

SECTION 23 05 93**TESTING, ADJUSTING, AND BALANCING (TAB) FOR HVAC****PART 1 - GENERAL****1.1 RELATED DOCUMENTS**

- A. This Section shall be related to the General Provisions of the contract, including General and supplementary conditions.
- B. Refer to Section 23 050 for General Provisions.

1.2 SCOPE OF WORK

- A. The work included in this Section consists of the furnishing of all labor, instruments, tools and services required in connection with the Testing, Adjusting and Balancing (TAB) of the Heating, Ventilating and Air Conditioning (HVAC) systems as described in the mechanical specifications and shown on the mechanical Drawings, or reasonably implied therefrom, to include the overall commissioning of systems and subsystems such as verification of operation of each control device and all equipment sequences of operation.
- B. TAB of the HVAC systems will be performed by an impartial Technical Firm who is a member of the Associated Air Balance Council (AABC) and whose operations are limited only to the field of professional TAB work. Owner shall select the TAB firm at an early stage of the project and notify the Contractor of TAB firm that shall be employed. TAB services shall be paid for directly by Owner. TAB firm to submit proposal to Owner at same time main proposal is due, refer to Proposal Form 00 30 00. TAB firm shall provide pricing where noted on proposal form. TAB services shall be performed by one of the following pre-qualified TAB Firms:
 - 1. Engineered Air Balance (EAB)
 - 2. Delta T
 - 3. Air Balancing Company (ABC).
- C. TAB Firm is responsible to and shall submit all reports directly to the Engineer and as requested to the Owner.
- D. TAB services shall result in the optimum temperature, humidity, airflow, ventilation rates, and noise levels in the conditioned spaces of the building.

- E. The following basic components of the HVAC systems shall be tested, adjusted and balanced:
 - 1. Air distribution systems.
 - 2. Air moving equipment.
 - 3. Cooling systems.
 - 4. Heating systems.
 - 5. Control systems verification to include end devices, control sequences of operation and energy management system control and monitoring point verification.
- F. Document Review
 - 1. The TAB Firm shall be responsible for reviewing the HVAC Drawings and specifications relating to the TAB services for proper arrangement and adequate provisions of devices for testing, adjusting and balancing.
 - 2. TAB Firm shall review HVAC manufacturer's submittal data relative to balanceability.
 - 3. TAB Firm shall review submitted HVAC automatic temperature control sequences for conformity to the specifications.
- G. Three (3) hard bound copies and three (3) .PDF file copies saved onto USB Drive of final report shall be submitted to the owner, or representative thereof, indicating a summary of actual operating data and any abnormal operating conditions. The report will contain all required information as described within this specification.

1.3 SERVICES OF CONTRACTOR

- A. Contractor shall start up and test all materials and equipment which normally require testing. All piping, ductwork, etc., shall be tested to meet code requirements or the specification requirements, whichever is the more stringent. All equipment shall operate a sufficient length of time at the Contractor's expense to prove to the Architect, Engineer, and Owner that the equipment is free from mechanical defects, runs smoothly and quietly and performs satisfactorily to meet the requirements set forth in the Mechanical Drawings and Specifications.
- B. In order that all HVAC systems can be properly tested, adjusted and balanced, the Contractor shall operate the HVAC systems at his expense for the length of time necessary to properly verify their completion and readiness for TAB, and shall further operate and pay all costs of operation during the TAB period. Operating expenses to be paid for by the Contractor (not TAB firm) will include, but not necessarily be limited to, the following:
 - 1. Utility costs; electrical, gas, etc., as applicable.
 - 2. Personnel costs to start, operate and stop all HVAC equipment.
 - 3. All start-up labor and materials costs.
 - 4. All maintenance costs.

