SECTION 230593 - TESTING, ADJUSTING, AND BALANCING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

B. Division 23 Section "Common Work Results for HVAC"

1.2 SUMMARY

A. This Section includes testing, adjusting, and balancing (TAB) of mechanical systems.

1.3 SUBMITTALS

A. Qualification Data: Within 30 days from Contractor's Notice to Proceed, submit 2 copies of evidence that TAB firm and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.

B. Certified TAB Reports: Submit two copies of reports prepared, as specified in this Section, on approved forms certified by TAB firm. Warranties specified in this Section.

C. Use standard forms from AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems." NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems." SMACNA's TABB "HVAC Systems - Testing, Adjusting, and Balancing." TAB firm's forms approved by Architect. TABB "Contractors Certification Manual."

1.4 QUALITY ASSURANCE

A. TAB Firm Qualifications: Perform all work in accordance with AABC, TABB, or NEBB procedures.

B. TAB Report Forms: Use standard forms from AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems" or NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems".

C. Instrumentation Type, Quantity, and Accuracy: As described in AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems or NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems," Section II, "Required Instrumentation for NEBB Certification."

D. Instrumentation Calibration: Calibrate instruments at least every six months or more frequently if required by instrument manufacturer. Keep an updated record of instrument calibration that indicates date of calibration and the name of party performing instrument calibration.

1.5 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 TAB activities.

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

C. Perform TAB after leakage and pressure tests on air and water distribution systems have been satisfactorily completed.

PART 2 - GENERAL

2.1 EXAMINATION AND PREPARATION

A. Prior to commencing testing adjusting and balancing of environmental systems, verify the following HVAC Operational Readiness conditions, if deficiencies are evident, submit Deficiency Report to Architect. Do not begin testing, adjusting, and balancing of environmental system until deficiencies have been remedied.

B. Mechanical contractor shall prepare the systems as required by the Section 230500 Paragraph “Test Adjust and Balance Readiness”.

C. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

2.2 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Perform testing and balancing procedures on each system according to the procedures contained in AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems" NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" SMACNA's TABB "HVAC Systems - Testing, Adjusting, and Balancing" 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 insulation Specifications for this Project.

C. Mark equipment and balancing device settings with paint or other suitable, permanent identification material, including damper-control positions, valve position indicators, and similar controls and devices, to show final settings. Permanently and legibly identify the location points of duct test ports. If the ductwork has exterior insulation, the identification shall be made on the exterior side of the insulation. All penetrations through ductwork and ductwork insulation shall be sealed to prevent air leaks and maintain integrity of vapor barrier.

D. Report on noise problems to the Contractor, A/E, and Owner which are discovered during balancing.

E. Existing Systems T-A-B

1. Perform a preconstruction inspection of existing equipment that is to remain and be reused.

a. EF-45 existing dishwasher fan

2. Report on the operating condition of the equipment and the results of the measurements taken. Report deficiencies.
3. Before performing testing and balancing of existing systems, inspect existing equipment that is to remain and be reused to verify that existing equipment has been cleaned and refurbished.
4. Perform testing and balancing of existing systems to the extent that existing systems are affected by the renovation work.
5. Compare the indicated airflow of the renovated work to the measured fan airflows and determine the new fan, speed, filter, and coil face velocity.
6. Verify that the indicated airflows of the renovated work result in filter and coil face velocities and fan speeds that are within the acceptable limits defined by equipment manufacturer.
7. T-A-B procedures for various HVAC systems shall be in accordance with the specification hereinafter.

2.3 TOLERANCES

A. Set HVAC system airflow and water flow rates within the following tolerances:

1. Fans: -5% to +10%
2. Supply Air Outlets: 0% to +10%.
3. Exhaust/Return Air Inlets: -10% to 0%

2.4 FINAL REPORT

A. The TAB activities described shall culminate in a report neatly typed and arranged. Include with the data the date tested, personnel present, and a list of all measurements taken. The intent of the final report is to provide a reference of actual operating conditions for the Owner’s operations personnel.

B. Include a list of instruments used for procedures, along with proof of calibration. Include instrument calibration report data: instrument type and make, serial number, application, dates of use, and dates of calibration.

