

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Testing, adjusting and balancing of air systems.
2. Testing, adjusting and balancing of hydronic, steam and refrigerating systems.
3. Measurement of final operating condition of HVAC systems.
4. Sound measurement of equipment operating conditions.
5. Vibration measurement of equipment operating conditions.

B. Related Sections:

1. Section 23 09 23 - Direct-Digital Control System for HVAC: Requirements for coordination between DDC system and testing, adjusting, and balancing work.
2. Section 23 09 93 - Sequence of Operations for HVAC Controls: Sequences of operation for HVAC equipment.

1.02 REFERENCES

A. Associated Air Balance Council:

1. AABC MN-1 - National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems.

B. American Society of Heating, Refrigerating and Air-Conditioning Engineers:

1. ASHRAE 111 - Practices for Measurement, Testing, Adjusting and Balancing of Building Heating, Ventilation, Air-Conditioning and Refrigeration Systems.

C. Natural Environmental Balancing Bureau:

1. NEBB - Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems.

1.03 SUBMITTALS

A. Division 01 - Submittal Procedures: Submittal procedures.

- B. Prior to commencing Work, submit report forms or outlines indicating adjusting, balancing, and equipment data required. Include detailed procedures, agenda, sample report forms and copy of AABC National Project Performance Guaranty or a Copy of NEBB Certificate of Conformance Certification.
- C. Prior to commencing Work, submit TAB contractor's qualification including the past five year experience and reference projects and proof of latest calibration date of each instrument.
- D. Test Reports: Indicate data on either AABC MN-1 National Standards for Total System Balance forms, forms prepared following ASHRAE 111 or NEBB Report forms.
- E. Field Reports: Indicate deficiencies preventing proper testing, adjusting, and balancing of systems and equipment to achieve specified performance.
- F. Submit draft copies of report for review prior to final acceptance of Project.
- G. Furnish reports in soft cover, 3-ring binder manuals, complete with table of contents page and indexing tabs, with cover identification at front and side. Include set of reduced drawings with air outlets and equipment identified to correspond with data sheets, and indicating thermostat locations. Reports shall be signed/sealed by a Professional Engineer in the state where the project is located.
- H. Preliminary Effort:
 - 1. Immediately after award of the HVAC Contract, the TAB Contractor shall review the Drawings and Specifications and shall indicate any deficiencies (or additional features) in the air or water systems which would preclude (or improve) proper adjusting or balancing. These include:
 - a. Additional air volume dampers.
 - b. Additional water balance devices.
 - c. Installation of additional air flow measuring devices.
 - d. Installation of additional "Peet's Plugs" ports, etc.
 - 2. Submit for approval sample forms that he intends to use for tabulating balancing reports which shall include fan and pump or other equipment tags or labels. These forms should be similar to the AABC forms or NEBB equivalent.
 - 3. Describe the instrumentation (including accuracy limitations) of each device proposed for use on this project for air and water balancing. As a minimum, instrumentation usage application and accuracy limitations acceptable on this project shall be those described in "HVAC Systems - Testing, Adjusting and Balancing" published by Sheet Metal and Air-Conditioning National Association, Inc. (SMACNA).

1.04 CLOSEOUT SUBMITTALS

- A. Division 01 - Execution and Closeout Requirements: Closeout procedures.

- B. Project Record Documents: Record actual locations of flow measuring stations balancing valves and rough setting.
- C. Operation and Maintenance Data: Furnish final copy of testing, adjusting, and balancing report inclusion in operating and maintenance manuals.

1.05 QUALITY ASSURANCE

- A. Perform Work in accordance with IBC-NJ.
- B. Perform Work in accordance with AABC MN-1 National Standards for Field Measurement and Instrumentation, Total System Balance, ASHRAE 111 or NEBB Procedural Standards for Testing, Balancing and Adjusting of Environmental Systems.
- C. Prior to commencing Work, calibrate each instrument to be used. Upon completing Work, recalibrate each instrument to assure reliability.

1.06 QUALIFICATIONS

- A. Agency: Company specializing in testing, adjusting, and balancing of systems specified in this section with minimum five (5) years documented experience certified by AABC or Certified by NEBB.
- B. Perform Work under supervision of AABC registered professional engineer experienced in performance of this Work and licensed in State of New Jersey.

