SECTION 230594

TESTING, ADJUSTING, AND BALANCING

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Testing, adjustment, and balancing of air systems.

B. Testing, adjustment, and balancing of hydronic and steam systems.

C. Adjusting total HVAC systems to provide indicated quantities.

D. Measurement of final operating condition of HVAC systems.

E. Setting quantitative performance of HVAC equipment.

F. Sound measurement of equipment operating conditions.

G. Vibration measurement of equipment operating conditions.

H. Verify that automatic control devices are functioning properly.

I. Reporting results of the activities and procedures specified in this section.

1.02 REFERENCES

A. AABC MN-1 - AABC National Standards for Total System Balance; Associated Air Balance Council.

B. ASHRAE Std 111 - Practices for Measurement, Testing, Adjusting and Balancing of Building Heating, Ventilation, Air-Conditioning, and Refrigeration Systems; American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc..

C. NEBB (TAB) - Procedural Standards for Testing Adjusting Balancing of Environmental Systems; National Environmental Balancing Bureau.

1.03 SUBMITTALS

A. Final Reports - Include following information in report:
   1. Indicate deficiencies in systems that would prevent proper testing, adjusting, and balancing of systems and equipment to achieve specified performance.
   2. Prior to commencing work, submit report forms or outlines indicating adjusting, balancing, and equipment data required.
   3. Submit draft copies of report for review prior to final acceptance of Project. Provide final copies for Architect/Engineer and for inclusion in operating and maintenance manuals.
   4. Provide four (4) copies of reports in 3-ring binder manuals, complete with index 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.
   5. Air Data: Include design and actual values for the following:
      a. Average entering air, dry-bulb and wet-bulb, temperature in degrees Fahrenheit.
      b. Average leaving air, dry-bulb and wet-bulb, temperature in degrees Fahrenheit.
      c. Ambient temperature, dry-bulb and wet-bulb, in degrees Fahrenheit.
   6. Steam Test Data:
      a. Include design and actual values for inlet pressure in psig and temperature in degrees Fahrenheit.
   7. Include detailed procedures, agenda, sample report forms and copy of AABC National Project Performance Guaranty prior to commencing system balance.
   8. Test Reports: Indicate data on AABC MN-1 forms.
   9. Include the following in each report:
      a. Title Page.

b. Name, address and telephone number of Testing, Adjusting, and Balancing Agency.
c. Project name.
d. Project number.
e. Project location.
f. Project Engineer name and address.
g. Project Contractor name and address.
h. Report date.
i. Signature of testing, adjusting, and balancing agent who certifies the report.
j. Summary of contents, including the following:
    1) Design versus final performance.
    2) Notable characteristics of systems.
    3) Description of system operation sequence if it varies from the Contract Documents.
k. Nomenclature sheets for each item of equipment.
l. Notes to explain why certain final data in the body of reports vary from design values.
m. Fan curves.
n. Manufacturer's test data.
o. Field test reports prepared by system and equipment installers.
p. Other information relative to equipment performance, but do not include approved shop drawings or product data.

B. Project Record Documents: Record actual locations of flow measuring stations and balancing valves and rough setting.

1.04 QUALITY ASSURANCE

A. Perform total system balance in accordance with AABC MN-1.
    1. Maintain one copy of each document on site.

B. TAB Agency Qualifications: Company specializing in the testing, adjusting, and balancing of systems specified in this Section certified by AABC and NEBB.

C. Perform Work under supervision of AABC Certified Test and Balance Engineer experienced in performance of this Work and licensed at the University of Missouri - Columbia.

1.05 PRE-BALANCING MEETING

A. Convene a meeting one week prior to commencing work of this Section. Coordinate meeting with Owner's Representative.

B. Provide seven (7) days advance notice for each test. Include scheduled test dates and times.

1.06 SEQUENCING AND SCHEDULING

A. Sequence work to commence after completion of systems and schedule completion of work before Substantial Completion of Project.

B. Schedule and provide assistance in final adjustment and test of life safety system, smoke evacuation system, and smoke control system with Fire Authority.

PART 2 PRODUCTS - NOT USED

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine contract documents to become familiar with project requirements. Contract Documents are defined in the General and Special Conditions of the Contract.

B. Verify that systems are complete and operable before commencing work. Ensure the following conditions:
    1. Systems are started and operating in a safe and normal condition.

2. Temperature control systems are installed complete and operable. Calibration and commissioning are part of this scope.
3. Proper thermal overload protection is in place for electrical equipment.
4. Verify free travel and proper operation of control devices such as damper and valve operators.
5. Final filters are clean and in place. If required, install temporary media in addition to final filters.
6. Duct systems are clean of debris.
7. Fans are rotating correctly.
8. Fire and volume dampers are in place and open.
9. Air coil fins are cleaned and combed.
10. Balancing devices are properly installed and locations are accessible and appropriate for effective balancing and for efficient system and equipment operation.
11. Access doors are closed and duct end caps are in place.
12. Air outlets are installed and connected.
13. Duct system leakage is minimized.
14. Hydronic systems are flushed, filled, and vented.
15. Pumps are rotating correctly.
16. Proper strainer baskets are clean and in place.
17. Service and balance valves are open.

