

## DIVISION 23 – HEATING VENTILATING AND AIR CONDITIONING

### SECTION 23 05 93-01 – SYSTEM TESTING

#### PART 1: GENERAL

##### 1.01 Summary

- A. Testing, adjusting and balancing (TAB) of the air conditioning systems and related ancillary equipment will be performed by an impartial technically qualified TAB firm selected and employed by the Owner, separate and apart from the construction contract.
- B. The Firm shall be capable of performing the services specified at the location of the facility described with the time specified, of preparing and submitting the detailed report of the actual field work performed and following up the basic work as may be required.

##### 1.02 Qualifications

- A. The Firm shall be one which is organized to provide professional services of this specified type in the State of Texas and as a minimum shall have one (1) Professional Engineer licensed in the State of Texas, with current registration, to perform such professional services. This engineer shall be personally responsible for developing the job site data as required in the test procedures outlined in these Specifications.
- B. The Firm shall have operated a minimum of five (5) years under its current Firm name and shall be in good standing with the State of Texas, Franchise Tax Board. The Firm shall submit their full incorporated name, Charter Number and Taxpayer's I.D. Number for proper verification of the firm's status.
- C. The Firm shall be capable of providing a performance bond, by a bonding company licensed to do business in the State of Texas, if determined by the Owner that such a bond is required. The amount of the bond which may be required shall be equal to the cost of the proposal submitted, or in the case of more than one proposal, the sum of all such proposals and any awarded work in progress.
- D. The Firm shall maintain current insurance coverage in the minimum amounts shown below. If the firm normally carries such insurance coverage (minimum or higher) incident to its operation, additional insurance for the specific proposal or proposals is not required. The minimum insurance coverage required are:
  - 1. Worker's Compensation as required by law.
  - 2. General Liability for not less than \$2,000,000. aggregate.
  - 3. Fire Damage, and Extended Coverage, Vandalism and Malicious Mischief, in the full amount of Contract. The above policies shall be carried with companies satisfactory to the Owner. Certificates of each of the above policies, together with a written statement by the issuing company, stating that said policy will not be canceled without ten (10) days prior written notice to the Board of Regents of the University of Texas system, shall be delivered to the Owner before any work is started.

- E. All personnel used on the job site shall be either Professional Engineers or Engineering Technicians, who shall have been permanent, full time employees of the firm for a minimum of six (6) months prior to the start of work for this specific project.
- F. The TAB firm shall submit biographical data on the individual proposed to directly supervise the TAB work, as well as other personnel scheduled to perform the technical work under the contract. It shall also submit a background record of at least five years of specialized experience in the field of air hydronic system balancing and shall possess properly calibrated instrumentation. The supervisory personnel for the TAB firm shall be permanent, full time employees of the Firm.

### **1.03 References**

- A. AABC – National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems, fifth Edition 1989.
- B. ASHRAE – 1991 HVAC Applications Chapter 34: Testing, Adjusting and Balancing.
- C. ANSI/ASHRAE Standard 111-1988 – Practices for Measurement, Testing, Adjusting and Balancing of Buildings, Heating, Ventilation, Air Conditioning and Refrigeration Systems.

### **1.04 Documents**

- A. The TAB firm shall, as a requirement of the TAB contract, arrange with the Architect to compile on set of mechanical specifications, all pertinent change orders, and the following:
  - 1. One complete set of Drawings less the structural sheets.
  - 2. One set of mechanical floor plans of the conditioned spaces. These Drawings shall be ozalid type (blue or black on light background) reproductions to facilitate marking.
- B. Approved submittal data on equipment installed, and related changes as required to accomplish the test procedures outlined in Paragraphs 1.6 through 1.10 of this Specification will be available through the Owner.

