

## PART 1 – GENERAL

### 1.1 RELATED DOCUMENTS

- A. Drawings and Divisions 00 and 01, apply to this Section.
- B. Related Sections:
  - 1. Division 23.

### 1.2 SUMMARY

- A. This Section includes testing, adjusting, and balancing HVAC systems to produce design objectives, including the following:
  - 1. Balancing airflow and water flow within distribution systems, including submains, branches, and terminals, to indicated quantities according to specified tolerances.
  - 2. Adjusting total HVAC systems to provide indicated quantities.
  - 3. Measuring electrical performance of HVAC equipment.
  - 4. Setting quantitative performance of HVAC equipment.
  - 5. Verifying that automatic control devices are functioning properly.
  - 6. Measuring sound and vibration.
  - 7. Reporting results of the activities and procedures specified in this Section.

### 1.3 CODES AND STANDARDS

- A. Codes and Standards shall be the current version adopted by the Authority Having Jurisdiction.

### 1.4 DEFINITIONS

- A. **Adjust:** To regulate fluid flow rate and air patterns at the terminal equipment, such as to modify fan speed or adjust a damper.
- B. **Balance:** To proportion flows within the distribution system, including submains, branches, and terminals, according to design quantities.
- C. **Draft:** A current of air, when referring to localized effect caused by one or more factors of high air velocity, low ambient temperature, or direction of airflow, whereby more heat is withdrawn from a person's skin than is normally dissipated.
- D. **Procedure:** An approach to and execution of a sequence of work operations to yield repeatable results.
- E. **Report Forms:** Test data sheets for recording test data in logical order.
- F. **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.
- G. **Suction Head:** The height of fluid surface above the centerline of the pump on the suction side.

- H. System Effect: A phenomenon that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
- I. System Effect Factors: Allowances used to calculate a reduction of the performance ratings of a fan when installed under conditions different from those presented when the fan was performance tested.
- J. Terminal: A point where the controlled medium, such as fluid or energy, enters or leaves the distribution system.
- K. Test: A procedure to determine quantitative performance of a system or equipment.
- L. Testing, Adjusting, and Balancing Agent: The entity responsible for performing and reporting the testing, adjusting, and balancing procedures.
- M. AMCA: Air Movement and Control Association.
- N. CTI: Cooling Tower Institute.
- O. NEBB: National Environmental Balancing Bureau.
- P. SMACNA: Sheet Metal and Air Conditioning Contractors' National Association.
- Q. TAB: Testing, Balancing, and Adjusting.

#### 1.5 ACCEPTABLE CONTRACTORS

- A. Neudorfer Engineers, Inc.
- B. Hardin and Sons, Inc.
- C. National Indoor Air Care.
- D. Airtest Co., Inc.

#### 1.6 SUBMITTALS

- A. Quality-Assurance Submittals: Within 30 days from the Contractor's Notice to Proceed, submit 2 copies of evidence that the testing, adjusting, and balancing Agent and this Project's testing, adjusting, and balancing team members meet the qualifications specified in the "Quality Assurance" Article below.
- B. Contract Documents Examination Report: Within 45 days from the Contractor's Notice to Proceed, submit 2 copies of the Contract Documents review report as specified in Part 3 of this Section.
- C. Strategies and Procedures Plan: Within 60 days from the Contractor's Notice to Proceed, submit 2 copies of the testing, adjusting, and balancing strategies and step-by-step procedures as specified in Part 3 "Preparation" Article below. Include a complete set of report forms intended for use on this Project.
- D. Report Forms: Submit 2 copies of reports prepared, as specified in this Section, on approved forms certified by the testing, adjusting, and balancing Agent.

- E. Warranty: Submit 2 copies of special warranty specified in the "Warranty" Article below.
- F. Balancing Report:
  - 1. Comply with Section 23 05 00, paragraph "Submittals," subparagraph A, regarding format of TAB report, except title "Balancing Report."
  - 2. Submit completed Balancing Report as indicated, including the following:
    - a. System Diagrams/Floor Plans.
    - b. Air Apparatus Test Reports.
    - c. Apparatus Coil Test Reports.
    - d. Gas/Oil Fired Heat Apparatus Test Reports.
    - e. Electric Coil/Duct Heater Test Reports.
    - f. Fan Test Reports.
    - g. Rectangular and Round Duct Traverse Reports.
    - h. Air Outlet Test Reports.
    - i. Terminal Unit Coil Check Reports.
    - j. Packaged Chiller Test Reports.
    - k. Package Rooftop/Heat Pump/Air Conditioning Unit Test Reports.
    - l. Compressor and/or Condenser Test Reports.
    - m. Cooling Tower or Evaporative Condenser Test Reports.
    - n. Heat Exchanger/Converter Test Reports.
    - o. Pump Test Reports.
    - p. Boiler Test Reports.
    - q. Instrument Calibration Report.

