

15990: TESTING AND BALANCING

SUMMARY

Air and water balancing shall be performed by an independent Test and Balance Agency retained either as a direct subcontractor to the Contractor or separately by the Owner. Coordinate appropriate procurement method with the Capital Projects during the design phase. Require that the general and mechanical contractors provide all tests, inspections, and preparations necessary to facilitate activities of the Test and Balance Agency. Final test and balance report shall be submitted and approved prior to project Substantial Completion.

QUALITY ASSURANCE

Test and Balance Agency shall be a certified member of the Associated Air Balance Council with at least 10 years of experience in the testing and balancing of HVAC systems (Topflight Specs Note: Verify that use of years of experience is appropriate on publicly bid projects. See also year requirements under personnel experience below. Language can be changed to “verifiable successful experience in . . .”). Test and Balance Agency shall be regularly engaged and specialize in the testing and balancing of HVAC systems. Testing and balancing shall be performed in complete accordance with the "National Standards for Total System Balance," as published by the Associated Air Balance Council (AABC).

Personnel Qualifications: Require that the Test and Balance Agency assign personnel that have experience in projects of similar type and scope. Require submittal of names, qualifications, and project experience of all personnel proposed to perform testing and balancing.

- Field supervisor with day-to-day responsibility for the work shall be an AABC Certified Test and Balance Engineer with at least 10 years of testing and balancing experience in related projects. Qualifications shall include at least 5 recent projects of similar size, type, complexity, and regulatory requirements supervised and/or executed by the individual proposed for the project. The approved AABC Certified Test and Balance Engineer shall directly supervise day-to-day activities and shall be on the job site every day that testing and balancing work is performed.
- Technicians performing work shall be AABC Certified Test and Balance Technicians with at least 5 years of testing and balancing experience in related projects. Qualifications shall include at least 5 recent projects of similar size, type, complexity, and regulatory requirements executed by technicians proposed for the project.
- Apprentices used for this work shall have at least 3 years of testing and balancing experience in related projects. Qualifications shall include at least 3 recent projects of similar size, type, and complexity executed by apprentices proposed

for the project. Apprentices shall at all times work under the full-time direction and guidance of AABC Certified Test and Balance Technicians or Engineers.

- No testing, adjusting, balancing, or measurements shall be performed by personnel who are not approved by the Owner's Representative. The Owner's Representative retains the right to reject the qualifications of any personnel proposed for this project based on a reasonable review of submitted qualifications. Where specific personnel are rejected, require the submittal of alternate personnel with acceptable qualifications.

Instrumentation: Require that instruments have the maximum field measuring accuracy and are best suited to the function being measured. Scale ranges shall be appropriate for the value being measured. Utilize instruments with minimum scale and maximum subdivisions available for each measurement.

Performance Guaranty: Require the submittal of an "AABC National Performance Guaranty" for each project. The guaranty shall certify that all systems are balanced to optimum performance within the limits of the design and installation. The Test and Balance Agency shall furnish all labor and material to restore system performance, to the satisfaction of and at no cost to the Owner, any system that fails to maintain optimum performance during the warranty period.

SUBMITTALS

Preliminary submittals shall include:

- Qualifications of the Test and Balance Agency and of personnel to be assigned to the project.
- Detailed procedures for the project.
- Report forms filled out for the project.

Intermediate submittals shall include:

- Written reports describing any system deficiencies or components which do not function properly.
- Intermediate test and balance reports as specified below.

Final submittal shall include:

- Test and balance report typed in final form, including drawings identifying locations of every air outlet and inlet and pitot traverse. A draft report shall be submitted for review by the Owner's Representative and project Mechanical Engineer. The final report shall address all comments and be approved by the project Mechanical Engineer.

- Fan and pump curves with design and actual operation points plotted.
- Certificates of calibration for all instruments used.
- HVAC controls coordination report.
- Performance Guaranty.
- The AABC Certified Test and Balance Engineer who supervised and is responsible for the work shall sign the final balance report, certifying the accuracy of the results and that work has been performed in accordance with specified standards and procedures.

