

# Project Manual

for

The University of Texas MD Anderson Cancer Center  
Houston, Texas

## R11 Aesthetic Renewal

**MD ANDERSON PROJECT : 18-0033**

**A/E PROJECT : 182158.007**

**PROJECT DELIVERY METHOD : Design-Bid-Build**

Issue for Construction

### **OWNER'S REPRESENTATIVE**

*Ms. Kaye G. Sutton  
Project Manager and Owner's Representative*

### **MD Anderson Cancer Center**

*1515 Holcombe Blvd.  
Houston, TX 77030*

### **PROJECT ARCHITECT**

*Ian Sinnett  
Perkins+Will  
2218 Bryan Street Suite 200  
Dallas, TX 75201  
214.823.8728*

### **PROJECT ENGINEER**

*Heather Camden  
E&C Engineers  
1010 Lamar, Suite 650  
Houston, TX 77002  
713.580.8850*

### **PROJECT ARCHITECT/ENGINEER'S CONSULTANTS**

*AV Design and Technology  
Darrell Tackett  
Datacom Design Group  
7600 Burnet Rd, Suite 350  
Austin, TX 78757*

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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. 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 dampers are properly located and functional.
3. All supply, return, exhaust and transfer grilles, registers, diffusers and terminal devices are installed and airflow at each device shall be verified.
4. 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.
5. All single and/or double duct variable and constant volume terminal units ("mixing boxes") shall be installed and functional (i.e. controls functioning).
6. Duct systems and air handling units and coils are clean and free of debris.
7. 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. 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.

**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.
  - 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. 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.
4. 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.
5. 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. Alarms.
  - f. Sequences of Operation.
6. 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. 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. Zone Air Flow: Adjust each HVAC VAV terminal unit and VAV air handling unit for design CFM.
  2. 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.
  3. 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.
  4. Maximum and minimum air flow on terminal units.

### 3.02 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 the calibration and operation of all controllers.
  7. Observe the locations of all thermostats and humidistats for potential erratic operation from outside influences such as sunlight, drafts, or cold walls.
  8. 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.
  9. 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.
  10. Verify that all controller setpoints meet the Contract Documents.
  11. Check all dampers for free travel.

12. Verify the operation of all interlock systems.
13. 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.

## 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) 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. 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.
- G. Flexible ductwork connections to equipment shall not be insulated.
- H. 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.
- I. 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.
- J. 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.
- K. 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
Supply Air (Hot, Cold, Combination)	Outside of Mechanical Rooms	D1	2"
Return Air, Relief Air, and Exhaust Air	All	D1	1"
Supply Air Diffusers	Top of Diffuser	D1	2"

END OF SECTION 23 07 13

## 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. AWS D1.1 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.

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. 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.
3. 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.
4. 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 <sup>(1)</sup>
Supply and Return Systems:		
Terminal Units to Supply Air Device	Galvanized Steel <sup>(2)</sup>	Low Pressure
Exhaust Systems:		
Exhaust Air Device to Exhaust Distribution	Galvanized Steel <sup>(2)</sup>	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.

## 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. ALL DUCTS SHALL BE CONSTRUCTED USING SMACNA GAUGES AND BRACING AS REQUIRED TO AVOID THE USE OF TIE RODS HWEREVER POSSIBLE.
- 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 CONICAL BELLMOUTH FITTINGS AND TAPS

- A. Conical bellmouth fittings shall be made from 26-gage G-90 coated galvanized steel. 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 from 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".

## 2.06 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.

## 2.07 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.

### **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. 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. Project inspector shall be notified to inspect all field fabricated offsets before cover-up or external insulation is applied.
- G. 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.
- H. Support flexible ducts as per SMACNA standards to prevent sags, kinks and to have 90 degree turns.
- I. 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.
- 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 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.
- B. 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. Duct access doors.
  - 3. Duct test holes.

#### 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.

### **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 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.

#### 2.05 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. 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.
- H. Where access doors are installed above a suspended ceiling, this Contractor shall be responsible for the proper location of ceiling access doors.

### **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. 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.
- F. 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.
- G. 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.



- H. 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.

**END OF SECTION 23 33 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

### 2.03 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. 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.
- C. Provide round neck connection as scheduled on Drawings.

### 2.04 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.

### 2.05 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.

### 2.06 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.

#### 2.07 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.

#### 2.08 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.

### **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**

## **SECTION 25 00 10 – BUILDING AUTOMATION SYSTEMS (BAS) GENERAL - RETROFIT**

### **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. Section includes:
  - 1. Description of Work.
  - 2. Quality Assurance.
  - 3. System Architecture.
  - 4. Distributed Processing Units/Quantity and Location.
  - 5. Demolition and Reuse of Existing Materials and Equipment.
  - 6. Sequence of Work.
- B. Furnish and install a direct digital control and building automation system (BAS). The new BAS shall utilize electronic sensing, microprocessor-based digital control, and electronic actuation of dampers and valves (except where noted otherwise) to perform control sequences and functions specified. The BAS for this Project will generally consist of monitoring and control of systems described herein. Reference shall also be made to control Drawings, Sequence of Operation, and points lists. This project shall include relocation of existing temperature sensors and verification of proper operation of dual duct boxes only.
- C. The HVAC systems being controlled are dual duct boxes. This Section defines the manner and method by which these controls function.

#### **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. American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE).