#### 1.7 SEQUENCING/SCHEDULING

- A. Phase in properly with Construction Schedule.

#### 1.8 QUALITY ASSURANCE

- A. Regulatory Requirements:
  - 1. Comply with all applicable city, county, and state codes and ordinances. In case of conflict with drawings or specifications, the codes and ordinances govern.
  - 2. Basis:
    - a. International Building Code.
    - b. International Plumbing Code.
    - c. International Mechanical Code.
    - d. NFPA-90A.
    - e. NFPA 101.
- B. Agent Qualifications: Engage a testing, adjusting, and balancing agent certified by NEBB, not affiliated with mechanical contractor. Certified agent shall be a full-time employee of the TAB contractor.
- C. Experience: Minimum 5 years on projects of similar scope and complexity.
- D. Testing, Adjusting, and Balancing Conference: Meet with the Owner's and the Architect's representatives on approval of the testing, adjusting, and balancing strategies and procedures plan to develop a mutual understanding of the details. Ensure the participation of testing, adjusting, and balancing team members, equipment manufacturers' authorized

service

representatives, HVAC controls installer, and other support personnel. Provide 7 days' advance notice of scheduled meeting time and location.

1. Agenda Items: Include at least the following:
  - a. Submittal distribution requirements.
  - b. Contract Documents examination report.
  - c. Testing, adjusting, and balancing plan.
  - d. Work schedule and Project site access requirements.
  - e. Coordination and cooperation of trades and subcontractors.
  - f. Coordination of documentation and communication flow.

E. Certification of Testing, Adjusting, and Balancing Reports: Certify the testing, adjusting, and balancing field data reports. This certification includes the following:

1. Review field data reports to validate accuracy of data and to prepare certified testing, adjusting, and balancing reports.
2. Certify that the testing, adjusting, and balancing team complied with the approved testing, adjusting, and balancing plan and the procedures specified and referenced in this Specification.

F. Testing, Adjusting, and Balancing Reports: Use standard forms from NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems."

G. Instrumentation Type, Quantity, and Accuracy: As described in NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems," Section II, "Required Instrumentation for NEBB Certification."

H. Instrumentation Calibration: Calibrate instruments as required by NEBB certification or more frequently if required by the instrument manufacturer.

## 1.9 PROJECT CONDITIONS

A. Partial Owner Occupancy: The Owner may occupy completed areas of the building before Substantial Completion. Cooperate with the Owner during testing, adjusting, and balancing operations to minimize conflicts with the Owner's operations.

## 1.10 COORDINATION

A. Coordinate the efforts of factory-authorized service representatives for systems and equipment, HVAC controls installers, and other mechanics to operate HVAC systems and equipment to support and assist testing, adjusting, and balancing activities.

B. Notice: Provide 7 days' advance notice for each test. Include scheduled test dates and times.

C. Perform testing, adjusting, and balancing after leakage and pressure tests on air and water distribution systems have been satisfactorily completed.

## 1.11 WARRANTY

A. General Warranty: The special performance guarantee specified in this Article shall not deprive the Owner of other rights the Owner may have under other provisions of the Contract

Documents and shall be in addition to, and run concurrent with, other warranties made by the Contractor under requirements of the Contract Documents.

- B. Special Guarantee: Provide a guarantee on NEBB forms stating that NEBB will assist in completing the requirements of the Contract Documents if the testing, adjusting, and balancing Agent fails to comply with the Contract Documents. Guarantee includes the following provisions:
- C. The certified Agent has tested and balanced systems according to the Contract Documents.
- D. Systems are balanced to optimum performance capabilities within design and installation limits.

## PART 2 – PRODUCTS

### 2.1 GENERAL

- A. Comply with "Quality Assurance" provisions, specifications, and manufacturer's data. Where these may be in conflict, the more stringent requirements govern.