RENOVATION PROJECTS

Pre-demolition Measurements: Evaluate the impact of new work on the air and water balance in adjacent areas and, where appropriate, require the following measurements before demolition begins or as soon as ceiling access is made available.

- Measure airflow in every duct entering or leaving the project area as close as possible to the project boundary, unless this information is not pertinent.
- Measure airflows in other spaces outside the project area that will be affected by demolition or new work.
- Where connection to existing ducts will be made, measure available static pressure at the points of connection.
- Where new ducts are connected to existing supply or exhaust fan systems, measure and report fan and motor data. Notify the Owner's Representative in writing if existing fan system(s) are operating close to capacity and not able to adequately serve the project area.

Intermediate Air Balancing: Whenever demolition, capping of existing ducts, or connection of new ductwork to existing systems causes airflows to change outside of the project area, provide immediate air balancing to adjust fan speed, main duct dampers, and branch dampers so that existing airflows and pressure relationships are maintained outside of the project area. Intermediate test and balance reports are to be submitted within 24 hours after completion of duct modifications that affect airflows in other areas. Handwritten documentation on approved AABC forms will be acceptable for intermediate test and balance reports.

PREPARATION

Require the following pre-balance preparation by the Test and Balance Agency:

- Review the Drawings and Specifications and notify the Owner’s Representative in writing if the installation poses any potential balancing problems or if any additional balancing devices that are not shown or specified are necessary for a total system balance.
- Review shop drawings to verify that all necessary balancing devices will be provided. Confirm final schedule and coordination issues. Identify the times and scope of any intermediate air balancing required during the construction.
- Identify Testing Locations: After rough-in of ducts, piping, and equipment is complete, identify traverse locations, access requirements, and final placement of all balancing devices.
 - Drill minimum 1/2-inch diameter holes in ductwork for temperature, pressure, and velocity readings. Drill test holes in the following locations:
 - Each side of each filter, fan, coil, and multi-blade damper.
 - 6 inches on center for traverse readings in all main ducts.
 - In each new branch duct connecting to an existing duct.
 - As directed in the field.
 - Install a “Ventlok 699” Instrument Test Hole with red painted cap in each hole.
 - Trim and vapor seal duct insulation around all test holes.
 - Test holes shall be fully visible and accessible from ceiling access openings.
 - Indicate above-ceiling testing locations in the final test and balance report.

Require the following pre-balance preparation by the Contractor and trade subcontractors:

- Provide ceiling access as necessary for pre-demolition airflow measurements specified below.
- Install all dampers and other balancing devices shown or specified and check to be sure they are properly installed, fully open, and in good working order.
- Complete all punch list items that will affect balancing of the system.
- Fully coordinate with electrical and HVAC controls subcontractors the readiness, correctness, and the safety of the electrical power and control systems before starting any equipment.

- Start-up and test new and modified systems. Place all systems in automatic operation. Operate the systems for a minimum of 72 consecutive hours without shutdown with all equipment in good working order.
- Schedule work of other trades to eliminate system shutdowns once balancing is started, and assure uninterrupted access to mechanical equipment and conditioned spaces.
- Air Systems:
 - Clean interior of all plenums, air handler casings, and ducts.
 - Check that duct volume damper and fire smoke dampers are fully open.
 - Verify that air filters are in place. Calibrate and adjust air filter gauges.
 - Check for correct fan rotation.
 - Check for adequate motor horsepower to start and run fans.
 - Check for proper lubrication.
 - Check sheave alignment and belt tension at all fans.
 - Remove adjustable pitch pulleys from the motor shaft. Clean and lightly oil the shaft and pulley threads, and remount the pulley. Final adjustment shall be by the Test and Balance Agency.
 - Check fans for stable and quiet operation at design RPM.
 - Set sheaves to provide indicated capacities at specified static pressures. Furnish and install replacement sheaves as directed by the Test and Balance Agency during system balance.
 - Provide holes in drive guards that will permit tachometer readings without removing guards.
- Water Systems:
 - Comb heating and cooling coil fins and prove water flow to all coils.
 - Remove air from water systems.
 - Clean all system strainers. Remove temporary strainer liners.
 - Check that isolation valves, automatic control valves, and circuit balancing valves are 100 percent open.

