

SECTION 220593 - TESTING, ADJUSTING AND BALANCING FOR PLUMBING SYSTEMS

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.

1.2 SUMMARY

- A. This Section specifies the requirements and procedures total plumbing systems testing, adjusting, and balancing. Requirements include measurement and establishment of the fluid quantities of the plumbing systems as required to meet design specifications, and recording and reporting the results.
- B. Test, adjust, and balance the following plumbing systems:
 - 1. Hot Water Return Systems
 - 2. Additional Tests
- C. Related Sections:
 - 1. Section 22 05 03 "Submittals for Plumbing".

1.3 DEFINITIONS

- A. Adjust: To regulate fluid flow rate at the terminal equipment, such as to reduce pump speed or adjust a valve.
- B. Balance: To proportion flows within the distribution system, including submains and branches, 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 fluid.
- D. NC: Noise criteria.
- E. NEBB: National Environmental Balancing Bureau
- F. Procedure: An approach to and execution of a sequence of work operations to yield repeatable results.
- G. Report Forms: Test data sheets for recording test data in logical order.

- H. 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.
- I. Suction Head: The height of fluid surface above the centerline of the pump on the suction side.
- J. System Effect: A phenomenon that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
- K. System Effect Factors: Allowances used to calculate a reduction of the performance ratings of a pump when installed under conditions different from those presented when the pump was performance tested.
- L. TAB: Testing, adjusting, and balancing.
- M. Test: A procedure to determine quantitative performance of systems or equipment.
- N. Testing, Adjusting, and Balancing (TAB) Firm: The entity responsible for performing and reporting TAB procedures.

1.4 ACTION SUBMITTALS

- A. Agency Data
 - 1. Submit proof that the proposed testing, adjusting, and balancing agency meets the qualifications specified below.
- B. Maintenance Data: Submit maintenance and operating data that include how to test, adjust, and balance the building systems. Include this information in maintenance data specified in Division 1.
- C. Certified Reports: Submit testing, adjusting, and balancing reports bearing the seal and signature of the Test and Balance Engineer. The reports shall be certified proof that the systems have been tested, adjusted, and balanced in accordance with the referenced standards; are an accurate representation of how the systems have been installed; are a true representation of how the systems are operating at the completion of the testing, adjusting, and balancing procedures; and are an accurate record of all final quantities measured, to establish normal operating values of the systems. Follow the procedures and format specified below:
 - 1. Final Report: Upon verification and approval prepare final reports, type written, and organized and formatted as specified below. Submit 2 complete sets of final reports.
 - 2. Report Format: Report forms shall be those standard forms prepared by the referenced standard for each respective item and system to be tested, adjusted, and balanced. Bind report forms complete with schematic systems diagrams and other data in reinforced, vinyl, three-ring binders. Provide binding edge labels with the

project identification and a title descriptive of the contents. Divide the contents of the binder into the below listed divisions, separated by divider tabs:

- a. General Information and Summary
 - b. Domestic Hot Water Return Systems
- D. Qualification Data: Within 30 days from Contractor's Notice to Proceed, submit 6 copies of evidence that the TAB firm and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.
- E. Contract Documents Examination Report: Within 30 days from Contractor's Notice to Proceed, submit 6 copies of the Contract Documents review report as specified in Part 3.
- F. Strategies and Procedures Plan: Within 60 days from Contractor's Notice to Proceed, submit 6 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.
- G. Certified TAB Reports: Submit two copies of reports prepared, as specified in this Section, on approved forms certified by TAB firm.
- H. Sample Report Forms: Submit two sets of sample TAB report forms.

