Metal Flexible Duct	As Specified

AIR SYSTEM	**MATERIAL**	**MINIMUM PRESSURE CLASSIFICATION (1)**
Vivarium Supply Air Valve to Air Device	316L Stainless Steel (5)	Low Pressure
Exhaust Systems:		
Exhaust Air Device to Exhaust Distribution	Galvanized Steel (2)	Low Pressure
Exhaust Air Distribution	Galvanized Steel	Medium Pressure
General Exhaust Vertical Riser to Fan	Galvanized Steel	Medium Pressure
Tunnel Washer Exhaust	316L Stainless Steel	Medium Pressure(3)
Rack Washer Exhaust	316L Stainless Steel	Medium Pressure
General Lab Exhaust Air Device to Horizontal Distribution	Galvanized Steel	Low Pressure
Hood/Biosafety Cabinet Exhaust to Horizontal Distribution	316L Stainless Steel	Medium Pressure

AIR SYSTEM	MATERIAL	MINIMUM PRESSURE CLASSIFICATION (1)
Combination Lab and General Exhaust Horizontal Distribution (Serving General Exhaust and 3 or fewer CFHs)	316L Stainless Steel	Medium Pressure(4)
Combination Lab and General Exhaust Horizontal Distribution (Serving General Exhaust and 4 or more CFHs)	Galvanized Steel	Medium Pressure(4)
Combination Lab and General Exhaust Vertical Riser	Galvanized Steel	Medium Pressure(4)
Combination Lab and General Exhaust Riser to Filter Housing/Exhaust Plenum	Galvanized Steel	Medium Pressure(4)
Combination Lab and General Exhaust Fan to Exhaust Stack (including Exhaust Stack	316L Stainless Steel	Medium Pressure (4)
Vivarium General Exhaust Air Valve to Air Device	316L Stainless Steel (5)	Low Pressure

B. Notes to Table:

1. Positive pressure unless noted otherwise in Table.

2. Air device connections may be made with insulated flexible duct as specified herein.

3. Verify minimum pressure classification per NFPA 96 requirements.

4. Applies to exhaust system for general laboratory exhaust, fume hoods, and biosafety cabinets. Refer to Drawings for construction of any additional exhaust systems.

5. Where ductwork systems are subject to routine decontamination (HPV, Clidox, etc.), provide 316L stainless steel ductwork as indicated.

2.03 DUCTWORK MATERIAL AND CONSTRUCTION

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 on Drawings. All air distribution ductwork shall be fabricated, erected, supported, etc., in accordance with all applicable standards of SMACNA where such standards do not conflict with NFPA 90A and where class of construction equals or exceeds that noted herein.

B. Ductwork shall be constructed of G-90 coated galvanized steel of ASTM A653 and A924 Standards.

C. Minimum gage of round, oval or rectangular ductwork shall be 26 gage per SMACNA Standards.

D. All duct sizes shown on the Drawings are clear inside dimensions. Allowance shall be made for internal lining, where specified, to provide the required free area.

E. 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 future connections/phases, otherwise plastic covers are acceptable.

F. Except for specific duct applications specified herein, all sheet metal shall be constructed from prime galvanized steel sheets and/or coils up to 60 inches in width. Each sheet shall be stenciled with manufacturer's name and gage.

G. Sheet metal must conform to SMACNA sheet metal tolerances as outlined in SMACNA's "HVAC Duct Construction Standards."

H. Where ducts are exposed to view (including equipment rooms) and where ducts pass through walls, floors or ceilings; furnish and install sheet metal collars around the duct.

I. Spin-in fittings shall be as specified under Section 23 33 00 – Ductwork Accessories.

J. Duct Sealing: All ductwork, regardless of system pressure classification, shall be sealed in accordance with Seal Class A, as referenced in SMACNA Standards. All transverse joints, longitudinal seams, and duct wall penetrations shall be sealed.

1. 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 inches wide open weave fiberglass scrim tape. Sufficient additional sealant shall then be applied to completely embed the cloth.

2. Sealant shall be water based latex UL 181A-M sealant with flame spread of 0 and smoke developed of 0. Sealants shall be Hard Cast Iron Grip 601, Ductmate Pro Seal, Foster 32-19, Childers CP-146 or Design Polymerics DP 1010.

3. Scrim tape shall be fiberglass open weave tape, 3 inches wide, with maximum 20/10 thread count, similar to Hardcast FS-150.

4. Sealer shall be rated by the manufacturer and shall be suitable for use at the system pressure classification of applicable ductwork.

5. Except as noted, oil or solvent-based sealants are specifically prohibited.

6. For exterior applications, “Uni-Weather” (United McGill Corporation), solvent-based sealant, or Foster 32-19 shall be used.

2.04 RECTANGULAR AND ROUND DUCTWORK

A. Metal gages listed in SMACNA HVAC Duct Construction Standards, Metal and Flexible Duct, are the minimum gages which shall be used. Select metal gage heavy enough to withstand the physical abuse of the installation. In no case shall ductwork be less than 26 gage per SMACNA Standards.

B. All longitudinal seams for rectangular duct shall be selected for the specified material and pressure classification. Seams shall be as referenced in SMACNA Standards.

C. Longitudinal seams in laboratory hood exhaust ducts shall be welded.

D. All transverse joints and intermediate reinforcement on rectangular duct shall be as shown in SMACNA Standards. Transverse joints shall be selected consistent with the specified pressure classification, material, and other provisions for proper assembly of ductwork.

E. Spiral round duct and fittings shall be as manufactured by United McGill Sheet Metal Company or approved equivalent. All fittings shall be factory fabricated, machine formed and welded from galvanized sheet metal.

F. Joints in spiral duct and fittings shall be assembled, suspended, sealed, and taped per manufacturer’s published assembly and installation instructions.

G. Contractor may use DUCTMATE or Ward Industries coupling system, as an option, on rectangular ductwork. The DUCTMATE or Ward Industries system shall be installed in strict accordance with manufacturer’s recommendations.

H. Rectangular ductwork field fabricated offsets shall not exceed 30 degrees.

2.05 FLAT OVAL DUCTWORK AND FITTINGS

A. Oval ducts shall be spiral flat oval or welded flat oval equivalent to those of United McGill Sheet Metal Company with gage and reinforcing as recommended by the manufacturer. Duct may be shop fabricated of completely welded construction in accordance with SMACNA Standards.

B. Oval ducts greater than 24 inch x 72 inch shall be longitudinal seam, flat oval duct, rolled, welded and provided in standard lengths of 5 and 10 feet. Transverse joints shall be factory welded or field connected with flanges or slip couplings. Duct will be fabricated from galvanized steel meeting ASTM A 527 standards.

C. Duct reinforcing angles shall be of sizes specified for same size rectangular duct. Galvanized angles shall be used where standing seams are specified for rectangular duct.

D. Oval fittings shall comply with requirements, sealing, etc., similar to that specified for round ductwork. Manifolding taps may be permitted without increasing the length of run in the branch duct system.

E. Elbows in oval ducts may be smooth long radius or 5-piece 90-degree elbows and 3-piece 45-degree elbows. Joints in sectional elbows shall be sealed as specified for duct sealing.

2.06 CONICAL BELLMOUTH FITTINGS AND TAPS

A. Conical bellmouth fittings shall be made from 26-gage G-90 coated galvanized steell. Two-piece construction with a minimum overall length of 6 inches and factory sealed for high-pressure requirements. Average of loss coefficient for sizes 6, 8 and 10 shall be less than 0.055.

B. Provide each fitting with minimum 24-gage damper plate with locking quadrant operator and sealed end bearings. Damper blade shall be securely attached to shaft to prevent damper form rotating around shaft. Shaft shall be extended to clear insulation.

C. Provide a flange and gasket with adhesive peel-back paper for ease of application. The fittings shall be further secured by sheet metal screws spaced evenly at no more than 4 inches on center with a minimum of four (4) screws per fitting.

D. Conical bellmouth fittings shall be Series 3000G as manufactured by Flexmaster U.S.A., Inc. or Buckley Air Products, Inc., “AIR-TITE”.

2.07 CASINGS AND PLENUMS - 2 INCH W.G. PRESSURE CLASS

A. All 2 inch w.g. pressure class casings and plenums for mixed air plenums shall be constructed in accordance with SMACNA Standards.

