SECTION 23 0593

TESTING, ADJUSTING AND BALANCING FOR HVAC

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Initial testing, adjustment, and balancing of air systems.

B. Winter and Summer Seasonal testing, adjustment, and balancing of air systems.

C. Initial testing, adjustment, and balancing of hydronic systems.

D. Winter and Summer Seasonal Testing, adjustment, and balancing of HVAC systems.

E. Measurement of final operating condition of HVAC systems.

F. Testing of control sensors, controllers and safeties.

G. Commissioning activities.

1.02 RELATED REQUIREMENTS

A. Section 01 4000 - Quality Requirements: Employment of testing agency and payment for services.

B. Section 23 0800 - Commissioning of HVAC.

C. Section 23 3300 - Air Duct Accessories.

1.03 REFERENCE STANDARDS

A. AABC MN-1 - AABC National Standards for Total System Balance; Associated Air Balance Council; 2002.

B. NEBB (TAB) - Procedural Standards for Testing Adjusting Balancing of Environmental Systems; 2005, Seventh Edition.

1.04 SUBMITTALS

A. Refer to Section 23 0510 - General HVAC Requirements for submittal procedures.

B. Field Quality-control Testing of Laboratory Fume Hoods:
   1. Product Data sheets for all equipment proposed for use in on-site as-installed testing.
   2. List of laboratory fume hoods to be tested. Submit a minimum of one week prior to commencement of testing.

C. Initial Review: Submit results of testing and balancing agency's examination of documents and systems within 30 days after Notice to Proceed.

D. Initial Report: Indicate deficiencies in systems that would prevent proper testing, adjusting, and balancing of systems and equipment to achieve specified performance.
   1. Submit under provisions of Section 01 4000.
   2. Submit prior to Contractor's Request for Material Completion.
   3. Submit copies of report for review prior to final acceptance of Project. Provide final copies for Architect and for inclusion in operating and maintenance manuals.
   4. Include actual instrument list, with manufacturer name, serial number, and date of calibration.
   5. Form of Test Reports: Where the TAB standard being followed recommends a report format use that; otherwise, follow ASHRAE Std 111.
   6. Units of Measure: Report data in both I-P (inch-pound) and SI (metric) units.
   7. Test Reports: Indicate data on AABC MN-1 forms, forms prepared following ASHRAE Std 111, or NEBB forms.
   8. Include the following on the title page of each report:
      a. Name of Testing, Adjusting, and Balancing Agency.
      b. Address of Testing, Adjusting, and Balancing Agency.
      c. Telephone number of Testing, Adjusting, and Balancing Agency.
      d. Project name.

e. Project location.
f. Project Architect.
g. Project Engineer.
h. Project Contractor.
i. Report date.

E. Seasonal Reports: Submit seasonal report within 14 days of completion of seasonal adjustments. Include test reports for any equipment that could not be tested at the initial report due to season, temperature or other conditions.
1. List of deficiencies noted, adjustments made and corrective action taken.
2. Temperature of each conditioned space and dry bulb setting of controlling thermostat.
3. Temperature at all sensors in equipment, space duct or pipe and settings of controllers.
4. Date and outdoor DB and WB range during the time of the seasonal test.

PART 2 PRODUCTS - NOT USED

PART 3 EXECUTION

3.01 GENERAL REQUIREMENTS

A. Perform total system balance in accordance with one of the following:
1. AABC MN-1, AABC National Standards for Total System Balance.
2. NEBB Procedural Standards for Testing Adjusting Balancing of Environmental Systems.

B. Begin work after completion of systems to be tested, adjusted, or balanced and complete work and submit Report prior to the Final Observation of the project.

C. TAB Agency Qualifications:
1. Company specializing in the testing, adjusting, and balancing of systems specified in this section.
2. Having minimum of five years documented experience.
3. Certified by one of the following:
a. AABC, Associated Air Balance Council: www.aabchq.com; upon completion submit AABC National Performance Guaranty.
b. NEBB, National Environmental Balancing Bureau: www.nebb.org/#sle.
4. Company shall an independent firm with no relationship with any Contractor on this Project.

D. TAB Supervisor and Technician Qualifications: Certified by same organization as TAB agency.

E. Perform Work under supervision of AABC Certified Test and Balance Engineer or NEBB Certified Testing, Balancing and Adjusting Supervisor experienced in performance of this Work and licensed at the State in which the Project is located.

F. Reports shall be certified by a AABC Certified Test and Balance Engineer or NEBB Certified Testing, Balancing and Adjusting Supervisor experienced in performance of this Work.