### **1.05 Responsibilities of the TAB Firm**

- A. The TAB personnel shall check, adjust, and balance the components of the air conditioning system which will result in optimal noise, temperature, and airflow conditions in the conditioned spaces of the building while the equipment of the system is operating economically. This is intended to be accomplished after the system components are installed and operating as provided for in the Contract Documents. It is the responsibility of the Mechanical Contractor to place the equipment into service. Variable air volume systems shall be balanced in accordance with AABC 1989 Standard, Fifth Edition.
- B. Liaison and Early Inspection:
  - 1. The TAB firm personnel on the job shall act as liaison between the Owner, Architect and Contractor. The following reviews (observations) and tests shall be performed by the TAB Agency:

- a. During the design stage, before the documents are finalized, review the mechanical drawings and specifications for balance-ability and provide commentary.
  - b. During construction, review all HVAC submittals such as control diagrams, air handling devices, etc., that pertain to commissioning work and balance-ability.
  - c. Allow for a fixed number of trips to the project site, over and above those required for testing and balancing for inspection of installation of the mechanical piping systems, sheet metal work, temperature controls and other component parts of the heating, air conditioning and ventilating systems during the construction stage. These inspections shall be made prior to and/or at the above ceiling inspections. Commentary will be provided to the Owner of each observation.
  - d. Test one (1) 8" single duct terminal box for performance capability and leakage as described in Section 23 36 16. The shipment of the box to the TAB Agency's lab will be at the manufacturer's cost and the test period will be for three (3) weeks from receipt of the box. Submittal data will not be approved until box testing passes. If the sample box is rejected for any reason the second test will be at the Contractor's cost and the time allowed will restart when the box is received at the TAB Agency.
  - e. Test 10% of the single duct boxes for casing and damper leakage when the shipment arrives at the project site. All testing (except for the initial boxes) shall be performed on site. Boxes requiring re-testing will be charged to the Contractor at the unit price provided to the Owner.
2. During the balancing process, as abnormalities and malfunctions of equipment or components are discovered by the TAB personnel, the Owner shall be advised in writing so that the condition can be corrected by the Mechanical Contractor. The written document need not be formal but must be understandable and legible. Data from malfunctioning equipment shall not be recorded in the final TAB report. The TAB firm shall not instruct or direct the Contractor in any of the work but will make such reports as are necessary to the Owner.

#### **1.06 Final Air Balance**

- A. General: When systems are complete and ready for operation, the TAB Consultant will perform a final air balance for all air systems and record the results. The 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% 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 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. The general scope of balancing by the TAB Consultant will include, but is not limited to, the following:

1. Filters: check air filters and filter media and balance only system with essentially clean filters and filter media. The Division 15 Contractor shall install new filters and filter media prior to the final air balance.
2. Blower Speed: Measure RPM at each fan or blower to design requirements. Where a speed adjustment is required, the Division 15 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 of 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 Temperature: Set controls for full cooling and for full heating loads. Read and record entering and leaving dry bulb and wet bulb temperatures (cooling only) at each cooling coil, heating coil and HVAC terminal unit. At the time of reading record water flow and entering and leaving water temperatures. (In variable flow systems adjust the water flow to design for all the above readings)
7. Zone Air Flow: Adjust each zone of multizone units, each HVAC terminal unit and air handling unit for design CFM.
8. Outlet Air Flow: Adjust each exhaust inlet and supply diffuser, register and grille to within +/-5% of design air CFM. Include all terminal points of air supply and all points of exhaust. Note: For Labs and Rooms that are negative exhaust air flow shall be set to design +/-10% and supply to design – 5%. Positive areas will have opposite tolerances.
9. Pitot Tube Traverses: For use in future troubleshooting by maintenance personnel, all exhaust ducts, main supply ducts and return ducts shall have air velocity and volume measured and recorded by the traverse method. Locations of these traverse test stations shall be described on the sheet containing the data.
10. Maximum and minimum air flow on terminal boxes.