1.5 QUALITY ASSURANCE

- A. Codes and Standards:
- 1. AABC: "National Standards for Total System Balance".
 - 2. ASHRAE: ASHRAE Handbook, Systems Volume, Chapter 37, Testing, Adjusting, and Balancing.
- B. Agency Qualifications
- 1. The Plumbing Contractor shall procure the services of an independent Balance and Testing Agency, approved by the Engineer, and a member of NEBB, which specializes in the balancing and testing of plumbing systems, to balance, adjust and test all water systems and equipment as herein specified.
 - 2. All work by this agency shall be done under direct supervision of a qualified plumbing Engineer employed by this agency.
 - 3. All instruments used by this agency shall be accurately calibrated and maintained in good working order.
- C. The Balance and Testing Agency must provide the technicians with the following instruments including, but not limited to, for field use:
- 1. One set of pressure gages and fittings.
 - 2. Thermocouple unit and thermocouples.

3. Set of balancing cock adjustment wrenches.
 4. Portable field flowmeter.
- D. TAB Firm Qualifications: Engage a TAB firm certified by NEBB.
- E. TAB Conference: Meet with Owner's and Architect's representatives on approval of TAB strategies and procedures plan to develop a mutual understanding of the details. Ensure the participation of TAB team members, equipment manufacturers' authorized service representatives, HVAC controls installers, and other support personnel. Provide seven days' advance notice of scheduled meeting time and location.
1. Agenda Items: Include at least the following:
 - a. Submittal distribution requirements.
 - b. The Contract Documents examination report.
 - c. TAB plan.
 - d. Work schedule and Project-site access requirements.
 - e. Coordination and cooperation of trades and subcontractors.
 - f. Coordination of documentation and communication flow.
 2. Certification of TAB Reports: Certify TAB field data reports. This certification includes the following:
 - a. Review field data reports to validate accuracy of data and to prepare certified TAB reports.
 - b. Certify that TAB team complied with approved TAB plan and the procedures specified and referenced in this Specification.
- F. TAB Report Forms: Use standard forms from NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" or TAB firm's forms approved by Architect.
- G. Instrumentation Type, Quantity, and Accuracy: Required Instrumentation for NEBB Certification."
- H. 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.

1.6 SEQUENCING AND SCHEDULING

- A. Systems shall be fully operational prior to beginning procedures.

1.7 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.

1.8 COORDINATION

- A. Coordinate the efforts of factory-authorized service representatives for systems and equipment, controls installers, and other mechanics to operate plumbing 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 plumbing systems have been satisfactorily completed.

1.9 GUARANTEE

- A. Special Guarantee: Provide a guarantee on NEBB forms stating that NEBB will assist in completing requirements of the Contract Documents if TAB firm fails to comply with the Contract Documents. Guarantee shall include the following provisions:
 - 1. The certified TAB firm has tested and balanced systems according to the Contract Documents.
 - 2. Systems are balanced to optimum performance capabilities within design and installation limits.

PART 2 - PRODUCTS (NOT APPLICABLE)**PART 3 - EXECUTION****3.1 GENERAL**

- A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems' designs that may preclude proper testing and balancing of systems and equipment.
- B. Examine systems for installed balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings. Note the locations of devices that are not accessible and/or deficiencies exist within the design of the contract drawings to allow for proper testing and balancing prior to installation.
- C. Examine the reviewed submittals for plumbing systems and equipment.

- D. Examine system and equipment installations and verify that field quality control testing, cleaning and adjusting specified in individual system and equipment Sections.
- E. Examine plumbing equipment and verify that bearings are greased and equipment with functioning controls are ready for operation.
- F. Examine operating safety interlocks and controls on plumbing equipment.
- G. Report deficiencies discovered before and during performance of the testing and balancing procedures. Observe and record system reactions to changes in conditions. Record default setpoints if different from indicated values.
- H. Verify the domestic hot water return system is correctly balanced to ensure all hot water return loop(s) maintain the designed set delivery temperature.

3.2 PRELIMINARY PROCEDURES FOR PLUMBING SYSTEM BALANCING

- A. Examine valves for proper installation and function.
- B. Examine equipment performance data including pump curves.
- C. Open valves to full open position.
- D. Remove, clean and reinstall all strainers.
- E. Lubricate all motors and bearings.