3.02 EXAMINATION

A. Review the contract documents and existing conditions for appurtenances and arrangement for balancing prior to the installation of any equipment or material. the Contractor shall notify Architect of any omissions noted within 30 days of the Contractor's notice to proceed.

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.
3. Proper thermal overload protection is in place for electrical equipment.
4. All filters are clean and in place. If required, install temporary media in addition to filters.
5. Duct systems are clean of debris.
6. Fans are rotating correctly.
7. Fire and volume dampers are in place, accessible, operable and open. Report observation on test report.

8. Smoke dampers are in place, damper and operator are accessible, damper is operable, and open. Report observation on test report.
9. All dampers and operators function smoothly from shut-off to full open.
10. Air coil fins are cleaned and combed.
11. Access doors are installed at specified components are accessible, 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.

3.03 PREPARATION

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

B. Testing of equipment shall be simultaneous where components of a systems are connected; e.g. DX coil and condensing unit.

3.04 ADJUSTMENT TOLERANCES

A. Air Handling Systems: Adjust to within plus or minus 5 percent of design for supply systems and plus or minus 10 percent of design for return and exhaust systems.

B. Air Outlets and Inlets: Adjust total to within plus 5 percent and minus 5 percent of design to space. Adjust outlets and inlets in space to within plus or minus 10 percent of design.

C. Laboratory Spaces:
   1. Air Inlets: Adjust total to within plus 5 percent and minus 0 percent of design to space. Adjust inlets in each space to within plus 5 percent or minus 10 percent of design.
   2. Fume Hoods: Adjust for 100 FPM average face velocity with the sash at 18 inches above the work surface.
   3. Air Outlets: Adjust total to within plus 0 percent and minus 5 percent of design to space. Adjust outlets in each space to within plus 5 percent or minus 10 percent of design.
   4. Ensure tolerances result in airflow from the corridors or adjacent non-laboratory spaces into each laboratory.

D. Building Pressure: Ensure that installation tolerances result in each floor of the building being positively pressurized with respect to outside ambient pressure.

E. Hydronic Systems: Adjust to within plus or minus 10 percent of design.

3.05 RECORDING AND 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. Mark on drawings the locations where traverse and other critical measurements were taken and cross reference the location in the final report.

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

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

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

G. Duct pressure tests shall be reviewed and accepted prior to installing insulation.

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. Close openings after measurement with permanent manufactured plugs.

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 the extent 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 by drive sheave adjustment. Provide drive changes required to place belt in mid-position at final RPM. 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 pressure drops at all components including filters and fans, 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. Adjust operators on outside air dampers to ensure tight seal when shut.

J. Measure temperature conditions across outside air, return air, and exhaust dampers to check leakage.

K. The differential at the time of balance between the outside and return air streams shall be 15 degrees F, minimum, when the outside air quantities are established by temperature differential.

L. 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.

M. Measure building static pressure and adjust supply, return, and exhaust air systems to provide required relationship between each to maintain positive building pressure near the building entries under all operational sequences.

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 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.

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 COMMISSIONING

A. Perform prerequisites prior to starting commissioning activities.

B. Perform Prefunctional Checklists for:

1. Air side systems.
2. Water side systems.

C. Fill out Prefunctional Checklists for:
1. Air side systems.
2. Water side systems.

D. Furnish to the Commissioning Authority, upon request, any data gathered but not shown in the final TAB report.

E. Re-check minimum outdoor air intake flows and maximum and intermediate total airflow rates for 50 percent of the air handlers plus a random sample equivalent to 25 percent of the final TAB report data as directed by Commissioning Authority.
1. Original TAB agency shall execute the re-checks, witnessed by the Commissioning Authority.
2. Use the same test instruments as used in the original TAB work.
3. Failure of more than 10 percent of the re-checked items of a given system shall result in the rejection of the system TAB report; rebalance the system, provide a new system TAB report, and repeat random re-checks.
4. For purposes of re-check, failure is defined as follows:
a. Air Flow of Supply and Return: Deviation of more than 10 percent of instrument reading.
b. Minimum Outside Air Flow: Deviation of more than 20 percent of instrument reading; for inlet vane or VFD OSA compensation system using linear proportional control, deviation of more than 30 percent at intermediate supply flow.
c. Temperatures: Deviation of more than one degree F.
d. Air and Water Pressures: Deviation of more than 10 percent of full scale of test instrument reading.
e. Sound Pressures: Deviation of more than 3 decibels, with consideration for variations in background noise.
5. For purposes of re-check, a whole system is defined as one in which inaccuracies will have little or no impact on connected systems; for example, the air distribution system served by one air handler or the hydronic chilled water supply system served by a chiller or the condenser water system.

