

SECTION 15950

TESTING, ADJUSTING, AND BALANCING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section

1.2 SUMMARY

- A. This section includes testing, adjusting and balancing (TAB) to produce design objectives for the following
 - 1. Air systems
 - a. Constant-volume air systems
 - 2. Laboratory fume hood airflow balancing

1.3 DEFINITIONS

- A. Adjust: To regulate fluid flow rate and air patterns at the terminal equipment, such as to reduce fan speed or adjust a damper
- B. Balance: To proportion flows within the distribution system, including submains, branches, and terminals, according to indicated quantities
- C. Barrier or Boundary: Construction, either vertical or horizontal, such as walls, floors, and ceilings that are designed and constructed to restrict the movement of airflow, smoke, odors, and other pollutants
- D. Draft: A current of air, when referring to localized effect caused by one or more factors of high air velocity, low ambient temperature, or direction of airflow, whereby more heat is withdrawn from a person's skin than is normally dissipated
- E. Procedure: An approach to and execution of a sequence of work operations to yield repeatable results
- F. Static Head: The pressure due to the weight of the fluid above the point of measurement. In a closed system, static head is equal on both sides of the pump
- G. Suction Head: The height of fluid surface above the centerline of the pump on the suction side
- H. System Effect Factors: Allowances used to calculate a reduction of the performance ratings of a fan when installed under conditions different from those presented when the fan was performance tested

- I. TAB: Testing, adjusting, and balancing
- J. Terminal: A point where the controlled medium, such as fluid or energy, enters or leaves the distribution system
- K. Test: A procedure to determine quantitative performance of systems or equipment
- L. Testing, Adjusting, and Balancing (TAB) Firm: The entity responsible for performing and reporting TAB procedures

1.4 SUBMITTALS

- A. Strategies and Procedures Plan: Within 30 days from Contractor's Notice to Proceed, submit copies of TAB strategies and step-by-step procedures as specified in Part 3 "Preparation" article. Include a complete set of report forms intended for use on this Project
- B. Certified TAB Reports: Submit two copies of reports prepared, as specified in this Section, on approved forms certified by TAB firm

1.5 QUALITY ASSURANCE

- A. TAB Firm Qualifications: Engage a TAB firm certified by AABC, NEBB, or TABB
- B. TAB Report Forms: Use standard forms from TAB firm's forms approved by Architect/Engineer
- C. Instrumentation Calibration: Calibrate instruments at least every six months or more frequently if required by instrument manufacturer
 - 1. Keep an updated record of instrument calibration that indicates date of calibration and the name of party performing instrument calibration
- D. ASHRAE/IESNA 90.1-2004 Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2004, Section 6.7.2.3 - "System Balancing."

1.6 PROJECT CONDITIONS

- A. Full Owner Occupancy: Owner will occupy the site and existing building during entire TAB period. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations
- B. Partial Owner Occupancy: Owner may occupy completed areas of building before Substantial Completion. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations

1.7 COORDINATION

- A. Coordinate the efforts of factory-authorized service representatives for systems and equipment, HVAC controls installers, and other mechanics to operate HVAC systems and equipment to support and assist TAB activities

- B. Notice: Provide seven days' advance notice for each test. Include scheduled test dates and times
- C. Perform TAB after leakage and pressure tests on air and water distribution systems have been satisfactorily completed

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems' designs that may preclude proper TAB of systems and equipment
 - 1. Contract Documents are defined in the General and Supplementary Conditions of Contract
 - 2. Verify that balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are required by the Contract Documents. Verify that quantities and locations of these balancing devices are accessible and appropriate for effective balancing and for efficient system and equipment operation
- B. Examine approved submittal data of HVAC systems and equipment
- C. Examine Project Record Documents described in Division 1 Section "Project Record Documents"
- D. Examine design data, including HVAC system descriptions, statements of design assumptions for environmental conditions and systems' output, and statements of philosophies and assumptions about HVAC system and equipment controls
- E. Examine equipment performance data including fan and pump curves. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system. Calculate system effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from those presented when the equipment was performance tested at the factory. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," Sections 7 through 10; or in SMACNA's "HVAC Systems--Duct Design," Sections 5 and 6. Compare this data with the design data and installed conditions
- F. Examine system and equipment installations to verify that they are complete and that testing, cleaning, adjusting, and commissioning specified in individual Sections have been performed
- G. Examine system and equipment test reports

