

## SECTION 23 05 93 - TESTING, ADJUSTING, AND BALANCING FOR HVAC

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. All sections of the project manual are directly applicable to this specification section. Should a conflict arise between specification sections or between specifications and drawings and/or code requirements, the contractor shall notify the Architect/Engineer of the conflict in writing. If direction is not provided prior to the submission of the bid, the contractor shall price the more extensive system.

#### 1.2 SUMMARY

- A. General: TAB Firm shall check, adjust, and balance components of the HVAC systems 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.
  - 1. It is the responsibility of the HVAC and/or Control Systems Contractor to place the equipment into service.
  - 2. During the balancing process, as the TAB Firm discovers abnormalities and malfunctions of equipment or components, the TAB Firm shall advise the HVAC and/or Control Systems 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.
- B. Liaison and Early Field Inspection: TAB Firm shall act as a liaison between the Owner, Architect and Contractor. During construction, review all HVAC submittals such as control diagrams, air handling devices, etc., that pertain to the ability to satisfactorily balance systems and advise in writing accordingly.
- C. Section Includes:
  - 1. Balancing Air Systems:
    - a. Constant-volume air systems.
  - 2. Testing, Adjusting, and Balancing Primary Equipment:
    - a. Motors.
  - 3. Duct leakage tests.
  - 4. Control system coordination and verification.

#### 1.3 DEFINITIONS

- A. AABC: Associated Air Balance Council.

- B. BAS: Building automation systems.
- C. NEBB: National Environmental Balancing Bureau.
- D. TAB: Testing, adjusting, and balancing.
- E. TAB Specialist: An independent entity meeting qualifications to perform TAB work.
- F. TDH: Total dynamic head.

#### 1.4 PREINSTALLATION MEETINGS

- A. TAB Conference: If requested by the Owner, conduct a TAB conference at Penn State University, Harrisburg Campus after approval of the TAB strategies and procedures plan to develop a mutual understanding of the details. Provide a minimum of 14 days' advance notice of scheduled meeting time and location.

##### 1. Minimum Agenda Items:

- a. The Contract Documents examination report.
- b. The TAB plan.
- c. Needs for coordination and cooperation of trades and subcontractors.
- d. Proposed procedures for documentation and communication flow.

#### 1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: Within 30 days of Contractor's Notice to Proceed, submit documentation that the TAB specialist and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.
- B. Contract Documents Examination Report: Within 30 days of Contractor's Notice to Proceed, submit the Contract Documents review report as specified in Part 3.
- C. Strategies and Procedures Plan: Within 30 days of Contractor's Notice to Proceed, submit TAB strategies and step-by-step procedures as specified in "Preparation" Article.
- D. System Readiness Checklists: Within 30 days of Contractor's Notice to Proceed, submit system readiness checklists as specified in "Preparation" Article.
- E. Examination Report: Submit a summary report of the examination review required in "Examination" Article.
- F. Certified TAB reports.
- G. 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.
- H. Instrument calibration reports, to include the following:
  - 1. Instrument type and make.

2. Serial number.
3. Application.
4. Dates of use.
5. Dates of calibration.

#### 1.6 QUALITY ASSURANCE

- A. Testing, adjusting, and balancing (TAB) of the HVAC systems and related ancillary equipment will be performed by a technically qualified TAB Firm. 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.
- B. 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 Pennsylvania. TAB Firm shall submit full incorporated name, Charter Number, and Taxpayer's I.D. Number for proper verification of TAB Firm's status.
- C. 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.
- D. 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.
- E. TAB Contractor required Qualifications: Certified by AABC or NEBB.
  1. TAB Field Supervisor: Employee of the TAB specialist and certified by AABC or NEBB.
  2. TAB Technician: Employee of the TAB specialist and certified by AABC or NEBB as a TAB technician.
- F. Instrumentation Type, Quantity, Accuracy, and Calibration: Comply with requirements in ASHRAE 111, Section 4, "Instrumentation."
- G. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 7.2.2 - "Air Balancing."
- H. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.7.2.3 - "System Balancing."
- I. 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.
- J. TAB scope is not complete until all issues are resolved to University's satisfaction.

#### 1.7 FIELD CONDITIONS

- A. Full Owner Occupancy: Owner will occupy the site and remainder of existing building during entire TAB period. Only the areas specifically designated to be renovated shall not regularly be occupied by Owner during the construction phase. 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.