C. Examine approved submitted data of HVAC systems and equipment.

D. Submit field reports. Report defects and deficiencies noted during performance of services which prevent system balance to the Owner's Representative.

E. Beginning of work means acceptance of existing conditions.

3.02 PREPARATION

A. Provide instruments required for testing, adjusting, and balancing operations. Make instruments available to Architect/Engineer to facilitate spot checks during testing.

B. Provide additional balancing devices as required.

C. Prepare a testing, adjusting and balancing plan that includes strategies and step-by-step procedures.

3.03 INSTALLATION TOLERANCES

A. Air Handling Units: Adjust to within plus 5 to 0 percent.

B. Exhaust Fans: Adjust total to within plus 5 to 0 percent.

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

3.04 GENERAL TESTING AND BALANCING PROCEDURES

A. Cut insulation, ducts, pipes and equipment cabinets 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.

B. 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.

3.05 ADJUSTING

A. Ensure recorded data represents actual measured or observed conditions.

B. Permanently mark settings of valves, dampers, and other adjustment devices allowing settings to be restored. Set and lock memory stops.

C. After adjustment, take measurements to verify balance has not been disrupted or that such disruption has been rectified.

D. Leave systems in proper working order, replacing belt guards, closing access doors, closing doors to electrical switch boxes, and restoring thermostats to specified settings.

E. At final inspection, recheck random selections of data recorded in report. Recheck points or areas as selected and witnessed by the Owner.

F. Check and adjust systems approximately six months after final acceptance and submit report.

3.06 AIR SYSTEM PROCEDURE

A. Adjust air handling and distribution systems to provide required or design supply, return, and exhaust air quantities at site altitude.

B. Make air quantity measurements in 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 and noise.

E. Use volume control devices to regulate air quantities only to extend that adjustments do not create objectionable air motion or sound levels. Effect volume control by duct internal devices such as dampers and splitters.

F. Vary total system air quantities by adjustment of fan speeds. Provide drive changes required. Vary branch air quantities by damper regulation.

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 the 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, and exhaust dampers to check leakage.

K. Where modulating dampers are provided, take measurements and balance at extreme conditions. Balance variable volume systems at maximum air flow rate, full cooling, and at minimum air flow rate, full heating.

L. Check multi-zone units for motorized damper leakage. Adjust air quantities with mixing dampers set first for cooling, then heating, then modulating.

M. For variable air volume system powered units set volume controller to air flow setting indicated. Confirm connections properly made and confirm proper operation for automatic variable air volume temperature control.

N. On fan powered VAV boxes, adjust air flow switches for proper operation.

3.07 WATER SYSTEM PROCEDURE

A. Adjust water systems to provide required or 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 the system.

C. 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.

D. Effect system balance with automatic control valves fully open 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, full flow in one part may be simulated by temporary restriction of flow to other parts.

3.08 SCHEDULES

A. Equipment Requiring Testing, Adjusting, and Balancing:
   1. Fire Pumps
   2. Sprinkler Air Compressor
   3. Electric Water Coolers
   4. Plumbing Pumps
   5. Steam Condensate Pumps
   6. HVAC Pumps
   7. Forced Air Furnaces
   8. Packaged Roof Top Heating/Cooling Units
   9. Packaged Terminal Air Conditioning Units
   10. Unit Air Conditioners
   11. Computer Room Air Conditioning Units
   12. Air Coils
   13. Terminal Heat Transfer Units
   14. Air Handling Units
   15. Fans
   16. Air Filters
   17. Air Terminal Units
   18. Air Inlets and Outlets
   19. Controls Compressor

B. Report:
   1. 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 amount of building pressurization
      e. Nomenclature used throughout report
      f. Test conditions
   2. Instrument List:
      a. Instrument
      b. Manufacturer
      c. Model number
      d. Serial number
      e. Range
      f. Calibration date

C. Electric Motors:

1. Manufacturer
2. Model/Frame
3. HP/BHP
4. Phase, voltage, amperage; nameplate, actual, no load
5. RPM
6. Service factor
7. Starter size, rating, heater elements
8. Sheave Make/Size/Bore

D. V-Belt Drives:
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

E. Pumps:
1. Identification/number
2. Manufacturer
3. Size/model
4. Impeller
5. Service
6. Design flow rate, pressure drop, BHP
7. Actual flow rate, pressure drop, BHP
8. Discharge pressure
9. Suction pressure
10. Total operating head pressure
11. Shut off, discharge and suction pressures
12. Shut off, total head pressure

F. Cooling Tower:
1. Tower identification/number
2. Manufacturer
3. Model number
4. Serial number
5. Rated capacity
6. Entering air WB temperature, specified and actual
7. Leaving air WB temperature, specified and actual
8. Ambient air DB temperature
9. Condenser water entering temperature
10. Condenser water leaving temperature
11. Condenser water flow rate
12. Fan RPM

