SECTION 23 05 93

TESTING, ADJUSTING AND BALANCING FOR HVAC

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.
6. Testing and Balancing of stair pressurization system.
7. Testing and Balancing of isolation rooms and pressure monitoring systems.

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.

1.03 SUBMITTALS

A. Division 01 - Submittal Procedures: Submittal procedures.

B. Prior to commencing Work, submit proof of latest calibration date of each instrument.

C. Test Reports: Indicate data on AABC MN-1 National Standards for Total System Balance forms containing information indicated in Schedules.

D. Field Reports: Indicate deficiencies preventing proper testing, adjusting, and balancing of systems and equipment to achieve specified performance.

E. 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.

F. Submit draft copies of report for review prior to final acceptance of Project.

G. Furnish reports in soft cover, letter size, 3-ring binder manuals, complete with table of contents page and indexing tabs, with cover identification at front and side. Include set of reduced details with air outlets and equipment identified to correspond with data sheets, and indicating thermostat locations.

H. Preliminary Submittals: Within 30 days after receipt of above preliminary information and data, the Agency shall submit the following through Developer Design/Builder:

1. Agenda: Submit 3 sets of complete Agenda including details of the entire HVAC system to be balanced. Agenda shall represent final Total System Balance Report as per Chapter 29 of AABC National Standards, 1982, less field test data. Areas of intended field test inputs shall be represented by fully labeled blank spaces.
2. Pre-construction Plan Check and Construction Review Reports: Submit 3 sets of defined in AABC National Standards, 1982 (Chapter 25) including reports:

   a. Demonstrating complete understanding of the design intent by the Test and Balance Agency.
   b. Identifying potential problems for performing the Total System Balance and suggesting possible changes to allow most effective Total System Balance.

3. Total System Balance Schedule: Submit 3 sets of this schedule based on critical-path-network-analysis method and furnishing the Developer Design/Builder and County's representative with a planning tool to include the testing and balancing into overall project schedule. Schedule shall consist of graphical and columnar reports and shall be updated periodically to reflect total project schedule.

I. Guarantee: Submit 3 sets of AABC National Project Performance Guaranty.

J. Certifications: Submit the certificates from mechanical Subcontractor as specified hereinafter.

K. Reports, Test Reports, and Information: Submit six sets as specified hereinafter.

L. Test and Balance Company shall fill in the actual values for air changes, supply air, return air, exhaust air and infiltration in the ventilation table for the Developer/Design Builder. A copy of the spreadsheet can be obtained for the engineer of record.

1.04 WORK BY MECHANICAL SUBCONTRACTOR

A. Mechanical subcontractor shall certify in writing that the system, as scheduled for balancing, is operational and complete. Completeness shall include not only the physical installation, but mechanical subcontractor's certification that prime movers, fans, pumps, refrigeration machines, boilers, etc., are installed in good working order, and full load performance has been preliminarily tested under certification of mechanical subcontractor. Before any testing and balancing is started, a complete report shall be set to the Agency.

1.05 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.

1.06 QUALITY ASSURANCE

A. Perform Work in accordance with AABC MN-1 National Standards for Field Measurement and Instrumentation, Total System Balance.

B. Maintain one copy of each document on site.

C. Prior to commencing Work, calibrate each instrument to be used. Upon completing Work, recalibrate each instrument to assure reliability.

1.07 QUALIFICATIONS

A. Qualifications of Agency: Total systems balance shall be performed by an independent Agency certified by the Associated Air Balance Council (AABC), which specializes in and whose business is dedicated to the testing, adjusting, and verification of HVAC system performance. Work of this section shall conform to AABC Specifications referred to in Chapters 17 through 26 of the AABC National Standards and other criteria as set forth in this Section.

B. Information furnished to the air balance agency: Agency shall be furnished with the following information and data:

1. Preliminary: Within 30 days after selection and approval:

a. Details of the work.
b. Specifications covering all work to be tested and balanced.
c. Written consent.

2. Exceptions: Following shall be furnished as submittals are approved and the work progresses:

a. Change orders affecting work to be tested and balanced.
b. Copies of approved submittals for work to be tested and balanced, including approved Shop Drawings, equipment submittals and the approved temperature control drawings.
c. Project schedule
d. Completely operable systems.

1.08 PRE-INSTALLATION MEETINGS

A. Division 01 - Administrative Requirements: Pre-installation meeting.

B. Convene minimum one week prior to commencing work of this section.

1.09 SEQUENCING

A. Division 01 - Summary: Work sequence.

B. Sequence balancing between completion of systems tested and Date of Substantial Completion.

1.10 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 system 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. Fire and volume dampers are in place and open.
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.
12. Hydronic systems are flushed, filled, and vented.
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 County's Representative to facilitate spot checks during testing.

