

**Testing, Adjusting, & Balancing**  
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**PART 1 - GENERAL**

- A. Work related to this Section is specified in other sections. Other sections of these Specifications also apply even though not described here.
- B. The Work consists of water and air balancing. Set main fan unit for full recirculation, full outside and minimum outside air conditions. Take and record measurements required at each of the three conditions. Report any problem on obtaining design conditions to design engineer prior to complete balance for corrective action.
- C. Measure each air outlet and calibrate zone terminal unit for design air quantity at each zone. Set minimum and maximum conditions for variable air volume (VAV) units. Set maximum volumes at full cooling conditions. Adjust volume dampers for each outlet to balance air quantities as shown on Drawings. Space balancing to be done with doors closed.
- D. Hydronic balancing to be done by using appropriate instruments for flow measuring devices. Set bypass valves at each three way valve such that pressure drop on full bypass flow equals coil pressure drop on full coil flow. Once design flows are established, operate heating & cooling systems at design temperature conditions and measure air temperature rise (heating) and air temperature drop (cooling) for design conditions.
- E. Once all conditions have been tested, adjusted, and calibrated report any conditions outside 10% of design parameters to Engineer for appropriate action or correction.

**1.1 RELATED WORK**

- A. The Contractor may perform pipe testing for leakage and functionality. A certified independent Balance Contractor is to perform and record the adjusting and balancing of flows, pressures, and recording of equipment data.
- B. Prior to start of Work, submit name of proposed subcontractor performing balancing services, and prepare final balance reports.
- C. For testing, adjusting, and balancing the system, the Contractor is responsible for the following:
  - 1. Prepare each system for testing and balancing.
  - 2. Cooperate with testing organization and provide access to equipment and systems. Operate systems at designated times, and under conditions required for proper testing, adjusting, and balancing.
  - 3. Notify testing organization prior to time system will be ready for testing, adjusting, and balancing in order to meet construction schedule.
  - 4. Verify installation of system to be tested is complete and in continuous operation.
  - 5. Verify ambient conditions and related facilities are in full operation.

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1.2 QUALITY CONTROL

- A. Balance Contractor shall be an agency specializing in the adjusting and balancing of air and hydronic systems specified in this Section, and with minimum five years documented experience. Agency shall be certified or be pre-approved to perform Work under supervision of AABC (American Association of Balancing Contractors) or NEBB (National Environmental Balancing Bureau). Submit name of balancing firm to Engineer for approval, prior to the bid.
- B. Pre-approved balancing firms are:
  - 1. Air Introduction & Regulation (A.I.R)
  - 2. Northwest Engineering
  - 3. Precision Air Balance
  - 4. Professional Air Balance
  - 5. Pacific Coast Air Balance
  - 6. Southern Oregon Engineering
- C. Total system balance shall be performed in accordance with AABC National Standards for Field Measurement and Instrumentation, ASHRAE - 2007 Applications Handbook Chapter 37, and NEBB Procedural Standards for Testing, Balancing and Adjusting of Environmental Systems.
- D. Each report form should bear signature of recorder and that of supervisor of reporting organization. The report should also identify each instrument used, and latest date of calibration of each.

1.3 TESTING AND BALANCING

- A. Provide Balance Data For:
  - 1. Air Handler Units and Exhaust Fans
  - 2. Supply Air Outlets
  - 3. Return/Exhaust Air Outlets
  - 4. Air Terminal Devices
- B. Sequence balancing work to commence after completion of systems and before substantial completion of Project.
- C. Forms shall include the following information:
  - 1. Title Page:
    - a. Company name, address and phone number
    - b. Project name and location
    - c. Project Engineer
    - d. Project Contractor
    - e. Project altitude
  - 2. Instrument List
    - a. Instrument Type
    - b. Manufacturer
    - c. Model
    - d. Serial Number
    - e. Range

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- f. Calibration date
- 3. Electric Motors:
  - a. Manufacturer
  - b. HP/BHP
  - c. Phase, voltage, amperage; nameplate, actual, no load
  - d. RPM
  - e. Service factor
  - f. Starter size, rating, heater elements