### 2.2 TAB INSTRUMENTATION

- A. Furnish materials and equipment necessary to properly measure system capacities, electrical voltage and current, fan speeds, static pressures, air velocities, water pressure drops, refrigeration pressures, and other readings necessary to evaluate system performance and adjust quantities to those indicated. TAB Contractor retains possession of materials and equipment after project is completed.
- B. Instrumentation shall be accurate, with calibration histories available for examination upon request.
- C. Instrumentation shall be used in accordance with manufacturer instructions.

## PART 3 – EXECUTION

### 3.1 INSPECTION

- A. Verify installation conditions as satisfactory to receive work of this Section. Do not begin work until any unsatisfactory conditions are corrected.

### 3.2 EXAMINATION

- A. Examine Contract Documents to become familiar with project requirements and to discover conditions in systems' designs that may preclude proper testing, adjusting, and balancing of systems and equipment.
  - 1. Contract Documents are defined in the General and Supplementary Conditions of the Contract.
  - 2. Verify that balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are required by the Contract Documents. Verify that quantities and locations of these balancing devices are accessible and appropriate for effective balancing and for efficient system and equipment operation.

- B. Examine approved submittal data of HVAC systems and equipment.
- C. Examine project record documents described in Division 01 Section "Project Record Documents."
- D. Examine equipment performance data, including fan and pump curves. 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.
- E. Examine system and equipment installations to verify that they are complete and that testing, cleaning, adjusting, and commissioning specified in individual Specification Sections have been performed.
- F. Examine system and equipment test reports.
- G. Examine systems for functional deficiencies that cannot be corrected by adjusting and balancing.
- H. Examine air-handling equipment to ensure clean filters have been installed, bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.
- I. Examine terminal units, such as variable-air-volume boxes and mixing boxes, to verify that they are accessible and their controls are connected and functioning.
- J. Examine strainers for clean screens and proper perforations.
- K. Examine 3-way valves for proper installation for their intended function of diverting or mixing fluid flows.
- L. Examine heat-transfer coils for correct piping connections and for clean and straight fins.
- M. Examine open-piping-system pumps to ensure absence of entrained air in the suction piping.
- N. Examine equipment for installation and for properly operating safety interlocks and controls.
- O. Examine automatic temperature system components to verify the following:
  - 1. Dampers, valves, and other controlled devices operate by the intended controller.
  - 2. Dampers and valves are in the position indicated by the controller.
  - 3. Integrity of valves and dampers for free and full operation and for tightness of fully closed and fully open positions. This includes dampers in multizone units, mixing boxes, and variable-air-volume terminals.
  - 4. Automatic modulating and shutoff valves, including 2-way valves and 3-way mixing and diverting valves, are properly connected.
  - 5. Thermostats and humidistats are located to avoid adverse effects of sunlight, drafts, and cold walls.
  - 6. Sensors are located to sense only the intended conditions.
  - 7. Sequence of operation for control modes is according to the Contract Documents.
  - 8. Controller set points are set at design values. Observe and record system reactions to changes in conditions. Record default set points if different from design values.
  - 9. Interlocked systems are operating.
  - 10. Changeover from heating to cooling mode occurs according to design values.
  - 11. Verify minimum outdoor supply air setting.

- P. Report deficiencies discovered before and during performance of testing, adjusting, and balancing procedures.

### 3.3 PREPARATION

- A. Field verify locations of new and existing work prior to commencing work of this Section.
- B. Protect surrounding areas and surfaces to preclude damage from work of this Section.
- C. Prepare a testing, adjusting, and balancing plan that includes strategies and step-by-step procedures.
- D. Complete system readiness checks and prepare system readiness reports. Verify the following:
  - 1. Permanent electrical power wiring is complete.
  - 2. Hydronic systems are filled, clean, and free of air.
  - 3. Automatic temperature-control systems are operational.
  - 4. Equipment and duct access doors are securely closed.
  - 5. Manual volume dampers, smoke, fire, and combination fire/smoke dampers are open.
  - 6. Isolating and balancing valves are open and control valves are operational.
  - 7. Ceilings are installed in critical areas where air-pattern adjustments are required and access to balancing devices is provided.
  - 8. Windows and doors can be closed so design conditions for system operations can be met.
  - 9. Building construction is sealed in areas where specified pressurization of an area is designated on contract documents.

