

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

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General Conditions and Division 01 Specification Sections, apply to this Section.
- B. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.02 SUMMARY

- A. Perform all Work required to prepare the building HVAC systems for testing, adjusting, and balancing (TAB) Work indicated by the Contract Documents, including the following:
 - 1. Preparation of air systems for testing, adjusting and balancing.
 - 2. Preparation of hydronic and steam systems for testing, adjusting and balancing.
 - 3. Providing materials and labor to assist TAB Firm in meeting testing, adjusting and balancing requirements.
- B. Testing, adjusting and balancing of the air conditioning systems and related ancillary equipment will be performed by a technically qualified TAB Firm. The preparation for and corrections necessary for the testing, adjusting and balancing of these systems, as described herein, are the responsibility of this Contractor.
- C. Make any changes or replacements to the sheaves, belts, dampers and valves required for correct balance as advised by the TAB Firm, at no additional cost to the Owner.

1.03 REFERENCE STANDARDS

- A. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.
- B. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.
- C. All materials, installation and workmanship shall comply with the applicable requirements and standards addressed within the following references:
 - 1. AABC: National Standards for Testing and Balancing Heating, Ventilating and Air Conditioning Systems.
 - 2. AABC: Testing and Balancing Procedures.
 - 3. ASHRAE HVAC Applications Chapter 37: Testing, Adjusting and Balancing.

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

1.04 QUALITY ASSURANCE

- A. Provide and coordinate the services of qualified, responsible Subcontractors, suppliers and personnel as required to correct, repair, and/or replace any and all deficient items or conditions found during the course of this project, including during the testing, adjusting and balancing period.
- B. In order that systems may be properly tested, adjusted, and balanced, the Contractor shall operate systems at Contractor's expense for the length of time necessary to properly verify the systems' completion and readiness for TAB.
- C. Project Contract completion schedules shall allow for sufficient time to permit the completion of TAB services prior to Owner occupancy. Allow adequate time for the testing and balancing activities during the construction period and prior to Substantial Completion.

PART 2 - PRODUCTS

2.01 GENERAL

- A. None used.

PART 3 - EXECUTION

3.01 PREPARATION

- A. Contractor shall be responsible to prepare the building heating, ventilating, and air conditioning systems ready for TAB when scheduled.
- B. Operational readiness requires that construction status of the building will permit the closing of doors, windows, ceilings installed, etc., to obtain simulated or projected operating conditions.
- C. Notification of System Readiness:
 1. Upon completion of the system installation Work, the Contractor shall notify the Owner and TAB Firm in writing, certifying that the Work has been accomplished and that the air conditioning systems are in operational readiness for testing, adjusting, and balancing.
 2. TAB Firm shall notify the Contractor of TAB Firm's readiness for balancing.
 3. Should the TAB Firm be notified as described above, and the TAB Work commenced and the systems are found NOT to be in readiness or a dispute occurs as to the readiness of the systems, the Contractor shall request an inspection be made by a duly appointed representative of the Owner, Architect, TAB Firm and the Contractor. This inspection will establish to the satisfaction of the represented parties whether or not the systems meet the basic requirements for TAB services. Should the inspection reveal the TAB services notification to have been premature, all cost of the inspection and wasted Work accomplished by the TAB Firm shall be the responsibility of the Contractor.

3.02 INSTALLATION

- A. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.
- B. All installation shall be in accordance with manufacturer's published recommendations.
- C. Allow sufficient time for the TAB Firm to perform TAB Firm's Work within the Project schedule. Complete installation Work by system or floor, whichever is the most efficient for scheduling. Develop the Project schedule in close coordination with the TAB Firm.
- D. The Drawings and Specifications indicate valves, dampers and miscellaneous adjustment devices for the purpose of adjustment to obtain optimum operating conditions. Install these devices in a manner that will leave the devices accessible and readily able to be adjusted. Immediately correct any malfunction encountered that the TAB Firm reports so that the balancing Work can proceed with minimal delay.
- E. Contractor shall promptly correct deficiencies of materials and workmanship identified as delaying completion of TAB Work.