B. All casings shall enclose the filter and automatic dampers as shown on the Drawings. Casings shall be fabricated of galvanized sheet metal erected with three-foot center maximum standing seams reinforced with ¼-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 indicated on the Drawings 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. Casings shall be tested and provided tight at a pressure of three inches water column.

E. Insulate per Section 23 07 13.

2.08 CASINGS AND PLENUMS – 6 INCH W.G. PRESSURE CLASS

A. Shall enclose filters and automatic dampers at air handling unit systems. Casings shall be constructed of cellular, standing seam panels with 3 inch deep reinforced “hat” sections as manufactured by metal deck manufacturers and as described in SMACNA Standards.

B. All openings to the casing shall be properly sealed to prevent air leakage. Install access doors for easy access to equipment. Access doors 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 outside. Hinges shall be equivalent to Ventlok #370.

C. Anchor casing by the use of galvanized angle irons sealed and bolted to the curb and floor of the apparatus casing as indicated in SMACNA Standards.

D. A fan discharge diffuser plate shall be located on the fan discharge and shall be constructed of 10 gage steel perforated plate installed in 6 inch channel iron frames (8.2#) rigidly supported to withstand the fan discharge velocity. Perforations shall be 3/8 inch (0.375 inch) staggered on 11/16 inch centers (27 percent 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 the diffuser plate, coat with rust-resistant paint. After installation, touch up diffuser plate and paint channel iron frames with rust-resistant paint.

E. Provide 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.

F. Insulate per Section 23 07 13.

2.09 ELBOWS RECTANGULAR DUCTS

A. Construct elbows as follows in order of preference:

1. Long radius, unvaned elbows.

2. Short radius, single thickness vaned elbows.

3. Rectangular, double thickness vaned elbows.

B. Long radius elbows shall have a centerline radius of not less than one and one-half (1-1/2) times the duct width. Short radius elbows shall have a centerline radius of not less than one times the duct width.

C. Contractor shall have the option to substitute short radius vaned elbows, but shall request the substitution at the time of submittal of Product Data.

D. Provide turning vanes in all rectangular elbows and offsets.

E. Job fabricated turning vanes, if used, shall be fabricated of the same gage and type of material as the duct in which they are installed. Vanes must be fabricated for same angle as duct offset. Submit Shop Drawings on factory fabricated and job fabricated turning vanes.

F. 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.

G. In 90-degree turns that are over 12 inches wide in the plane of the turn, provide and install double thickness vanes on integral side rails. For ducts under 12 inches in width, use single thickness vanes. The installation of the turning vanes shall be as described for single thickness vanes. On other types of turns or elbows, single thickness trailing edge vanes shall be used.

2.10 FLEXIBLE DUCT

A. Flexible duct shall be used where flexible duct connections are shown on the Drawings to air distribution devices and terminal units and as scheduled under “Ductwork System Applications.

B. Acoustical Flexible Duct to Diffusers, Grilles, and Terminal Units:

1. Maximum flex duct length 6’-0” (six feet), installed with no more than 90 degrees of bend to diffusers and grilles. Where longer duct runs or more bends are necessary, provide rigid round ductwork.

2. Maximum flex duct length 2’-0” (two feet), installed as a straight run to the inlet of the terminal units.

3. Acoustical flexible duct shall be manufactured with an acoustically rated CPE inner film as the core fabric, mechanically locked by a corrosion-resistant galvanized steel helix.

4. Core shall be factory pre-insulated with a total thermal performance of R-3.5 or greater. Outer jacket shall be a fire retardant polyethylene vapor barrier jacket with a perm rating not greater than 0.10 per ASTM E 96, Procedure A.

5. Duct shall be rated for a minimum positive working pressure of 6 inches w.g. and a negative working pressure of 4 inches w.g. minimum.

6. Temperature range shall be –20 degrees F to 250 degrees F.

7. Duct must comply with the latest NFPA Bulletin 90A and be listed and labeled by Underwriter's Laboratories, Inc., as Class I Air Duct, Standard 181, and meet GSA, FHA and other U. S. Government standards; flame spread less than 25; smoke developed less than 50.

8. Acoustical flexible duct shall be similar to Flexmaster Type 8M for construction and acoustical performance standards.

C. Metal Flexible Duct:

1. May be used for terminal unit connections from sheet metal ductwork where shown on the Drawings.

2. Maximum length 2’-0” (two feet), installed in straight runs only. Where longer duct runs or direction changes are necessary, provide rigid round ductwork.

3. Duct shall be constructed of 0.005 inch thick 3003-H14 aluminum alloy in accordance with ASTM B209. Duct shall be spiral wound into a tube and spiral corrugated to provide strength and flexibility.

4. Core shall be factory pre-insulated with a total thermal performance of R-3.5 or greater. Outer jacket shall be fire retardant metalized vapor barrier jacket of fiberglass reinforced aluminum foil, with a permeance rating not greater then 0.05 per ASTM E96, Procedure A.

5. The duct shall be rated for a minimum positive and negative working pressure of 10 inch w.g.

6. Temperature range shall be –40 degrees F to 250 degrees F.

7. Duct must comply with the latest NFPA Bulletin 90A and be listed and labeled by Underwriter's Laboratories, Inc., as Class I Air Duct, Standard 181, and meet GSA, FHA and other U. S. Government standards; flame spread less than 25; smoke developed less than 50.

8. Metal flexible duct shall be similar to Flexmaster triple lock Type TL-M.

2.11 STAINLESS STEEL DUCTWORK

A. Applies to general laboratory exhaust, fume hood, biosafety cabinet, radioisotope hood, vivarium supply and exhaust systems subject to routine decontamination (HPV, Clidox, etc.), and moisture exhaust systems where indicated on the Drawings and as specified herein.

B. Stainless steel shall be 316-L with welded longitudinal seams and welded transverse joints. Welds on exposed ductwork shall be positioned for minimum view and shall be ground and polished. Duct sealant shall not be used to seal this ductwork.

C. All ductwork risers shall be installed as vertical as possible within the constraints of the design indicated on the Drawings.

D. In all cases, ductwork shall be installed so that the washdown water, where installed, shall drain back to the hood.

E. Metal gages shall be not less than the following:

DUCT SIZE	GAGE
30-inch diameter or less	18
31-inch to 60-inch diameter	16
61-inch diameter or greater	14
Greater than 60 x 42 (rectangular or oval)	Comply with SMACNA

F. The joining of stainless steel ductwork with galvanized ductwork where indicated in the Drawings shall use ductwork construction methods specified herein for galvanized ductwork.

G. Connections to Air Devices Cabinets or Hoods:

1. Where approved by Owner, flexible stainless steel ducting can be used in lieu of hard pipe stainless steel at cabinets or hoods

2. For all non insulated duct applications flexible ducting shall be 316TI stainless steel; pressure rated for 12 inches w.g. positive and negative; UL 181, Class 0 air duct rated; Velocity Rated for 5500 fpm. Similar to Flexmaster Type SS-NI-TL.

3. For all insulated duct applications, flexible ducting shall be 316 stainless steel; pressure rated for 12 inches w.g. positive and negative; UL 181, Class 1 air duct rated; Velocity Rated for 5500 fpm. Similar to Flexmaster Type SS-TLM.

PART 3 - EXECUTION

3.01 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. Cleanliness:

1. Before installing ductwork, wipe ductwork to a visibly clean condition.

2. During construction, provide temporary closures of metal or taped polyethylene on open ductwork and duct taps to prevent construction dust or contaminants from entering ductwork system. Seal ends of ductwork prior to installation to keep ductwork interior clean. Remove closures only for installation of the next duct section.

3. For ductwork supplying Clean Rooms, Operating Rooms and other Critical Care areas, sanitize ductwork with a biocidal agent EPA approved for HVAC systems immediately prior to sealing ductwork.

4. During duration of construction, maintain the integrity of all temporary closures until air systems are activated.

D. Provide openings in ductwork where required to accommodate thermometers, controllers and other devices. Provide pitot 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. Sleeve of pitot tube opening shall be no more than one inch long. Opening shall be one inch wide to accept pitot tube.

E. Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities.

F. Slope underground ducts to plenums or low pump out points at 1:500. Provide access doors for inspection.

G. Coat buried, metal ductwork without factory jacket with one coat and seams and joints with additional coat of asphalt base protective coating.