### 3.4 GENERAL TESTING AND BALANCING PROCEDURES

- A. Perform testing and balancing procedures on each system according to the procedures contained in NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" and this Section.
- B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary to allow adequate performance of procedures. After testing and balancing, close probe holes and patch insulation with new materials identical to those removed. Restore vapor barrier and finish according to the insulation Specifications for this Project.
- C. Mark equipment settings with paint or other suitable, permanent identification material, including damper-control positions, valve indicators, fan-speed-control levers, and similar controls and devices, to show final settings.
- D. Set automatic stops on metering balancing valves and butterfly valves with memory, and ensure volume damper locking mechanisms are tightened down in the balanced position.

### 3.5 FUNDAMENTAL AIR SYSTEMS' BALANCING PROCEDURES

- A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck 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 the airflow patterns from the outside-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.

### 3.6 TOLERANCES

- A. Set HVAC system airflow and water flow rates within the following tolerances:
  - 1. Supply, Return, and Exhaust Fans: Zero to plus 10 percent of fan design air volume, including leakage.
  - 2. Outside Air: Minus 5 percent to plus 5 percent
  - 3. Air Outlets and Inlets:
    - a. Critical Spaces that are Code Required Positive Rooms:
      - 1) Supply Air: Zero to plus 10 percent.
      - 2) Exhaust and Return Air: Minus 10 percent to zero.
    - b. Critical Spaces that are Code Required Negative Rooms:
      - 1) Supply Air: Minus 10 percent to zero.
      - 2) Exhaust and Return Air: Zero to plus 10 percent.
    - c. Non-Critical Spaces: Minus 10 percent to plus 10 percent.
    - d. Note: Critical spaces are defined on [the "Zoning and Pressure Relationship" sheets as Code Required Pressures][or insert project specific location in documents].
  - 4. Heating Water Flow Rate: Minus 5 percent to plus 5 percent.
  - 5. Chilled Water Flow Rate: Minus 5 percent to plus 5 percent.

### 3.7 REPORTING

- A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article above, 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

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tions to HVAC systems and general construction to allow access for performance measuring and balancing devices.

- B. **Status Reports:** As Work progresses, prepare 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.

### 3.8 FINAL REPORT

- A. **General:** Typewritten, or computer printout in letter-quality font, on standard bond paper, in 3-ring binder, tabulated and divided into sections by tested and balanced systems.
- B. Include a certification sheet in front of binder signed and sealed by the certified testing and balancing engineer.
1. Include a list of the instruments used for procedures, along with proof of calibration.
- C. **Final Report Contents:** In addition to the 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, but do not include approved Shop Drawings and Product Data.
- D. **General Report Data:** In addition to the form titles and entries, include the following data in the final report, as applicable:
1. Title page.
  2. Name and address of testing, adjusting, and balancing Agent.
  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 testing, adjusting, and balancing Agent who certifies the report.
  10. Summary of contents, including the following:
    - a. Design versus final performance.
    - b. Notable characteristics of systems.
    - c. Description of system operation sequence if it varies from the Contract Documents.
  11. Nomenclature sheets for each item of equipment.
  12. Data for terminal units, including manufacturer, type size, and fittings.
  13. Notes to explain why certain final data in the body of reports vary from design values.
  14. Test conditions for fans and pump performance forms, including the following:
    - a. Settings for outside-, 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.
- E. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present with single-line diagrams and include the following:
1. Quantities of outside, supply, return, and exhaust airflows.
  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.
- F. Air-Handling Unit Test Reports: For air-handling units with coils, include the following:
1. Unit Data: Include the following:
    - a. Unit identification.
    - b. Location.
    - c. Make and type.
    - d. Model number and unit size.
    - e. Manufacturer's serial number.
    - f. Unit arrangement and class.
    - g. Discharge arrangement.
    - h. Sheave make, size in inches, and bore.
    - i. Sheave dimensions, center-to-center and amount of adjustments in inches.
    - j. Number of belts, make, and size.
    - k. Number of filters, type, and size.
  2. Motor Data: Include the following:
    - a. 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. Sheave dimensions, center-to-center and amount of adjustments in inches.
  3. Test Data: Include design and actual values for the following:
    - 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. Filter static-pressure differential in inches wg.
    - f. Preheat coil static-pressure differential in inches wg.
    - g. Cooling coil static-pressure differential in inches wg.
    - h. Heating coil static-pressure differential in inches wg.
    - i. Outside airflow in cfm.
    - j. Return airflow in cfm.
    - k. Outside-air damper position.