2. ASHRAE 135: BACnet - A Data Communication Protocol for Building Automation and Control Networks. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. and all current addenda and annexes.
3. Electronics Industries Alliance:
  - a. EIA-709.1-A-99: Control Network Protocol Specification.
  - b. EIA-709.3-99: Free-Topology Twisted-Pair Channel Specification.
  - c. EIA-232: Interface between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange.
  - d. EIA-458: Standard Optical Fiber Material Classes and Preferred Sizes.
  - e. EIA-485: Standard for Electrical Characteristics of Generator and Receivers for use in Balanced Digital Multipoint Systems.
  - f. EIA-472: General and Sectional Specifications for Fiber Optic Cable.
  - g. EIA-475: Generic and Sectional Specifications for Fiber Optic Connectors and all Sectional Specifications.
  - h. EIA-573: Generic and Sectional Specifications for Field Portable Polishing Device for Preparation Optical Fiber and all Sectional Specifications.
  - i. EIA-590: Standard for Physical Location and Protection of Below-Ground Fiber Optic Cable Plant and all Sectional Specifications.
4. NEMA Compliance:
  - a. NEMA 250: Enclosure for Electrical Equipment.
  - b. NEMA ICS 1: General Standards for Industrial Controls.
5. NFPA Compliance:
  - a. NFPA 90A: "Standard for the Installation of Air Conditioning and Ventilating Systems" where applicable to controls and control sequences.
  - b. NFPA 70: National Electrical Code (NEC).
6. Institute of Electrical and Electronics Engineers (IEEE):
  - a. IEEE 142: Recommended Practice for Grounding of Industrial and Commercial Power Systems.
  - b. IEEE 802.3: CSMA/CD (Ethernet – Based) LAN.
  - c. IEEE 802.4: Token Bus Working Group (ARCNET – Based) LAN.
  - d. IEEE 519: Recommended Practices and Requirements for Harmonic Control in Electric Power Systems.



#### 1.04 QUALITY ASSURANCE

- A. Apogee Product Line Demonstrated History: The product line being proposed for the Project must have an installed history of demonstrated satisfactory operation for a length of one (1) year since date of final completion in at least ten (10) installations of comparative size and complexity. Documents with references shall be submitted verifying this requirement has been met at Owner's request.

#### 1.05 SUBMITTALS

- A. General: Submit documents under provisions of Division 01. Two (2) copies of the materials shall be delivered directly to MD ANDERSON Monitoring Services staff, in addition to the copies required by other Sections. In addition, an electronic version of the completed materials shall be provided on CD or DVD. Refer to Section 25 08 10 for additional Commissioning submittal requirements.
- B. Electronic Submittals: While all requirements for hard copy submittal apply, control submittals and operation and maintenance (O&M) information shall also be provided in electronic format as follows:
1. Drawings and Diagrams: Shop Drawings shall be provided on electronic media as an AutoCAD drawing per Owner's CAD standards. All 'x reference' and font files must be provided with AutoCAD files.
  2. Other Submittals: All other submittals shall be provided in Adobe Portable Document Format.
- C. Product Data: Submit manufacturer's technical product data for each control device, panel, and accessory furnished, indicating dimensions, capacities, performance and electrical characteristics, and material finishes. Include installation and start-up instructions.
- D. Record Documents:
1. Siemens shall submit separately and directly to Owner a pricing breakdown of all cost associated to Project for review. This is to include but not be limited to material quantity, description, unit list price, multiplier, cost, extended cost, material costs adjustment less Owner's discount price, outside material price totaled and itemized, itemized subcontract price associated to Project, and total Project support price.
    - a. Siemens labor hours quantities shall be itemized by mechanical labor, electrical labor, and design and management labor. Hour quantities shall be itemized by journeyman rate, technician rate and design/management rate with quantity of hours listed separately.
    - b. All estimated overtime shall be disclosed. Profit for Project shall be disclosed. Total Project price shall not exceed the sum of the listed itemized costs.
    - c. Provide an accurate spreadsheet breakdown of physical point counts of all analog inputs, analog outputs, digital inputs, digital outputs, building controllers and application specific controllers. The total point count for the project shall be itemized in a logical manner to allow the owner to confirm point count accuracy. Below is an example.

<b>Project Physical Point Count</b>	Drawing M-006	Drawing M-007	Drawing M-008	Drawing M-010	Drawing M-014	Drawing M-015
Physical Digital Input(s)						
Physical Digital Output(s)						
Physical Analog Input(s)						
Physical Analog Output(s)						
Building Controller(s)						
Application Specific Controller(s)						
<b>TOTALS</b>						

- d. All subcontracts greater than \$10K shall be competitively priced by a minimum of two owner approved subcontractors. Both subcontract proposals shall be fully disclosed.
  - e. This pricing summary, including any attachments, is intended only for the Owner and contains confidential and/or privileged information. Any unauthorized review; use, disclosure or distribution is prohibited.
2. Qualifications: Manufacturer, installer, and key personnel qualifications as indicated for the appropriate item above.
  3. Shop Drawings: Submit Shop Drawings electronically on AutoCAD software for each control system, including a complete drawing for each air handling unit, system, pump, device, etc. with all point descriptors, addresses and point names indicated. Shop Drawings shall contain the following information:
    - a. System Architecture and System Layout:
      - 1) One-line diagram indicating schematic locations of all control units, workstations, LAN interface devices, gateways, etc. Indicate network number, device ID, address, device instance, MAC address, drawing reference number, and controller type for each control unit. Indicate media, protocol, baud rate, and type of each LAN. All optical isolators, repeaters, end-of-line resistors, junctions, ground locations etc. shall be located on the diagram.
      - 2) Provide floor plans locating all control units, workstations, servers, LAN interface devices, gateways, etc. Include all WAN and LAN communication wiring routing, power wiring, power originating sources, and low voltage power wiring. Indicate network number, device ID, address, device instance, MAC address, drawing reference number, and controller type for each control unit. Indicate media, protocol, baud rate, and type of each LAN. All optical isolators, repeaters, end-of-line resistors, junctions, ground locations etc. shall be located on the floor plans. Wiring routing conditions shall be maintained accurately throughout the construction period and the Record Drawings shall be updated to accurately reflect accurate, actual installed conditions.