3.03 SYSTEMS VERIFICATION

- A. Air Distribution Systems:
 - 1. Verify installation for conformity to the Contract Documents. All supply, return, and exhaust ducts shall be terminated and pressure tested for leakage as required by the Contract Documents.
 - 2. All volume, smoke and fire/smoke dampers are properly located and functional. Dampers serving requirements of minimum and maximum outside, return, and relief air shall provide tight closure and full opening, smooth and free operation.
 - 3. All supply, return, exhaust and transfer grilles, registers, diffusers and terminal devices are installed and airflow at each device shall be verified.
 - 4. Air handling systems, units and associated apparatus, such as heating and cooling coils, filter sections, access doors, etc., shall be sealed or blanked-off to eliminate excessive uncontrolled bypass or leakage of air.
 - 5. All fans (supply, return and exhaust) operating and verified for freedom from vibration, with proper fan rotation and belt tension. Heater elements in motor starters are of proper size and rating. Record motor amperage and voltage on each phase at Start-up and running, and verify they do not exceed nameplate ratings.
 - 6. All single and/or double duct variable and constant volume terminal units ("mixing boxes") shall be installed and functional (i.e. controls functioning).
 - 7. Duct systems and air handling units and coils are clean and free of debris.
 - 8. Air systems are pressure independent and can be tested by floor, riser, system, etc. but once the all systems are installed, the total flows and system tracking will require final testing, adjusting and balancing.

B. Water Circulating Systems:

1. Open all valves to their full open position, close bypass stop valves. Set mixing valves to full-flow through systems components. After the system is flushed and checked for proper operation, remove and clean all strainers. Repeat the operation until circulating water is clean.
2. All water circulating systems shall be full and free of air. Expansion tanks shall be set for proper water level and all air vents shall be installed at high points of systems and operating freely. Systems shall be cleaned and flushed. Chemicals shall be added to closed systems to treat piping and inhibit corrosion.
3. Installation and system verification of condenser water, hot water, and chilled water systems must be 100 percent complete prior to balancing.

C. Building Automation System (BAS):

1. Verify that all control components are installed in accordance with the Contract Documents and that all control components are functional, including all electrical interlocks, damper sequences, air and water resets, fire and freeze stats, high and low temperature thermostats, safeties, etc.
2. Verify that all controlling instruments are calibrated and set for design operating conditions with the exception of room thermostats or sensors, which shall be calibrated at the completion of TAB services with cooperation between the TAB Firm and BAS Provider.
3. BAS Provider shall thoroughly check all controls, sensors, operators, sequences, etc. before notifying the TAB Firm that the building automation system is operational. The BAS Provider shall provide technical support, including technicians and necessary computers, to the TAB Firm for a complete check of these systems.
4. BAS Provider shall assist the Contractor with functional performance testing and point-to-point testing back to the main graphics.

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. Fan Data (Supply and Exhaust):
 - a. Identification and location.
 - b. Manufacturer.
 - c. Model.
 - d. Air flow, specified and actual.
 - e. Total static pressure (total external), specified and actual.
 - f. Inlet pressure.
 - g. Discharge pressure.

- h. Fan RPM.
4. Air Handler Return Air/Outside Air Data (If fans are used, provide fan data as noted above):
- a. Identification and location.
 - b. Design return air flow.
 - c. Actual return air flow.
 - d. Design outside air flow.
 - e. Return air temperature.
 - f. Outside air temperature.
 - g. Required mixed air temperature.
 - h. Actual mixed air temperature.
5. 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.
6. Air Monitoring Station Data:
- a. Identification and location.
 - b. System.
 - c. Size.
 - d. Area.
 - e. Design velocity.