- C. The drawings and specifications have indicated valves, dampers and miscellaneous adjustment devices for the purpose of testing, adjusting and balancing the HVAC systems to obtain optimum operating conditions. It will be the responsibility of the Contractor to install these devices in a manner that will leave them fully accessible and readily adjustable to include access to allow recording of all motor and fan nameplate data. The TAB firm shall be consulted if there is a questionable arrangement of a control or adjustable device. Should any such device not be readily accessible, the Contractor shall provide access as required by the TAB firm.
- D. Contractor shall provide and coordinate the services of qualified, responsible sub-contractors, suppliers, and personnel as required to correct, repair or replace any and all deficient items or conditions found before and during the TAB period.
- E. As a part of this Project Contract, the Contractor shall make any changes in the sheaves, belts, motors, and dampers, or the addition of dampers as required, to correctly balance the HVAC systems as required by the TAB firm at no additional cost.
- F. Provide sufficient time in Project Contract completion schedule to permit the completion of TAB services prior to Owner occupancy of the project.
- G. Contractor shall furnish without charge to the TAB Firm:
 - 1. One set of mechanical specifications.
 - 2. All pertinent change orders and Addenda.
 - 3. Two complete sets of mechanical plans with latest revisions.
 - 4. "As-installed" drawings.
 - 5. Approved control diagrams.
 - 6. Approved manufacturer's submittals for all HVAC equipment.
- H. Have all HVAC systems complete and in operational readiness prior to notifying the TAB Firm that the project is ready for TAB services. So certify in writing to the Engineer, and Owner that such a condition exists. Complete operational readiness prior to commencement of TAB Services shall include the following:
 - 1. Construction status of building shall permit the closing of doors and windows, ceilings installed, etc., to permit the obtaining of projected actual operating conditions.
 - 2. Air Distribution Systems:
 - a. Verify installation for conformity to design of all supply, return and exhaust ducts. Document and certify that all duct leakage tests as required by the mechanical specifications have been performed and the test results are within specified limits (provide copies of leakage test results). TAB firm shall be notified of the time when all leakage tests are to be conducted to allow them to witness as needed.

- b. Verify that all volume dampers, smoke dampers and fire dampers are properly located, functional and open; verify that properly located, sized, and labeled access doors are installed in ducts and in general construction (ceilings, walls, furrings, etc.).
- c. Verify that outside air and relief air dampers provide tight closure, open fully and operate smoothly and freely (Roof Top, and Split DX A/C units).
- d. Verify that all supply, return, exhaust and transfer air diffusers, grilles and registers are installed as indicated on the mechanical Drawings.
- e. Verify that all heating coils, cooling coils, filter sections, access doors, etc., have been blanked and sealed to eliminate the bypass of air around the coils, filters, etc. or leakage of air into or out of the unit.
- f. Install clean filters at each air handling unit or filter grille, and maintain these filters for the complete period that the subject system is being tested, adjusted, and balanced. Refer to Section 23 3000.
- g. Verify that all (supply and exhaust) fans are operational including proper fan rotation, operates free from vibrations, belts are properly aligned, and belt tension is proper.
- h. Verify that all motor starter overload heater elements are of proper size and rating; nameplate amperage to be within the range of the heater element size.
- i. Make a record of actual motor amperage and voltage, per phase, and verify that they do not exceed nameplate ratings.
- j. Verify specified vibration isolation accessories are correctly installed and adjusted.
- k. Insure that all fan drive components, motors, belts, sheaves, and fan wheels are all accessible to allow for servicing and verification of name plate data, sizes, and model and serial numbers, as applicable.

I. Automatic Controls:

- 1. Verify that all control components are installed in accordance with project requirements and are functional as intended by these specifications, including all electrical interlocks, damper and valve sequences, air and water temperature resets, duct smoke detectors, high limit pressure sensors, freezestats, safeties, etc.
- 2. Verify that all controlling instruments are calibrated and set for designed operating conditions with the exception of room thermostats which shall be calibrated at the completion of TAB services with cooperation between TAB Firm and controls system installer.
- 3. Automatic temperature control and/or energy management system installer shall thoroughly check all controls, sensors operators, sequences of operation, etc. before notifying the TAB agency that the automatic temperature controls and energy management system are operational. Automatic temperature control and/or energy management system installer shall provide technical support (technicians

and necessary hardware and software) to the TAB agency to allow for a complete check out of these systems.

4. The controls system installer shall also provide trending reports with the specific points and trend intervals, as requested by the TAB firm or engineer, when abnormal conditions are experienced.
5. The scope of the TAB work as defined herein is indicated in order that the contractor will be apprized of his responsibility regarding the coordination and assistance required to complete the project requirements for final TAB. The TAB Firm will be responsible to the Engineer, and Owner for the satisfactory execution of the TAB services.

1.4 SERVICES OF THE TAB FIRM

A. TAB Firm Qualifications:

1. TAB Firm shall be one which is organized to provide independent professional testing, adjusting and balancing services. The firm shall have one (1) Professional Engineer licensed in the State of Texas, with current registration, on their staff. TAB Firm shall have operated a minimum of ten (10) years, under its current firm name.
2. All personnel used on the job site shall be either TAB engineers or TAB technicians, who shall have been permanent, full-time employees of the Firm for a minimum of one (1) year prior to working on this specific project.
3. TAB Firm shall submit the following to the Engineer and/or Owner for approval prior to commencing services:
 - a. Name and biographical data of the firms Professional Engineer and all other key personnel to be assigned to this project.
 - b. Proof of company operation for a minimum of ten (10) years.
 - c. Current AABC certification.
 - d. Documentation of number of full time staff size, specifically those personnel who perform or supervise the performance of TAB work.