F. In the presence of the Commissioning Authority, verify that:
1. Final settings of all valves, splitters, dampers and other adjustment devices have been permanently marked.
2. The air system is being controlled to the lowest possible static pressure while still meeting design loads, less diversity; this shall include a review of TAB methods, established control setpoints, and physical verification of at least one leg from fan to diffuser having all balancing dampers wide open and that during full cooling of all terminal units taking off downstream of the static pressure sensor, the terminal unit on the critical leg has its damper 90 percent or more open.
3. The water system is being controlled to the lowest possible pressure while still meeting design loads, less diversity; this shall include a review of TAB methods, established control setpoints, and physical verification of at least one leg from the pump to the coil having all balancing valves wide open and that during full cooling the cooling coil valve of that leg is 90 percent or more open.
4. The building pressure control sequences operate as specified through a range of CFMs and maintain the building positive under all conditions.
5. Adjust air system economizer operation for stable damper operation and ensure that operation does not open building doors.

3.09 CONTROL SYSTEM PROCEDURE

A. Low Limit Thermostats, Fire Thermostats, Smoke Detectors and other Safety devices: Test and verify operation. Record setpoint.

B. Sequence of Operation: Operate systems thru specified Sequence and confirm system function.

C. Thermostats, Input/Output sensors and Controls: Measure temperature or flow at device and record measurement and setting of controller.

D. Flow Rate Transducers: Calibrate flow meters. Confirm accuracy of flow meter by testing thru a four point operating range.

E. Airflow Measuring Stations: Calibrate flow measuring station. Confirm accuracy by testing thru a four point operating range.

F. Humidistats, Humidity Input/Output sensors and Controls: Measure temperature and relative humidity at device and record measurement and setting of controller.

3.10 BALANCE UNDER SEASONAL OPERATING CONDITIONS

A. After the initial balance has been completed, reviewed and accepted; the contractor shall balance and adjust the system under seasonal operating conditions by performing operational tests over a minimum period of eight hours under both cooling and heating conditions.

B. These tests shall be performed only after each piece of equipment has been individually tested, and is verified to be in correct operating condition, and shall be made at times when outdoor dry bulb temperatures are above 85 F for cooling, or below 50 F for heating.

C. When test is run during the cooling cycle the building must be occupied, and all lights shall be turned on for a minimum of six (6) hours. Doors to all spaces shall be closed and all space thermostats set at its normal setpoint.

D. Purpose: Prove correctness of installation; prove functioning of capacity and safety controls; prove calibration of operating controls; and prove stability of operation under actual loading conditions.

3.11 SCOPE

A. Test, adjust, and balance the following:
1. Fans, Powered Ventilators and Exhausters
2. Air Terminal Units.
3. Airflow Measuring Stations
4. Air Inlets and Outlets.

3.12 MINIMUM DATA TO BE REPORTED

A. 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.

B. 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.

C. Air Moving Equipment:
1. Location.
2. Manufacturer.
3. Model number.
4. Serial number.
5. Arrangement/Class/Discharge.
6. Air flow, specified and actual.
7. Wide Open Airflow test: airflow and static pressure with all terminals open to 100% design airflow.
8. Return air flow, specified and actual.
9. Outside air flow, specified and actual.
10. Total static pressure (total external), specified and actual.
11. Inlet pressure.
12. Discharge pressure.
13. Sheave Make/Size/Bore.
14. Number of Belts/Make/Size.
15. Fan RPM.
16. Describe filter condition.
17. Plot actual fan operating point on fan curve chart.
18. For heat wheel, provide concurrent entering and leaving dry-bulb and wet-bulb for each airstream.

D. 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.
12. Plot actual operating point on pump curve chart.

E. 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.

F. Airflow Measuring Stations:
1. Identification/location.
2. System.
3. Size.
4. Area.

5. Design velocity.
6. Design air flow.
7. Test velocity.
8. Test air flow.

G. Air 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 at 1 foot upstream of unit inlet
12. Fan-powered units:
    a. Supply air temperature leaving FPU when air valve is at maximum design flow.
    b. Coincident (with LAT measurement) entering air temperature to air valve.
    c. Fan static pressure - discharge of unit.
    d. Fan speed setting

H. 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.
11. Relative position of balancing damper

I. Space Temperature and Humidity:
1. Temperature and humidity (whether controlled or not) of each conditioned space
2. Setpoint of each controlling thermostat or humidity sensing device.

END OF SECTION