C. Final Report Contents: In addition to 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 Shop Drawings and Product Data.

D. General Report Data: In addition to form titles and entries, include the following data in the final report, as applicable:

1. Title page.
2. Name and address of TAB firm.
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 TAB firm who certifies the report.

10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
11. Summary of contents including the following: Indicated versus final performance, Notable characteristics of systems; Description of system operation sequence if it varies from the Contract Documents.
12. Nomenclature sheets for each item of equipment.
13. Notes to explain why certain final data in the body of reports varies from indicated values.

E. Provide report data for procedures described herein.

PART 3 - TAB PROCEDURES

3.1 PROCEDURES FOR MOTORS – THIS APPLIES TO ALL HVAC SYSTEM MOTORS

A. Motors, 1/2 HP and Larger: Test at final balanced conditions and record the following data:

1. Manufacturer, model, and serial numbers.
2. Motor horsepower rating.
3. Motor rpm.
4. Efficiency rating.
5. Full-load amperage and service factor.
6. Nameplate and measured voltage, each phase.
7. Nameplate and measured amperage, each phase.
8. Starter thermal-protection-element rating.

B. Motors Driven by Variable-Frequency Controllers: Test for proper operation at speeds varying from minimum to maximum. Record observations, including controller manufacturer, model and serial numbers, and nameplate data. Adjust VFDs to skip critical frequencies.

3.2 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

A. System Diagrams: Include schematic layouts of as-built air distribution systems. Present each system with single-line diagram and include the following:

1. Quantities of outside, supply, return, and exhaust airflows.
2. Duct, outlet, and inlet sizes.
3. Terminal units.
4. Volume dampers.

B. Test and adjust fan RPM to design requirements. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.

C. Test and record motor full load nameplate rating and actual ampere draw.

D. Test and record system static pressures, fan suction, and discharge; static pressure across each component that makes up an air system. Measure static pressures entering and leaving other devices under final balanced conditions.

E. Compare design data with installed conditions to determine variations in design static pressures versus actual static pressures. Compare actual system effect factors with calculated system effect factors to identify where variations occur.

F. Recommend corrective action to align design and actual conditions. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload will occur. Measure amperage in all operating modes to determine the maximum required brake horsepower.

G. Adjust all main supply and return air duct to within tolerances of proper design CFM. Make air velocity measurements in ducts by Pitot tube traverse entire cross sectional area of duct in accordance with SMACNA equal area method or Log Linear method. Measure static pressure at a point downstream from the balancing damper and adjust volume dampers until the proper static pressure is achieved. Where sufficient space in sub-main and branch ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow for that zone. Re-measure each sub-main and branch duct after all have been adjusted. Continue to adjust sub-main and branch ducts to indicated airflows within specified tolerances.

H. Test and adjust each diffuser, grille, and register. Reading and tests of diffusers, grilles, and registers shall include design CFM and adjusted CFM.

I. Adjust patterns of adjustable outlets for proper distribution without drafts.

J. In coordination with the ATC contractor, set adjustments of automatically operated dampers to operate as specified, indicated and/or noted.

K. Adjust outside air automatic and manual dampers for design conditions within specified tolerances.

L. Air-Handling Unit Test Reports: For air-handling units, include the following:

1. Test conditions for fan performance forms including the following:

    a. Settings for outside-, return-, and exhaust-air dampers.
    b. Conditions of filters.
    c. Fan drive settings including settings and percentage of maximum pitch diameter.
    d. Settings for supply-air, static-pressure controller.
    e. Other system operating conditions that affect performance.

2. 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.

3. Motor Data: as specified hereinbefore.
4. Test Data (Indicated and Actual Values):

    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. Coil static-pressure differential for each coil in inches wg.
g. Outside airflow in cfm.
h. Return airflow in cfm.
i. Outside-air damper position.
j. Return-air damper position.
k. Fan VFD Hz.

M. Fan Test Reports:

1. Fan Data:

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.
i. Number of belts, make, and size.