- Verify completion of pump alignment, pre-operating checks, and preliminary testing. See Standards included in 15500, "HVAC Piping."

TESTING AND BALANCING ACTIVITIES

Require that all work conform to standard requirements and procedures contained in the AABC "National Standards for Total System Balance" and "Test and Balance Procedures", and recommended procedures contained in the ASHRAE HVAC Applications Handbook. Test and Balance Agency shall perform all recommended procedures, tests, measurements, and adjustments indicated in these standards, whether specified or not, as required for a total system balance.

Where the project is to be completed in phases, require complete testing and balancing at the end of each phase of work, so that spaces may be occupied according to the project schedule.

Balancing Criteria and Requirements:

- Air inlets and outlets of 200 CFM or less shall be balanced to within plus 10 percent to minus 0 percent of design; larger inlets and outlets shall be balanced to within plus 5 percent to minus 0 percent of design. Fans shall be balanced to within plus 10 percent to minus 0 percent of design. Temperature readings shall be accurate to within 0.5 degree F. Water flow readings shall be accurate to within 5 percent. Pressure readings shall be accurate to within 0.5 psi for water systems and 0.01-inch w.g. for air systems.
- Instruments shall have been calibrated within the last 6 months and checked for accuracy prior to starting the balancing procedure. Make velocity readings with an instrument that does not require a separate timer.
- All readings, measurements, and observations shall be recorded on printed AABC data sheets and tabulated with appropriate calculations.

Air System Balancing:

- The intent is to obtain design CFM at all outlets and inlets with minimum possible fan speed and system static pressure, and with acceptable noise levels in occupied areas. At least one main zone volume damper and one branch volume damper in each zone shall be fully open at the end of balancing. Final position of manual dampers shall be plainly marked after balancing is complete.
- Test and Balance Agency shall make special note wherever abnormal installed conditions (such as crimped flexible ducts, tight offsets, and unusual tap-ins or fittings) do not permit a proper air balance without increasing main duct static pressure or fan speed. Abnormal conditions shall be reported as early as possible, preferably during preliminary observations, and submitted with static pressure and

airflow measurements that will permit analysis and identification of necessary corrective actions.

- Test and Balance Agency shall make allowance for air filter resistance at the time of the tests. Air handling systems should be balanced with the final (dirty filter) air resistance imposed using blank-off plates.
- Test and Balance Agency shall fully balance variable air volume systems and equipment at scheduled maximum and minimum flow conditions.
- Test and Balance Agency shall make adjustments at diffusers and registers to prevent drafts at the occupant level in the space.
- Positive or negative pressure relationships between supply and exhaust CFM shall be achieved in spaces wherever shown on the Drawings or required by Code. Required air pressure relationships are absolute and shall be met regardless of allowed tolerances for airflow adjustments.
- Require that the final test and balance report include static pressure profiles of all balanced air handling systems, including static pressure measurements across fans, filters, main heating and cooling coils, sound traps, main duct modulating control dampers, in main and branch ducts near riser shafts, and upstream of variable air volume boxes. Include diagrams and/or drawings to document system static pressures.
- Require that the following measurements be made at duct smoke detector locations:
 - Differential pressure measurements across duct smoke detector sampling tubes.
 - Velocity profiles with air velocity measurements at 6-inch intervals at sampling tube locations.
 - Any other measurements requested by the Owner's Representative or authorities having jurisdiction to ensure that duct smoke sensors are installed in accordance with their listing requirements.
- Include detailed instructions in the Specifications or on the Drawings so that special balancing activities are addressed and included in the final test and balance report. These might include:
 - The establishment of minimum outside air and exhaust airflows at air handling units with variable air volume or economizer controls.
 - The establishment and calibration of maximum and minimum duct static pressure and airflow setpoints.

- The establishment of normal and default speed setpoints for variable frequency drives.
- Constant volume and variable air volume fume hood certification in accordance with UCB EH&S requirements, ASHRAE Standard 110, and other appropriate reference standards.
- Sound testing for HVAC noise in sensitive areas.
- Vibration measurements of rotating HVAC equipment.
- Smoke control system testing.