- b. Schematic flow diagram of each air and water system showing fans, coils, dampers, valves, pumps, heat exchange equipment and control devices. Include written description of sequence of operation.
- c. All physical points on the schematic flow diagram shall be indicated with names, descriptors, and point addresses identified as listed in the point summary table.
- d. With each schematic, provide a point summary table listing building number and abbreviation, system type, equipment type, full point name, point description, Ethernet backbone network number, network number, device ID, object ID (object type, instance number). If this information is not available at the time of Shop Drawings submittals, furnish with O&M manual documentation for Owner review and approval. See Section 25 15 10 for additional requirements.
- e. Label each control device with setting or adjustable range of control.
- f. Label each input and output with the appropriate range.
- g. Provide a Bill of Materials with each schematic. Indicate device identification to match schematic and actual field labeling, quantity, actual product ordering number, manufacturer, description, size, voltage range, pressure range, temperature range, etc. as applicable.
- h. With each schematic, provide valve and actuator information including size, Cv, design flow, design pressure drop, manufacturer, model number, close off rating, etc. Indicate normal positions of spring return valves and dampers.
- i. Indicate all required electrical wiring. Electrical wiring diagrams shall include both ladder logic type diagram for motor starter, control, and safety circuits and detailed digital interface panel point termination diagrams with all wire numbers and terminal block numbers identified. Provide panel termination Drawings on separate Drawings. Ladder diagrams shall appear on system schematic. Clearly differentiate between portions of wiring that is existing, factory-installed and portions to be field-installed.
- j. Details of control panels, including controls, instruments, and labeling shown in plan or elevation indicating the installed locations.
- k. Sheets shall be consecutively numbered.
- l. Each sheet shall have a title indicating the type of information included and the HVAC system controlled.
- m. Table of Contents listing sheet titles and sheet numbers.
- n. Legend and list of abbreviations.
- o. Record copies of product data, as built control Shop Drawings and final sequence of operation updated to reflect the final installed condition.
- p. Provide network architecture Record Drawings showing all nodes including a description field with specific controller identification, description and location information.

- q. Provide record riser diagram showing the location of all controllers. Indicate device instance, MAC address and drawing reference number.

E. Operation and Maintenance Data:

1. Submit maintenance instructions and spare parts lists for each type of control device, control unit, and accessory.
2. Submit BAS User's Guides (Operating Manuals) for each controller type and for all workstation hardware and software and workstation peripherals.
3. Submit BAS advanced Programming Manuals for each controller type and for all workstation software.
4. Manufacturer's Certificates: For all listed and/or labeled products, provide certificate of conformance.
5. Product Warranty Certificates: Submit manufacturer's product warranty certificates covering the hardware provided.

1.06 SYSTEM ARCHITECTURE

- A. The communication speed between the controllers, LAN interface devices, CSS, and operator interface devices shall be sufficient to ensure fast system response time under any loading condition. Contractor shall submit guaranteed response times with Shop Drawings including calculations to support the guarantee. In no case shall delay times between an event, request, or command initiation and its completion be greater than those listed herein. Contractor shall modify their BAS control design as necessary to accomplish these performance requirements. Generally requirements do not apply when a remote connection must be established via modem:
  1. 5 seconds between a Level 1 (critical) alarm occurrence and enunciation at operator workstation.
  2. 10 seconds between a Level 2 alarm occurrence and enunciation at operator workstation.
  3. 20 seconds between a Level 3-5 alarm occurrence and enunciation at operator workstation.
  4. 10 seconds between an operator command via the operator interface to change a set point and the subsequent change in the controller.
  5. 5 seconds between an operator command via the operator interface to start/stop a device and the subsequent command to be received at the controller.
  6. 10 seconds between a change of value or state of an input and it being updated on the operator interface.
  7. 10 seconds between an operator selection of a graphic and it completely painting the screen and updating at least ten (10) points.
- B. Interruptions or fault at any point on any Primary Controller LAN shall not interrupt communications between other BAS nodes on the network. If a LAN is severed, two (2) separate networks shall be formed and communications within each network shall continue uninterrupted.

1.07 DELIVERY, STORAGE AND HANDLING

- A. Provide factory-shipping cartons for each piece of equipment and control device. Maintain cartons during shipping, storage and handling as required to prevent equipment damage, and to eliminate dirt and moisture from equipment. Store equipment and materials inside and protect from weather.

1.08 WARRANTY

- A. Contractor shall warranty all products and labor for a period of one year after Substantial Completion.
- B. The Owner reserves the right to make changes to the BAS during the Warranty Period. Such changes do not constitute a waiver of warranty. Contractor shall warrant parts and installation work regardless of any such changes made by Owner, unless the Contractor provides clear and convincing evidence that a specific problem is the result of such changes to the BAS. Any disagreement between Owner and Contractor on such matters shall be subject to resolution through the Contract 'Disputes' clause.
  - 1. At any time during the Warranty Period that Contractor is on the Project Site for maintenance, emergency, or normal service, Contractor shall notify Owner via MD ANDERSON Monitoring Services and the local building operating personnel.
  - 2. Contractor shall notify said personnel of all work anticipated being involved for the service work. In addition, no work affecting system operation shall commence until express permission is granted.

**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. The BAS and digital control and communications components installed as Work of this Contract shall be an integrated distributed processing system of the following manufacturer or communication protocol. No other products will be considered as substitutions.
  - 1. Siemens Building Technologies - APOGEE: Provide control products and systems that completely integrate and operate from the existing APOGEE system currently in operation at the institution. All access, programming, alarming, and system configuration shall be utilized from the existing system software and database without any third party programs or gateways.
  - 2. Substitutions: None

2.03 MATERIALS AND EQUIPMENT

- A. Materials shall be new, the best of their respective kinds without imperfections or blemishes, and shall not be damaged in any way. Used equipment shall not be used in any way for the permanent installation except where Drawings or Specifications specifically allow existing materials to remain in place.

## 2.04 UNIFORMITY

- A. To the extent practical, all equipment of the same type serving the same function shall be identical and from the same manufacturer.

## 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. Fasteners requiring explosive powder (shooting) or pneumatic-driven actuation will not be acceptable under any circumstances.
- D. Refer to additional requirements in other Sections of this Specification.

### 3.02 SURGE PROTECTION

- A. Contractor shall furnish and install any power supply surge protection, filters, etc. as necessary for proper operation and protection of all BCs, AAC/ASCS operator interfaces, printers, routers, gateways and other hardware and interface devices. All equipment shall be capable of handling voltage variations 10 percent above or below measured nominal value, with no affect on hardware, software, communications, and data storage.