## 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.
- B. Examine installed systems for balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are applicable for intended purpose and are accessible.
- C. Examine the approved submittals for HVAC systems and equipment.
- 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 ceiling plenums and underfloor air plenums used for supply, return, or relief air to verify that they are properly separated from adjacent areas. Verify that penetrations in plenum walls are sealed and fire-stopped if required.
- F. Examine equipment performance data including fan and pump curves.
  - 1. 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.
  - 2. Calculate system-effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA's "HVAC Systems - Duct Design." Compare results with the design data and installed conditions.
- G. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.
- H. Examine test reports specified in individual system and equipment Sections.
- I. Examine HVAC equipment and verify that bearings are greased, belts are aligned and tight, filters are clean, and equipment with functioning controls is ready for operation.
- J. Examine terminal units, such as variable-air-volume boxes, and verify that they are accessible and their controls are connected and functioning.

- K. Examine strainers. Verify that startup screens have been replaced by permanent screens with indicated perforations.
- L. Examine control valves for proper installation for their intended function of throttling, diverting, or mixing fluid flows.
- M. Examine heat-transfer coils for correct piping connections and for clean and straight fins.
- N. Examine system pumps to ensure absence of entrained air in the suction piping.
- O. Examine operating safety interlocks and controls on HVAC equipment.
- P. 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 the following:
  - 1. Equipment and systems to be tested.
  - 2. Strategies and step-by-step procedures for balancing the systems.
  - 3. Instrumentation to be used.
  - 4. Sample forms with specific identification for all equipment.
- B. Perform system-readiness checks of HVAC systems and equipment to verify system readiness for TAB work. Include, at a minimum, the following:
  - 1. Airside:
    - a. Verify that leakage and pressure tests on air distribution systems have been satisfactorily completed.
    - b. Duct systems are complete with terminals installed.
    - c. Volume, smoke, and fire dampers are open and functional.
    - d. Clean filters are installed.
    - e. Fans are operating, free of vibration, and rotating in correct direction.
    - f. Variable-frequency controllers' startup is complete and safeties are verified.
    - g. Automatic temperature-control systems are operational.
    - h. Ceilings are installed.
    - i. Windows and doors are installed.
    - j. Suitable access to balancing devices and equipment is provided.

### 3.3 GENERAL PROCEDURES FOR TESTING AND BALANCING

- A. Perform testing and balancing procedures on each system according to the procedures contained in AABC's "National Standards for Total System Balance" or NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" and in this Section.
- B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures.

1. After testing and balancing, patch probe holes in ducts with same material and thickness as used to construct ducts.
  2. After testing and balancing, install test ports and duct access doors that comply with requirements defined in air duct accessories specifications.
  3. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to requirements of insulation specifications.
- C. All instruments used for measurements shall be accurate, and calibration histories for each instrument shall be available for examination. Calibration and maintenance of all instruments shall be in accordance with the requirements of AABC or NEBB.
- D. Accuracy of measurements shall be in accordance with AABC or NEBB Standards.
- E. In addition, the Contractor shall check the operation of all automatic temperature control equipment; verify all thermostat, aquastat, airstat, etc., set-points and operations; and enlist the aid of the control Subcontractor to make necessary adjustments where required.
- F. Mark equipment and balancing devices, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.
- G. Take and report testing and balancing measurements in inch-pound (IP) units.
- H. Coordinate with Controls Contractor as required to establish and document balanced positions and set points for damper and valve actuator position.

#### 3.4 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

- A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Cross-check the summation of required outlet volumes with required fan volumes.
- B. Prepare schematic diagrams of systems' "as-built" duct layouts.
- C. For variable-air-volume systems, develop a plan to simulate diversity.
- D. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.
- E. Check airflow patterns from the outdoor-air louvers and dampers and the return- and exhaust-air dampers through the supply-fan discharge and mixing dampers.
- F. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
- G. Verify that motor starters are equipped with properly sized thermal protection.
- H. Check dampers for proper position to achieve desired airflow path.
- I. Check for airflow blockages.
- J. Check condensate drains for proper connections and functioning.
- K. Check for proper sealing of air-handling-unit components.