G. Heat Exchangers:
1. Identification/number
2. Location
3. Service
4. Manufacturer
5. Model number
6. Serial number
7. Steam pressure, design and actual
8. Primary water entering temperature, design and actual
9. Primary water leaving temperature, design and actual
10. Primary water flow, design and actual
11. Primary water pressure drop, design and actual
12. Secondary water leaving temperature, design and actual

13. Secondary water leaving temperature, design and actual
14. Secondary water flow, design and actual
15. Secondary water pressure drop, design and actual

H. Cooling Coils:
1. Identification/number
2. Location
3. Service
4. Manufacturer
5. Air flow, design and actual
6. Entering air DB temperature, design and actual
7. Entering air WB temperature, design and actual
8. Leaving air DB temperature, design and actual
9. Leaving air WB temperature, design and actual
10. Water flow, design and actual
11. Water pressure drop, design and actual
12. Entering water temperature, design and actual
13. Leaving water temperature, design and actual
14. Saturated suction temperature, design and actual
15. Air pressure drop, design and actual

I. Heating Coils:
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

J. Electric Duct Heaters:
1. Manufacturer
2. Identification/number
3. Location
4. Model number
5. Design kW
6. Number of stages
7. Phase, voltage, amperage
8. Test voltage (each phase)
9. Test amperage (each phase)
10. Air flow, specified and actual
11. Temperature rise, specified and actual

K. Fresh Air Heat Pump Dehumidification Equipment:
1. Manufacturer
2. Identification/number
3. Location
4. Model number
5. Size
6. Design air flow and actual air flow
7. Outdoor air temperature (dry-bulb and wet-bulb)
8. Cooling coil (pressure and temperature change across the coil)
9. Heating coil (pressure and temperature change across the coil)

10. Supply air temperature (dry-bulb and wet-bulb)
11. Sheave Make/Size/Bore
12. Number of Belts/Make/Size
13. Fan RPM

L. Air Moving Equipment:
1. Identification / Location
2. Manufacturer
3. Model number
4. Serial number
5. Arrangement/Class/Discharge
6. Air flow, specified and actual
7. Return air flow, specified and actual
8. Outside air flow, specified and actual
9. Total static pressure (total external), specified and actual
10. Inlet pressure
11. Discharge pressure
12. Sheave Make/Size/Bore
13. Number of Belts/Make/Size
14. Fan RPM
15. Return air temperature
16. Outside air temperature
17. Required mixed air temperature
18. Actual mixed air temperature
19. Design outside/return air ratio
20. Actual outside/return air ratio

M. Exhaust Fans:
1. Location
2. Manufacturer
3. Model number
4. Serial number
5. Air flow, specified and actual
6. Total static pressure (total external), specified and actual
7. Inlet pressure
8. Discharge pressure
9. Sheave Make/Size/Bore
10. Number of Belts/Make/Size
11. Fan RPM

N. Duct Traverses:
1. System zone/branch
2. Duct size
3. Area
4. Design velocity
5. Design air flow
6. Test velocity
7. Test air flow
8. Duct static pressure
9. Air temperature
10. Air correction factor

O. Duct Leak Tests:
1. Description of ductwork under test
2. Duct design operating pressure
3. Duct design test static pressure
4. Duct capacity, air flow
5. Maximum allowable leakage duct capacity times leak factor

6. Test apparatus
    a. Blower
    b. Orifice, tube size
    c. Orifice size
    d. Calibrated
7. Test static pressure
8. Test orifice differential pressure
9. Leakage

P. Air Monitoring Stations:
1. Identification/location
2. System
3. Size
4. Area
5. Design velocity
6. Design air flow
7. Test velocity
8. Test air flow

Q. Flow Measuring Stations:
1. Identification/number
2. Location
3. Size
4. Manufacturer
5. Model number
6. Serial number
7. Design Flow rate
8. Design pressure drop
9. Actual/final pressure drop
10. Actual/final flow rate
11. Station calibrated setting

R. Terminal Unit Data:
1. Manufacturer
2. Type, constant, variable, single, dual duct
3. Identification/number
4. Location
5. Model number
6. Size
7. Minimum static pressure
8. Minimum design air flow
9. Maximum design air flow
10. Maximum actual air flow
11. Inlet static pressure

S. Air Distribution Tests:
1. Air terminal number
2. Room number/location
3. Terminal type
4. Terminal size
5. Area factor
6. Design velocity
7. Design air flow
8. Test (final) velocity
9. Test (final) air flow
10. Percent of design air flow

T. Sound Level Reports:

1. Location
2. Octave bands - equipment off
3. Octave bands - equipment on

U. Vibration Tests:
   1. Location of points:
      a. Fan bearing, drive end
      b. Fan bearing, opposite end
      c. Motor bearing, center (if applicable)
      d. Motor bearing, drive end
      e. Motor bearing, opposite end
      f. Casing (bottom or top)
      g. Casing (side)
      h. Duct after flexible connection (discharge)
      i. Duct after flexible connection (suction)
   2. Test readings:
      a. Horizontal, velocity and displacement
      b. Vertical, velocity and displacement
      c. Axial, velocity and displacement
   3. Normally acceptable readings, velocity and acceleration
   4. Unusual conditions at time of test
   5. Vibration source (if non-complying)

END OF SECTION