- f. Design air flow.
 - g. Test velocity.
 - h. Test air flow.
7. Variable or Constant Volume Terminal Unit Test Sheet:
- a. Identification number.
 - b. Room number/location.
 - c. Terminal type (FP if fan powered) and / or (SDVV, SDCV, DDVV, DDCV), and (HWRH or ERH if reheat coil is used).
 - d. Terminal size.
 - e. Area factor.
 - f. Design velocity.
 - g. Design maximum and minimum air flow.
 - h. Test (final) velocity.
 - i. Test (final) maximum and minimum air flow.
 - j. For DDC instrumentation: Measure and record computer readout and calibration factor at the final measurement conditions.
 - k. Air dry bulb temperature at the discharge of the terminal unit.
8. Cooling Coil Data:
- a. Identification number.
 - b. Location.
 - c. Service.
 - d. Manufacturer.
 - e. Entering air DB temperature, design and actual.
 - f. Entering air WB temperature, design and actual.
 - g. Leaving air DB temperature, design and actual.
 - h. Leaving air WB temperature, design and actual.
 - i. Water pressure flow, design and actual.
 - j. Water pressure drop, design and actual.
 - k. Pressure independent control valve water pressure drop, design and actual.

- l. Entering water temperature, design and actual.
 - m. Leaving water temperature, design and actual.
 - n. Air quantity CFM design, and CFM actual.
 - o. Air pressure drop, design and actual.
 - p. Sensible Btu/hr design, and actual.
 - q. Total Btu/hr design, and actual.
9. Heating Coil Data:
- a. Identification number.
 - b. Location.
 - c. Service.
 - d. Manufacturer.
 - e. Air flow, design and actual.
 - f. Water flow (gpm) or Steam mass flow rate (lbs per hour) design and actual.
 - g. Pressure drop water (feet w.g.) or steam (psid), design and actual.
 - h. Pressure independent control valve water pressure drop, design and actual.
 - i. Entering water or steam temperature, design and actual.
 - j. Leaving water or steam temperature, design and actual.
 - k. Entering air temperature, design and actual.
 - l. Leaving air temperature, design and actual.
 - m. Air quantity CFM design, and CFM actual.
 - n. Air pressure drop, design and actual.
 - o. Sensible Btu/hr design, and actual.
 - p. Electric heat kW, number of stages, kW per stage – specified and actual (if applicable).
10. Control verification indicating date performed and any abnormalities identified:
- a. Point Location/Description.
 - b. EMS Readout (Setpoint and Actual).
 - c. Actual Readout.

- d. Interlocks.
 - e. Safeties:
 - 1) VSD Normal Operation.
 - 2) VSD Bypass Operation.
 - f. Alarms.
 - g. Sequences of Operation.
11. Include in the appendix all submittals for air handling units, pumps, fans, heat exchangers, energy recovery units control system, etc.

PART 2 - PRODUCTS

Not used.

PART 3 - EXECUTION

3.01 AIR BALANCE

- A. When systems are installed and ready for operation, the TAB Firm shall perform an air balance for all air systems and record the results. The outside, supply, exhaust and return air volume for each air handling unit, supply fan and exhaust fan and the supply, exhaust or return air volume for each distribution device shall be adjusted to within +/- 5 percent of the value shown on the Drawings. Air handling unit and fan volumes shall be adjusted by changing fan speed and adjusting volume dampers associated with the unit. Air distribution device volume shall be adjusted using the spin-in tap damper for flexible duct connected devices and the device opposed blade damper (OBD) for duct connected devices. Air distribution devices shall be balanced with air patterns as specified. Duct volume dampers shall be adjusted to provide air volume to branch ducts where such dampers are shown.
- B. The general scope of balancing by the TAB Firm shall include, but is not limited to, the following:
 - 1. Filters: Check air filters and filter media and balance only systems with essentially clean filters and filter media. The Contractor shall install new filters and filter media prior to the final air balance.
 - 2. Blower Speed: Measure RPM at each fan or blower to design requirements. Where a speed adjustment is required, the Contractor shall make any required changes.
 - 3. Ampere Readings: Measure and record full load amperes for motors.
 - 4. Static Pressure: Static pressure gains or losses shall be measured across each supply fan, cooling coil, heating coil, return air fan, air handling unit filter and exhaust fan. These readings shall be measured and recorded for this report at the furthest air device or terminal unit from the air handler supplying that device. Static pressure readings shall also be provided for systems, which do not perform as designed.