- L. Verify that air duct system is sealed as specified in ductwork specifications.
- M. It is unacceptable for balancing contractor to indicate that a system has been balanced as far as the existing sheaves permit. Coordinate with HVAC Contractor to change pulleys, belts, sheaves, etc., as required.
- N. All adjustable sheaves shall be replaced with suitable fixed sheaves prior to final acceptance by the University.
- O. When room air pressurization relationships are specified or required by code, confirm proper balance of airflows and pressurization with respect to adjacent rooms and corridors.

### 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. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.
    - b. Where duct conditions allow, measure airflow by Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses to obtain total airflow.
    - c. Where duct conditions are not suitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.
    - d. If a reliable Pitot-tube traverse or coil traverse is not possible, measure airflow at terminals and calculate the total airflow.
  - 2. Measure fan static pressures as follows:
    - a. Measure static pressure directly at the fan outlet or through the flexible connection.
    - b. Measure static pressure directly at the fan inlet or through the flexible connection.
    - c. Measure static pressure across each component that makes up the air-handling system.
    - d. Report artificial loading of filters at the time static pressures are measured.
  - 3. 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.
  - 4. Obtain approval from Architect/Engineer for adjustment of fan speed higher or lower than indicated speed. Comply with requirements in HVAC Sections for air-handling units for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.
  - 5. 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 occurs. 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.
  - 1. Measure airflow of submain and branch ducts.

2. Adjust submain and branch duct volume dampers for specified airflow.
3. Re-measure each submain and branch duct after all have been adjusted.

C. Adjust air inlets and outlets for each space to indicated airflows.

1. Set airflow patterns of adjustable outlets for proper distribution without drafts.
2. Measure inlets and outlets airflow.
3. Adjust each inlet and outlet for specified airflow.
4. Re-measure each inlet and outlet after they have been adjusted.

D. Verify final system conditions.

1. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to design if necessary.
2. Re-measure and confirm that total airflow is within design.
3. Re-measure all final fan operating data, rpms, volts, amps, and static profile.
4. Mark all final settings.
5. Test system in economizer mode. Verify proper operation and adjust if necessary.
6. Measure and record all operating data.
7. Record final fan-performance data.

### 3.6 PROCEDURES FOR MOTORS

A. Motors 1/2 HP and Larger: Test at final balanced conditions and record the following data:

1. Manufacturer's name, model number, and serial number.
2. Motor horsepower rating.
3. Motor rpm.
4. Phase and hertz.
5. Nameplate and measured voltage, each phase.
6. Nameplate and measured amperage, each phase.
7. Starter size and thermal-protection-element rating.
8. Service factor and frame size.

B. Motors Driven by Variable-Frequency Controllers: Test manual bypass of controller to prove proper operation.

### 3.7 DUCT LEAKAGE TESTS

- A. Witness the duct pressure testing performed by Installer.
- B. Verify that proper test methods are used and that leakage rates are within specified tolerances.
- C. Report deficiencies observed.

### 3.8 CONTROL SYSTEMS COORDINATION AND VERIFICATION

A. In the process of HVAC system Testing, Adjusting and Balancing, perform the following:

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 temperature control system is operating within the design limitations.
3. Confirm that the sequences of operation are in compliance with Contract Documents.
4. Verify that controllers and any air and water flow measuring devices are calibrated and function together as intended.
5. Observe the calibration and operation of all controllers.
6. Verify that controller set points are as indicated.
7. Verify the operation of lockout or interlock systems.
8. Verify the operation of valve and damper actuators.
9. Verify that controlled devices are properly installed and connected to correct controller.
10. Verify that the intended controllers operate all dampers, valves and other controlled devices.
11. Verify that controlled devices travel freely and are in position indicated by controller: open, closed, or modulating.
12. Verify the proper application of all normally opened and normally closed valves.
13. Verify location and installation of sensors to ensure that they sense only intended temperature, humidity, or pressure. Check for potential erratic operation from outside influences such as sunlight, drafts, or cold walls.
14. 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.
15. 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.
16. 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.
17. Perform variable volume system verification to assure the system and system components track with changes from full flow to minimum flow.

B. Reporting: Include a summary of verifications performed, remaining deficiencies, and variations from indicated conditions.

C. During the balancing process, as the TAB Firm discovers abnormalities and malfunctions of equipment or components, the TAB Firm shall advise the HVAC and/or Control Systems 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.