2. Motor Data: as specified hereinbefore.
3. Test Data (Indicated and Actual Values):

a. Total airflow rate in cfm.
b. Total system static pressure in inches wg.
c. Fan rpm.
d. VFD Hz.
e. Discharge static pressure in inches wg.
f. Suction static pressure in inches wg.

N. Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:

1. Report Data:

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. Indicated airflow rate in cfm.
h. Indicated velocity in fpm.
i. Actual airflow rate in cfm.
j. Actual average velocity in fpm.
k. Barometric pressure in psig.

3.3 PROCEDURES FOR DOMESTIC HOT WATER RECIRCULATION SYSTEMS

A. Prepare test reports with pertinent design data and number in sequence starting at pump to end of system.

B. System Diagrams: Include schematic layouts of as-built domestic hot water systems. Present each system with single-line diagram and include the following:

1. Water flow rates.
2. Pipe and valve sizes and locations.
3. Recirculation valve settings/flows

C. Balancing shall include the following minimum data:

1. Pump flow
2. Balancing valve flows: proportionally balance flow to each recirculation loop.

D. Pumps:

1. Adjust balancing valves at pumps to obtain design water flow. Record pressure rise across pumps and GPM flow from pump curve. Permanently mark the balanced position for each valve. (Note: If discharge valves on the pumps are used for balancing, record the head being restricted by the valves).
2. Do not deadhead the pumps. Check pump-motor load. If motor is overloaded, throttle main flow-balancing device so motor nameplate rating is not exceeded. Running amps and brake horsepower of pump motor under full flow and no flow conditions.
3. Calculate impeller size by plotting the shutoff head on pump curves and include the following pump test report data:
4. Unit Data:

    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. Pump rpm.
    i. Impeller diameter in inches.
    j. Motor Data: as specified herein before.

5. Test Data (Indicated and Actual Values):

    a. Static head in feet of head or psig.
    b. Pump shutoff pressure in feet of head or psig.
    c. Full-open flow rate in gpm.
    d. Full-open pressure in feet of head or psig.
    e. Final discharge pressure in feet of head or psig.
    f. Final suction pressure in feet of head or psig.
    g. Final total pressure in feet of head or psig.
    h. Final water flow rate in gpm.
    i. Voltage at each connection.

3.4 PROCEDURES FOR EXHAUST HOODS

A. Commercial Kitchen Hoods

1. Measure, adjust, and record the airflow of each kitchen hood. For kitchen hoods designed with integral makeup air, measure and adjust the exhaust and makeup airflow. Measure airflow by duct

Pitot-tube traverse. If a duct Pitot-tube traverse is not possible, provide an explanation in the report of the reason(s) why and also the reason why the method used was chosen.

2. The sheet metal contractor will provide welded test ports with caps in the exhaust duct for the duct Pitot tube traverse. Coordinate required locations with the sheet metal contractor.
3. After balancing is complete, do the following:

    a. Measure and record the static pressure at the hood exhaust-duct connection.
    b. Measure and record the hood face velocity. Make measurements at multiple points across the face of the hood. Perform measurements at a maximum of 12 inches between points and between any point and the perimeter. Calculate the average of the measurements recorded. Verify that the hood average face velocity complies with the Contract Documents and governing codes.
    c. Check the hood for capture and containment of smoke using a smoke-emitting device. Observe the smoke pattern. Make adjustments to room airflow patterns to achieve optimum results.

4. Visually inspect the hood exhaust duct throughout its entire length in compliance with authorities having jurisdiction. Begin at the hood connection and end at the point it discharges outdoors. Report findings.

    a. Check duct slopes as required.
    b. Verify that duct access is installed as required.
    c. Verify that point of termination is as required.
    d. Verify that duct air velocity is within the range required.
    e. Verify that duct is within a fire-rated enclosure.

5. Report deficiencies.

3.5 TESTING OF BUILDING AUTOMATION SYSTEMS

A. Assist the BAS Contractor as follows:

1. Work with the Temperature Control Contractor to ensure the most effective total system operation is within the design limitations, and to obtain mutual understanding of intended control performance.
2. Measure exhaust fan CFM and Hz. Coordinate with Section 230993.

END OF SECTION 230593