- l. Return-air damper position.
        - m. Vortex damper position.
  - G. Apparatus-Coil Test Reports: For apparatus coils, include the following:
    - 1. Coil Data: Include the following:
      - a. System identification.
      - b. Location.
      - c. Coil type.
      - d. Number of rows.
      - e. Fin spacing in fins per inch.
      - f. Make and model number.
      - g. Face area in sq. ft.
      - h. Tube size in NPS.
      - i. Tube and fin materials.
      - j. Circuiting arrangement.
    - 2. Test Data: Include design and actual values for the following:
      - a. Airflow rate in cfm.
      - b. Average face velocity in fpm.
      - c. Air pressure drop in inches wg.
      - d. Outside-air, wet- and dry-bulb temperatures in deg F.
      - e. Return-air, wet- and dry-bulb temperatures in deg F.
      - f. Entering-air, wet- and dry-bulb temperatures in deg F.
      - g. Leaving-air, wet- and dry-bulb temperatures in deg F.
      - h. Water flow rate in gpm.
      - i. Water pressure differential in feet of head or psig.
      - j. Entering-water temperature in deg F.
      - k. Leaving-water temperature in deg F.
      - l. Refrigerant expansion valve and refrigerant types.
      - m. Refrigerant suction pressure in psig.
      - n. Refrigerant suction temperature in deg F.
      - o. Inlet steam pressure in psig.
- H. Gas- and Oil-Fired Heat Apparatus Test Reports: In addition to the manufacturer's factory startup equipment reports, include the following:
  - 1. Unit Data: Include the following:
    - a. System identification.
    - b. Location.
    - c. Make and type.
    - d. Model number and unit size.
    - e. Manufacturer's serial number.
    - f. Fuel type in input data.
    - g. Output capacity in Btuh.
    - h. Ignition type.
    - i. Burner-control types.
    - j. Motor horsepower and rpm.
    - k. Motor volts, phase, and hertz.
    - l. Motor full-load amperage and service factor.
    - m. Sheave make, size in inches, and bore.

- n. Sheave dimensions, center-to-center and amount of adjustments in inches.
2. Test Data: Include design and actual values for the following:
    - a. Total airflow rate in cfm.
    - b. Entering-air temperature in deg F.
    - c. Leaving-air temperature in deg F.
    - d. Air temperature differential in deg F.
    - e. Entering-air static pressure in inches wg.
    - f. Leaving-air static pressure in inches wg.
    - g. Air static-pressure differential in inches wg.
    - h. Low-fire fuel input in Btuh.
    - i. High-fire fuel input in Btuh.
    - j. Manifold pressure in psig.
    - k. High-temperature-limit setting in deg F.
    - l. Operating set point in Btuh.
    - m. Motor voltage at each connection.
    - n. Motor amperage for each phase.
    - o. Heating value of fuel in Btuh.
- I. 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: Include the following:
      - a. System identification.
      - b. Location.
      - c. Coil identification.
      - d. Capacity in Btuh.
      - 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: Include design and actual values for the following:
      - a. Heat output in Btuh.
      - 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.
- J. Fan Test Reports: For supply, return, and exhaust fans, include the following:
    1. Fan Data: Include the following:
      - 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. Sheave dimensions, center-to-center and amount of adjustments in inches.
  2. Motor Data: Include the following:
    - a. 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. Sheave dimensions, center-to-center and amount of adjustments in inches.
    - g. Number of belts, make, and size.
  3. Test Data: Include design and actual values for the following:
    - 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.
- K. 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: Include the following:
    - 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. Design airflow rate in cfm.
    - h. Design velocity in fpm.
    - i. Actual airflow rate in cfm.
    - j. Actual average velocity in fpm.
    - k. Barometric pressure in psig.
- L. Air-Terminal-Device Reports: For terminal units, include the following:
  1. Unit Data: Include the following:
    - a. System and air-handling unit identification.
    - b. Location and zone.
    - c. Test apparatus used.
    - d. Area served.
    - e. Air-terminal-device make.
    - f. Air-terminal-device number from system diagram.
    - g. Air-terminal-device type and model number.
    - h. Air-terminal-device size.
    - i. Air-terminal-device effective area in sq. ft.