**1.4 BALANCING - AIR**

- A. Air Moving Equipment:
  - 1. Location
  - 2. Manufacturer
  - 3. Model
  - 4. Air flow, specified and actual
  - 5. Return air flow, specified and actual
  - 6. Outside air flow, specified and actual
  - 7. Total static pressure (total external), specified and actual
  - 8. Inlet pressure
  - 9. Discharge pressure
  - 10. Fan RPM
- B. V-Belt Drive:
  - 1. Identification/location
  - 2. Required driven RPM
  - 3. Driven sheave, diameter and RPM
  - 4. Belt, size and quantity
  - 5. Motor sheave, diameter and RPM
  - 6. Center to center distance, maximum, minimum, and actual
- C. Air Distribution Terminal Unit:
  - 1. Air terminal number
  - 2. Room number/location
  - 3. Terminal type
  - 4. Terminal size
  - 5. Design velocity
  - 6. Design air flow
  - 7. Test (final) velocity
- D. Outlet (Grille, Register, Diffuser):
  - 1. Location
  - 2. Manufacturer
  - 3. Model
  - 4. Deflection/Pattern
  - 5. Air flow, specified and actual
  - 6. Area Factor

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1.5 BALANCING - WATER

- A. Pump Data:
  - 1. Identification/location
  - 2. Manufacturer
  - 3. Size/Model
  - 4. Impeller
  - 5. Design flow rate, pressure drop, BHP
  - 6. Actual flow rate, pressure drop, BHP
  - 7. Discharge pressure
  - 8. Suction pressure
  - 9. Total operating head pressure
  - 10. Shutoff, discharge and suction pressures
  - 11. Shutoff, total head pressure
  
- B. Cooling Coil Data:
  - 1. Identification/Number
  - 2. Location
  - 3. Manufacturer
  - 4. Air Flow, design and actual
  - 5. Entering Air DB Temperature, design and actual
  - 6. Entering Air WB Temperature, design and actual
  - 7. Leaving Air DB Temperature, design and actual
  - 8. Leaving Air WB Temperature, design and actual
  - 9. Water Flow, design and actual
  - 10. Water Pressure Drop, design and actual
  - 11. Entering Water Temperature, design and actual
  - 12. Leaving Water Temperature, design and actual
  - 13. Air Pressure Drop, design and actual
  
- C. Heating Coil Data:
  - 1. Identification/Number
  - 2. Location
  - 3. Service
  - 4. Manufacturer
  - 5. Air Flow, design and actual
  - 6. Water Flow, design and actual
  - 7. Water Pressure Drop, design and actual
  - 8. Entering Water Temperature, design and actual
  - 9. Leaving Water Temperature, design and actual
  - 10. Entering Air Temperature, design and actual
  - 11. Leaving Air Temperature, design and actual
  - 12. Air Pressure Drop, design and actual
  
- D. Submit record documents. Accurately record locations of flow measuring stations, balancing valves and rough setting.

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**PART 2 - PRODUCTS**

**2. 1 FAN BELTS AND SHEAVES**

- A. Provide one additional set of sheave and belt assemblies for adjustment of fans to meet design parameters if required.

**2. 2 PATCHING MATERIALS**

- A. Material:
  - 1. Seal, patch, and repair ductwork, piping, and equipment drilled or cut for testing purposes.
  - 2. Plastic plugs with retainers may be used to patch drilled holes in ductwork and housings.
  - 3. Piping shall be capped with materials the same as piping system.
  - 4. Insulation shall be neatly hemmed with metal or plastic edging, leaving test points visible for future testing.

**2. 3 TEST INSTRUMENTS**

- A. Standards: Utilize instruments and equipment of type, precision, and capacity as recommended in the NEBB "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" and AABC manual MN-1.
- B. Test Instruments:
  - 1. All instruments used for measurements shall be accurate and calibration histories for each instrument shall be available for examination.
  - 2. Each test instrument shall be calibrated by an approved laboratory or by the manufacturer.
  - 3. A representative has the right to request instrument recalibration, or the use of other instruments and test methodology, where accuracy of readings is questionable.
- C. Additional Instruments:
  - 1. Permanently installed measuring instruments, such as temperature and pressure gauges, shall be checked against transfer standard instruments.
  - 2. Any instrument which does not meet specification requirement shall be replaced or recalibrated.
- D. Cone Instruments:
  - 1. The Contractor shall employ manufactured enclosure type cones, capable of air volume direct readings, for all diffuser/grille/register air flow measurements.
  - 2. The readout meters shall meet calibration requirements.