H. Set plenum doors 6 to 12 inches above floor. Arrange door swings so that fan static pressure holds door in closed position.

I. 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 for ducts where concealed.

J. All visible welds in ductwork between biosafety cabinets, canopy hoods and fume hoods and the ceiling shall be ground and polished.

K. Slope duct toward grilles for moisture-laden ducts. Provide drain and trap at elbow of main moisture exhaust duct system.

L. Project inspector shall be notified to inspect all field fabricated offsets before cover-up or external insulation is applied.

M. Flexible Duct:

1. The terminal ends of the duct core shall be secured by compression coupling or stainless steel worm gear type clamp.

2. Fittings on terminal units and on sheet metal duct shall have flexible duct core slipped over duct and coupling or clamp tightened, then connection sealed with sealant. Insulation of flexible duct shall be slipped over connection to point where insulation abuts terminal unit or insulation on duct.

3. These insulation connections shall be sealed by embedding fiberglass tape in the sealant and coating with more sealant to provide a vapor barrier.

N. Support flexible ducts as per SMACNA standards to prevent sags, kinks and to have 90 degree turns.

O. Hangers and Supports:

1. All ductwork supports shall be in accordance with Table 4-1 (rectangular duct) and Table 4-2 (round duct) of the SMACNA Standards, with all supports directly anchored to the building structure.

2. Rectangular duct shall have at least one pair of supports on minimum 8’-0" (eight feet) centers. All horizontal round and flat oval ducts shall have ducts hangers spaced 10’-0" (ten feet) maximum.

3. Lower attachment of hanger to duct shall be in accordance with Table 4-4 of the SMACNA Standards.

4. Vertical ducts shall be supported where they pass through the floor lines with 1-1/2 inch x 1-1/2 inch x 1/4 inch angles for duct widths up to 60 inches. Above 60 inches in width, the angles must be increased in strength and sized on an individual basis considering space requirements.

5. Hanger straps on duct widths 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 sides.

6. Hanger straps on duct widths over 60 inches shall be bolted to duct reinforcing with 3/8 inch bolts minimum.

3.02 DUCTWORK SYSTEM CLEANING

A. If the system has been operated without scheduled filters or if the integrity of temporary closures has been compromised, Contractor shall have ductwork cleaned according to National Air Duct Cleaners Association (NADCA) Standards by a Certified Regular Member of the NADCA.

1. For ductwork supplying Clean Rooms or patient care areas, also sanitize the ductwork interior per NADCA standards with a biocidal agent approved by the EPA for use in HVAC Systems.

B. Before turning the installation over to the Owner, Contractor shall certify that the air handling systems have only been operated with scheduled filters in place. Otherwise, Contractor shall present evidence that the ductwork was cleaned as required above.

3.03 TESTING

A. All medium and high pressure duct systems (positive or negative) shall be pressure tested according to SMACNA test procedures (HVAC Air Duct Leakage Test Manual). Notify Owner minimum seven (7) calendar days in advance of leakage testing.

1. Design pressure for testing ductwork shall be determined from the maximum pressure generated by the fan at the nominal motor horsepower selected.

2. Total allowable leakage shall not exceed 1 percent of the total system design airflow rate.

3. When partial sections of the duct system are tested, the summation of the leakage for all sections shall not exceed the total allowable leakage.

4. Leaks identified during leakage testing shall be repaired by:

a. Complete removal of the sealing materials.

b. Thorough cleaning of the joint surfaces.

c. Installation of multiple layers of sealing materials.

5. The entire ductwork system shall be tested, excluding connections upstream of the terminal units (i.e. ductwork shall be capped immediately prior to the terminal units, and tested as described above).

6. After testing has proven that ductwork is installed and performs as specified, the terminal units shall be connected to ductwork and connections sealed with extra care. Contractor shall inform the Owner when joints may be visually inspected for voids, splits, or improper sealing of the joints. If any leakage exists in the terminal unit connections/joints after the systems have been put into service, leaks shall be repaired as specified for other leaks.

7. Fixed flow measurement devices (i.e. orifice tubes, nozzles, etc.) shall have current calibration documentation showing that the device was verified to a National Institute Of Standards and Technology (NIST) standard within the previous five years or as recommended by the manufacture and be accurate to at least +/- 2% of reading.

8. Pressure measurement instrumentation (i.e. manometer) shall have current calibration documentation showing that the device was verified to a NIST standard within the previous year or as recommended by the manufacture. Instrumentation shall have an accuracy of at least +/- 2% of reading and have a resolution of 2:1 with respect to the measured pressure (i.e. resolution of 0.01 measured 0.1).

B. All low-pressure duct systems (positive or negative) shall be inspected for visible and audible signs of leakage.

1. Leaks identified by inspection shall be repaired by:

a. Complete removal of the sealing materials.

b. Thorough cleaning of the joint surfaces.

c. Installation of multiple layers of sealing materials.

2. Discrepancies found during testing and balancing between duct traverses and diffuser/grille readings shall result in re-inspection, repair and retest until discrepancies are eliminated.

C. At the option of the Owner, if documented in writing, Contractor may be allowed to eliminate testing of terminal units 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 Owner, only if documented in writing prior to testing.]

D. Ductwork leakage testing and/or inspection shall be performed prior to installation of external ductwork insulation.

END OF SECTION 23 31 00

SECTION 23 33 00 – DUCTWORK ACCESSORIES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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.

1.02 SUMMARY

A. Perform all Work required to provide and install the following ductwork accessories indicated by the Contract Documents with supplementary items necessary for proper installation.

1. Airflow control dampers and spin-in fittings.

2. Fire dampers, smoke dampers, and combination fire and smoke dampers.

3. Flexible duct connections.

4. Duct access doors.

5. Screens

6. Duct test holes.

7. Guy wire systems.

1.03 REFERENCE STANDARDS

A. The latest published edition of a reference 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. AMCA 500D – Laboratory Method of Testing Dampers for Rating.

2. AMCA 500L – Laboratory Method of Testing Louvers for Rating.

3. NFPA 90A - Installation of Air Conditioning and Ventilating Systems.

4. NFPA 101 - Life Safety Code.

5. SMACNA - HVAC Duct Construction Standards.

6. UL 33 - Heat Responsive Links for Fire-Protection Service.

7. UL 555 – Standard for Fire Dampers.

8. UL 555C – Standard for Ceiling Dampers.

9. UL 555S – Standard for Smoke Dampers.

1.04 SUBMITTALS

A. Product Data:

1. Provide product data for shop fabricated assemblies including, but not limited to, volume control dampers, duct access doors, and duct test holes. Provide product data for hardware used.

B. Record Documents:

1. Fire Dampers: The damper manufacturer's literature submitted for approval prior to the installation shall include performance data developed from testing in accordance with AMCA 500D standards and shall show the pressure drops for all sizes of dampers required at anticipated air flow rates. Maximum pressure drop through fire damper shall not exceed 0.05-inch water gauge.

2. Combination Fire/Smoke Dampers: Assign identification numbers for each damper with corresponding number noted on Drawings. Provide air quantity, size, free area of damper, pressure drop and proposed velocity through each damper. Provide manufacturer's data of damper and its accessories or options. At Owner's request, provide two (2) dampers (18 inch x 12 inch) for the purpose of illustrating damper operation to Owner's operating and maintenance personnel.

PART 2 - PRODUCTS

2.01 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.

2.02 MANUFACTURERS

A. Dampers:

1. Greenheck.

2. Louvers and Dampers, Inc.

3. Nailor Industries.

4. Prefco.

5. Ruskin.

6. Portorff

B. Regulators, Locking Quadrants:

1. Ventfabrics

2. Mercer Rubber

2.03 AIR FLOW CONTROL DAMPERS

A. Furnish and install dampers where shown on the Drawings and wherever necessary for complete control of airflow, including all supply, return, outside air, and exhaust branches, "division" in main supply, return and exhaust ducts, and each individual air supply outlet. Where access to dampers through a permanent suspended ceiling (gypsum board) is necessary, the Contractor shall be responsible for the proper location of the access doors.

B. Dampers larger than three (3) square feet in area shall be controlled by a self-locking splitter damper assembly.

C. Volume damper 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 gage galvanized steel supported on one-half inch (1/2") diameter rust-proofed axles. Axle bearings shall be the self-lubricating ferrule type.