2. Test Data: Include design and actual values for the following:
  - 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.
  
- M. System-Coil Reports: For reheat coils and water coils of terminal units, include the following:
  1. Unit Data: Include the following:
    - a. System and air-handling unit identification.
    - b. Location and zone.
    - c. Room or riser served.
    - d. Coil make and size.
    - e. Flowmeter type.
  
  2. Test Data: Include design and actual values for the following:
    - a. Airflow rate in cfm.
    - b. Entering-water temperature in deg F.
    - c. Leaving-water temperature in deg F.
    - d. Water pressure drop in feet of head or psig.
    - e. Entering-air temperature in deg F.
    - f. Leaving-air temperature in deg F.
  
- N. Packaged Chiller Reports: For each chiller, include the following:
  1. Unit Data: Include the following:
    - a. Unit identification.
    - b. Make and model number.
    - c. Manufacturer's serial number.
    - d. Refrigerant type and capacity in gal.
    - e. Starter type and size.
    - f. Starter thermal protection size.
  
  2. Condenser Test Data: Include design and actual values for the following:
    - a. Refrigerant pressure in psig.
    - b. Refrigerant temperature in deg F.
    - c. Entering-water temperature in deg F.
    - d. Leaving-water temperature in deg F.
    - e. Entering-water pressure in feet of head or psig.
    - f. Water pressure differential in feet of head or psig.
  
  3. Evaporator Test Reports: Include design and actual values for the following:
    - a. Refrigerant pressure in psig.
    - b. Refrigerant temperature in deg F.
    - c. Entering-water temperature in deg F.

- d. Leaving-water temperature in deg F.
  - e. Entering-water pressure in feet of head or psig.
  - f. Water pressure differential in feet of head or psig.
4. Compressor Test Data: Include design and actual values for the following:
- a. Make and model number.
  - b. Manufacturer's serial number.
  - c. Suction pressure in psig.
  - d. Suction temperature in deg F.
  - e. Discharge pressure in psig.
  - f. Discharge temperature in deg F.
  - g. Oil pressure in psig.
  - h. Oil temperature in deg F.
  - i. Voltage at each connection.
  - j. Amperage for each phase.
  - k. The kW input.
  - l. Crankcase heater kW.
  - m. Chilled water control set point in deg F.
  - n. Condenser water control set point in deg F.
  - o. Refrigerant low-pressure-cutoff set point in psig.
  - p. Refrigerant high-pressure-cutoff set point in psig.
5. Refrigerant Test Data: Include design and actual values for the following:
- a. Oil level.
  - b. Refrigerant level.
  - c. Relief valve setting in psig.
  - d. Unloader set points in psig.
  - e. Percentage of cylinders unloaded.
  - f. Bearing temperatures in deg F.
  - g. Vane position.
  - h. Low-temperature-cutoff set point in deg F.
- O. Compressor and Condenser Reports: For refrigerant side of unitary systems, stand-alone refrigerant compressors, air-cooled condensing units, or water-cooled condensing units, include the following:
1. Unit Data: Include the following:
    - a. Unit identification.
    - b. Location.
    - c. Unit make and model number.
    - d. Manufacturer's compressor serial numbers.
    - e. Compressor make.
    - f. Compressor model and serial numbers.
    - g. Refrigerant weight in lb.
    - h. Low ambient temperature cutoff in deg F.
  2. Test Data: Include design and actual values for the following:
    - a. Inlet-duct static pressure in inches wg.
    - b. Outlet-duct static pressure in inches wg.
    - c. Entering-air, dry-bulb temperature in deg F.