3.3 PREPARATION

- A. Prepare a testing and balancing 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. Prepare system-readiness checklists for use by systems installers in verifying system readiness for T&B. These shall include, at a minimum, the following:
 - 1. Piping is complete with terminals installed.
 - 2. Systems are flushed, filled and air purged.
 - 3. Strainers are pulled and cleaned.
 - 4. Shutoff and balance valves have been verified to be 100 percent open.
 - 5. Pumps are started and proper rotation is verified.
 - 6. Pump gage connections are installed directly at pump inlet and outlet flanges or in discharge and suction pipe prior to valves or strainers.
 - 7. Variable-frequency controllers' start-up is complete and safeties are verified.
 - 8. Suitable access to balancing devices and equipment is provided.

3.4 MEASUREMENTS

- A. Provide all required instrumentation to obtain proper measurements, calibrated to the tolerances specified in the referenced standards. Instruments shall be properly maintained and protected against damage.

3.5 PERFORMING TESTING, ADJUSTING, AND BALANCING

- A. Perform testing and balancing procedures on each system identified, in accordance with the detailed procedures outlined in the referenced standards.
- B. Cut insulation and piping for installation of test probes to the minimum extent necessary to allow adequate performance of procedures.
 - 1. Patch insulation and housings using materials identical to those removed.
 - 2. Seal piping after testing. Then test for leaks and repair if found.
 - 3. Seal insulation to re-establish integrity of the vapor barrier.
- C. Mark equipment settings, including valve indicators and similar controls and devices, to show final settings. Mark with paint or other suitable, permanent identification materials.
- D. Retest, adjust, and balance systems subsequent to significant system modifications, and resubmit test results.

3.6 GENERAL PROCEDURES FOR PLUMBING SYSTEMS

- A. Prepare test reports for pumps. Obtain approved submittals and any manufacturer-recommended testing procedures.
- B. Verify that hydronic systems are ready for testing and balancing:
 - 1. Check liquid level in expansion tank.
 - 2. Check that makeup water-has adequate pressure to highest vent.
 - 3. Check that valves are in their proper position.
 - 4. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
 - 5. Verify that motor starters are equipped with properly sized thermal protection.
 - 6. Check that air has been purged from the system.
- C. Adjust pumps to deliver total design gpm.
 - 1. Measure total water flow.
 - a. Position valves for full flow through valves.
 - b. Measure flow by main flow meter, if installed.
 - c. If main flow meter is not installed determine flow by pump total dynamic head (TDH) or exchanger pressure drop.

2. Measure pump TDH as follows:
 - a. Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
 - b. Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
 - c. Convert pressure to head and correct for differences in gauge heights.
 - d. Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.
 - e. With all valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved.
 3. Monitor motor performance during procedures and do not operate motor in an overloaded condition.
- D. Adjust flow measuring devices installed in mains and branches to design water flows.
1. Measure flow in main and branch pipes.
 2. Adjust main and branch balance valves for design flow.
 3. Re-measure each main and branch after all have been adjusted.
- E. Adjust flow measuring devices installed at terminals for each space to design water flows.
1. Measure flow at all balancing valves.
 2. Adjust each terminal to design flow.
 3. Re-measure each terminal after all have been adjusted.
- F. For systems with pressure-independent valves:
1. Measure differential pressure and verify that it is within manufacturer's specified range.
 2. Perform temperature tests after all flows have been verified.
- G. For systems without pressure-independent valves:
1. Measure and balance by pressure drop or temperature method.
 2. If balanced by pressure drop, perform temperature tests after all flows have been verified.
- H. Verify final system conditions as follows:
1. Re-measure and confirm that total water flow is within design.
 2. Re-measure all final pumps' operating data, TDH, volts, amps, static profile.
 3. Mark all final settings.
- I. Verify that all memory stops have been set.

3.7 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/Hertz (Hz)
 - 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 the manual bypass of the controller to prove proper operation.