B. TAB Firm Responsibilities:

1. Liaison: The TAB personnel on the job shall act as liaison between the Architect, Engineer, Owner and Contractor.
2. Inspect the installation of mechanical piping systems, sheet metal work, temperature controls and other component parts of the HVAC systems during the early construction stages, and at other appropriate stages, for the purpose of reviewing that part of the work relating to proper arrangement and adequate provisions for TAB.
3. When performing inspection services prepare a punch list to be copied to the Engineer and Contractor noting observed deficiencies that would prevent adequate access to equipment and components installed or missing that would prevent the TAB Services from being carried out successfully.
4. Witness the duct static pressure test performed on duct systems required to be pressure tested (primarily limited to the any grease exhaust ductwork testing) to

verify proper testing procedures are followed and documented. Include time for witnessing test performed. Should the initial testing be unsatisfactory, then witnessing of the retest will be required. Document tests witnessed in writing.

C. TAB Firm Services:

1. TAB personnel shall, upon completion of the installation and start-up of the mechanical equipment systems, test, adjust and balance the HVAC systems to provide optimum temperature, airflow and noise conditions in the conditioned spaces in the building while the HVAC equipment is operating efficiently.
2. The Firm shall be responsible for testing, adjusting, balancing and logging actual data on all air distribution and air moving equipment, fans, heating and cooling equipment and the operating conditions of all motors, etc. as indicated in this specification.
 - a. Air Distribution Devices:
 - 1) Preset all volume dampers in the 100% open position.
 - 2) Determine and verify proper air pattern deflection devices have been installed.
 - 3) Verify size and types of all air devices installed, versus, the sizes and types indicated on the Drawings.
 - 4) Read out all air distribution devices served by their source (Split DX A/C Unit or Heat Pump Unit, Roof Top A/C Heat Pump Unit, Supply Fan, Exhaust Fan, etc.)
 - 5) Balance all air distribution devices proportional to design CFM.
 - 6) Adjust source to design CFM.
 - 7) Verify that all air distribution devices are within plus or minus 10% of design (and all proportional to one another on each system).
 - b. Supply/Exhaust Fans:
 - 1) Verify correct fan rotation.
 - 2) If belt driven, verify proper belt tension and that fan and motor sheaves are properly aligned.
 - 3) Verify that all safeties and interlocks are operational.
 - 4) Verify correct size and rating of motor overload protection.
 - 5) Verify fan motor is not overloaded; amperage readings do not exceed nameplate rating, for each phase, as applicable.
 - 6) Determine total air quantities of system served by the respective fan. Air quantities to be determined by duct traverse if duct configuration permits and air velocity is 800 to 1000 feet per minute or greater. If the duct main is not suitable for traverse then traverse branch ducts as required to total air flows supplied by the system.

- 7) If air volume is less than design and motor capacity is available, adjust fan to design CFM. If new sheave or sheaves and belts are required, data will be submitted to Contractor.
 - 8) Witness positive pressure duct leakage tests performed by the contractor on large exhaust systems to minimize duct leakage in these systems.
 - 9) Balance air distribution system (see Air Distribution Devices).
- c. Fire, Fire-Smoke, and Smoke Dampers:
- 1) Verify operation of all fire-smoke and smoke dampers only by witnessing the Contractor fully opening and closing these dampers.
 - 2) Verify each fire, fire-smoke, and smoke damper is located where indicated on the Drawings and tagged or identified with a permanent fire resistant tag or stencil (at access door location).
 - 3) Verify that each fire, fire-smoke, and smoke damper is provided with a suitably sized and located access door to allow full testing and observation of damper operation. Verify each duct access damper has suitable access through general construction features.
 - 4) Witness the Contractor testing each fire-smoke and smoke damper which shall be manually released, allowed to fully close, verifying it has a tight fit when closed, and then verify it does not bind when opening or closing.
 - 5) Witness each fire-smoke and smoke damper being fully opened by the Contractor and the fusible links on the fire damper portion of fire-smoke dampers being reset by the Contractor to include other related devices on smoke-fire dampers.
 - 6) Verify that all fire dampers are fully opened.
 - 7) Identify all dampers requiring repair or having a faulty installation.
 - 8) Write down pertinent information on damper testing tags to verify dates tested and initials of tester to confirm a successful test was conducted.
- d. Rooftop Air Conditioning Units (RTU):
- 1) Verify that the outside, return and relief air dampers are operational and move freely.
 - 2) Verify that filters are clean at the time of testing.
 - 3) Verify correct evaporator and return or relief air (as applicable) fan rotation.
 - 4) If belt driven, verify proper belt tension and that fan and motor sheaves are properly aligned. If direct drive, verify that motor is multi-speed motor and adjust speed setting for air balance purposes.