### 3.03 CONTROL POWER SOURCE AND SUPPLY

- A. BAS Provider shall extend all power source wiring required for operation of all equipment and devices provided under Division 25 and the Drawings if not specified under Division 26.
- B. General requirements for obtaining power include the following:
  - 1. All control power for a given stand alone controller and all associated controls for this stand alone controller shall originate from the same circuit.
  - 2. All mechanical equipment which is supplied with emergency power shall have the DDC controller supplied with emergency power.
  - 3. Provide an uninterruptible power supply (UPS) as indicated on the Drawings or as necessary. UPS shall protect against blackouts, brownouts, surges and noise.
    - a. UPS shall include LAN port and modem line surge protection.
    - b. UPS shall be sized for a 7-minute full load runtime, 23-minute 1/2 load runtime, with a typical runtime of up to 60 minutes. Transfer time shall be 2-4 milliseconds.
    - c. UPS shall provide a 480-joule suppression rating and current suppression protection for 36,000 amps and provide 90 percent recharge capability in 2-4 hours. Suppression response time shall be instantaneous. UPS low voltage switching shall occur when supply voltage is less than 94 volts.

- d. Provide a Maintenance Bypass Switch that allows input voltage to bypass the UPS and directly power the connected equipment if an abnormal condition prevents the UPS from supporting the load, or if the UPS is required to be taken out of service.
- e. Provide all software, cables, peripherals etc. for a complete system.

**END OF SECTION 25 00 10**

## **SECTION 25 08 10 – BAS COMMISSIONING - RETROFIT**

### **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. Section includes:
  - 1. BAS and equipment testing and Start-up.
  - 2. Validation of proper and thorough installation of BAS and equipment.
  - 3. Functional testing of control systems.
  - 4. Documentation of tests, procedures, and installations.
  - 5. Coordination of BAS training.
  - 6. Documentation of BAS Operation and Maintenance materials.
- B. This Section defines responsibilities of the Contractor to commission the BAS.
- C. The term "Owner" shall include a representative from MD ANDERSON Building Automation Services but is not limited to represent the Owner exclusively. Coordinate all activities to include all of the Owner's representatives.
- D. Commissioning is the process of ensuring that all building systems are installed and perform interactively according to the design intent, the systems are efficient and cost effective and meet the Owner's operational needs, the installation is adequately documented, and that the Operators are adequately trained. It serves as a tool to minimize post-occupancy operational problems. It establishes testing and communication protocols in an effort to advance the building systems from installation to full dynamic operation and optimization.
- E. The Contractor shall direct, coordinate, and oversee the Commissioning process and witness functional performance tests.
- F. The Owner's TAB Firm may write the Owner approved control sequence verification sheets for functional performance tests and develop forms using the BAS Provider's point log to test each point back to the graphical interface. The BAS Provider shall furnish the Contractor with an estimated time to complete this task, which Contractor will incorporate in the Project Schedule. In the event Owner's TAB Firm is not under contracted for the Project, the Contractor shall write the Owner approved sequence verification sheets for functional performance tests.



### 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 all references.

### 1.04 CONTRACTOR RESPONSIBILITIES

- A. Completely install and thoroughly inspect, startup, test, adjust, balance, and document all systems and equipment.
- B. Assist Owner and/or TAB Firm in verification and functional performance testing. This will generally include the following:
  - 1. Attend Commissioning progress and coordination meetings.
  - 2. Prepare and submit required draft forms and systems information.
  - 3. Establish trend logs of system operation as specified herein.
  - 4. Demonstrate system operation.
  - 5. Manipulate systems and equipment to facilitate testing.
  - 6. Provide instrumentation necessary for verification and performance testing.
  - 7. Manipulate control systems to facilitate verification and performance testing.
  - 8. Train Owner as specified in this Section.
- C. Compensation for Retesting: Contractor shall compensate Owner for Site time necessitated by incompleteness of systems or equipment at time of functional performance testing. All testing failures, which require on-Site time for retesting, will be considered actual damages to the Owner. All parties under Contract with the Owner who are affected by the retesting shall be included in the Contract modification.

### 1.05 SUBMITTALS

- A. The following list outlines the general sequence of events for submittals and commissioning:
  - 1. Submit product data and Shop Drawings, and receive approval.
  - 2. Submit BAS logic documentation, and receive approval.
  - 3. Submit background graphic screens, and receive approval.
  - 4. Submit Start-Up Checklists and manufacturer's start-up procedures for all equipment provided by the Contractor.
  - 5. Install BAS.

6. Submit BAS Start-Up Test Agenda and Schedule for review.
7. Receive BAS Startup Test Agenda/schedule approval.
8. Submit Training Plan.
9. Simulate sequencing and debug program off-line to the extent practical.
10. Place systems under BAS control where applicable during a scheduled outage.
11. Perform BAS Startup where applicable during a scheduled outage.
12. Prepare and initiate trend log data storage and format trend graphs.
13. Submit completed BAS Start-Up Reports and initial draft of the Operating and Maintenance (O&M) Manuals.
14. Receive BAS Startup Report approval and approval to schedule Demonstrations and Commissioning.
15. Demonstrate systems to Owner.
16. Submit Trend Logs in format specified.
17. Receive demonstration approval and approval to schedule Acceptance Period.
18. Train Owner on BAS operation and maintenance.
19. Substantial Completion.
20. Begin Acceptance Phase.
21. Two-week Operational Test.
22. Perform Functional Performance Testing including point to point verification to graphical interface.
23. Receive Acceptance Period approval, which is Functional Completion for the BAS.
24. Train Owner on final sequences and modes of operation.
25. Install framed control Drawings.
26. Provide Level 1 password access to the Owner.
27. Revise and re-submit Record Drawings and O&M Manuals.
28. Manager of Building Automation Services sign-off required.
29. Final Acceptance.
30. Begin Warranty Phase.
31. Schedule and begin Opposite Season acceptance period.
32. Receive Opposite Season acceptance period approval.

33. Submit Record Drawings and O&M Manuals.
34. Update framed control Drawings.
35. Complete Owner Training.
36. End-of-Warranty date/period.

## **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 INSTRUMENTATION**

- A. Instrumentation required to verify readings and to test the system and equipment performance shall be provided by Contractor and made available to Owner. Generally, no testing equipment will be required beyond that required to perform Contractor's Work under these Contract Documents. All equipment used for testing and calibration shall be NIST/NBS traceable and calibrated within the preceding 6-month period. Certificates of calibration shall be submitted.