1.07 SEQUENCING

- A. Division 01 - Summary: Work sequence.
- B. Sequence balancing between completion of systems tested and Date of Substantial Completion.

1.08 SCHEDULING

- A. Division 01 - Administrative Requirements: Coordination and project conditions.
- B. Schedule and provide assistance in final adjustment and test of life safety smoke evacuation and smoke control systems with Fire Authority.

PART 2 – PRODUCTS -

Not Used.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Division 01 - Administrative Requirements: Coordination and project conditions.
- B. Verify systems are complete and operable before commencing work. Verify the following:
 - 1. Systems are started and operating in safe and normal condition.
 - 2. Temperature control systems are installed complete and operable.
 - 3. Proper thermal overload protection is in place for electrical equipment.
 - 4. Final filters are clean and in place. If required, install temporary media in addition to final filters.
 - 5. Duct systems are clean of debris.
 - 6. Fans are rotating correctly.
 - 7. Smoke, fire and volume dampers are in place and operational.
 - 8. Air coil fins are cleaned and combed.
 - 9. Access doors are closed and duct end caps are in place.
 - 10. Air outlets are installed and connected.
 - 11. Duct system leakage is minimized. Duct leak tests are approved
 - 12. Hydronic systems are flushed, filled, vented and pressure tested.
 - 13. Pumps are rotating correctly.
 - 14. Proper strainer baskets are clean and in place or in normal position.
 - 15. Service and balancing valves are open.

3.02 PREPARATION

- A. Furnish instruments required for testing, adjusting, and balancing operations.
- B. Make instruments available to Architect/Engineer to facilitate spot checks during testing.
- C. Periodic Inspections Of The Project During Construction
 - 1. Prior to commencement of balancing, the TAB Contractor shall make periodic inspections of the project during construction (as noted below) and

shall report in writing to the Architect any deviations from Contract Documents relating to testing, balancing, and adjustment work concerning:

- a. Equipment:
 - 1) Installation
 - 2) Placement
- b. Inaccessible installation of the following balancing hardware:
 - 1) Ports
 - 2) Plugs
 - 3) Balance damper handles
 - 4) Other such items

3.03 EXECUTION

- A. Assist Division 26 Contractors to set up and test smoke control systems, as part of his Fire Alarm System.
- B. The HVAC Contractor and its selected and approved balancing firm shall report to and review the work required with the Architect prior to beginning of work. At least two (2) one-day inspections of the Water and Air Systems at appropriate times during construction shall be made by the balancing firm and it shall report its findings to the Architect. All openings, pressure taps, wells and closures required, over and above those shown on the drawings, to perform the required test and adjustments shall be installed during or after construction at no additional cost to the Owner.
- C. The Contractor shall furnish all services for a minimum of two complete adjustments of water systems and air handling and exhaust systems, water and air distribution and controls, for the first cooling season and for the first heating season after the job is in complete operation under load conditions. Contractor shall provide at least two sets of belts, pulley and drive. One set for initial balancing and replace with the second set for final balancing.
- D. During all tests, it shall be demonstrated that the systems are free from leaks and that all parts of the system will operate correctly. The Balancing firm shall make final adjustments to all equipment and controls as may be required for proper operation, maintaining correct temperatures in all parts of the building. Controls shall be adjusted by the Control Manufacturer's mechanics on the advise of the balancing firm.
- E. 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 should be taken to correct the problem(s), including noise and vibration.
- F. The following work shall be included by the balancing firm:
 - 1. Supervise the balancing of all water circulation systems and parts thereof installed under this Contract to obtain the water quantities and temperature

drops in all parts of the system specified in the plans and in the specifications, or as required by the Professional.