3.03 INSTALLATION TOLERANCES

A. Air Handling Systems: Adjust to within plus or minus 3 percent of design.

B. Air Outlets and Inlets: Adjust outlets and inlets in space to within plus or minus 10 percent of design and maintaining the pressure differential indicated on the ventilation table.

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

3.04 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 County.

3.05 AIR SYSTEM PROCEDURE

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

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. Make drive changes, install additional dampers, etc. as may be required on the job at no additional cost to the County.

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.

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 for the systems without VFD (variable frequency drive).

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. 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 positive static pressure near building entries.

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

N. For constant 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.

O. On fan powered VAV boxes, adjust airflow switches for proper operation.

P. Test an Balance stair pressurization system to meet pressure differential and door opening force requirement for each stair and vestibule on each floor. Adjust fan speed and diffusers until pressure requirement is met at all floors.

3.06 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.

3.07 DUCT PRESSURE TESTING

A. General

1. High, medium, and low pressure ductwork systems tested during construction prior to insulation. Test ducts lengths a maximum of 100 feet at time for risers and 150 feet for horizontal ducts. All ductwork tested and approved prior to installation of insulation.
2. Riser branches shall be isolated with seals, plugs, or caps. Riser installed in shafts shall be tested in sections to allow erection of shaft wall and duct insulation as approved by County's Representative.
3. Tests shall be performed in presence of the County's Representative who must verify recorded test data for test pressure and air leakage for tested duct length.
4. Test equipment: Rotary blower, calibrated orifice section, and gauge board.
5. Pressure test procedure:

    a. Check and alert the Mechanical Contractor of any required seals of all openings in duct and plenum section to be tested.
    b. Connect the test apparatus to test section using a flexible duct connection or hose.
    c. Close damper on blower suction side, to prevent excessive build-up of pressure.
    d. Start blower and gradually open damper on suction side of blower.
    e. Build-up pressure on test section to required limit.
    f. Determine amount of air leakage by make-up air flow measurements and make repairs as required.
    g. Total allowable leakage shall not exceed 1% per minute based upon the total operating CFM of the system being tested. Total leakage is determined by summation of leakage for each section of system tested.
    h. All negative pressure ducts, including return and exhaust system shall be tested by same procedure as positive pressure supply ducts.
    i. Report final results of duct testing.

B. Main Supply Ductwork Systems: Extending from the discharge of supply fans to the inlet of air terminal units.

1. Test pressures: 5 inch WG.
2. The allowable leak measured in CFM varies depending upon the length of duct tested and as follows:

    a. Main duct maximum 1% of the designed CFM on the total length and proportioned to the duct being tested.

C. Negative Pressure Ductwork Systems: Return and exhaust air ducts.

1. Test pressures: System operating pressure 2 inch minimum.
2. The allowable leak measured in CFM varies depending upon the length of duct tested and as follows:

    a. Main duct maximum 1% of the designed CFM on the total length and proportioned to the duct being tested.

3. The allowable leakage shall not exceed 1% per minute based upon the total peak operating CFM of system being tested. Total leakage is determined by summation of leakage for each section of the system tested.

D. Leak tests shall be performed and recorded separately for each system for:

1. Main duct.
2. Risers.
3. Branch duct per floor as selected by engineer. No testing through purchased items such as fire dampers, CAV boxes, flexduct or grilles.

E. Test Failures: Notify Developer Design/Builder to repair duct system if test pressure and leakage is not attained. Repairs and sealing to be done with sheet metal and sealant by Mechanical Contractor Division 23.

F. Total system leakage shall not exceed 5% including leakage through combination smoke damper terminal boxes.

3.08 SCHEDULES

A. Equipment Requiring Testing, Adjusting, and Balancing:

1. Plumbing Pumps.
2. Steam Condensate Pumps.
3. HVAC Pumps.
4. Computer Room Air Conditioning Units.
5. Air Coils.
6. Fan Coil Units.
7. Air Handling Units.
8. Fans.
9. Air Filters.
10. Air Terminal Units.
11. Air Inlets and Outlets.
12. Heat Exchangers.

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 Developer Design/Builder
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. Heat Exchanger:

a. Identification/number
b. Location
c. Service
d. Manufacturer
e. Model number
f. Serial number
g. Steam pressure, design and actual
h. Primary water entering temperature, design and actual
i. Primary water leaving temperature, design and actual
j. Primary water flow, design and actual
k. Primary water pressure drop, design and actual
l. Secondary water leaving temperature, design and actual
m. Secondary water leaving temperature, design and actual
n. Secondary water flow, design and actual
o. Secondary water pressure drop, design and actual