D. Volume dampers and other manual dampers shall be carefully fitted, and shall be manually controlled by damper regulators as follows:

1. On exposed uninsulated ductwork the locking quadrant shall be made with a base plate of 16-gage cold-rolled steel and a heavy die cast handle designed with a 3/8 inch bearing surface. A 1/4 inch-20 zinc plated wing nut shall firmly lock the handle in place.

2. On exposed externally insulated ductwork the regulator shall be 4-1/4 inch diameter, for 1/2 inch rod, designed for use on duct with insulation thickness specified for duct, and shall have four (4) 3/16 inch holes provided to rivet or screw regulator to the duct surface. The flange that covers the raw edge of the insulation shall be high enough so that it slightly compresses the insulation and holds insulation in place. The handle shall be 3/8 inch above the flange, and shall easily turn without roughing up the insulation.

3. On concealed ductwork above inaccessible ceilings, the regulator shall be 2-5/8 inch diameter chromium plated cover plate that telescopes into the base, for 1/2 inch rod. Regulator shall be cast into a box for mounting in ceilings. Base shall be 1-1/2 inch deep. The cover shall be secured by two screws that can be easily removed for damper adjustment.

4. Furnish and install end bearings for the damper rods on the end opposite the quadrant.

E. Spin-in fittings may be used for duct taps to air devices and shall include dampers on all duct to air devices (diffusers and grilles) even though a volume damper is specified for the air device. Spin-in fittings shall be similar to Flexmaster FLD with BO3 including a 2 inch buildout, nylon bushings, locking quadrant similar to Duro Dyne KR-3, and a 3/8 inch square rod connected to the damper with U-bolts. Spin-in fittings shall be sealed at the duct tap with sealant as specified herein. Determine location of spin-in fittings after terminal units are hung or after location of light fixtures are confirmed to minimize flexible duct lengths and sharp bends.

2.04 FIRE DAMPERS

A. Each fire damper shall be constructed and tested in accordance with Underwriters Laboratories Safety Standard 555, latest edition. Dampers shall possess a 1-1/2 hour or 3 hour (as appropriate for the construction shown in the architectural Drawings) protection rating, 160 or 165 degrees F fusible link, and shall bear a U.L. label in accordance with Underwriters' Laboratories labeling procedures. Construct fire dampers such that damper frame material and curtain material are galvanized.

B. Fire dampers shall be curtain blade type and damper shall be constructed so that the blades are out of the air stream to provide 100 percent free area of duct in which the damper is housed.

C. Equip fire dampers for vertical or horizontal installation as required by location shown on Drawings. Install fire dampers in wall and floor openings utilizing steel sleeves, angles and other material and practices as 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 minimum 1-1/2 inch by 1-1/2 inch by 14 gage 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 duct gage as 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 inch water gauge static pressure.

D. All fire dampers shall be dynamic rated type.

E. Completely seal the damper assembly to the building components using manufacturer recommended material(s).

2.05 COMBINATION FIRE/SMOKE DAMPERS

A. Each combination fire/smoke damper shall be 1-1/2 hour fire rated under UL Standard 555, Current 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 same. 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). 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.) All ratings shall be dynamic.

B. Damper frame shall be minimum 20-gage 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. Dampers may be either parallel or opposed blade type. Blades shall be constructed with a minimum of 14-gage equivalent thickness. Blade edge seal material shall be able to withstand 450 degrees F. Jamb seals shall be flexible stainless steel compression type or lap seal type.

C. In addition to the leakage ratings specified herein, combination fire/smoke dampers and their operators shall be qualified under UL555S to an elevated temperature of 350 degrees F. Electric operators shall be installed by the damper manufacturer at the time of damper fabrication. Damper and operator shall be supplied as a single entity that meets all applicable UL555 and UL555S qualifications for both dampers and operators. Manufacturer shall provide a factory-assembled sleeve. Sleeve shall be minimum 20-gage for dampers where neither width nor height exceeds 48 inches or 16-gage where either dimension equals or exceeds 48 inches.

D. As part of the UL qualification, dampers shall have demonstrated a capacity to operate (open and close) under HVAC system operation conditions, with pressures at least 4 inches water gauge in the closed position, and 2500 fpm air velocity in the open position.

E. Each combination fire/smoke damper, except as noted hereinafter, shall be equipped with a UL Classified firestat/releasing device. The firestat/releasing device shall electrically (24 VAC) and mechanically (pneumatically) 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. Damper must be operable while the temperature is above 350 degrees F. 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 system, and remote indicating/control stations or building automation system (BAS).

F. Damper releasing device shall be mounted within the airstream. Device shall be activated and the damper shall close and lock when subjected to duct temperatures in excess of approximately 285 degrees F.

G. Motors for operation of smoke dampers shall be smoke system fail safe, spring return normally open supplies and normally closed returns, or as indicated on the Drawings, 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. Furnish all required relays, EP switches, wiring piping and other labor and material necessary to completely interconnect the smoke detector system.

H. Furnish each damper in a square or rectangular configuration. Furnish and install sleeves manufactured by the approved damper manufacturer for each damper. Construct sleeves with square or rectangular to square, rectangular, round, or oval adapters as required. Dampers shall be installed in the sleeves in accordance with manufacturer's U.L. installation instructions. The entire assembly, following installation, shall operate smoothly and be capable of withstanding 6 inch water gauge static pressure.

I. Each combination fire/smoke damper shall be equipped with a Damper Test Switch. The damper test switch will have the ability to "cycle test" the fire/smoke damper by pushing and holding the test button until the damper has cycled.

J. All combination fire/smoke dampers shall be dynamic type.

K. Completely seal the damper assembly to the building components using manufacturer recommended material(s).

2.06 SMOKE DAMPERS

A. Each smoke damper shall be dynamic rated type 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 same. 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. 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). Maximum air pressure drop through each 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.) All ratings shall be dynamic.

B. Damper frame shall be minimum 16ga galvanized formed into a structural hat channel shape with corner braces for reinforcement, as approved in testing by Underwriters Laboratories. Bearings shall be stainless steel sleeve type turning in an extruded hole in the frame or an extruded frame raceway. Dampers shall be opposed blade type. Blades shall be airfoil shaped double skin construction. Blade edge seal material shall be silicone rubber designed to withstand 450 degrees F. Jamb seals shall be aluminum flexible metal compression type.

C. In addition to the leakage ratings specified herein, smoke dampers and their operators shall be qualified under UL555S to an elevated temperature of 350 degrees F. 120 VAC electric operators shall be installed by the damper manufacturer at the time of damper fabrication. Damper and operator shall be supplied as a single entity that meets all applicable UL555 and UL555S qualifications for both dampers and operators.

D. 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 2000 fpm air velocity in the open position.

E. The damper must be operable while the temperature is above 350 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. Position indicator switches shall be capable of interfacing electrically with the smoke detectors, building fire alarm systems, and remote indicating/control stations (BAS).

F. Motors for operation of smoke dampers shall be smoke system fail safe, spring return normally open supplies and normally closed returns, or as indicated on the Drawings, and shall be furnished and installed by the damper manufacturer as required by the UL rating mentioned above. Motors shall be (electric) or (pneumatic) to match the type of temperature control system specified elsewhere in this Specification. Furnish all required relays, EP switches, wiring piping and other labor and material necessary to completely interconnect the smoke detector system.

G. Furnish each damper in a square or rectangular configuration. Furnish and install sleeves manufactured by the approved damper manufacturer for each damper. Construct sleeves with square or rectangular to square, rectangular, round, or oval adapters as required. Install dampers in the sleeves in accordance with manufacturer's UL installation instructions. Entire assembly, following installation, shall operate smoothly and be capable of withstand 6 inch water guage static pressure.

H. Each smoke damper shall be equipped with a Damper Test Switch. The damper test switch will have the ability to "cycle test" the smoke damper by pushing and holding the test button until the damper has cycled.

I. All smoke dampers shall be dynamic type.

J. Completely seal the damper assembly to the building components.

2.07 FLEXIBLE CONNECTIONS

A. Where ducts connect to, flexible connections shall be made using "Flexmaster TL-M" or "Ventglas" fabric that is temperature-resistant, fire-resistant, waterproof, mildew-resistant and practically airtight, weighing approximately thirty ounces (30 oz.) per square yard. Ventglas is good for connections for inside building environments where ultra-violet light is not present.