5. Equipment Air Flow: Adjust and record exhaust, return, outside and supply air CFM(s) and temperatures, as applicable, at each fan, blower and coil.
6. Coil Temperatures: Set controls for full cooling and for full heating loads. Read and record entering and leaving dry bulb and wet bulb temperatures (cooling only) at each cooling coil, heating coil and reheat coil at each VAV terminal unit. At the time of reading record water flow and entering and leaving water temperatures (In variable flow systems adjust the water flow to design for all the above readings).
7. Zone Air Flow: Adjust each HVAC VAV terminal unit and VAV air handling unit for design CFM.
8. Outlet Air Flow: Adjust each exhaust inlet and supply diffuser, register and grille to within + 5 percent of design air CFM. Include all terminal points of air supply and all points of exhaust. Note: For Labs and rooms that are negative exhaust air flow shall be set to design + 10 percent and supply to design - 5 percent. Positive areas will have opposite tolerances.
9. Pitot Tube Traverses: For use in future troubleshooting by Owner, all exhaust ducts, main supply ducts and return ducts shall have air velocity and volume measured and recorded by the traverse method. Locations of these traverse test stations shall be described on the sheet containing the data.
10. Maximum and minimum air flow on terminal units.

3.02 HYDRONIC SYSTEM BALANCE

- A. When systems are installed and ready for operation, the TAB Firm shall perform water balance for each chilled and heating hot water system.
- B. The general scope of balancing by the TAB Firm shall include, but not be limited to, the following:
 1. Adjusted System Tests: Adjust pressure independent control valves at each coil and heat exchanger for design flow, +/- 5 percent, in accordance with valve manufacturer's published commissioning procedure. Pressure independent valve manufacturer will provide service tool and/or service software for use in this commissioning process, and provide training in its use. Adjust balancing valves at pumps to obtain design water flow. Record pressure rise across pumps and GPM flow from pump curve. Permanently mark the balanced position for each valve. (Note: If discharge valves on the pumps are used for balancing record the head being restricted by the valves).
 2. Temperature Readings: Read and record entering and leaving water temperature at each water coil, converter and heat exchanger. Adjust as necessary to design conditions. Provide final readings at all thermometer well locations.

3. Pressure Readings: Water pressure shall be recorded at all gauge connections. Pressure readings at coils and pumps shall be related to coil and pump curves in terms of GPM flow through flow measuring status, if provided and installed, at each air handler. The flow of water through all water coils shall be adjusted by manipulating pressure independent control valves, in accordance with valve manufacturer's published commissioning procedures until the rated pressure drops across each coil is obtained and total water flow is verified by flow measuring status. Verify required pressure drop across each pressure independent control valve. For coils equipped with 3-way valves, the rated pressure drop shall first be adjusted through the coils. The bypass valve shall then be adjusted on each coil until an equal pressure drop between supply and return connections is the same as with the flow through the coil.

3.03 BUILDING AUTOMATION SYSTEMS

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

1. Work with the Building Automation System (BAS) Provider and Owner to ensure the most effective total system operation within the design limitations, and to obtain mutual understanding of intended control performance.
2. Verify that all control devices are properly connected.
3. Verify that the intended controllers operate all dampers, valves and other controlled devices.
4. Verify that all dampers and valves are in the position indicated by the controller; open, closed, or modulating.
5. Verify the integrity of valves and dampers in terms of tightness of close-off and full-open positions. This includes all duct-mounted dampers, dampers in terminal units, and fire/smoke dampers.
6. Observe that all valves are properly installed in the piping system in relation to direction of flow and location. Observe that all pressure independent control valves are properly installed in accordance with manufacturer's published installation instructions.
7. Observe the calibration and operation of all controllers.
8. Verify the proper application of all normally opened and normally closed valves.
9. Observe the locations of all thermostats and humidistats for potential erratic operation from outside influences such as sunlight, drafts, or cold walls.
10. Observe the locations of all sensors to determine whether their position will allow them to sense only the intended temperatures or pressures of the media. BAS Provider will relocate sensors as deemed necessary by the TAB Firm or Contractor.
11. Verify that the sequence of operation for any control mode is in accordance with approved Shop Drawings and Specifications. Verify that no demand for simultaneous heating and cooling occurs at the terminal units.
12. Verify that all controller setpoints meet the Contract Documents.
13. Check all dampers for free travel.