- d. Leaving-air, dry-bulb temperature in deg F.
  - e. Condenser entering-water temperature in deg F.
  - f. Condenser leaving-water temperature in deg F.
  - g. Condenser water temperature differential in deg F.
  - h. Condenser entering-water pressure in feet of head or psig.
  - i. Condenser leaving-water pressure in feet of head or psig.
  - j. Condenser water pressure differential in feet of head or psig.
  - k. Control settings.
  - l. Unloader set points.
  - m. Low-pressure-cutout set point in psig.
  - n. High-pressure-cutout set point in psig.
  - o. Suction pressure in psig.
  - p. Suction temperature in deg F.
  - q. Condenser refrigerant pressure in psig.
  - r. Condenser refrigerant temperature in deg F.
  - s. Oil pressure in psig.
  - t. Oil temperature in deg F.
  - u. Voltage at each connection.
  - v. Amperage for each phase.
  - w. The kW input.
  - x. Crankcase heater kW.
  - y. Number of fans.
  - z. Condenser fan rpm.
  - aa. Condenser fan airflow rate in cfm.
  - bb. Condenser fan motor make, frame size, rpm, and horsepower.
  - cc. Condenser fan motor voltage at each connection.
  - dd. Condenser fan motor amperage for each phase.
- P. Cooling Tower or Condenser Test Reports: For cooling towers or condensers, include the following:
- 1. Unit Data: Include the following:
    - a. Unit identification.
    - b. Make and type.
    - c. Model and serial numbers.
    - d. Nominal cooling capacity in tons.
    - e. Refrigerant type and weight in lb.
    - f. Water-treatment chemical feeder and chemical.
    - g. Number and type of fans.
    - h. Fan motor make, frame size, rpm, and horsepower.
    - i. Fan motor voltage at each connection.
    - j. Sheave make, size in inches, and bore.
    - k. Sheave dimensions, center-to-center and amount of adjustments in inches.
    - l. Number of belts, make, and size.
  - 2. Pump Test Data: Include design and actual values for the following:
    - a. Make and model number.
    - b. Manufacturer's serial number.
    - c. Motor make and frame size.
    - d. Motor horsepower and rpm.
    - e. Voltage at each connection.
    - f. Amperage for each phase.



R. Pump Test Reports: For pumps, include the following data. Calculate impeller size by plotting the shutoff head on pump curves.

1. Unit Data: Include the following:

- a. Unit identification.
- b. Location.
- c. Service.
- d. Make and size.
- e. Model and serial numbers.
- f. Water flow rate in gpm.
- g. Water pressure differential in feet of head or psig.
- h. Required net positive suction head in feet of head or psig.
- i. Pump rpm.
- j. Impeller diameter in inches.
- k. Motor make and frame size.
- l. Motor horsepower and rpm.
- m. Voltage at each connection.
- n. Amperage for each phase.
- o. Full-load amperage and service factor.
- p. Seal type.

2. Test Data: Include design and actual values for the following:

- a. Static head in feet of head or psig.
- b. Pump shutoff pressure in feet of head or psig.
- c. Actual impeller size in inches.
- d. Full-open flow rate in gpm.
- e. Full-open pressure in feet of head or psig.
- f. Final discharge pressure in feet of head or psig.
- g. Final suction pressure in feet of head or psig.
- h. Final total pressure in feet of head or psig.
- i. Final water flow rate in gpm.
- j. Voltage at each connection.
- k. Amperage for each phase.

S. Boiler Test Reports: For boilers, include the following:

1. Unit Data: Include the following:

- a. Unit identification.
- b. Location.
- c. Service.
- d. Make and type.
- e. Model and serial numbers.
- f. Fuel type and input in Btuh.
- g. Number of passes.
- h. Ignition type.
- i. Burner-control types.
- j. Voltage at each connection.
- k. Amperage for each phase.

2. Test Data: Include design and actual values for the following:

- a. Operating pressure in psig.
- b. Operating temperature in deg F.
- c. Entering-water temperature in deg F.
- d. Leaving-water temperature in deg F.
- e. Number of safety valves and sizes in NPS.
- f. Safety valve settings in psig.
- g. High-limit setting in psig.
- h. Operating-control setting.
- i. High-fire set point.
- j. Low-fire set point.
- k. Voltage at each connection.
- l. Amperage for each phase.
- m. Draft fan voltage at each connection.
- n. Draft fan amperage for each phase.
- o. Manifold pressure in psig.

T. Instrument Calibration Reports: For instrument calibration, include the following:

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

### 3.9 ADDITIONAL TESTS

- A. Within 90 days of completing testing, adjusting, and balancing, perform additional testing and balancing to verify that balanced conditions are being maintained throughout and to correct unusual conditions.
- B. Seasonal Periods: If initial testing, adjusting, and balancing procedures were not performed during near-peak summer and winter conditions, perform additional inspections, testing, and adjusting during near-peak summer and winter conditions.

**END OF SECTION**