B. Material used outdoors shall be resistant to ultra-violet sunrays. There shall be a minimum of one-half inch (1/2-inch) slack in the connections, and a minimum of two and one-half inches (2-1/2-inch) distance between the edges of the. This does not apply to air handling units with internal isolation. A more rugged flexible material that is resistant to ultra violet rays needs to be used when connecting an exhaust fan or exhaust air plenum to ductwork. Mercer Rubber supplies a more durable flex connection for outdoor use.

C. Connections to Chemical Fume Hoods

1. Flexible connections shall be made using a coupling with stainless steel bands as manufactured by Fernco, Inc.

2.08 ACCESS DOORS

A. Furnish and install in the ductwork, hinged rectangular, pressure relief, or round "spin-in" access doors to provide access to all fire dampers, mixed air plenums, steam reheat coils (install upstream), automatic dampers, etc.

B. Where ductwork is insulated, access doors shall be double skin doors with one inch (1") of insulation in the door.

C. Where duct size permits, 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).

D. Latches for rectangular doors smaller than 18 inch x 16 inch shall be Ventlok No. 100 or 140.

E. Doors for zone heating coils shall be Ventlok, stamped, insulated access doors, minimum 10 inch x 12 inch, complete with latch and two (2) hinges, or twelve inches (12") in diameter.

F. Round access doors shall be "Inspector Series" spin-in type door as manufactured by Flexmaster USA.

G. Grease duct access doors shall be as manufactured by Dura Systems Barriers Inc.

H. Doors for personnel access to ductwork shall be nominal twenty-four inches (24") in diameter. Doors may be fabricated in a local approved sheet metal shop in accordance with SMACNA Standards.

I. Where access doors are installed above a suspended ceiling, this Contractor shall be responsible for the proper location of ceiling access doors.

2.09 SCREENS

A. Furnish and install screens on all duct, fan, etc., openings furnished by this Contractor which lead to, or are located outdoors.

B. Screens shall be No. 16 gage, one-half inch (1/2") mesh in removable galvanized steel frame.

C. Provide safety screens meeting OSHA requirements for protection of maintenance personnel on all fan inlets and fan outlets to which no ductwork is connected.

2.10 GUY WIRE SYSTEM

A. Provide 1/4-inch diameter American Aircraft Steel Cable (plastic coated) with clip for vertical stack off utility fans on roof, with eyebolts for attachment to anchor systems on the roof.

PART 3 - EXECUTION

3.01 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. 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.

D. Provide all dampers furnished by the BAS Provider in strict accordance with manufacturer’s written installation instruction and requirements of these Specifications.

E. 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.

1. Instructions to A/E and Contractor:

a. Fire dampers, smoke dampers and combination fire smoke dampers should not be installed where ducts pass through non fire/smoke rated architectural or structural components. Remove all fire and smoke dampers and combination fire smoke dampers from non-fire rated structural architectural or structural.

F. Provide backdraft dampers on exhaust fans or exhausts ducts where indicated. Install dampers so that they will open freely.

G. Flex connectors are not required at equipment with internally isolated fans. Cover connections to medium and high pressure fans with leaded vinyl sheet, held in place with metal straps where noted on the Owner's drawings.

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 on Drawings. 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.

1. Furnish and install Ventlok No. 699 instrument test holes in the return air duct and in the discharge duct of each fan unit.

2. Install test holes in locations as required to measure pressure drops across each item in the system, e.g., outside air louvers, filters, fans, coils, intermediate points in duct runs, etc.

J. Access doors as specified elsewhere shall be provided for access to all parts of the fire and combination fire and smoke dampers. Doors shall open not less than 90 degrees following installation and shall be insulated type where installed in insulated ducts.

K. Install each fire and combination fire and smoke 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 and UL555S.

3.02 TESTING

A. After each fire damper, smoke damper and combination fire and smoke damper has been installed and sealed in their prescribed openings and prior to installation of ceilings, Contractor shall, as directed by Owner, activate part or all dampers as required to verify "first-time" closure. The activation must be scheduled as part of the commissioning and witnessed by an institutional representative.

B. Activation of damper shall be accomplished by manually operating the resettable link, disconnecting the linkage at the fire damper fusible link, and manually operating the fire/smoke damper through the pneumatic or electronic controls as appropriate.

C. Failure of damper to close properly and smoothly on the first attempt will be cause to replace the entire damper assembly.

D. Coordinate smoke damper system interlock requirements with the fire alarm system.

END OF SECTION 23 33 00

SECTION 23 36 00 – AIR TERMINAL UNITS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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.

1.02 SUMMARY

A. Perform all Work required to provide and install the following products as indicated by the Contract Documents with supplementary items necessary for proper installation.

1. Single duct variable or constant volume terminal units.

2. Integral heating coils.

3. Integral controls.

4. Integral sound attenuator.

1.03 REFERENCE STANDARDS

A. The latest published edition of a reference 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. NFPA 90A - Installation of Air Conditioning and Ventilation Systems.

2. UL 181 - Factory-Made Air Ducts and Connectors.

3. ARI Standard 880 for Air Terminals.

4. ANSI/ASHRAE Standard 130 – Methods of Testing for Rating Ducted Air Terminal Units.

1.04 SUBMITTALS

A. Product Data:

1. Shop Drawings of product data indicating configuration, general assembly, access space required for service, and materials used in fabrication.

2. Electronic or Printed Catalog performance ratings that indicate nominal inlet size, CFM, applicable static pressure at the inlet or discharge of terminal unit, and noise criteria with sound octave band and sound decibel test in accordance with ARI 880, for the insulation lining selected.

3. Leakage curves indicating inlet static pressure and actual tested leakage rates shall be submitted for all non-standard or custom-built terminal units.

4. Unit manufacturer shall test and certify that each terminal unit used on this Project has been tested as specified.

B. Record Documents:

1. Submit under provision of Division 01.

C. Operation and Maintenance Data:

1. Operating instructions and maintenance manuals indicating maintenance and repair data, parts lists.

D. Sample Units:

1. One sample, 8 inch size, production run unit of each type shall be submitted for examination and approval by the Engineer, Owner, and TAB Firm.

2. This sample unit shall be submitted in addition to the required written submittal, well in advance of any requirement for installation of units, but absolutely no later than 60 calendar days after the Notice to Proceed with Construction.

3. Contractor shall allow a minimum of three (3) weeks for testing of the sample unit from the time shipped to the TAB Firm. The TAB Firm will test single duct terminal for casing leakage, damper leakage, and the specification requirements. The fan powered terminal will be tested for damper leakage, airflow tracking from minimum primary to maximum primary, discharge pressures from 0.25 inches w.c. to 0.6 inches w.c. with three different airflows (maximum, midpoint, and minimum). The fan powered terminal must maintain its downstream airflow ±5 percent. The fan powered terminal will be observed to maintain the Specification requirement. This period shall restart if the sample unit is rejected and another unit is resubmitted.

4. If rejected for any reason, Contractor shall expedite the documented corrections and shall resubmit a sample unit as soon as possible.

5. Any delay in submittal of the unit for approval shall not be grounds for Contractor’s claim of delay. If approved, the unit shall remain in the possession of the Owner at the Project Site for comparison with units as shipped to the Project.

6. Unit(s) shall be installed in the Project, at an accessible, marked location.

1.05 SHIPMENT TESTING PRIOR TO INSTALLATION

A. Shipment Testing: At the Owner's discretion, a minimum of ten (10) percent of each size single duct terminal unit (but no less than one unit of each size on the Project) will be tested at the Project Site for casing leakage and damper leakage. Fan powered terminals units will be tested for damper leakage and for conformance to this Specification. Contractor shall allow sufficient time during construction for the TAB Firm to perform all testing as may be required.

B. Unit Non-Performance:

1. If results of the shipment testing show that any of the units do not perform as specified, then an additional ten (10) percent of each size unit (but no less than one unit of a size, unless 100 percent of the size has been tested) shall be tested.

2. If this testing, in the Owner's opinion, shows that ten (10) percent or more of the units tested do not perform as specified, then 100 percent of all unit sizes shall be tested for conformance with these Specifications.

3. The results of that testing shall be reviewed carefully between the Contractor, manufacturer, Owner, and Engineer. A method of repair or replacement of units will be negotiated. The Owner, however, shall maintain the right of final approval of any proposed solution.