### **2.03 TAB AND COMMISSIONING PORTABLE OPERATORS TERMINAL**

- A. For new Projects, Contractor shall provide portable operators terminal or hand held device to facilitate Testing, Adjusting, and Balancing (TAB) and calibration. This software or device shall support all functions and allow querying and editing of all parameters required for proper calibration and Start-up.
- B. Connections shall be provided local to the device being calibrated. For instance, for terminal units, connection of the operator's terminal shall be either at the sensor or at the terminal unit. Otherwise a wireless system shall be provided to facilitate this local functionality.

## **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.

### **3.02 BAS START-UP TESTING, ADJUSTING, CALIBRATION**

- A. Work and/or systems installed under this Division shall be fully functioning prior to Demonstration and Acceptance Phase. Contractor shall start, test, adjust, and calibrate all work and/or systems under this Contract, as described below:
  1. Inspect the installation of all devices. Review the manufacturer's installation instructions and validate that the device is installed in accordance with them.

2. Verify proper electrical voltages and amperages, and verify that all circuits are free from faults.
3. Verify integrity/safety of all electrical connections.
4. Coordinate with Owner's TAB Firm to obtain control settings that are determined from balancing procedures. Record the following control settings as obtained from Owner's TAB Firm, and note any TAB deficiencies in the BAS Start-Up Report:
  - a. Optimum duct static pressure setpoints for VAV air handling units.
  - b. Minimum outside air damper settings for air handling units.
  - c. Optimum differential pressure setpoints for variable speed pumping systems.
  - d. Calibration parameters for flow control devices such as VAV terminal units and flow measuring stations.
    - 1) Contractor shall provide hand-held device as a minimum to the TAB Firm to facilitate calibration. Connection for any given device shall be local to it (i.e. at the VAV terminal unit or at the thermostat). Hand-held device or portable operator's terminal shall allow querying and editing of parameters required for proper calibration and start-up.
5. Test, calibrate, and set all digital and analog sensing and actuating devices. Calibrate each instrumentation device by making a comparison between the BAS display and the reading at the device, using an instrument traceable to the National Bureau of Standards, which shall be at least twice as accurate as the device to be calibrated (e.g., if field device is +/-0.5 percent accurate, test equipment shall be +/-0.25 percent accurate over same range). Record the measured value and displayed value for each device in the BAS Start-up Report.
6. Check and set zero and span adjustments for all transducers and transmitters.
7. For dampers and valves:
  - a. Check for adequate installation including free travel throughout range and adequate seal.
  - b. Where loops are sequenced, check for proper control without overlap.
8. For actuators:
  - a. Check to insure that device seals tightly when the appropriate signal is applied to the operator.
  - b. Check for appropriate fail position, and that the stroke and range is as required.
  - c. For pneumatic operators, adjust the operator spring compression as required to achieve close-off. If positioner or volume booster is installed on the operator, calibrate per manufacturer's procedure to achieve spring range indicated. Check split-range positioners to verify proper operation. Record settings for each device in the BAS Pre-Commissioning Report.
  - d. For sequenced electronic actuators, calibrate per manufacturer's instructions to required ranges.

9. Check each digital control point by making a comparison between the control command at the CU and the status of the controlled device. Check each digital input point by making a comparison of the state of the sensing device and the Operator Interface display. Record the results for each device in the BAS Start-Up Report.
10. For outputs to reset other manufacturer's devices (for example, VSDs) and for feedback from them, calibrate ranges to establish proper parameters. Coordinate with representative of the respective manufacturer and obtain their approval of the installation.
11. Verify proper sequences by using the approved checklists to record results and submit with BAS Start-Up Report. Verify proper sequence and operation of all specified functions.
12. Verify that all safety devices trip at appropriate conditions. Adjust setpoints accordingly.
13. Tune all control loops to obtain the fastest stable response without hunting, offset or overshoot. Record tuning parameters and response test results for each control loop in the BAS Start-up Report. Except from a startup, maximum allowable variance from set point for controlled variables under normal load fluctuations shall be as follows. Within 3 minutes of any upset (for which the system has the capability to respond) in the control loop, tolerances shall be maintained (exceptions noted):
  - a. Space Temperature:  $\pm 1$  degrees F within 30 minutes.
  - b. Air flow control:  $\pm 5$  percent of setpoint velocity.
14. For interface and DDC control panels:
  - a. Ensure devices are properly installed with adequate clearance for maintenance and with clear labels in accordance with the Record Drawings.
  - b. Ensure that terminations are safe, secure and labeled in accordance with the Record Drawings.
  - c. Check power supplies for proper voltage ranges and loading.
  - d. Ensure that wiring and tubing are run in a neat and workman-like manner, either bound or enclosed in trough.
  - e. Check for adequate signal strength on communication networks.
  - f. Check for standalone performance of controllers by disconnecting the controller from the LAN. Verify the event is annunciated at Operator Interfaces. Verify that the controlling LAN reconfigures as specified in the event of a LAN disconnection.
  - g. Ensure that all outputs and devices fail to their proper positions/states.
  - h. Ensure that buffered and/or volatile information is held through power outage.
  - i. With all system and communications operating normally, sample and record update/annunciation times for critical alarms fed from the panel to the Operator Interface.
  - j. Check for proper grounding of all DDC panels and devices.
15. For Operator Interfaces:

- a. Verify that all elements on the graphics are functional and are properly bound to physical devices and/or virtual points, and that hot links or page jumps are functional and logical.
  - b. Output all specified BAS reports for review and approval.
  - c. Verify that the alarm printing and logging is functional and per requirements.
  - d. Verify that trends are archiving to disk and provide a sample to the Owner for review.
  - e. Verify that paging/dial-out alarm annunciation is functional.
  - f. Start-up and check out control air compressors, air drying, and filtering systems in accordance with the appropriate section and with manufacturer's instructions.
  - g. Verify proper interface with fire alarm system.
- B. Submit Start-Up Test Report: Report shall be completed, submitted, and approved prior to Substantial Completion.