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**PART 3 - EXECUTION**

**3.1 GENERAL**

- A. Before commencing balance work, verify that systems are complete and operable. Ensure the following:
  - 1. Equipment is operable and in a safe and normal condition.
  - 2. Promptly report abnormal conditions in mechanical systems, or conditions which prevent system balance.
  - 3. Temperature control systems are installed complete and operable.
  - 4. Proper thermal overload protection is in place for electrical equipment.

**3.2 WATER BALANCE**

- A. Ensure the following:
  - 1. Hydronic systems have been flushed, filled, and vented.
  - 2. The pump rotation is correct.
  - 3. Proper strainer baskets are clean and in place.
  - 4. Service and balance valves are open at beginning of balance.
  - 5. verify proper water level in expansion tanks in system.
  - 6. Verify air vents in high points of wter are properly installed and operataing freely.
- B. Adjust hydronic systems to plus or minus 10 percent of design conditions indicated.
  - 1. Test and record pump shut-off head.
  - 2. Test and record pump wide-open head.
- C. Permanently mark settings of valves and other adjustment devices, allowing settings to be restored. Set and lock memory stops.
- D. 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 indicated for balance point.
- E. Where available pump capacity is less than total flow requirements or individual system parts, flow in one part may be simulated by temporary restriction of flow to other parts.
- F. Where applicable use circuit setters to equalize flow to each coil. Adjust pump to proper flow.
- G. Adjust systems to provide 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. Effect system balancer with automatic control valves fully open to heat transfer elements.

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- H. Use calibrated orifices, fittings and pressure gages 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 the system.
- I. After adjustment, take measurements to verify balance has not been disrupted, or that such disruption has been rectified.
- J. List complete data of tested equipment.
- K. Open all line valves to full open position, close coil by-pass stop valves, then set mixing control valve to full coil flow.
- L. Hydronic Distribution, Each System:
  - 1. Check all conditions at all coils for required performance at design conditions.
  - 2. Check conditions at all primary source equipment for performance of design conditions.
  - 3. Read and record pump heads, motor data, and amperage draw.
  - 4. Read and adjust water flow for design conditions.
  - 5. Set all memory stops and mark position of adjuster on balancing valves.
  - 6. Perform the following tests, and balance each chiller and heating system in accordance with the following requirements:
  - 7. Set hydronic heating recovery pumps to proper gallons per minute (gpm) delivery.
  - 8. Adjust heating water flow through boiler(s).
  - 9. Test and record entering and leaving water temperatures through boilers.
  - 10. Test and record water temperatures at inlet and outlet side of each terminal unit. Note rise or drop in temperatures from source.
  - 11. Proceed to balance each terminal unit in conjunction with air test procedures.
  - 12. Upon completion of flow readings and adjustments at coils, mark all settings and record data.
  - 13. After adjustment to coils are made, recheck settings at the pumps and boilers and readjust if required.
  - 14. Record and check the following items at each coil:
    - a. Inlet water temperatures.
    - b. Leaving water temperatures.
    - c. Water pressure drop of each coil.
  - 15. Pump operating suction and discharge pressures and final total dynamic head.
  - 16. List all mechanical specifications of pumps.
  - 17. Rated and actual running amperage of pump motor.