### 3.9 TOLERANCES

A. Set HVAC system's airflow rates and water flow rates within the following tolerances:

1. Supply, Return, and Exhaust Fans and Equipment with Fans: minus 0 or plus 10 percent.
2. Air Outlets and Inlets: minus 0 or plus 10 percent.
3. Heating-Water Flow Rate: minus 0 or plus 10 percent.
4. Cooling-Water Flow Rate: minus 0 or plus 10 percent.

B. Maintaining pressure relationships as designed shall have priority over the tolerances specified above.

### 3.10 PROGRESS REPORTING

- A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article, prepare a report on the adequacy of design for systems balancing devices. Recommend changes and additions to systems balancing devices to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance measuring and balancing devices.
- B. Status Reports: Prepare biweekly progress reports to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems found in systems being tested and balanced. Prepare a separate report for each system and each building floor for systems serving multiple floors.

### 3.11 FINAL REPORT

- A. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.
  - 1. An electronic document of the final report shall be submitted on applicable AABC or NEBB Reporting Forms for review and approval by the Professional and University.
    - a. Each electronic document shall be intuitive, fully-organized, with selectable table of contents that includes tabs and/or bookmarks linked to be able to skip directly to each associated section.
    - b. **All documents shall be fully text searchable.** Use electronically created and populated forms and systems diagrams.
    - c. When scanning of paper originals is a necessary last resort, it shall be done with optical character recognition (OCR) technology. Verify that all pages on every document have been scanned. Review each page to ensure that the scan captures original detail. If images appear too dark or too light, or smudged, rescan the page to ensure proper image quality and legibility. Color charts or other documents where color is required to convey full information shall be scanned in color.
    - d. Coordinate with the Office of Physical Plant's Facility Asset Management (FAM) Program, Document Management Subdivision, for electronic submission requirements, including file naming structure guidelines. Contact List:
      - 1) Craig Dubler, FAM Program Manager, crd137@psu.edu, (814) 865-0089
      - 2) Ken Vasko, Facilities Specialist, kev12@psu.edu, (814) 863-4564
- B. Each individual final Reporting Form submitted must bear the signature of the person who recorded the data and the signature of the testing and balancing supervisor of the performing firm.
- C. If more than one certified firm performs the TAB work, all final reports shall be submitted by that firm having managerial responsibility.
- D. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.
- E. Include a list of instruments used for procedures, along with proof of calibration including dates of calibration to be submitted with the final report.

- F. Certify validity and accuracy of field data.
- G. The final test report shall include appropriate reference to all problems regarding the system(s) encountered prior to, during and after testing and what action taken to correct the problems (s), including noise and vibration.
- H. An approved copy of the balancing report shall be included in the Maintenance Manual submittal.
- I. Final Report Contents: In addition to certified field-report data, include the following:
  - 1. Pump curves.
  - 2. Fan curves.
  - 3. Manufacturers' test data.
  - 4. Field test reports prepared by system and equipment installers.
  - 5. Other information relative to equipment performance; do not include Shop Drawings and Product Data.
- J. General Report Data: In addition to form titles and entries, include the following data:
  - 1. Title page.
  - 2. Name and address of the TAB specialist.
  - 3. Project name.
  - 4. Project location.
  - 5. Architect's name and address.
  - 6. Engineer's name and address.
  - 7. Contractor's name and address.
  - 8. Report date.
  - 9. Signature of TAB supervisor who certifies the report.
  - 10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
  - 11. Summary of contents including the following:
    - a. Indicated versus final performance.
    - b. Notable characteristics of systems.
    - c. Description of system operation sequence if it varies from the Contract Documents.
  - 12. Nomenclature sheets for each item of equipment.
  - 13. Data for terminal units, including manufacturer's name, type, size, and fittings.
  - 14. Notes to explain why certain final data in the body of reports vary from indicated values.
  - 15. Test conditions for fans and pump performance forms including the following:
    - a. Settings for outdoor-, return-, and exhaust-air dampers.
    - b. Conditions of filters.
    - c. Cooling coil, wet- and dry-bulb conditions.
    - d. Face and bypass damper settings at coils.
    - e. Fan drive settings including settings and percentage of maximum pitch diameter.
    - f. Inlet vane settings for variable-air-volume systems.
    - g. Settings for supply-air, static-pressure controller.
    - h. Other system operating conditions that affect performance.
- K. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:

1. Quantities of outdoor, supply, return, and exhaust airflows including system total airflow rates.
  2. Water and steam flow rates.
  3. Duct, outlet, and inlet sizes.
  4. Pipe and valve sizes and locations.
  5. Terminal units.
  6. Balancing stations.
  7. Position of balancing devices.
- L. Electric-Coil Test Reports: For electric furnaces, duct coils, and electric coils installed in central-station air-handling units, include the following:
1. Unit Data:
    - a. System identification.
    - b. Location.
    - c. Coil identification.
    - d. Capacity in Btu/h.
    - e. Number of stages.
    - f. Connected volts, phase, and hertz.
    - g. Rated amperage.
    - h. Airflow rate in cfm.
    - i. Face area in sq. ft..
    - j. Minimum face velocity in fpm.
  2. Test Data (Indicated and Actual Values):
    - a. Heat output in Btu/h.
    - b. Airflow rate in cfm.
    - c. Air velocity in fpm.
    - d. Entering-air temperature in deg F.
    - e. Leaving-air temperature in deg F.
    - f. Voltage at each connection.
    - g. Amperage for each phase.
- M. Fan Test Reports: For supply, return, and exhaust fans, include the following:
1. Fan Data:
    - a. System identification.
    - b. Location.
    - c. Make and type.
    - d. Model number and size.
    - e. Manufacturer's serial number.
    - f. Arrangement and class.
    - g. Sheave make, size in inches, and bore.
    - h. Center-to-center dimensions of sheave and amount of adjustments in inches.
  2. Motor Data:
    - a. Motor make, and frame type and size.
    - b. Horsepower and rpm.
    - c. Volts, phase, and hertz.
    - d. Full-load amperage and service factor.

- e. Sheave make, size in inches, and bore.
- f. For variable speed systems, document VFD frequency at design airflow
- g. Center-to-center dimensions of sheave, and amount of adjustments in inches.
- h. Number, make, and size of belts.

3. Test Data (Indicated and Actual Values):

- a. Total airflow rate in cfm.
- b. Total system static pressure in inches wg.
- c. Fan rpm.
- d. Discharge static pressure in inches wg.
- e. Suction static pressure in inches wg.

N. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:

1. Report Data:

- a. System and air-handling-unit number.
- b. Location and zone.
- c. Traverse air temperature in deg F.
- d. Duct static pressure in inches wg.
- e. Duct size in inches.
- f. Duct area in sq. ft..
- g. Indicated airflow rate in cfm.
- h. Indicated velocity in fpm.
- i. Actual airflow rate in cfm.
- j. Actual average velocity in fpm.
- k. Barometric pressure in psig.

O. Air-Terminal-Device Reports:

1. Unit Data:

- a. System and air-handling unit identification.
- b. Location and zone.
- c. Apparatus used for test.
- d. Area served.
- e. Make.
- f. Number from system diagram.
- g. Type and model number.
- h. Size.
- i. Effective area in sq. ft..

2. Test Data (Indicated and Actual Values):

- a. Airflow rate in cfm.
- b. Air velocity in fpm.
- c. Preliminary airflow rate as needed in cfm.
- d. Preliminary velocity as needed in fpm.
- e. Final airflow rate in cfm.
- f. Final velocity in fpm.
- g. Space temperature in deg F.

P. Instrument Calibration Reports:

1. Report Data:
  - a. Instrument type and make.
  - b. Serial number.
  - c. Application.
  - d. Dates of use.
  - e. Dates of calibration.

### 3.12 VERIFICATION OF TAB REPORT

- A. The TAB specialist's test and balance engineer shall conduct the inspection in the presence of Architect/Engineer.
- B. Architect/Engineer shall randomly select measurements, documented in the final report, to be rechecked. 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.
- C. If 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."
- D. 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.
- E. If TAB work fails, proceed as follows:
  1. TAB specialists shall recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes; resubmit the final report and request a second final inspection.
  2. If the second final inspection also fails, Owner may contract the services of another TAB specialist to complete TAB work according to the Contract Documents and deduct the cost of the services from the original TAB specialist's final payment.
  3. If the second verification also fails, Architect/Engineer may contact AABC Headquarters regarding the AABC National Performance Guaranty.
- F. Prepare test and inspection reports.

### 3.13 ADDITIONAL TESTS

- A. Within 90 days of completing TAB, perform additional TAB 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 TAB during near-peak summer and winter conditions.

END OF SECTION