3.8 PROCEDURES FOR TESTING, ADJUSTING, AND BALANCING EXISTING SYSTEMS

- A. Perform a preconstruction inspection of existing equipment that is to remain and be reused.
 - 1. Measure and record the operating speed, flow, and static pressure of each pump.
 - 2. Measure motor voltage and amperage. Compare the values to motor nameplate information.
 - 3. Check the condition of strainers.
 - 4. Report on the operating condition of the equipment and the results of the measurements taken. Report deficiencies.

- B. Before performing testing and balancing of existing systems, inspect existing equipment that is to remain and be reused to verify that existing equipment has been cleaned and refurbished. Verify the following:
 - 1. New strainers are installed.
 - 2. Pumps are clean.
 - 3. Deficiencies noted in the preconstruction report are corrected.

- C. Perform testing and balancing of existing systems to the extent that existing systems are affected by the renovation work.
 - 1. Compare the indicated flow of the renovated work to the measured pump flows, and determine the new pump speed.
 - 2. Verify that the indicated flows of the renovated work result in pump speeds that are within the acceptable limits defined by equipment manufacturer.
 - 3. Adjust pump speeds within the limits of the installed drives to achieve design airflow.
 - 4. Balance system to design flows indicated.

D. Renovations:

1. In areas where existing pumping equipment is being utilized, balancing contractor shall pre-check each piece of equipment water flows and main pump water flows and pressure drop prior to demolition and provide a report outlining existing water flows prior to any work. Any discrepancies of existing to remain water flows plus new water flows compared to proposed design water flows shall be brought to the attention of the engineer prior to any work.
2. The balancing contractor shall re-check and adjust each piece of existing equipment to water flows after new construction and balance equal to flows before construction.
3. The balancing contractor shall balance existing pump water flows after new construction to the combined water flows of new and reused equipment. Change out existing pump impellers and motors as required to obtain total pump flow and ramp up existing pumps as required to obtain design water flows. Replace strainers as required to obtain design water flows.

- E. Pump(s) shall be balanced so that VFD speed at 55 hz shall be equal to design water flow to allow for an increase in flow using the VFD.

3.9 FINAL TEST AND BALANCE REPORT

- A. The report shall be a complete record of the plumbing system performance, including conditions of operation, items outstanding, and any deviations found during the T&B process. The final report also provides a reference of actual operating conditions for the owner and/or operations personnel. All measurements and test results that appear in the reports must be made on site and dated by the test and balance engineers.
- B. The report must be organized by systems and shall include the following information as a minimum:
1. Title Page:
 - a. NEBB certified company name
 - b. Company address
 - c. Company telephone number
 - d. Project identification number
 - e. Location
 - f. Project Architect
 - g. Project Engineer
 - h. Project Contractor
 - i. Project number
 - j. Date of report
 - k. NEBB Certification Statement
 - l. Name, signature, and certification number of TBE
 2. Table of Contents.
 3. National Performance Guaranty.

4. Report Summary:
 - a. The summary shall include a list of items that do not meet design tolerances, with information that may be considered in resolving deficiencies.
 5. Instrument List:
 - a. Type.
 - b. Manufacturer.
 - c. Model.
 - d. Serial Number.
 - e. Calibration Date.
 6. T&B Data
- C. One copy of the final test and balance report shall be sent to the engineer of record. Provide five additional copies to the contractor.

3.10 VERIFICATION OF T&B REPORT

- A. Final Verification:
1. After testing and balancing is complete and accurately documented in the final report, request that a final verification be made by the engineer of record
 2. The engineer of record 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.
 3. 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."
 4. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final verification, the testing and balancing shall be considered incomplete.

3.11 REVERIFICATION

- A. T&B Agency shall recheck all measurements and make adjustments as required to complete the balancing. Revise the final report and balancing device settings to include all changes; resubmit the final report and request a second verification.
- B. If the second verification also fails, the engineer of record may contact NEBB Headquarters regarding the NEBB National Performance Guaranty.

3.12 ADDITIONAL TESTS

- A. Seasonal Periods: If initial T&B procedures were not performed during near-peak conditions, the engineer of record may request a flow recheck to further verify performance at near-peak conditions.

END OF SECTION 220593