C. Should for any reason, the testing as described in this Section prove that any of the units do not perform as specified, 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 in this Section, 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 TAB Firm, but also those incurred by the Owner as may be specifically required for this purpose.

1.06 WARRANTY

A. Provide one year manufacturer's warranty under provisions of Division 01.

PART 2 - PRODUCTS

2.01 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.

2.02 MANUFACTURERS

A. Manufacturer: Company specializing in manufacturing the products specified in this Section with minimum three (3) years documented experience.

B. The same manufacturer shall provide all products supplied and/or installed under this Section.

C. Manufacturers:

1. Nailor Industries.

2. Titus.

3. Krueger.

4. Metal Aire.

5. Price.

6. Trane.

2.03 GENERAL CONSTRUCTION

A. This section applies to single duct, dual duct, and fan powered terminal unit configurations as described within this Specification.

B. Casing Construction:

1. Units shall be constructed of 20 gage galvanized steel.

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.

3. 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.

C. Ductwork Connections:

1. Construct units 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).

2. The discharge connection shall include flange connection for use by the Contractor to secure the discharge ductwork or appurtenances to the unit and shall be reinforced to provide a rigid assembly.

3. External insulation shall be as specified in the Contract Documents for duct insulation with full vapor barrier.

D. Single Duct Casing Leakage: Assembled units shall be constructed such that casing leakage does not exceed 1.0 percent of terminal unit rated airflow at 4 inches w.g. of inlet static pressure.

E. Casing Liners:

1. Liners for Administrative and Non-Critical Patient Care and Laboratory Applications:

a. Terminal unit casing shall lined with a 4 lb density, rigid board, non-porous insulation with reinforced foil covering that does not support bacterial or fungal growth. Liner shall be attached to the unit casing by insulation adhesive and full-seam-length Z-strips to enclose and seal the insulation cut edges.

b. Insulation shall meet requirements of UL181 and NFPA 90A, and achieve an equivalent R value of 4.

c. Edges and seams shall be sealed or "captured" using sheet metal, formed to hold the insulation. Insulation shall be neatly installed with no rough edges to interrupt the smooth flow of air through the unit.

d. Casing shall be insulated throughout its interior.

2. Liners for Critical Patient Care Applications (Doublewall):

a. Terminal unit casing shall be double wall lined with 1-inch thick, 1.5 lb density fiberglass insulation enclosed between the unit casing and a non-perforated, internal sheet metal cover. The interior wall cover shall be 22 gage galvanized steel. The interior wall cover shall extend over the fiberglass insulation and cover the liner cut edges. The exterior cover shall be 20 gage galvanized steel.

b. Insulation shall meet requirements of UL181 and NFPA 90A.

c. Casing shall be insulated throughout its interior.

d. Critical Patient Care Applications include, but are not limited, to the following:

1) All inpatient rooms, including airborne infection isolation rooms and protective environment rooms.

2) All operating and procedure rooms.

3) Surgery prep and post-anesthesia care units (PACU), recovery rooms.

4) Laboratories not being served by laboratory air valves.

F. Damper:

1. Damper blades shall be minimum 18 gage galvanized steel or equivalent 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 rustproof 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. The dampers shall be constructed with the proper rigidity to prevent deformation of the damper blade. 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.

2. Damper Leakage: Units shall be tested for inlet leakage with 4 inches w.g. static pressure imposed. The maximum percent leakage from all tests shall be reported. The following table provides the maximum allowable damper leakage for the various size diameter inlets at 4 inches w.g. differential pressure.

INLET DIAMETER (INCHES)	MAXIMUM ALLOWABLE CFM (AREA X 2000 FPM)	MAXIMUM ALLOWABLE CFM DAMPER LEAKAGE
6	393	6.0
8	698	11.0
10	1091	17.0
12	1571	20.0
14	2138	30.0

3. Flow Measurement: Airflow through the unit shall be accomplished by the use of a multi-port velocity pressure cross sensor or multi-axis flow ring devices with a minimum of four (4) radial distribution pick-up points connected to a center averaging chamber. The chamber is to be designed with adequate internal passages to prevent restrictions that can possibly contribute to control 'hunting'. Calibration of each terminal unit with the building automation system (BAS) Provider's controller is to be performed by the manufacturer prior to shipping the terminal unit to the Project Site.

4. [Thermal Anemometry: Terminal Unit Velocity Sensors (Applicable only to a Single Point Probe): The probe shall utilize thermal anemometry as the sensing technique. Velocity range shall be 0 to 3250 feet per minute (fpm) and with an installed accuracy of ± 25 fpm. The velocity probe shall include an insertion type-mounting bracket that mounts flush to the supply duct. The velocity probe shall be mounted parallel to the damper shaft with 1/3 or 2/3 penetration into the duct. The velocity probe shall be mounted a minimum of two duct diameters upstream of the terminal inlet for the pneumatic system. For the BAS, both sensors shall be mounted immediately upstream of the terminal unit.]Electronic probes shall be temperature compensated.

G. Access Plenum:

1. Single duct units with hot water coils shall be provided with an access section or plenum between the single duct terminal and the coil for coil inspection. Plenum construction shall be equal to the quality of materials and workmanship of the terminal unit.

2. Access plenum may also be used as a transition. Construct with a transition angle not to exceed 15 degrees.

3. Access plenum shall contain a minimum of a 12 inch diameter or 12 inch x 12 inch (or full unit width if less than 12 inches) access door as specified in Section 23 33 00.

4. Door frame may be bolted, screwed, or flanged and sealed to the casing. Door shall be gasketed and shall be doublewall construction or insulated similar to main casing. Door shall be held in place with latches or other captive retainer devices.

H. Hot Water Heating Coil:

1. Hot water coils installed in conjunction with terminal units as scheduled on the Drawings shall be factory installed having one or two tube rows and a maximum of 10 aluminum fins per inch. Airside pressure drop shall be limited to 0.2 inches w.g. at unit rated cold airflow water pressure drop shall not exceed five feet water gauge. Construct and test coils in accordance with UL and/or ARI Standards.

2. Provide full fin collars for accurate fin spacing and maximum fin-to-tube contact. Tubes shall be ½ inch diameter seamless copper with minimum wall thickness of 0.015 inches, leak tested at 300 psig air pressure under water.

3. Provide male sweat-type water connections.

4. Side and end plates shall be minimum 20 gage galvanized sheet metal construction.

5. Protect tube ends with tube end caps of sheet metal similar to casing material. Insulate within the caps. Contractor shall insulate tube sheets and coil casings in same manner as adjacent ductwork.

6. Electric Heating Coil: Electric heating coils installed in conjunction with terminal units as scheduled on the Drawings shall be factory-installed. Heaters shall be UL listed for zero clearance and meet all applicable requirements of the NEC. Resistance wire shall be 80 percent nickel and 20 percent chromium. Furnish heater with airflow switch, SCR power to heating elements or magnetic contactors, fan relay, control voltage transformer, high limit thermal cut-out, and a NEMA 1 electrical enclosure.

I. Unit Controls:

1. General Performance: Flow stations, control transformers, disconnect switch, and controls enclosure shall be furnished, mounted and adjusted by the terminal unit manufacturer to assure their proper placement within the units. If DDC controls of another manufacturer (not the terminal unit manufacturer) are provided for the Project, the terminal unit manufacturer shall be responsible only for construction of the terminal unit and installation of internal control components installed at the manufacturer's factory and shall not be responsible for 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 in connection with terminal units shall be the responsibility of the BAS Provider.

2. 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 future flexibility, 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.

3. Control Sequences: The control sequence arrangements shall be as described on the Drawings. Terminal units shall be shipped from the manufacturer with all necessary control devices to accomplish each sequence, except as may be prohibited by the BAS Provider. The desired sequence shall be adjustable according to space usage or a change in space conditions.

J. DDC Controls Protocol/Description:

1. BAS Provider will be responsible for providing all damper actuators, linkages, flow transducers, controllers, room temperature sensors, and any other devices required for unit control, except as specified below.

2. BAS Provider will be responsible for calibrating the actuator and its controller through TAB work for scheduled airflow rates. Units shall be capable of field calibration and readjustment with external gauge taps.

3. Unit manufacturer shall provide unit inlet flow sensor and pneumatic tubing for BAS Provider's use.

4. Unit manufacturer shall factory install all devices furnished by BAS Provider to result in a complete functioning unit. Unit manufacturer shall be responsible for reviewing compatibility of devices furnished by BAS Provider to units provided.