2. Supervise the balancing of the air conditioning and ventilating systems to achieve the air quantities specified at each air inlet, outlet and damper shown on the plans at the proper conditions of static pressure and temperature differential. Conduct all leakage tests on high (pressure) velocity ductwork in a manner acceptable to the Architect. Leakages shall not exceed 3% of total air to be delivered.
3. Enlist and provide cooperation of equipment manufacturer where needed to obtain proper equipment performance. Change motor or fan sheaves to field design capacity or most efficient operation conditions as required.
4. Study and report on noise and vibration problems which may develop in the course of system balancing.
5. Submit separate reports on the cooling and heating water circulating systems, ATC system, and heating and ventilating systems. These reports shall certify test methods and instruments used, all readings obtained, temperature and pressure drops, RPM of equipment, amperage of all motors, air quantities at each outlet supply, return and air balancing problems encountered, and suggestions. Reports to be submitted to the Architect and the Owner shall include data on all tests in the form normally used by AABC and NEEB. The reports must, however, be varied to suit these specifications. Reports shall include fan and pump curves for the final speeds developed from the fan manufacturer's performance test data for all major equipment and schematics for all systems tested.
6. Perform tests on heating systems when the outside temperature is averaging less than 30°F and on cooling systems when the outside temperature is above 80°F.
7. Instruct the Building Maintenance employees for a minimum of two weeks during the adjusting and balancing period. Obtain signed statements from each employee verifying this instruction has been received by each.
8. Carry out the "start-up" of the various systems with the Contractor and with any necessary assistance of the equipment manufacturer's representative.
9. Furnish all instruments and provide all instrumentation required to perform the above work. The equipment and instrumentation shall remain the property of the balancing subcontractor, however, all equipment must be first approved by the Architect before being used on the project.
10. Assist the Commissioning Agent to complete the project commissioning procedures.

3.04 INSTALLATION TOLERANCES

- A. Air Handling Systems: Adjust to within plus or minus 5 percent of design.
- B. Air Outlets and Inlets: Adjust total to within plus 5 percent and minus 5 percent of design to space. Adjust outlets and inlets in space to within plus or minus 5 percent of design. Exhaust outlets shall be balanced to within +5 percent of design.

- C. Hydronic Systems: Adjust to within plus or minus 5 percent of design.

3.05 ADJUSTING

- A. Division 01 - Execution and Closeout Requirements: Testing, adjusting, and balancing.
- B. Verify recorded data represents actual measured or observed conditions.
- C. Permanently mark settings of valves, dampers, and other adjustment devices allowing settings to be restored. Set and lock memory stops.
- D. After adjustment, take measurements to verify balance has not been disrupted. If disrupted, verify correcting adjustments have been made.
- E. Report defects and deficiencies noted during performance of services, preventing system balance.
- F. Leave systems in proper working order, replacing belt guards, closing access doors, closing doors to electrical switch boxes, and restoring thermostats to specified settings.
- G. At final inspection, recheck random selections of data recorded in report. Recheck points or areas as selected and witnessed by Owner.
- H. Prior to starting of balancing work, the Contractor shall:
 - 1. Adjust all balancing cocks and dampers open.
 - 2. Fill, vent, and clean all water systems.
 - 3. Place all equipment in operating condition.
 - 4. Clean all strainers.
 - 5. Remove all temporary air filters and install design filters.
 - 6. Install all flow measuring stations.
 - 7. Fill system with proper concentration of glycol solution.
- I. For the duration of the balancing work, the Contractor shall:
 - 1. Maintain mechanics at project at all times for system operation, trouble shooting, assistance, etc.
 - 2. Adjust fan drives or blade pitch or replace sheaves as required to meet system performance requirements.
 - 3. Provide necessary mechanical adjustments in conjunction with balancing procedure.

4. Replace all balancing valves or dampers in systems that cannot be manipulated to satisfy balancing requirements.
- J. Standard size (5" x 8") index cards, i.e. "check-out cards", shall be enclosed in a Vinafilm binder securely attached to each device as per the above.
- K. In cooperation with the Contractor, the TAB Contractor shall check and verify the satisfactory performance of static pressure of mass flow synchronization control loops and the ability of each control loop to hold a set-point and maintain stable fan or flow synchronization control. Operating tolerances for each loop set-point shall be obtained from the ATC Contractor.
- L. The TAB Contractor shall use flow meters where they are required for taking data. This shall include the use of air flow metering stations for air flow measurement in preference to taking data via pitot-static tube traverses of ducts where such devices can be used. Where pitot-static tube traverses are performed, the TAB Contractor shall seal test holes with snap-in plugs or he shall use approved caps made for this purpose. The use of tape to seal test holes shall not be allowed.
- M. Maintain specified acoustical performance of air systems; use dampering devices at air terminals to produce pressure drops not in excess of 0.15 in. w.g. for air balance trim.
- N. With all boxes in the duct system set at maximum flow, the fan capacity output and static pressure capability shall be determined by measurement and it shall be recorded. Fan capacity deficiencies shall be noted, recorded and reported to the Owner for corrective action. Duct leakage estimates shall also be noted and recorded and, if in excess of specified allowable reported to the Owner for corrective action.
- O. After satisfactory balance has been achieved, reset the duct system static pressure controller to the lowest set point compatible with scheduled air delivery.
- P. Note and record any box controller limit setting by number where applicable.
- Q. If the supply and return air flow serving a particular zone are synchronized for system self-balancing purposes, confirm by measurements the capacity and action of the self-balancing control loop to track and maintain differential flow requirements. Instrument signal air supply pressures will be recorded where possible, depending upon the control loop's supplier.
- R. The aim of all balancing adjustments shall be the minimum use of energy for fluid transport.
- S. All fans should be set at their lowest rpm or blade pitch to provide design flow; air dampers are to be used only for final trim.
- T. TAB Contractor shall verify accuracy and calibrate all measurement devices (flow sensors, pressure sensors, temperature devices, etc.) provided by Controls Contractor.