Water System Balancing:

- Require that chilled and heating hot water mains and branches be adjusted to flow rates as shown on the Drawings or as required to obtain required thermal performance. Before adjusting system circuit balancing valves, verify that normal design differential pressures exist in water lines at heating and cooling coils. Prohibit the use of service isolation valves for balancing.
- Require preliminary measurements and multiple readings of pump performance in accordance with requirements in Standards included in 15500, "HVAC Piping." For systems in which pump impellers will be trimmed for efficient operation, require that final measurements be made after pump impellers have been ground and reinstalled.
- The final test and balance report shall include design and measured flow rates and pressure drops at each point where design flow quantity is shown or scheduled on the Drawings, and water temperatures leaving and entering all coils when coils have had both air and water flows balanced.

Equipment Performance and Capacity Checks:

- Require that complete equipment performance documentation and test measurements be submitted in accordance with AABC "National Standards for Total System Balance" to demonstrate that all new and modified equipment is operating in accordance with scheduled performance criteria and manufacturer's published ratings. Where equipment is not performing in accordance with scheduled criteria or published ratings, analyze deficiencies and direct the Contractor to make appropriate corrections to allow equipment to perform efficiently and at required capacity.
- Seasonal Checks: During the first year of operation, if the Owner's Representative determines that heating or cooling capacities are not up to their expectation, require that the Test and Balance Agency provide additional system testing during periods of peak heating or cooling at no additional cost to the Owner. Based on

the results of this testing, direct the Contractor to make appropriate corrections so that heating and cooling systems provide required capacities.

HVAC CONTROLS COORDINATION

Require that the Test and Balance Agency cooperate with HVAC controls installer and other trades in making HVAC control system adjustments necessary to accomplish the required sequence of operation.

Where sequences require establishment of minimum and maximum airflows, multiple setpoints, reset schedules, or other variable conditions, the Test and Balance Agency shall provide all testing and balancing necessary to establish required setpoints. System performance shall be documented under all possible operating conditions.

Clearly delineate aspects of the control system installation and performance to be checked or tested by the Test and Balance Agency. Activities will vary with each project, but may include:

- Temperature and pressure readings to verify that control devices are properly calibrated and that sensors are properly positioned to read intended temperatures and pressures.
- Airflow measurements to verify control system setpoints at maximum and minimum airflows.
- Temperature measurements to verify that room temperature sensors and thermostats are properly calibrated and installed to avoid erratic operation due to air diffuser short circuiting or cold walls.
- Room and building pressurization measurements to verify that lobbies, laboratories, odorous rooms, clean spaces, and other sensitive areas have the correct air balance and pressure relationships.
- Automatic controllers and thermostats operate the correct control valves. Controller, thermostat, and control valve actions are correct.
- Setpoints meet the intent of the Sequence of Operation.
- System interlocks operate properly.

The final test and balance report shall include a checkout spreadsheet to document pertinent control system checking. Spreadsheet should include sensor and actual readings, device tag numbers, system, location, ranges, and other information.

FINAL ACCEPTANCE

At the time of final inspection, require the Test and Balance Agency to recheck, in the presence of the Owner's Representative, specific and random selections of water and air quantities and other data as recorded in the final test and balance report. Measurement and test procedures shall be the same as approved for the work.

Selections for recheck should not exceed 25 percent of the total number tabulated in the final report, except that 100 percent of air inlets and outlets in sensitive areas may be checked.

If random tests elicit a measured flow deviation of 10 percent or more from that recorded in the final test and balance report in ten percent or more of the selected recheck stations, the report shall be automatically rejected. In the event the report is rejected, all systems shall be readjusted and tested, new data recorded a new test and balance report submitted, and new inspection tests made, all at no additional cost to the Owner.

Final settings of all balancing valves, splitters, dampers, and other adjustment devices shall be permanently marked and locked in position and recorded by the Test and Balance Agency so that adjustment can be restored if disturbed at any time. Final balancing valve and damper positions shall be recorded in the final test and balance report.

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