K. Pressure and Leakage Certification:

1. Manufacturer shall certify that each unit used on the Project will perform as specified. Each unit shall bear a tag or decal listing the following specified information:

a. Test pressure.

b. Leakage CFM (damper).

c. Leakage CFM (casing except fan-powered units).

d. Date of manufacture.

e. Name of person performing test.

2.04 SINGLE DUCT VARIABLE OR CONSTANT VOLUME TERMINAL UNIT

A. Pressure independent, single duct variable or constant air volume control assemblies with integral attenuator, of the sizes, capacities and configurations as scheduled on the Drawings.

B. Unit pressure drop across the assembly with an equivalent 2000 fpm inlet velocity through the inlet shall not exceed 0.15 inches water gauge.

C. Sound Ratings: All sound power levels shall be obtained from testing in accordance with ARI Standard 880.

PART 3 - EXECUTION

3.01 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. Provide clearance for inspection, repair, replacement, and service. Ensure accessibility to all terminal unit electrical control panel doors, controllers and operators are located a minimum of 30 inches from all obstructions (walls, pipe, etc.).

D. Provide ceiling access doors or locate units above easily removable ceiling components.

E. Install terminal units with a minimum of four (4) diameters of straight duct directly prior to the entry into each terminal unit connection.

F. Support units individually from structure. Do not support from adjacent ductwork. For terminal units that are not internally isolated, refer to Section 20 05 48 for terminal unit vibration isolation requirements. Terminal units shall be supported using units hanger brackets and threaded rods.

G. Connect to ductwork in accordance with Section 23 31 00.

H. Install heating coils in accordance with Section 23 82 16.

I. Wiring and controller compartments, electronic motors and damper motors shall have a minimum 24 inch clear wide and deep working space readily accessible from lift out ceiling tiles or access panels.

END OF SECTION 23 36 00

SECTION 23 37 00 – AIR OUTLETS AND INLETS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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.

1.02 SUMMARY

A. Perform all Work required to provide and install diffusers, diffuser boots, registers/grilles, louvers, louver penthouses, roof hoods, and goosenecks indicated by the Contract Documents with supplementary items necessary for proper installation.

1.03 REFERENCE STANDARDS

A. The latest published edition of a reference 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. AMCA 500 - Test Method for Louvers, Dampers and Shutters.

2. ANSI/NFPA 90A - Installation of Air Conditioning and Ventilating Systems.

3. ARI 890 – Rating of Air Diffusers and Air Diffuser Assemblies.

4. ASHRAE 70 - Method of Testing for Rating the Air Flow Performance of Outlets and Inlets.

5. SMACNA 1035 - HVAC Duct Construction Standards - Metal and Flexible.

1.04 QUALITY ASSURANCE

A. Test and rate performance of air outlets and inlets in accordance with ASHRAE 70.

B. Test and rate performance of louvers in accordance with AMCA 500.

1.05 SUBMITTALS

A. Product Data:

1. Submit product data and Shop Drawings, indicating type, size, location, application, noise level, finish, and type of mounting.

2. Review requirements of outlets and inlets as to size, finish, and type of mounting prior to submitting product data.

B. Operation and Maintenance Data:

1. Submit manufacturer's installation instructions under provisions of Division 01.

PART 2 - PRODUCTS

2.01 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. Grilles, registers and diffusers shall be as scheduled on the Drawings Grilles, registers and diffusers shall be provided with sponge rubber or soft felt gaskets where noted on the Drawings Grilles, slot diffusers and laminar flow bars shall not be internally insulated. 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 (5) foot occupancy zone will not exceed 50 fpm nor be less than 25 fpm except where indicated otherwise. Noise levels shall not exceed those published in ASHRAE for the type of space being served (NC level). In the vicinity of lab hoods, terminal velocity at face of hood shall not exceed 20 fpm.

C. Locations of air distribution devices on Drawings are approximate and shall be coordinated with other trades to make symmetrical patterns and shall be influenced by the established general pattern of the lighting fixtures or architectural reflected ceiling plan, but primarily located to maintain proper air distribution. Where called for on Drawings, grilles, registers and diffusers shall be provided with deflecting devices and manual dampers. These grilles, registers, and diffusers shall be the standard product of the manufacturer, and subject to review by the Architect.

D. Provide a frame compatible with the type of ceiling or wall in which the devices are installed. Refer to Architectural Drawings for exact type of ceiling specified.

E. Coordinate color and finish of the devices with the Architect.

2.02 MANUFACTURERS

A. Grilles, Registers, and Diffusers:

1. Krueger Manufacturing Company.

2. Titus Products.

3. Price Industries.

4. Nailor Industries.

5. MetalAire

B. Louvers:

1. American Warming and Ventilating.

2. Ruskin.

3. Greenheck.

4. Arrow.

C. Roof Hoods:

1. Greenheck.

2. Cook.

3. Acme.

2.03 ROUND CEILING DIFFUSERS

A. Round, adjustable pattern, stamped or spun, multicore type diffuser to discharge air in 360-degree pattern, with sector baffles where indicated.

B. Project diffuser collar above ceiling face and connect to duct with duct ring. In plaster ceilings, provide plaster ring.

C. Fabricate of aluminum, unless otherwise noted, with factory baked enamel, off-white finish.

D. Provide multi-louvered equalizing grid where noted on Drawings.

2.04 RECTANGULAR CEILING DIFFUSERS

A. Rectangular, full louvered face, directional, removable multi-core type diffuser to discharge air in 360-degree pattern. Neck size shall be as scheduled on the Drawings. Provide filler panels, where required, for directional throw diffusers.

B. Fabricate frame and blades of extruded aluminum with factory baked enamel, off-white finish.

C. Provide multi-louvered equalizing grid .where noted on Drawings

D. Provide round neck connection as scheduled on Drawings.

2.05 PERFORATED FACE CEILING DIFFUSERS

A. Perforated face with fully adjustable pattern and removable face.

B. Fabricate of aluminum with factory baked enamel, off-white finish.

C. Provide multi-louvered equalizing grid where noted on Drawings.

D. Provide round neck connection as scheduled on Drawings.

2.06 SQUARE PANEL FACE SUPPLY AND RETURN AIR CEILING DIFFUSER

A. Architectural diffuser with a square panel centered within a square housing similar to the Titus OMNI model. Drawings that depict two-way and three-way throw options are achieved with the use of filler panel (where required) for directional throw diffusers.

B. Opposed blade volume dampers shall be provided with the diffuser, if scheduled on the Drawings. The volume damper design shall be similar to the Titus AG-75.

C. Although the manufacturers show this model being used only as a supply air device, this same diffuser can also be used as a return air device. The neck connection shall be the largest available neck size provided by the manufacturer.

D. Provide round neck connection as scheduled on Drawings.

2.07 CEILING EXHAUST AND RETURN REGISTERS/GRILLES

A. Streamlined blades, depth of which exceeds 3/4-inch spacing, with spring or other device to set blades, vertical face.

B. Fabricate 1-inch margin frame with concealed mounting.

C. Fabricate of steel with minimum 20 gage frames and minimum 22 gage blades, steel and aluminum with minimum 20 gage frame, or aluminum extrusions, with factory baked enamel finish.

D. Opposed blade damper with removable key operator, operable from face shall only be provided with the grille when it is scheduled on the Drawing.

2.08 PERFORATED FACE RETURN/EXHAUST GRILLES

A. Perforated face with back pan, removable face, and neck sizes as indicated on Drawings.

B. Provide frame type as indicated on Drawings.

C. Fabricate completely of 22 gage steel with a baked enamel off-white finish.

2.09 LIGHT TROFFER DIFFUSERS

A. Single plenum type constructed independent of light troffers with volume and pattern controllers with oval top or side air inlet as scheduled.

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.

2.10 PERFORATED FACE CEILING EXHAUST AND RETURN REGISTERS/GRILLES.

A. 0.0375-inch stainless steel non-aspirating perforated panels with stainless steel plenum for low-velocity applications.