3.06 AIR SYSTEM PROCEDURE

- A. Adjust air handling and distribution systems to obtain required or design supply, return, and exhaust air quantities at site altitude.
 - 1. Provide at least two (2) sets of belts, pulley and drives. One set for initial testing and replace it with second set of belts, pulley and drives for final balancing.
- B. Make air quantity measurements in main ducts by Pitot tube traverse of entire cross sectional area of duct.
- C. Measure air quantities at air inlets and outlets.
- D. Adjust distribution system to obtain uniform space temperatures free from objectionable drafts.
- E. Use volume control devices to regulate air quantities only to extent adjustments do not create objectionable air motion or sound levels. Effect volume control by using volume dampers located in ducts. The intent is to utilize minimum site energy and all fan systems should be properly setup to their lowest rpm to achieve design flow rates. Air dampers are to be used for final trim only.
- F. Vary total system air quantities by adjustment of fan speeds. Provide sheave drive changes to vary fan speed. Vary branch air quantities by damper regulation. Where VFD is provided, calibrate and adjust VFD speed.
- G. Provide system schematic with required and actual air quantities recorded at each outlet or inlet.
- H. Measure static air pressure conditions on air supply units, including filter and coil pressure drops, and total pressure across fan. Make allowances for 50 percent loading of filters.
- I. Adjust outside air automatic dampers, outside air, return air, and exhaust dampers for design conditions.
- J. Measure temperature conditions across outside air, return air, relief and exhaust dampers to check leakage.
- K. At modulating damper locations, take measurements and balance at extreme conditions. Balance variable volume systems at maximum airflow rate, full cooling, and at minimum airflow rate, full heating.
- L. Measure building static pressure and adjust supply, return, and exhaust air systems to obtain required relationship between each to maintain approximately 0.05 inches (12.5 Pa) positive static pressure near building entries.

- M. For variable air volume system powered units set volume controller to airflow setting indicated. Confirm connections properly made and confirm proper operation for automatic variable-air-volume temperature control.
- N. On fan powered VAV boxes, adjust airflow switches for proper operation.
- O. Verify that leakage on terminal boxes is within the allowable rates, not to exceed 2 percent of design flow.
- P. For all air systems, testing shall be done in all modes including minimum outside air mode and 100% economizer mode, etc.
- Q. Perform preliminary air balance. Remove and replace belts, pulley. Drive and balance system again.

3.07 WATER SYSTEM PROCEDURE

- A. Adjust water systems, after air balancing, to obtain design quantities.
- B. Use calibrated Venturi tubes, orifices, or other metered fittings and pressure gauges to determine flow rates for system balance. Where flow-metering devices are not installed, base flow balance on temperature difference across various heat transfer elements in system.
- C. Adjust systems to obtain specified pressure drops and flows through heat transfer elements prior to thermal testing. Perform balancing by measurement of temperature differential in conjunction with air balancing.
- D. Effect system balance with automatic control valves fully open or in normal position to heat transfer elements.
- E. Effect adjustment of water distribution systems by means of balancing cocks, valves, and fittings. Do not use service or shut-off valves for balancing unless indexed for balance point.
- F. Where available pump capacity is less than total flow requirements or individual system parts, simulate full flow in one part by temporary restriction of flow to other parts.