### 3.03 SENSOR CHECKOUT AND CALIBRATION

- A. General Checkout: Verify that all sensor locations are appropriate and are away from causes of erratic operation. Verify that sensors with shielded cable are grounded only at one end. For sensor pairs that are used to determine a temperature or pressure difference, make sure they are reading within 0.2 degrees F of each other for temperature and within a tolerance equal to 2 percent of the reading of each other for pressure. Tolerances for critical applications may be tighter.
- B. Calibration: Calibrate all sensors using one of the following procedures:
1. Sensors Without Transmitters - Standard Application: Make a reading with a calibrated test instrument within 6 inches of the site sensor at various points across the range. Verify that the sensor reading (via the permanent thermostat, gauge or BAS) is within the tolerances specified for the sensor. If not, adjust offset and range, or replace sensor. Where sensors are subject to wide variations in the sensed variable, calibrate sensor within the highest and lowest 20 percentage of the expected range.
  2. Sensors With Transmitters - Standard Application: Disconnect sensor. Connect a signal generator in place of sensor. Connect ammeter in series between transmitter and BAS control panel. Using manufacturer's resistance-temperature data, simulate minimum desired temperature. Adjust transmitter potentiometer zero until the ammeter reads 4 mA. Repeat for the maximum temperature matching 20 mA to the potentiometer span or maximum and verify at the OI. Record all values and recalibrate controller as necessary to conform to tolerances. Reconnect sensor. Make a reading with a calibrated test instrument within 6 inches of the site sensor. Verify that the sensor reading (via the permanent thermostat, gauge or BAS) is within the tolerances specified. If not, replace sensor and repeat. For pressure sensors, perform a similar process with a suitable signal generator.
- C. Sensor Tolerance: Sensors shall be within the tolerances specified for the device. Refer to Section 25 11 10.

### 3.04 BAS DEMONSTRATION

- A. All BAS Demonstration shall take place on the main Control Systems Server and MD ANDERSON WAN. Schedule to add system to main Control Systems Server and MD ANDERSON WAN with Owner at least two (2) weeks in advance to the demonstration. At the time of request, provide all documentation that the following criterions are met:
1. Updated BAS submittals in electronic and hard copy to Owner including the updated riser diagram for the system.
  2. Reports on verification of Network Layout Verification including but not limited to Building Controller locations, cable routes with length of cable between controllers and any trunk extenders or trunk isolators.
  3. Reports on verification of electrical characteristics of BAS network, communications and electrical integrity of Building Controllers.
  4. Reports on verification of traffic on BAS Network including but not limited to COVs between Building Controllers, point commands by the operator, point commands by program across the network, alarm reporting on the network, any unresolved points in the system, integrity of the ports on any Building Controller isolator/extender and results of Building Controller tests running at selected baud rate.
  5. Demonstrate to Owner the updates of databases without errors or faults between the temporary Control Systems Server and Building Controllers. If there is no temporary server, demonstrate to Owner after system is added to main Control Systems Server.
  6. Reports on verification of system log files, interruption of log files of system traffic and overall acceptable operation of the system where a temporary Control Systems Server is utilized.
- B. Demonstrate the operation of the BAS hardware, software, and all related components and systems to the satisfaction of the Owner. Schedule the demonstration with the Owner seven (7) calendar days in advance. Demonstration shall not be scheduled until all hardware and software submittals, and the Start-Up Test Report are approved. If the Work fails to conform to the Contract Documents, so as to require scheduling of additional Site visits by the Owner for re-demonstration, Contractor shall reimburse Owner for costs of subsequent Site visits.
- C. The Contractor shall supply all personnel and equipment for the demonstration, including, but not limited to, instruments, ladders, etc. Contractor-supplied personnel must be competent with and knowledgeable of all project-specific hardware, software, and the HVAC systems. All training documentation and submittals shall be at the Project Site.
- D. Demonstration shall typically involve small representative samples of systems/equipment randomly selected by the Owner.
- E. The system shall be demonstrated following the same procedures used in the Start-Up Test by using the approved Commissioning Checklists. Demonstration shall include, but not necessarily be limited to, the following:
1. Demonstrate that required software is installed on BAS workstations. Demonstrate that graphic screens, alarms, trends, and reports are installed as submitted and approved.
  2. Demonstrate that points specified and shown can be interrogated and/or commanded (as applicable) from all workstations, as specified.

3. Demonstrate that remote dial-up communication abilities are in accordance with these Specifications.
  4. Demonstrate correct calibration of input/output devices using the same methods specified for the Start-Up Tests. A maximum of 10 percent of I/O points shall be selected at random by the Owner for demonstration. Upon failure of any device to meet the specified end-to-end accuracy, an additional 10 percent of I/O points shall be selected at random by Owner for demonstration. This process shall be repeated until 100 percent of randomly selected I/O points have been demonstrated to meet specified end-to-end accuracy.
  5. Demonstrate that all DDC and other software programs exist at respective field panels. The Direct Digital Control (DDC) programming and point database shall be as submitted and approved.
  6. Demonstrate that all DDC programs accomplish the specified sequence of operation.
  7. Demonstrate that the panels and DDC network of panels automatically recover from power failures within five (5) minutes after power is restored.
  8. Demonstrate that the stand-alone operation of panels meets the requirements of these Specifications. Demonstrate that the panels' response to LAN communication failures meets the requirements of these Specifications.
  9. Identify access to equipment selected by the Owner. Demonstrate that access is sufficient to perform required maintenance.
  10. Demonstrate that required trend graphs and trend logs are set up per the requirements. Provide a sample of the data archive. Indicate the file names and locations.
- F. BAS Demonstration shall be completed and approved prior to Substantial Completion.
- G. Any tests successfully completed during the demonstration will be recorded as passed for the functional performance testing and will not have to be retested.

### 3.05 BAS ACCEPTANCE PERIOD

- A. After approval of the BAS Demonstration and prior to Contract Close Out Acceptance Phase shall commence. Acceptance Period shall not be scheduled until all HVAC systems are in operation and have been accepted, all required cleaning and lubrication has been performed.
- B. Operational Test: At the beginning of the Acceptance Phase, the system shall operate properly for two (2) weeks without malfunction, without alarm caused by control action or device failure, and with smooth and stable control of systems and equipment in conformance with these Specifications. At the end of the two weeks, Contractor shall forward the trend logs to the Owner for review. Owner shall determine if the system is ready for functional performance testing and document any problems requiring Contractor's attention.
  1. If the systems are not ready for functional performance testing, Contractor shall correct problems and provide notification to the Owner that all problems have been corrected. The Acceptance Period shall be restarted at a mutually scheduled time for an additional one-week period.
  2. This process shall be repeated until Owner issues notice that the BAS is ready for functional performance testing.