B. Provide quick-opening fasteners with safety chains.

C. Provide multi-louvered equalizing grid where noted on Drawings.

2.11 CEILING EGG CRATE EXHAUST AND RETURN REGISTERS/GRILLES

A. Fixed series of cubes comprised of 1/2 x 1/2 x 1-inch aluminum strips.

B. Fabricate one-inch margin aluminum frame.

C. Fabricate of aluminum with factory baked enamel finish.

D. Provide square uniform height plenum for ducted return and exhaust application of scheduled neck size.

2.12 CEILING LINEAR SLOT DIFFUSERS

A. Continuous linear flow bar slot with adjustable vanes for left, right, or vertical discharge, with volume control. Provide slot width, length and number of slots as scheduled on the Drawings.

B. Fabricate of aluminum extrusions with factory baked enamel finish.

C. Provide support clips and gasket as required for ceiling system.

D. Provide alignment strips for hairline joints and end caps where the slot terminates. Provide mitered corners.

E. Provide black matte finish for all interior exposed-to-view components.

F. Provide externally insulated supply air plenum by diffuser manufacturer.

G. Provide return slot diffuser same as supply, except without the adjustable vane control. Provide return air plenum for ducted return where indicated on Drawings.

2.13 PLENUM SLOT SUPPLY AND RETURN DIFFUSERS

A. Supply or return plenum slot, 3/4-inch, with single extruded aluminum curved deflector blade to create a tight horizontal airflow pattern across the ceiling. Provide slot width, length, and number of slots as scheduled on the Drawings.

B. Diffusers shall discharge air horizontally through two outside sections and vertically through a center down-blow section.

C. Standard nominal lengths shall be 2, 3, 4, or 5 feet. Units shall be constructed of 24 gage steel. Maximum height of the unit's plenum shall be 7-inches. Inlets shall have a minimum of 1-1/2-inch depth for duct connection. The standard finish shall be black on the face of the diffuser and pattern deflectors.

D. Diffuser shall be similar to Titus N-1-R diffuser.

2.14 PERIMETER SLOT SUPPLY AND RETURN DIFFUSERS

A. High induction supply and return plenum slot, the supply is a 3/4-inch fixed slot width that produces a horizontal discharge pattern, and a return air slot with a maximum 1-1/2-inch slot width. Provide length as scheduled on the Drawings.

B. Standard nominal lengths shall be 2, 3, 4, or 5 feet. Units shall be constructed of 24 gage steel. Maximum height of the units shall be 7-inches. Inlets shall have a minimum of 1-1/2-inch depth for duct connection. The standard finish shall be black on the face of the diffuser and pattern deflectors.

C. Diffuser shall be similar to the Titus N-1-R diffuser.

2.15 CEILING LINEAR EXHAUST AND RETURN GRILLES

A. Streamlined blades with 90-degree one-way deflection, 1/8-inch x 3/4-inch on 1/4-inch centers.

B. Fabricate 1-inch margin frame with countersunk screw mounting.

C. Fabricate of steel with 22 gage minimum frames and 22 gage minimum blades, steel and aluminum with 20 gage minimum frame, or aluminum extrusions, with factory baked enamel finish.

D. Opposed blade damper with removable key operator, operable from face shall only be provided with the grille when it is scheduled on the Drawing.

2.16 WALL SUPPLY REGISTERS/GRILLES

A. Streamlined and individually adjustable curved blades to discharge air along face of grille with two-way deflection.

B. Fabricate 1-inch margin frame with countersunk screw, concealed mounting and gasket.

C. Fabricate of aluminum extrusions with factory clear anodized finish.

D. Provide multi-louvered equalizing grid where noted on Drawings.

2.17 WALL EXHAUST AND RETURN REGISTERS/GRILLES

A. Streamlined blades, depth of which exceeds ¾-inch spacing, with spring or other device to set blades, vertical or horizontal face as scheduled.

B. Fabricate one-inch margin frame with concealed mounting.

C. Fabricate of aluminum with 20 gage minimum frame, or aluminum extrusions, with factory baked enamel finish.

2.18 LINEAR BAR WALL DIFFUSERS

A. Streamlined blades with 0 to 15 degree deflection, as scheduled, 1/8-inch x 3/4-inch or 1/4-inch centers.

B. Fabricate of aluminum extrusions, with factory clear anodized finish.

C. Fabricate 1/2-inch margin frame with concealed mounting and gasket.

D. Provide concealed fastening, straightening grids and alignment bars.

E. Provide externally insulated plenums by diffuser manufacturer.

F. Provide return bar diffusers same as supply with return air plenum.

G. Silhouette finish.

2.19 LINEAR FLOOR SUPPLY REGISTERS/GRILLES

A. Streamlined blades with zero degree deflection, 7/32-inch x 3/4-inch on 1/2-inch centers.

B. Fabricate of high-grade aluminum extrusions with factory clear anodized finish.

C. Fabricate 3/16-inch margin heavy margin frame with concealed mounting and gasket and mounting frame. Frameless flange for floor installation. Silhouette finish.

D. Provide concealed fastening, straightening grids and alignment bars.

2.20 LABORATORY RADIAL AIR SUPPLY DIFFUSERS

A. High-volume, low velocity performance.

B. Diffuser shall provide non-aspirating radial air pattern and shall be configured with air supply plenums with inlet collars to assure uniform velocity over the diffuser face.

C. Furnish stainless steel back pan and stainless steel faced diffusers for animal holding rooms.

D. Furnish aluminum back pan and aluminum-faced diffusers for laboratories.

E. Performance face drops below ceiling, single-pane back pan and single piece lower chamber. Sectioned diffuser is not acceptable.

2.21 WALL EXHAUST AND RETURN REGISTERS/GRILLES – SEVERE DUTY

A. Streamlined 40-degree fixed blades, at 1/2-inch spacing, with horizontal front blades.

B. Fabricate 1-1/4-inch margin frame with vandal-proof screws.

C. Fabricate totally of steel with minimum 18 gage frames and minimum 14 gage blades with factory baked enamel finish.

2.22 DOOR GRILLES

A. V-shaped louvers of 20 gage steel, 1-inch deep on 1/2-inch centers.

B. Provide 20 gage steel frame with auxiliary frame to give finished appearance on both sides of door, with factory prime coat finish.

2.23 LOUVERS

A. Provide 6-inch deep louvers with blades on 45-degree slope with center baffle and return bend, heavy channel frame, birdscreen on interior side with 1/2-inch square mesh for exhaust and 3/4-inch for intake.

B. Fabricate of 12 gage extruded aluminum, welded assembly, with factory prime coat finish.

C. Furnish with exterior angle flange for installation.

D. Fabricate louver penthouses with mitered corners and reinforce with structural angles.

E. Pass 750 feet per minute free velocity with less than 0.10 inches of water pressure drop, based in accordance with AMCA 500. Water penetration less than 0.025 ounce of water per foot of free area at 900 feet per minute. Provide a minimum of 45 percent free area.

2.24 ROOF HOODS

A. Fabricate air inlet or exhaust hoods in accordance with SMACNA 1035, 1-inch classification Duct Construction Standards.

B. Fabricate of galvanized steel, minimum 16 gage base and 20 gage hood, or aluminum, minimum 16 gage base and 18 gage hood; suitably reinforced; with removable hood; birdscreen with 1/2-inch square mesh for exhaust and 3/4-inch for intake, and factory prime coat finish.

C. Roof curb shall be coordinated with Owner and roofing Contractor.

D. Hood outlet area shall be minimum two times the throat area.

2.25 GOOSENECKS

A. Fabricate in accordance with SMACNA 1035, 1-inch classification, of minimum 18 gage galvanized steel.

B. Roof curb shall be coordinated with Owner and roofing Contractor.

PART 3 - EXECUTION

3.01 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. Check location of air outlets and inlets and make necessary adjustments in position to conform to architectural features, reflected ceiling plans, symmetry, and lighting arrangement.

D. Install air outlets and inlets to ductwork with airtight connection.

E. Provide balancing dampers on duct take-off to diffusers, grilles and registers, regardless of whether dampers are specified as part of the diffuser, grille, or register assembly. The use of extractors or scoops at duct take-off to diffusers, grilles and registers is not allowed.

F. Paint ductwork visible behind air outlets and inlets matte black. Refer to Division 09.

G. Provide all specialties and frames for air distribution devices as required for proper installation in ceiling type as indicated on Architectural Drawings. Provide all cutting and patching of T-bars, gypsum board, and other ceiling systems as required for installation of air devices.

END OF SECTION 23 37 00