- 5) Verify that all equipment safeties are operational, as applicable, (low and high pressure limit switches, freezestate, high static pressure, anti-recycle timer, etc.)
- 6) Verify correct size and rating of motor overload protection for each supply, return and relief fan motor.
- 7) Verify each fan motor above is not overloaded; amperage readings do not exceed motor nameplate rating.
- 8) Determine total supply and return air. Air quantities to be determined by duct traverse if duct configuration permits and air velocity is 800-1000 feet per minute or greater.
- 9) Balance air distribution system (see Air Distribution Devices).
- 10) If air volume is less than design and motor capacity is available, adjust fan or fans, to obtain supply and return design CFM quantities to within $\pm 10\%$ of design. If new sheave or sheaves and belts are required, data will be submitted to Contractor for change out. For direct drive fans, adjust fan speed setting. After adjustments are made, retest units to determine final air balance quantities.
- 11) If applicable, determine the required static pressure and submit the static pressure control set point to control contractor for setting. Final set point shall not be arbitrary, but shall be based on the minimum value to obtain design air flows at 100% operation.
- 12) Test and adjust the minimum outside air up to any maximum values scheduled, for demand controlled ventilation, and return air CFM relationship to design.
- 13) Verify all temperature control devices are set and calibrated at design set points.

e. Cooling and Heating Coils:

- 1) Verify that all coils and heat exchangers are installed properly.
 - 2) Verify that all cooling and heating coils have filters installed upstream of coils.
 - 3) Verify no simultaneous cooling and heating occurs at any piece of equipment except during a humidity control sequence.
 - 4) Verify operation of all safety devices.
 - 5) Record entering and leaving air dry bulb temperatures, as applicable, to determine actual air temperature drop or rise as compared to the design value for all equipment tested. Additionally, for cooling coils, record the entering and leaving wet bulb temperatures for each component.
3. During the balancing process, all abnormalities or malfunctions of equipment or components discovered by the TAB personnel, will be reported promptly to the Engineer, Owner and Contractor so that the condition can be corrected expediently.

4. The temperature controls will be verified for calibration and proper relationship between control devices. The Contractor will be advised of any instruments out of calibration so that the Automatic Temperature Controls (ATC) contractor can recalibrate, using data supplied by the TAB Firm as required.
5. Thoroughly test the Energy Management System (EMS), as applicable. The testing of the Energy Management System shall include all HVAC controls, sensors, operators, sequences, etc. The tests shall include verification that commands introduced at the EMS console actually occur and temperatures, pressures, etc. indicated at the EMS console correlate with the actual reading at the sensing point. The ATC and EMS contractor shall provide technical support to the TAB Firm for a complete check out of the HVAC temperature controls and the Energy Management System. The EMS workstation console and field direct digital control panel displays of measured variables such as temperature, relative humidity, and pressure shall have the displayed values offset through software to be within 0.3 Deg.F. of the temperature, 5.0 percent for relative humidity, 20 parts per million (ppm) for carbon dioxide, 10 parts per million (ppm) for carbon monoxide and 0.01% for pressure of the actual variables measured in the field, with recently calibrated test equipment, at the sensor locations.
6. After testing, adjusting and balancing to the design conditions, if comfort conditions are not being maintained, the air conditioning system shall be rebalanced within the limitations of the equipment installed to obtain comfort conditions. If comfort conditions cannot be obtained, a report will be submitted giving specific data regarding the trouble area.
7. Make not less than three (3) inspections within ninety (90) days after occupancy of the building, and make adjustments if required, to insure that satisfactory conditions are being maintained throughout. Inspections are to be coordinated with Architect, Engineer, and Owner; and shall be documented with a supplemental report containing data and information, as required, after each visit, to document in writing that such visit took place and to note any unusual operating conditions.
8. Make an inspection during the opposite season from that in which the initial adjustments were made and at that time make any necessary modifications to the initial adjustments required to produce optimum operation of the systemic components to produce the proper conditions in each conditioned space. The opposite season inspection shall be coordinated with the Architect/Engineer and Owner. This inspection shall be documented with a supplemental report containing any pertinent data and information regarding readings and adjustments made.