14. Verify the operation of all interlock systems.
15. Perform variable volume system verification to assure the system and system components track with changes from full flow to minimum flow.

END OF SECTION 23 05 93

SECTION 23 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.

B. Medium Pressure

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

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.

1.07 DELIVERY, STORAGE AND HANDLING

- A. Deliver products to the Project Site and store and protect products under provisions of Division 01 and Division 20.
- B. Protect materials from rust both before and after installation.

1.08 WARRANTY

- A. All ductwork shown on the Drawings, specified or required for the air conditioning and ventilating systems shall be constructed and erected in a first class workmanlike manner.
- B. The Work shall be guaranteed for a period of one (1) year from the Project Substantial Completion date against noise, chatter, whistling, vibration, and free from pulsation under all conditions of operation. After the system is in operation, should these defects occur, they shall be corrected as directed by the Owner at Contractor's expense.

PART 2 - PRODUCTS

2.01 GENERAL

- A. All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.

2.02 APPLICATION

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

AIR SYSTEM	MATERIAL	MINIMUM PRESSURE CLASSIFICATION ⁽¹⁾
Supply and Return Systems:		
Untreated Outside Air Intake (Louver) to AHU Plenum	304 Stainless Steel	Low Pressure
Treated Outside Air to AHU	Galvanized Steel	Medium Pressure
Single Zone FCU Supply	Galvanized Steel	Low Pressure

AIR SYSTEM	MATERIAL	MINIMUM PRESSURE CLASSIFICATION ⁽¹⁾
Exhaust Systems:		
Exhaust Air Device to Exhaust Distribution	Galvanized Steel	Low Pressure

B. Notes to Table:

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

2.03 DUCTWORK MATERIAL AND CONSTRUCTION

- A. All ductwork indicated on the Drawings, specified or required for the air conditioning and ventilating systems shall be of materials as hereinafter specified unless indicated otherwise on Drawings. All air distribution ductwork shall be fabricated, erected, supported, etc., in accordance with all applicable standards of SMACNA where such standards do not conflict with NFPA 90A and where class of construction equals or exceeds that noted herein.
- B. Ductwork shall be constructed of G-90 coated galvanized steel of ASTM A653 and A924 Standards.
- C. Minimum gage of round, oval or rectangular ductwork shall be 26 gage per SMACNA Standards.
- D. All duct sizes shown on the Drawings are clear inside dimensions. Allowance shall be made for internal lining, where specified, to provide the required free area.
- E. All holes in ducts for damper rods and other necessary devices shall be either drilled or machine punched (not pin punched), and shall not be any larger than necessary. All duct openings shall be provided with sheet metal caps if the openings are to be left unconnected for future connections/phases, otherwise plastic covers are acceptable.
- F. Except for specific duct applications specified herein, all sheet metal shall be constructed from prime galvanized steel sheets and/or coils up to 60 inches in width. Each sheet shall be stenciled with manufacturer's name and gage.
- G. Sheet metal must conform to SMACNA sheet metal tolerances as outlined in SMACNA's "HVAC Duct Construction Standards."
- H. Where ducts are exposed to view (including equipment rooms) and where ducts pass through walls, floors or ceilings; furnish and install sheet metal collars around the duct.
- I. Spin-in fittings shall be as specified under Section 23 33 00 – Ductwork Accessories.
- J. Duct Sealing: All ductwork, regardless of system pressure classification, shall be sealed in accordance with Seal Class A, as referenced in SMACNA Standards. All transverse joints, longitudinal seams, and duct wall penetrations shall be sealed.
 1. All seams and joints in shop and field fabricated ductwork shall be sealed by applying one layer of sealant, then immediately spanning the joint with a single layer of 3 inches wide open weave fiberglass scrim tape. Sufficient additional sealant shall then be applied to completely embed the cloth.