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**3.3 AIR BALANCE**

- A. Ensure the following:
  - 1. Fan rotation is correct.
  - 2. Final filters are clean and in place. If required, install temporary media, in addition to final filters.
  - 3. Fire and volume dampers are in place and open.
  - 4. Coil fins have been cleaned and combed.
  - 5. Volume dampers are in place and open at beginning of balance.
  - 6. Air outlets are installed and connected.
  - 7. Duct system leakage has been minimized.
- B. Permanently mark settings of dampers and other adjustment devices, allowing settings to be restored. Set and lock memory stops.
- C. Measure air quantities at air inlets and outlets.
- D. Measure static air pressure conditions on air supply units, including filter and coil pressure drops, and total pressure across the fan. Make allowances for 50 percent loading of filters.
- E. Adjust air handling systems to plus or minus 5 percent for supply systems, and plus or minus 10 percent for return system, for figures indicated. Advise Engineer if deficiencies are generally noted to enable proper corrective actions.
- F. Measure air quantities, where indicated on the Drawings, and record duct traverse reports as indicated.
- G. Adjust outside air automatic dampers, outside air, return air, and exhaust dampers for design conditions.
- H. Where modulating dampers are provided, take measurements and balance at extreme conditions.
- I. Use volume control devices to regulate air quantities, only to extent that adjustments do not create objectionable air motion or sound levels. Effect volume control by duct internal devices, such as dampers and splitters.
- J. Vary total system air quantities by adjustment of fan speeds. Provide drive changes and increase fan motor sizes as required. Vary branch air quantities by damper regulation.
- K. After adjustment, take measurements to verify balance has not been disrupted or that such disruption has been rectified.
- L. Central Rooftop HVAC Systems: Adjust fan speeds and motor drives for required air volume, within  $\pm 5\%$  maximum. Set speed to provide air volume at farthest run without excess static pressure. Provide additional sheaves and belts as required to accomplish speed adjustment for new fans. Record fan rpm.



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- M. Make Pitot Tube traverse of main supply ducts and obtain design CFM at fans. Read and adjust air supply, return, exhaust fan units to deliver design conditions at minimum OSA and at 100% OSA.
- N. Test Holes: Test holes shall be in a straight duct, as far as possible downstream from elbows, bends, take-offs, and other turbulence generating devices, to optimize reliability of flow measurements.
- O. Adjust all automatic dampers, outside air, return air, and exhaust dampers for design conditions.
- P. Where modulating dampers are provided, take measurements and balance at extreme conditions.
- Q. Read and record static air pressure conditions on all air handling equipment, including filters and coil pressure drops, and total pressure across the fan. A Dwyer Series 400 air velocity meter or equivalent shall be used for final static pressures at equipment and where critical readings are required. Make allowances for 50 percent loading of filters.
- R. Measure temperature conditions across all outside air, return air, and exhaust dampers to check leakage.
- S. Read and record motor data and amperage draw.
- T. Testing organization shall verify all controls for proper calibration and list controls requiring adjustment by control engineer.
- U. For Variable Air Volume (VAV) systems, establish minimum static pressure required at sensing point to permit operation over entire VAV range. Adjust fan speed so that at maximum demand is at 100% of VSD (variable speed drive). Adjust return fan speed so that return air volumes track with supply air volume at minimum exhaust air volume.
- V. Each grille, terminal unit, diffuser, and register shall be identified as to location and area served.
- W. Test and record entering and leaving air temperatures across all hydronic coils.
- X. Evaluate all building and room pressure conditions to determine adequate supply and return air conditions. Assure proper negative and positive pressure systems are within Engineer tolerances for specialty areas such as kitchen range hood and vapor hoods.
- Y. Evaluate all building and room pressure conditions to determine adequate performance of the system to maintain temperatures without draft.

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**3.4 COORDINATION**

- A. Deficiencies noted during the course of air balancing in the mechanical installation shall be promptly reported to the Engineer to allow corrective action to proceed.
- B. Periodic review of progress shall be provided as required or requested.