### **1.07 Final Chilled and Heating Hot Water Balance**

- A. General: When systems are completed and ready for operation, the TAB Consultant will perform a final water balance for each chilled and hot water system. The general scope of balancing by the TAB Consultant will include, but not be limited to, the following:

1. Adjusted System Tests: Adjust balancing valves at each coil and heat exchanger for design flow, +/-5%. Adjust balancing valves air pumps to obtain design water flow. Record pressure rise across pumps and GPM flow from pump curve. Permanently mark the balance position for each valve (Note: If discharge valves on the pumps are used for balancing record the head being restricted by the valves).
  2. Temperature Readings: Read and record entering and leaving water temperature at each water coil, converter, and heat exchanger. Adjust as necessary to secure design and conditions. Provide final readings at all thermometer will locations.
  3. Pressure Readings: Water pressure shall be recorded at all gauge connections. Pressure readings at coils and pumps shall be related to coil and pump curves in terms of GPM flow through flow measuring status, if provided and installed, at each air handler. The flow of water through all water coils shall be adjusted by manipulating valves until the rated pressure drops across each coil is obtained and total water flow is verified by flow measuring status. For coils equipped with 3-way valves, the rated pressure drop shall first be adjusted through the coils. The bypass valve shall then be adjusted on each coil until an equal pressure drop between supply and return connections is the same as with the flow through the coil.
  4. Ampere Readings: Reading and record full load amperes for each pump motor.
- B. Sound: Read and record sound levels at up to 15 locations in the building designated by the Engineer. All measurements shall be made using an Octave Band analyzer. All tests shall be conducted when the building is quiet in the presence of the Engineer if he so desires.
- C. Vibration: Read and record vibration for all water circulating pumps, air handling units, and fans which have motors larger than 10 HP. Include equipment vibration, bearing housing vibration, foundation vibration, and other tests as directed by the Engineer. Readings will be made using portable IRD (or approved equal) equipment capable of filtering out various unwanted frequencies and standard reporting forms. Maximum vibration at any point listed above, or specified, shall not exceed 1 mil on fans and 1 mil on pumps unless otherwise specified. Equipment manufacturers shall rectify all systems exceeding vibration tolerances.

### **1.08 Testing of Temperature Control Systems**

- A. In the process of performing the TAB work, the TAB Agency shall:
1. Work with the temperature control contractor to ensure the most effective total system operation within the design limitations, and to obtain mutual understanding of intended control performance.
  2. Verify that all control devices are properly connected.
  3. Verify that all dampers, valves, and other controlled devices are operated by the intended controller.

4. Verify that all dampers and valves are in the position indicated by the controller (open, closed or modulating).
  5. Verify the integrity of valves and dampers in terms of tightness of close-off and full-open positions. This includes dampers in multizone units, terminal boxes, and fire/smoke dampers.
  6. Observe that all valves are properly installed in the piping system in relation to direction of flow and location.
  7. Observe the calibration of all controllers.
  8. Verify the proper application of all normally opened and normally closed valves.
  9. Observe the locations of all thermostats and humidistats for potential erratic operation from outside influences such as sunlight, drafts, or cold walls.
  10. Observe the locations of all sensors to determine whether their position will allow them to sense only the intended temperatures or pressures of the media. Control Contractor will relocate as deemed necessary by the TAB Agency.
  11. Verify that the sequence of operation for any control mode is in accordance with approval shop drawings and specifications. Verify that no simultaneous heating and cooling occurs, unless specifically in a dehumidification mode.
  12. Verify that all controller setpoints meet the design intent.
  13. Check all dampers for free travel.
  14. Verify the operation of all interlock systems.
  15. Perform variable volume system verification to assure the system and its components track with changes from full flow to minimum flow.
- B. A systematic listing of the above testing and verification shall be included in the final TAB report.

### **1.09 Reports**

- A. The activities described in this section shall culminate in a report to be provided in quadruplicate (4) individually bound to the Owner, and also in digital format. Neatly type and arrange data. Include with the data the date tested, personnel present, weather conditions, nameplate record of test instrument and list all measurements taken after all corrections are made to the system. Record all failures and corrective action taken to remedy incorrect situation. The intent of the final report is to provide a reference of actual operating conditions for the Owner's operations personnel.
- B. All measurements and recorded readings (of air, water, electricity, etc.) that appear in the reports must have been made onsite by the permanently employed technicians or engineers of the Firm.