2. Sealant shall be water based latex UL 181A-M sealant with flame spread of 0 and smoke developed of 0. Sealants shall be Hard Cast Iron Grip 601, Ductmate Pro Seal, Foster 32-19, Childers CP-146 or Design Polymerics DP 1010.
3. Scrim tape shall be fiberglass open weave tape, 3 inches wide, with maximum 20/10 thread count, similar to Hardcast FS-150.
4. Sealer shall be rated by the manufacturer and shall be suitable for use at the system pressure classification of applicable ductwork.
5. Except as noted, oil or solvent-based sealants are specifically prohibited.

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. 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.

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

H. 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 TESTING

- A. All medium and high pressure duct systems (positive or negative) shall be pressure tested according to SMACNA test procedures (HVAC Air Duct Leakage Test Manual). Notify Owner minimum seven (7) calendar days in advance of leakage testing.
1. Design pressure for testing ductwork shall be determined from the maximum pressure generated by the fan at the nominal motor horsepower selected.
 2. Total allowable leakage shall not exceed 1 percent of the total system design airflow rate.
 3. When partial sections of the duct system are tested, the summation of the leakage for all sections shall not exceed the total allowable leakage.

4. Leaks identified during leakage testing shall be repaired by:
 - a. Complete removal of the sealing materials.
 - b. Thorough cleaning of the joint surfaces.
 - c. Installation of multiple layers of sealing materials.
 5. The entire ductwork system shall be tested, excluding connections upstream of the terminal units (i.e. ductwork shall be capped immediately prior to the terminal units, and tested as described above).
 6. After testing has proven that ductwork is installed and performs as specified, the terminal units shall be connected to ductwork and connections sealed with extra care. Contractor shall inform the Owner when joints may be visually inspected for voids, splits, or improper sealing of the joints. If any leakage exists in the terminal unit connections/joints after the systems have been put into service, leaks shall be repaired as specified for other leaks.
 7. Fixed flow measurement devices (i.e. orifice tubes, nozzles, etc.) shall have current calibration documentation showing that the device was verified to a National Institute Of Standards and Technology (NIST) standard within the previous five years or as recommended by the manufacture and be accurate to at least +/- 2% of reading.
 8. Pressure measurement instrumentation (i.e. manometer) shall have current calibration documentation showing that the device was verified to a NIST standard within the previous year or as recommended by the manufacture. Instrumentation shall have an accuracy of at least +/- 2% of reading and have a resolution of 2:1 with respect to the measured pressure (i.e. resolution of 0.01 measured 0.1).
- B. All low-pressure duct systems (positive or negative) shall be inspected for visible and audible signs of leakage.
1. Leaks identified by inspection shall be repaired by:
 - a. Complete removal of the sealing materials.
 - b. Thorough cleaning of the joint surfaces.
 - c. Installation of multiple layers of sealing materials.
 2. Discrepancies found during testing and balancing between duct traverses and diffuser/grille readings shall result in re-inspection, repair and retest until discrepancies are eliminated.
- C. Ductwork leakage testing and/or inspection shall be performed prior to installation of external ductwork insulation.

END OF SECTION 23 31 00

SECTION 23 33 00 – DUCTWORK ACCESSORIES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General Conditions and Division 01 Specification Sections, apply to this Section.
- B. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.02 SUMMARY

- A. Perform all Work required to provide and install the following ductwork accessories indicated by the Contract Documents with supplementary items necessary for proper installation.
 - 1. Airflow control dampers and spin-in fittings.
 - 2. Fire dampers.
 - 3. Flexible duct connections.
 - 4. Duct access doors.
 - 5. Screens
 - 6. 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.