**3.5 PROCEDURES AND INSTRUMENTS, GENERAL**

- A. Requirements: All systems and components thereof shall be adjusted to perform as required by drawings, schedule, and specifications.
- B. Test Duration: Operating tests of heating and cooling coils, fans, and other equipment shall be of not less than four hours duration after stabilized operating conditions have been established. Capacities shall be based on temperature and air and water quantities measured during such tests.
- C. Instrumentation:
  - 1. Method of application of instrumentation shall be in accordance with the approved agenda.
  - 2. All instruments shall be applied in accordance with the manufacturer's certified instructions.
  - 3. All labor, instruments, and appliances required shall be furnished by the Contractor.
  - 4. Where duct's design velocity and air quantity are both less than 1,000 (fpm/cfm), air quantity may be determined by measurement at terminals served.
- D. Air Terminal Balancing: Generally, measurement of flow rates by means of velocity meters applied to individual terminals, with or without cones or other adapters, shall be used only for balancing. Measurement of air quantities at each type of air terminal (inlet and outlet) shall be determined by the method approved for the balancing agenda.
- E. Air Motion: Air motion and distribution shall be as shown on drawings.
- F. Special Procedures: Where available pump capacity (as designed) is less than total flow requirements of individual heat transfer units of system served, full flow may be simulated by the temporary restriction of flow to portions of the system; specific procedures shall be delineated in the agenda.

**3.6 CERTIFIED REPORTS**

- A. Submittals: Five (5) copies of the reports described herein, covering air and water system performance, air motion (fpm), and sound pressure levels, shall be submitted prior to final tests and inspection.

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- B. Instrument Records. Types, serial numbers, and dates of calibration of all instruments shall be included.
- C. Reports: Reports shall identify items not conforming to contract requirements, or obvious deficiencies.
- D. Certification: Certification shall include checking of adherence to agenda, of calculations, of procedures, and evaluation of final summaries.

**3.7 TEST INSPECTIONS**

- A. Leave systems in proper working order, replacing belt guards, closing access doors, closing doors to electrical switch boxes, and restoring thermostats to specified settings.
- B. Test shall be made to demonstrate that capacities and performance of air and water systems comply with contract requirements.
- C. At the time of final inspection, the Contractor shall recheck, random selection of data (water and air quantities and air motion) recorded in certified report. In addition, rooftop HVAC systems including exhaust/relief fans shall be rechecked.
- D. Sections for recheck (specific plus random), in general, will not exceed 10 percent of the total number tabulated in the report, except that special air systems may require a complete recheck for safety reasons.
- E. At final inspection, recheck random selections of data recorded in report. Recheck points or areas as selected and witnessed by the Owner.
- F. Retests: If random tests elicit a measured flow deviation of 10 percent or more from that recorded in the certified report listings, as 10 percent or more of the rechecked selections, the report shall be rejected. In the event the report is rejected, 25% of all systems shall be readjusted and tested, new data recorded, new certified reports submitted, and new inspection tests made, all at no additional cost. Retainage time shall be based on the date of the final acceptance of the certified report.
- G. Recorded data shall represent actually measured, or observed condition. Record actual locations of flow measuring stations, balancing valves and settings.
- H. Marking of Settings:
  - 1. Following final acceptance of certified reports, the settings of all valves, splitters, dampers, and other adjustment devices shall be permanently marked by the Contractor so that adjustment can be restored if disturbed at any time.
  - 2. Devices shall not be marked until after final acceptance.

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- I. Submit copies of the recorded data to the Engineer, and the Owner at final inspection. Report to include type of instruments used, actual date when readings are made, and outdoor temperature.
- J. Ensure the following:
  - 1. Leave systems in proper working order, replacing belt guards, closing access doors, closing doors to electrical switch boxes, and restoring thermostats to specified settings.
  - 2. At final inspection, recheck random selections of data recorded in report. Recheck points or areas as selected and witnessed by the Engineer, Commissioning Agent, or Owner's Representative.
  - 3. Recorded data shall represent actually measured, or observed condition. Record actual locations of flow measuring stations, balancing valves and settings.

**3.8 AT COMPLETION OF WORK**

- A. Leave systems in proper working order, replacing belt guards, closing access doors, closing doors to electrical switch boxes, and restoring thermostats to specified settings.
- B. At final inspection, recheck random selections of data recorded in report. Recheck points or areas as selected and witnessed by the Owner.
- C. Recorded data shall represent actually measured, or observed condition. Record actual locations of flow measuring stations, balancing valves and settings.
- D. Submit copies of the recorded data to the Engineer, and the Owner at final inspection. Report to include type of instruments used, actual date when readings are made, and outdoor temperature.

**END OF SECTION**