- C. During the Acceptance Period, the Contractor shall maintain a hard copy log of all alarms generated by the BAS. For each alarm received, Contractor shall diagnose the cause of the alarm, and shall list on the log for each alarm, the diagnosed cause of the alarm, and the corrective action taken. If in the Contractor's opinion, the cause of the alarm is not the responsibility of the Contractor, Contractor shall immediately notify the Owner.

### 3.06 BAS OPERATOR TRAINING AND O&M MANUALS

- A. Provide up to four (4) complete sets of the approved Operations and Maintenance (O&M) Manuals (hard copy and one electronic copy) to be used for training.
- B. Contractor shall submit a Training Plan for the scope of training for which BAS Provider is responsible. Training Plan shall be forwarded to the Contractor who will compile, organize, format, and forward to the Engineer for review.
  - 1. Coordinate requirements of Training with the MD ANDERSON Monitoring Services Department.
- C. On-Site Training: Provide services of BAS Provider's qualified technical personnel for 8-hour days to instruct Owner's personnel in operation and maintenance of BAS. Instruction shall be in classroom setting at the Project Site for appropriate portions of the training. Training may be in non-contiguous days at the request of the Owner. The Owner shall notify Contractor seven (7) calendar days in advance of each day of requested training. The Contractor's designated training personnel shall meet with the Engineer and Owner for the purpose of discussing and fine-tuning the training agenda prior to the first training session. Training agenda shall generally be as follows:
  - 1. Basic Operator Workstation (OWS) Training – For all potential users of the OWS:
    - a. Brief walk-through of building, including identification of all controlled equipment and condensed demonstration of controller portable and built-in operator interface device display capabilities.
    - b. Brief overview of the various parts of the O&M Manuals, including hardware and software programming and operating publications, catalog data, controls installation Drawings, and DDC programming documentation.
    - c. Demonstration of workstation login/logout procedures, password setup, and exception reporting.
    - d. Demonstration of workstation menu penetration and broad overview of the various workstation features.
    - e. Overview of systems installed.
    - f. Present all Site-specific point naming conventions and points lists, open protocol information, configuration databases, back-up sequences, upload/download procedures, and other information as necessary to maintain the integrity of the BAS.
    - g. Overview of alarm features.
    - h. Overview of trend features.
    - i. Overview of workstation reports.

2. BAS Hardware Training – For Maintenance and Control Technicians:
    - a. Review of installed components and how to install/replace, maintain, commission, and diagnose them.
  3. BAS Technician Training:
    - a. Introduction to controller programming and overview of the programming application interface.
    - b. General review of sequence of operation and control logic for the Project Site, including standalone and fail-safe modes of operation.
    - c. Uploading/downloading and backing up programs.
    - d. Network administration.
    - e. Review of setpoint optimization and fine-tuning concepts.
- 3.07 WARRANTY PHASE BAS OPPOSITE SEASON TRENDING AND TESTING
- A. Trending: Throughout the Warranty Phase, trend logs shall be maintained. Contractor shall forward archive trend logs to the Owner for review upon Owner request. Owner will review these and notify Contractor of any warranty work required.
  - B. Opposite Season Testing: Within twelve (12) months of Substantial Completion, Contractor shall schedule and conduct with Owner, Opposite Season functional performance testing. BAS Provider shall participate in this testing and remedy any deficiencies identified.

**END OF SECTION 25 08 10**

## **SECTION 25 11 00 – BAS BASIC MATERIALS, INTERFACE DEVICES, AND SENSORS**

### **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. The extent of this project is relocating existing pneumatic temperature sensors..

#### **1.02 SUMMARY**

- A. Pneumatic Tubing.
- B. Wiring.
- C. Control Dampers and Actuators.
- D. Sensors.
- E. Pneumatic Control Components (Gauges, Switches, Relays, etc.).
- F. Electric Control Components (Switches, EP Valves, Thermostats, Relays, etc.).
- G. Transducers.
- H. Testing Equipment.
- I. Refer to Section 25 00 00 for general requirements.
- J. Refer to other Division 20 and Division 23 Sections for installation of instrument wells, valve bodies, and dampers in mechanical systems; not Work of this Section.
- K. Provide the following electrical work as work of this Section, complying with requirements of Division 26 Sections.
  - 1. Control wiring between field-installed controls, indicating devices, and unit control panels.
  - 2. Interlock wiring between electrically interlocked devices, sensors, and between a hand or auto position of motor starters as indicated for all mechanical and controls.
  - 3. Wiring associated with annunciator and alarm panels (remote alarm panels) and connections to their associated field devices.
  - 4. All other necessary wiring for fully complete and functional control system as specified.

#### **1.03 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 all references.

#### 1.04 WORK BY OTHERS

- A. Control Valves furnished under this Section shall be installed under the applicable piping Section under the direction of the BAS Provider who will be fully responsible for the proper operation of the valve.
- B. Control Dampers furnished under this Section shall be installed under the applicable air distribution or air handling equipment Section under the direction of the BAS Provider who will be fully responsible for the proper operation of the damper.
- C. Controlled Equipment Power Wiring shall be furnished and installed under Division 26. Where control involves 120 volt (V) control devices controlling 120V equipment, Division 26 Contractor shall extend power wiring to the equipment. BAS Provider shall extend it from the equipment to the control device.

## PART 2 - PRODUCTS

### 2.01 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. Provide electronic, pneumatic, and electric control products in sizes and capacities indicated, consisting of valves, dampers, controllers, sensors, and other components as required for complete installation. Except as otherwise indicated, provide manufacturer's standard materials and components as published in their product information; designed and constructed as recommended by manufacturer, and as required for application indicated.