1.04 SUBMITTALS

A. Product Data:

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

B. Record Documents:

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

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

2.04 FIRE DAMPERS

- A. Each fire damper shall be constructed and tested in accordance with Underwriters Laboratories Safety Standard 555, latest edition. Dampers shall possess a 1-1/2 hour or 3 hour (as appropriate for the construction shown in the architectural Drawings) protection rating, 160 or 165 degrees F fusible link, and shall bear a U.L. label in accordance with Underwriters' Laboratories labeling procedures. Construct fire dampers such that damper frame material and curtain material are galvanized.
- B. Fire dampers shall be curtain blade type and damper shall be constructed so that the blades are out of the air stream to provide 100 percent free area of duct in which the damper is housed.
- C. Equip fire dampers for vertical or horizontal installation as required by location shown on Drawings. Install fire dampers in wall and floor openings utilizing steel sleeves, angles and other material and practices as required to provide an installation equivalent to that utilized by the manufacturer when the respective dampers were tested by Underwriters Laboratories. Mounting angles shall be minimum 1-1/2 inch by 1-1/2 inch by 14 gage and bolted, tack welded or screwed to the sleeve at maximum spacing of 12 inches and with a minimum of two connections at all sides. Mounting angles shall overlap at least equal to the duct gage as defined by the appropriate SMACNA Duct Construction Standard, latest edition, and as described in NFPA 90A. The entire assembly, following installation, shall be capable of withstanding 6 inch water gauge static pressure.

- D. All fire dampers shall be dynamic rated type.
- E. Completely seal the damper assembly to the building components using manufacturer recommended material(s).

2.05 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.

2.06 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. Latches for rectangular doors smaller than 18 inch x 16 inch shall be Ventlok No. 100 or 140.
- D. Round access doors shall be "Inspector Series" spin-in type door as manufactured by Flexmaster USA.

2.07 SCREENS

- A. Furnish and install screens on all duct, fan, etc., openings furnished by this Contractor which lead to, or are located outdoors.
- B. Screens shall be No. 16 gage, one-half inch (1/2") mesh in removable galvanized steel frame.
- C. Provide safety screens meeting OSHA requirements for protection of maintenance personnel on all fan inlets and fan outlets to which no ductwork is connected.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.
- B. All installation shall be in accordance with manufacturer's published recommendations.
- C. Provide balancing dampers at points on low pressure supply, return, and exhaust systems where branches are taken from larger ducts as required for air balancing.
- D. Provide all dampers furnished by the BAS Provider in strict accordance with manufacturer's written installation instruction and requirements of these Specifications.
- E. Provide fire dampers, and combination fire and smoke dampers at locations indicated, where ducts and outlets pass through fire rated components. Install with required perimeter mounting angles, sleeves, breakaway duct connections, corrosion resistant springs, bearings, bushings and hinges.
 - 1. Instructions to A/E and Contractor:
 - a. Fire dampers should not be installed where ducts pass through non fire/smoke rated architectural or structural components. Remove all fire and smoke dampers and combination fire smoke dampers from non-fire rated structural architectural or structural.
- F. 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.
- G. 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.
- H. 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.
- I. 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.
- J. Install each fire damper square and true to the building. The installation shall not place pressure on the damper frame, but shall enclose the damper as required by UL555.

3.02 TESTING

- A. After each fire damper has been installed and sealed in their prescribed openings and prior to installation of ceilings, Contractor shall, as directed by Owner, activate part or all dampers as required to verify "first-time" closure. The activation must be scheduled as part of the commissioning and witnessed by an institutional representative.
- B. Activation of damper shall be accomplished by manually operating the resettable link, disconnecting the linkage at the fire damper fusible link.
- C. Failure of damper to close properly and smoothly on the first attempt will be cause to replace the entire damper assembly.

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 CEILING EGG CRATE EXHAUST AND RETURN REGISTERS/GRILLES

- A. Fixed series of cubes comprised of 1/2 x 1/2 x 1-inch aluminum strips.
- B. Fabricate one-inch margin aluminum frame.
- C. Fabricate of aluminum with factory baked enamel finish.
- D. Provide square uniform height plenum for ducted return and exhaust application of scheduled neck size.

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