1.5 TAB REPORT

- A. TAB report shall incorporate all performance data for the HVAC systems. The intent of the final report is to provide a reference of actual operating conditions for the Owner's operating personnel.
- B. All measurements and recorded readings (of air, water, electricity, etc.) that appear in the report must be made on site by the permanently employed technicians or engineers of the TAB Firm.

C. TAB report shall include but not be limited to the following:

1. Index.
2. Preface: A general discussion of the system, an outline of normal and ventilation modes of operation, any unusual operating conditions and any deficiencies not corrected as of the time the report was written.
3. Instrumentation List: A list of instruments used by type, model, range and calibration date. All instruments must be calibrated within six (6) months prior to the starting date of TAB services.
4. Air Distribution Devices (Supply, Exhaust, Return, and Relief Air type where Balance Dampers are Used):
 - a. Manufacturer, model and size.
 - b. Location.
 - c. Design and actual CFM (cooling and heating).
 - d. Air distribution devices, where a velocity indicating instrument is used to determine CFM; provide the required and actual velocity in FPM (when an air flow hood is used to determine CFM, only CFM is required to be recorded.)
5. Supply/Exhaust Fans:
 - a. Manufacturer, model and size; include neck size where different than the designated device size.
 - b. Location (Room name and number, above ceiling, roof mounted, etc.).
 - c. Design and actual CFM.
 - d. Design and actual fan RPM.
 - e. Design and actual static pressure (leaving minus entering).
 - f. Motor nameplate data.
 - g. Motor starter data and motor overload protection (heater) sizes and rating.
 - h. Actual motor amperage and voltage (all phases).

6. Fire Dampers:
 - a. Fill out a tag (provided by the Contractor) at each damper with a set of the tester's initials and the date that the damper was tested and operation verified, as witnessed by the TAB firm, as being acceptable.
 - b. Tags shall have additional spaces for future testing/verification.
7. Coils and Heat Exchangers:
 - a. Manufacturer, model, size and serial number where available.
 - b. Design and actual CFM.
 - c. Design and actual entering and leaving air static pressures.
 - d. Design and actual entering air dry bulb temperatures. Provide design and actual entering air wet bulb temperatures for each cooling coil.
 - e. Design and actual leaving air dry bulb temperatures. Provide design and actual leaving air wet bulb temperatures for each cooling coil.
 - f. Actual outside air temperature, dry and wet bulb, during testing.
8. Rooftop Air Conditioning Units:
 - a. Manufacturer, model, size and serial number.
 - b. Design and actual CFM (Supply, Return and Outside Air).
 - c. Design and actual Evaporator Fan RPM.
 - d. Static air pressure entering and leaving filters, coils, heaters, control dampers, and evaporator fan.
 - e. Evaporator, Return and Relief Air (as applicable) motor nameplate data.
 - f. Evaporator, Return and Relief Air (as applicable) fan motor starter data and motor overload protection heater sizes and rating (for each phase).
 - g. Actual evaporator motor amperage and voltage (all phases).
 - h. Filters; type, manufacturer, model, MERV rating, thickness, sizes, quantities of each size, actual static pressure drop across filters and condition (new, clean, dirty, loaded, wet, etc.).
 - i. Total unit Nameplate data (Volts, Amps, and overcurrent protection required).
 - j. Actual Unit volts and amps, for each phase, and actual overcurrent protection device rating, with the unit operating in full cooling.
 - k. Actual outside air temperature, dry and wet bulb (or relative humidity) during testing.
 - l. Condenser coil entering and leaving air dry bulb temperatures at full cooling.
- D. Instructions to Operating Personnel: TAB Firm shall instruct the operating personnel regarding the following:
 1. Systems Operation.
 2. Unusual Operating Conditions
 3. System Troubleshooting Procedures.

- E. Guarantee: Provide extended warranty of twelve (12) months after occupancy during which time the Engineer and/or Owner may, at his discretion, request check of the balance of any HVAC equipment. Provide TAB technicians to assist as required in making such tests. When any device is found not balanced in accordance with the mechanical plans and specifications, that HVAC system shall be completely re-balanced as directed by the Engineer and/or Owner at the TAB Firm's expense.

END OF SECTION