8. Cooling Coil Data:

    a. Identification/number
    b. Location
    c. Service
    d. Manufacturer
    e. Air flow, design and actual
    f. Entering air DB temperature, design and actual
    g. Entering air WB temperature, design and actual
    h. Leaving air DB temperature, design and actual
    i. Leaving air WB temperature, design and actual
    j. Water flow, design and actual
    k. Water pressure drop, design and actual
    l. Entering water temperature, design and actual
    m. Leaving water temperature, design and actual
    n. Saturated suction temperature, design and actual
    o. Air pressure drop, design and actual

9. Heating Coil Data:

    a. Identification/number
    b. Location
    c. Service
    d. Manufacturer
    e. Air flow, design and actual
    f. Water flow, design and actual
    g. Water pressure drop, design and actual
    h. Entering water temperature, design and actual
    i. Leaving water temperature, design and actual
    j. Entering air temperature, design and actual
    k. Leaving air temperature, design and actual
    l. Air pressure drop, design and actual

10. Unit Ventilator and Fan Coil Data:

    a. Manufacturer
    b. Identification/number
    c. Location
    d. Model number
    e. Size
    f. Air flow, design and actual
    g. Water flow, design and actual
    h. Water pressure drop, design and actual
    i. Entering water temperature, design and actual
    j. Leaving water temperature, design and actual
    k. Entering air temperature, design and actual
    l. Leaving air temperature, design and actual

11. Air Moving Equipment:

    a. Location
    b. Manufacturer
    c. Model number
    d. Serial number
    e. Arrangement/Class/Discharge
    f. Air flow, specified and actual
    g. Return air flow, specified and actual
    h. Outside air flow, specified and actual

i. Total static pressure (total external), specified and actual
j. Inlet pressure
k. Discharge pressure
l. Sheave Make/Size/Bore
m. Number of Belts/Make/Size
n. Fan RPM

12. Return Air/Outside Air Data:

a. Identification/location
b. Design air flow
c. Actual air flow
d. Design return air flow
e. Actual return air flow
f. Design outside air flow
g. Actual outside air flow
h. Return air temperature
i. Outside air temperature
j. Required mixed air temperature
k. Actual mixed air temperature
l. Design outside/return air ratio
m. Actual outside/return air ratio

13. Exhaust Fan Data:

a. Location
b. Manufacturer
c. Model number
d. Serial number
e. Air flow, specified and actual
f. Total static pressure (total external), specified and actual
g. Inlet pressure
h. Discharge pressure
i. Sheave Make/Size/Bore
j. Number of Belts/Make/Size
k. Fan RPM

14. Duct Traverse:

a. System zone/branch
b. Duct size
c. Area
d. Design velocity
e. Design air flow
f. Test velocity
g. Test air flow
h. Duct static pressure
i. Air temperature
j. Air correction factor

15. Duct Leak Test:

a. Description of ductwork under test
b. Duct design operating pressure
c. Duct design test static pressure
d. Duct capacity, air flow
e. Maximum allowable leakage duct capacity times leak factor

f. Test apparatus

1) Blower
2) Orifice, tube size
3) Orifice size
4) Calibrated

g. Test static pressure
h. Test orifice differential pressure
i. Leakage

16. Air Monitoring Station Data:

a. Identification/location
b. System
c. Size
d. Area
e. Design velocity
f. Design air flow
g. Test velocity
h. Test air flow

17. Flow Measuring Station:

a. Identification/number
b. Location
c. Size
d. Manufacturer
e. Model number
f. Serial number
g. Design Flow rate
h. Design pressure drop
i. Actual/final pressure drop
j. Actual/final flow rate
k. Station calibrated setting

18. Terminal Unit Data:

a. Manufacturer
b. Type, constant, variable, single, dual duct
c. Identification/number
d. Location
e. Model number
f. Size
g. Minimum static pressure
h. Minimum design air flow
i. Maximum design air flow
j. Maximum actual air flow
k. Inlet static pressure

19. Air Distribution Test Sheet:

a. Air terminal number
b. Room number/location
c. Terminal type
d. Terminal size
e. Area factor
f. Design velocity

g. Design air flow
h. Test (final) velocity
i. Test (final) air flow
j. Percent of design air flow

20. 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 TOTAL SYSTEM PERFORMANCE VERIFICATION

A. Immediately on completion of the system testing and balancing, the Agency shall conduct a 7-day continuous total system performance and capacity test; the Developer Design/Builder shall supply all energy and consumables and/or materials required for the test.

B. General: Outdoor DB and WB air temperatures and actual operating data for this test shall be taken simultaneously and hourly on all energy consuming equipment of cooling and heating plants and on any air and/or water distribution equipment which deviates more than 10% from design specifications.

C. Date Conversion and Reports: The data collected during this test shall be converted to KWH per ton for cooling equipment and KWH per MBH for the heating equipment and shall cover a minimum of four points on the equipment operating curve. These points shall be at 25%, 50%, 75% and 100% of full load test. Reports shall be prepared and submitted for all data and conversion.

END OF SECTION