3.08 SCHEDULES

- A. Equipment Requiring Testing, Adjusting, and Balancing but not limited to the following:
 - 1. Steam Condensate Pumps.
 - 2. HVAC Pumps.
 - 3. Heat Exchangers.

4. Condensing Units, split system AC units, fan coil units.
5. Air-Cooled Refrigerant Condensers.
6. Packaged Roof Top Heating/Cooling Units.
7. Air Coils.
8. Humidifier.
9. Terminal Heat Transfer Units (Unit heaters, cabinet unit heaters), fin- tube radiators.
10. Air Handling Units.
11. Fans.
12. Air Filters.
13. Air Terminal Units.
14. Air Inlets and Outlets.
15. Hydronic (hot water, chilled water) risers, circuits.

B. Report Forms:

1. Title Page:
 - a. Name of Testing, Adjusting, and Balancing Agency
 - b. Address of Testing, Adjusting, and Balancing Agency
 - c. Telephone and facsimile numbers of Testing, Adjusting, and Balancing Agency
 - d. Project name
 - e. Project location
 - f. Project Architect
 - g. Project Engineer
 - h. Project Contractor
 - i. Project altitude
 - j. Report date
2. Summary Comments:
 - a. Design versus final performance
 - b. Notable characteristics of system

- c. Description of systems operation sequence
 - d. Summary of outdoor and exhaust flows to indicate building pressurization
 - e. Nomenclature used throughout report
 - f. Test conditions
3. Instrument List:
- a. Instrument
 - b. Manufacturer
 - c. Model number
 - d. Serial number
 - e. Range
 - f. Calibration date
4. Electric Motors:
- a. Manufacturer
 - b. Model/Frame
 - c. HP/BHP and kW
 - d. Phase, voltage, amperage; nameplate, actual, no load
 - e. RPM
 - f. Service factor
 - g. Starter size, rating, heater elements
 - h. Sheave Make/Size/Bore
5. V-Belt Drive:
- a. Identification/location
 - b. Required driven RPM
 - c. Driven sheave, diameter and RPM
 - d. Belt, size and quantity
 - e. Motor sheave diameter and RPM
 - f. Center to center distance, maximum, minimum, and actual

6. Pump Data:
 - a. Identification/number
 - b. Manufacturer
 - c. Size/model
 - d. Impeller
 - e. Service
 - f. Design flow rate, pressure drop, BHP and kW
 - g. Actual flow rate, pressure drop, BHP and kW
 - h. Discharge pressure
 - i. Suction pressure
 - j. Total operating head pressure
 - k. Shut off, discharge and suction pressures
 - l. Shut off, total head pressure
7. Sound Level Report:
 - a. Location
 - b. Octave bands - equipment off
 - c. Octave bands - equipment on
 - d. RC level - equipment on
8. Vibration Test:
 - a. Location of points:
 - 1) Fan bearing, drive end
 - 2) Fan bearing, opposite end
 - 3) Motor bearing, center (when applicable)
 - 4) Motor bearing, drive end
 - 5) Motor bearing, opposite end
 - 6) Casing (bottom or top)
 - 7) Casing (side)
 - 8) Duct after flexible connection (discharge)
 - 9) Duct after flexible connection (suction)

- b. Test readings:
 - 1) Horizontal, velocity and displacement
 - 2) Vertical, velocity and displacement
 - 3) Axial, velocity and displacement
- c. Normally acceptable readings, velocity and acceleration
- d. Unusual conditions at time of test
- e. Vibration source (when non-complying)

3.09 FINAL APPROVAL

- A. This Contract shall include an extended period of 120 days after submittal of the final certified test report (approved by the Architect) for a given system, during which time the Owner may request a spot check, retest and/or resetting of any outlet or other item as listed in the certified test report; however, this request may not exceed 10% of the outlets or devices on each central system.
- B. If more than 5% of the total devices on a given central system test outside the prescribed limits set for air balance, the Owner shall have the option of revoking the test report and requiring a complete rebalance of the system in question.
- C. If a retest or spot check is requested, the TAB Contractor shall provide technicians and instruments in making any tests required during this period.
- D. Final acceptance will not be accorded the certified test report until the extended period of 120 days has expired.

END OF SECTION