- C. At the option of the Owner, all data sheets tabulated each day by TAB personnel shall be submitted for initial by the Owner. Those work sheets so initialed, or copies thereof, shall be presented as a supplement to the final TAB report.
- D. Submit reports on forms approved by the Owner and 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. 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. Return Air/Outside Air Data (If fans are used, same data as for 3 above)
  - a. Identification/location
  - b. Design return air flow
  - c. Actual return air flow
  - d. Design outside air flow
  - e. Return air temperature
  - f. Outside air temperature
  - g. Required mixed air temperature
  - h. Actual mixed air temperature
- 5. Electric Motors
  - a. Manufacturer
  - b. HP/BHP
  - c. Phase, voltage, amperage, nameplate, actual
  - d. RPM
  - e. Service factor
  - f. Starter size, heater elements, rating
- 6. V-Belt Drive
  - a. Identification/location
  - b. Required driven RPM
  - c. Driven sheave, diameter, and RPM
  - d. Belt, size, and quantity
  - e. Motor sheave, diameter, and RPM
  - f. Center-to-center distance, maximum, minimum, and actual
- 7. Duct Traverse
  - a. System zone/branch
  - b. Duct size
  - c. Area

- d. Design velocity
  - e. Design air flow
  - f. Test air flow
  - g. Duct static pressure
  - h. Air temperature
  - i. Air correction factor
8. Air Monitoring Station Data
- a. Identification/location
  - b. System
  - c. Size
  - d. Area
  - e. Design velocity
  - f. Design air flow
  - g. Test velocity
  - h. Test air flow
9. Air Distribution Test Sheet
- a. Air terminal number
  - b. Room number/location
  - c. Terminal type
  - d. Terminal size
  - e. Area factor
  - f. Design velocity
  - g. Design air flow
  - h. Test (final) velocity
  - i. Test (final) air flow
10. Pump Data
- a. Identification/number
  - b. Manufacturer
  - c. Size/model

- d. Impeller
- e. Service
- f. design flow rate, pressure drop, BHP
- g. Actual flow rate, pressure drop, BHP
- h. discharge pressure
- i. Suction pressure
- j. Total operating head pressure
- k. Shut off, discharge and suction pressure
- l. Shut off, total head pressure
- m. Pressure differential settings

#### 11. Cooling Coil Data

- a. Identification/number
- b. Location
- c. Service
- 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. Entering water temperature, design and actual
- l. Leaving water temperature, design and actual
- m. Air pressure drop, design and actual

#### 12. Heating Coil Data

- a. Identification/number
- b. Location
- c. Service
- d. Manufacturer

- e. Air flow, design and actual
  - f. Water flow, design and actual
  - g. Water pressure drop, design and actual
  - h. Entering water of steam temperature, design and actual
  - i. Leaving water temperature, design and actual
  - j. Entering air temperature, design and actual
  - k. Leaving air temperature, design and actual
13. Sound Level Report
- a. Location (Location established by the design engineer)
  - b. NC curve for eight (8) bands – equipment off
  - c. NC curve for eight (8) bands – equipment on
14. Vibration Test on equipment having 10 HP motors or above
- a. Location of points:
    - 1). Fan bearing, drive end
    - 2). Fan bearing, opposite end
    - 3). Motor bearing, center (if applicable)
    - 4). Motor bearing, drive end
    - 5). Motor bearing, opposite end
    - 6). Casing (bottom or top)
    - 7). Casing (side)
    - 8). Duct after flexible connection (discharge)
    - 9). Duct after flexible connection (suction)
  - b. Test readings:
    - 1). Horizontal, velocity and displacement
    - 2). Vertical, velocity and displacement
    - 3). Axial, velocity and displacement
  - c. Normally acceptable readings, velocity and acceleration
  - d. Unusual conditions at time of test
  - e. Vibration source (if non-complying)

15. Control verification indicating date performed and any abnormalities identified.

- a. Point Location/Description
- b. BAS/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

END OF SECTION 23 05 93.01