- H. Examine HVAC system and equipment installations to verify that indicated balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are properly installed, and that their locations are accessible and appropriate for effective balancing and for efficient system and equipment operation
- I. Examine systems for functional deficiencies that cannot be corrected by adjusting and balancing
- J. Examine HVAC equipment to ensure that clean filters have been installed, bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation
- K. Examine terminal units, such as variable-air-volume boxes, to verify that they are accessible and their controls are connected and functioning
- L. Examine strainers for clean screens and proper perforations
- M. Examine three-way valves for proper installation for their intended function of diverting or mixing fluid flows
- N. Examine system pumps to ensure absence of entrained air in the suction piping
- O. Examine equipment for installation and for properly operating safety interlocks and controls
- P. Examine automatic temperature system components to verify the following
 - 1. Dampers, valves, and other controlled devices are operated by the intended controller
 - 2. Dampers and valves are in the position indicated by the controller
 - 3. Integrity of valves and dampers for free and full operation and for tightness of fully closed and fully open positions. This includes dampers in multizone units, mixing boxes, and variable-air-volume terminals
 - 4. Automatic modulating and shutoff valves, including two-way valves and three-way mixing and diverting valves, are properly connected
 - 5. Thermostats and humidistats are located to avoid adverse effects of sunlight, drafts, and cold walls
 - 6. Sensors are located to sense only the intended conditions
 - 7. Sequence of operation for control modes is according to the Contract Documents
 - 8. Controller set points are set at indicated values
 - 9. Interlocked systems are operating
 - 10. Changeover from heating to cooling mode occurs according to indicated values
- Q. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values

3.2 PREPARATION

- A. Prepare a TAB plan that includes strategies and step-by-step procedures
- B. Complete system readiness checks and prepare system readiness reports. Verify the following
 - 1. Permanent electrical power wiring is complete
 - 2. Automatic temperature-control systems are operational
 - 3. Balance, smoke, and fire dampers are open
 - 4. Isolating and balancing valves are open and control valves are operational
 - 5. Ceilings are installed in critical areas where air-pattern adjustments are required and access to balancing devices is provided
 - 6. Windows and doors can be closed so indicated conditions for system operations can be met

3.3 GENERAL PROCEDURES FOR TESTING AND BALANCING

- A. Perform testing and balancing procedures on each system according to the procedures contained in and this Section
- B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary to allow adequate performance of procedures. After testing and balancing, close probe holes and patch insulation with new materials identical to those removed. Restore vapor barrier and finish according to insulation Specifications for this Project
- C. Mark equipment and balancing device settings with paint or other suitable, permanent identification material, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, to show final settings
- D. Take and report testing and balancing measurements in inch pound (IP) units

3.4 PROCEDURES FOR MOTORS

- A. Motors, ½ HP and Larger: Test at final balanced conditions and record the following data
 - 1. Manufacturer, model, and serial numbers
 - 2. Motor horsepower rating
 - 3. Motor rpm
 - 4. Efficiency rating
 - 5. Nameplate and measured voltage, each phase
 - 6. Nameplate and measured amperage, each phase
 - 7. Starter thermal-protection-element rating
- B. Motors Driven by Variable-Frequency Controllers: Test for proper operation at speeds varying from minimum to maximum. Test the manual bypass for the controller to prove proper operation. Record observations, including controller manufacturer, model and serial numbers, and nameplate data

3.5 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

- A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer
 1. Measure total airflow
 - a. Where sufficient space in ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow
 2. Measure fan static pressures as follows to determine actual static pressure
 - a. Measure outlet static pressure as far downstream from the fan as practical and upstream from restrictions in ducts such as elbows and transitions
 - b. Measure static pressure directly at the fan outlet or through the flexible connection
 - c. Measure inlet static pressure of single-inlet fans in the inlet duct as near the fan as possible, upstream from the flexible connection, and downstream from duct restrictions
 - d. Measure inlet static pressure of double-inlet fans through the wall of the plenum that houses the fan
 3. Measure static pressure across each component that makes up an air-handling unit, rooftop unit, and other air-handling and -treating equipment
 - a. Report the cleanliness status of filters and the time static pressures are measured
 4. Measure static pressures entering and leaving other devices, such as sound traps, heat-recovery equipment, and air washers, under final balanced conditions
 5. Review Record Documents to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions
 6. Obtain approval from Construction Manager for adjustment of fan speed higher or lower than indicated speed. Comply with requirements in Division 15 Sections for air-handling units for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance
 7. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload will occur. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower
- B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows within specified tolerances
 1. Measure airflow of submain and branch ducts
 - a. Where sufficient space in submain and branch ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow for that zone
 2. Measure static pressure at a point downstream from the balancing damper, and adjust volume dampers until the proper static pressure is achieved
 3. Remeasure each submain and branch duct after all have been adjusted. Continue to adjust submain and branch ducts to indicated airflows within