### 2.02 MATERIALS AND EQUIPMENT

1. Main Air Piping (between the compressors and the field control panels): Hard drawn copper tubing, ASTM B 88, Type L.
2. Branch Air Piping (to include main air between field control panels and field devices: Seamless copper tubing, Type K or L, ASTM B 88; with cast-bronze solder joint fittings, ANSI B1.18; or wrought-copper solder-joint fittings, ANSI B16.22; except brass compression-type fittings at connections to equipment. Solder shall be 95/5 tin antimony, or other suitable lead free composition solder.
3. Branch Air Piping Termination And Tubing Within Control Panels: Virgin polyethylene non-metallic tubing type FR, ASTM D 2737. Use compression or push-on brass fittings.

### **PART 3 - EXECUTION**

#### **3.01 PREPARATION**

- A. Examine areas and conditions under which control systems are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Owner.

#### **3.02 INSTALLATION OF CONTROL SYSTEMS**

- 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. General: Install systems and materials in accordance with manufacturer's instructions, roughing-in drawings and details shown on drawings. Install electrical components and use electrical products complying with requirements of the latest edition of the National Electrical Code and all local codes.
- D. Branch Control Air Piping: Accessible tubing is defined as that tubing run in mechanical equipment rooms; inside mechanical equipment enclosures, such as heating and cooling units, instrument panels; across roofs, in pipe chases, etc. Inaccessible tubing is defined as that tubing run in concrete slabs; furred walls; or ceilings with no access.
  - 1. Provide copper tubing with maximum unsupported length of three (3) feet for accessible tubing run exposed to view. Terminal single-line connections less than 18 inches length may be copper tubing, or polyethylene tubing run. Tubing exposed to ambient conditions must be properly protected from sunlight and protected from damage.
  - 2. Provide copper tubing for inaccessible tubing, other than in concrete pour. In a concrete pour polyethylene tubing may be used, install in rigid conduit or vinyl-jacketed polyethylene tubing. Install in galvanized rigid steel conduit at all exterior locations. Install in PVC Schedule 40 conduit if encased in concrete.
  - 3. Polyethylene tubing may be used in control panels provided it is run in a neat and orderly fashion, bundled where applicable, properly supported and installed in a neat and workman like manner. Fasten flexible connections bridging cabinets and doors, neatly along hinge side, and protect against abrasion.
  - 4. Pressure test control air piping at 30 psi (207 kPa) for 24 hours. Test fails if more than 2 psi loss occurs.
  - 5. Number-code or color-code tubing, except local individual room control tubing, for future identification and servicing of control system. Code shall be as indicated on approved installation drawings.
- E. Control Wiring: The term "control wiring" is defined to include providing of wire, conduit and miscellaneous materials as required for mounting and connection of electric control devices.

1. Wiring System: Install complete wiring system for electric control systems. Conceal wiring exposed in mechanical rooms and areas where other conduit and piping are exposed. Installation of wiring shall generally follow building lines. Install in accordance with the latest edition of the National Electrical Code and Division 26. Fasten flexible conductors bridging cabinets and doors, neatly along hinge side, and protect against abrasion. Tie and support conductors neatly.
2. Control Wiring Conductors: Install control wiring conductors, without splices between terminal points, color-coded. Install in neat workmanlike manner, securely fastened. Install in accordance with the latest edition of the National Electrical Code and Division 26.
3. Communication wiring, signal wiring and low voltage control wiring shall be installed separate from any wiring over thirty (30) volts. Signal wiring shield shall be grounded at controller end only, unless otherwise recommended by the controller manufacturer.
4. All WAN and LAN patch cords shall be approved and installed as directed by owner.
5. BAS low voltage wiring/cables: All cables shall have legible printed sleeve identification labels at each device and the panel termination.
  - a. Labels shall be Brady PermaSleeve TM, part number - "BPSPT-187-175-WT" or owner approved equivalent.
  - b. Each label shall be identified with the entire BAS point name utilized in the BAS database and the point address.
  - c. Install RJ11 modular jack plates for the Owner's spare alarm connection points specified on the drawing. The entire point address printed with black text on 1/2" high white labels shall be installed to identify each port of the RJ11 modular jack plate. Contractor shall confirm exact wall location with the Owner prior to installing
6. Terminate all control wiring internal to panels to screw terminals connections or owner approved wire connection equivalent. Wire nuts and/or splices are not allowed in panels. When terminating a wire cable, the cable jacket, cable shielding wire, and cable shielding material shall be finished in a neat consistent workmanlike manner.
7. [Install all control wiring external to panels in electric metallic tubing or raceway. Installation of wiring shall generally follow building lines. Provide compression type connectors. Install wiring in galvanized rigid steel conduit at all exterior locations and where subjected to moisture. Install in PVC Schedule 40 conduit if encased in concrete. All conduits penetrating partitions, walls or floors shall be sealed with a submitted and approved fire/smoke sealant material to prevent migration of air through the conduit system.
8. [Communication wiring, signal wiring and low voltage control wiring may be run without conduit in concealed, accessible locations if noise immunity is ensured.
  - a. Contractor shall be fully responsible for noise immunity and rewire in conduit if electrical or RF noise affects performance.
  - b. Accessible locations are defined as areas inside mechanical equipment enclosures, such as heating and cooling units, instrument panels etc.; in accessible pipe chases with easy access, or suspended ceilings with easy access. Installation of wiring shall generally follow building lines.

- c. Run in a neat and orderly fashion, bundled where applicable, and completely suspended (strapped to rigid elements or routed through wiring rings) away from areas of normal access. Tie and support conductors neatly with suitable nylon ties and not to exceed five (5) foot intervals.
  - d. Conductors shall not be supported by the ceiling system or ceiling support system. Conductors shall be pulled tight and be installed as high as practically possible in ceiling cavities. Wiring shall not be laid on the ceiling or duct.
  - e. Conductors shall not be installed between the top cord of a joist or beam and the bottom of roof decking.
9. Secondary LAN Communication cabling shall be provided in an Owner approved color dedicated to the BAS.
10. Number-code or color-code conductors appropriately for future identification and servicing of control system. Code shall be as indicated on approved installation drawings.

**END OF SECTION 25 11 00**