specified tolerances

- C. Measure air outlets and inlets without making adjustments
 - 1. Measure terminal outlets using a direct-reading hood or outlet manufacturer's written instructions and calculating factors
- D. Adjust air outlets and inlets for each space to indicated airflows within specified tolerances of indicated values. Make adjustments using branch volume dampers rather than extractors and the dampers at air terminals
 - 1. Adjust each outlet in same room or space to within specified tolerances of indicated quantities without generating noise levels above the limitations prescribed by the Contract Documents
 - 2. Adjust patterns of adjustable outlets for proper distribution without drafts

3.6 PROCEDURES FOR LABORATORY FUME HOODS

- A. Before performing laboratory fume hood testing, measure, adjust and record the supply airflow and airflow patterns of each supply air outlet that is located in the same room as the hood. Adjust the air outlet flow pattern to minimize turbulence and to achieve the desired airflow patterns at the face and inside the hood. Verify that adequate makeup air is available to achieve the indicated flow of the hood
- B. Measure, adjust, and record the airflow of each laboratory fume hood by duct Pitot-tube traverse with the laboratory fume hood sash in the design open position
 - 1. For laboratory fume hoods installed in variable exhaust systems, measure, adjust, and record the hood exhaust airflow at maximum and at minimum airflow conditions
 - 2. For laboratory fume hoods designed with integral makeup air, measure, adjust, and record the exhaust and makeup airflow
- C. After balancing is complete, do the following
 - 1. Measure and record the static pressure at the hood duct connection with the hood operating at indicated airflow
 - 2. Measure and record the face velocity across the open sash face area. Measure the face velocity at each point in a grid pattern. Perform measurements at a maximum of 12 inches between points and between any point and the perimeter of the opening
 - a. For laboratory fume hoods designed to maintain a constant face velocity at varying sash positions, also measure and record the face velocity at 50 and 25 percent of the design open sash position
 - b. Calculate and report the average face velocity by averaging all velocity measurements
 - c. Calculate and report the exhaust airflow by multiplying the calculated average face velocity by the sash open area. Compare this quantity with the exhaust airflow measured by duct Pitot-tube traverse. Report differences
 - d. If the average face velocity is less than the indicated face velocity, retest

- the average face velocity and adjust hood baffles, fan drives, and other parts of the system to provide the indicated average face velocity
3. Check each laboratory fume hood for the capture and containment of smoke by using a hand-held emitting device. Observe the capture and containment of smoke flow pattern across the open face and inside the hood. Make adjustments necessary to achieve the desired results

3.7 INSPECTIONS

A. Initial Inspection

1. After testing and balancing are complete, operate each system and randomly check measurements to verify that the system is operating according to the final test and balance readings documented in the Final Report
2. Randomly check the following for each system
 - a. Measure airflow of at least 10 percent of air outlets
 - b. Measure water flow of at least 5 percent of terminals
 - c. Measure room temperature at each thermostat/temperature sensor. Compare the reading to the set point
 - d. Measure sound levels at two locations
 - e. Measure space pressure of at least 10 percent of locations
 - f. Verify that balancing devices are marked with final balance position
 - g. Note deviations to the Contract Documents in the Final Report

B. Final Inspection

1. After initial inspection is complete and evidence by random checks verifies that testing and balancing are complete and accurately documented in the final report, request that a final inspection be made by Architect/Engineer
2. TAB firm test and balance engineer shall conduct the inspection in the presence of Architect/Engineer
3. Architect/Engineer shall randomly select measurements documented in the final report to be rechecked. The rechecking shall be limited to either 10 percent of the total measurements recorded, or the extent of measurements that can be accomplished in a normal 8-hour business day
4. If the rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED"
5. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected
6. TAB firm shall recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes and resubmit the final report
7. Request a second final inspection. If the second final inspection also fails, Owner shall contract the services of another TAB firm to complete the testing and balancing in accordance with the Contract Documents and deduct the cost of the services from the final payment

3.8 ADDITIONAL TESTS

- A. Within 90 days of completing TAB, perform additional testing and balancing to verify that balanced conditions are being maintained throughout and to correct unusual conditions
- B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional testing, inspecting, and adjusting during near-peak summer and winter conditions

END OF SECTION