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BuildingName
The Description of the Project
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SPECIFICATION DIVISION 23

NUMBER SECTION DESCRIPTION

DIVISION 23
SECTION 230593 - TESTING, ADJUSTING AND BALANCING (TAB)

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DIVISION 23 HEATING, VENTILATING AND AIR CONDITIONING (HVAC)
SECTION 230593 - TESTING, ADJUSTING AND BALANCING (TAB)

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, Standard General and Supplementary General Conditions, Division 1 Specification Sections, and other applicable Specification Sections including the Related Sections listed below, apply to this Section.

B. Related Sections

1. Section 230910: Laboratory Air Flow Controls - DDC
2. Section 230920: Laboratory Air Flow Controls - Analog

1.2 SCOPE OF WORK:

A. Adjust and balance the following systems:

1. Supply air systems
2. Return air systems
3. Exhaust air systems
4. Hydronic systems
5. Domestic hot water systems

B. Conduct the following systems testing:

1. Sound testing
2. Vibration testing
3. Fume hood testing
4. Equipment Performance Testing for the following equipment: (none)

C. Hydronic Balancing shall include as a minimum all devices for which a GPM is indicated in the plans, schedules or specifications.

D. Air Balancing shall include as a minimum all devices for which a CFM is indicated in the plans, schedules or specifications.

E. Testing, Adjusting and Balancing Reports, as detailed in part 3.

1.3 QUALITY ASSURANCE:

A. The Contractor shall obtain the services of an independent (third party) Test, Adjust and Balance (TAB) Contractor.

B. Air balance and water balance shall be done by the same Test and Balance Contractor.

C. Testing and balancing shall be performed in accordance with standards of either AABC ("National Standards for Field Measurement and Instrumentation - Total System Balance", Current Volume and Supplements,) or NEBB ("Procedural Standards for Testing, Adjusting and Balancing of Environmental Systems"), and ASHRAE Standard 111-1988.

D. The TAB supervisor shall be currently certified under the requirements of either NEBB or AABC, and shall directly supervise the project TAB activities. Supervisors shall be certified in all areas germane to the project's work scope: air, hydronic, fume hood and sound/vibration testing. Sound and vibration testing may be subcontracted to other qualified firms as approved by the Engineer.

E. Test equipment accuracies shall be no less than recommended by NEBB or AABC; provide higher accuracy test equipment if dictated by project needs. Test equipment shall have been calibrated within the time intervals recommended by NEBB or AABC, but in all cases shall have been calibrated within the last year.

1.4 ACCEPTABLE BALANCING CONTRACTORS:

A. The following are the only acceptable balancing companies:

1. Air Flow Testing
2. Enviro-Aire/ Total Balance, Inc.
3. Aerodynamics Inspecting Co.

1.5 SUBMITTALS

A. Provide the following for approval:

1. Test instrument list including the following information:
   a. Instrument type and accuracy
   b. Instrument manufacturer and model number
   c. Instrument serial number
   d. Copy of current calibration certificate
2. Proof of TAB supervisor certification.
3. Resume of the TAB supervisor and of all TAB technicians proposed for the project.
4. Proposed reporting forms for each TAB procedure.

1.6 SEQUENCING AND SCHEDULING:

A. Where performance testing is specified, equipment and systems must be tested under conditions that are near design conditions. Various components and systems shall be tested in summer or winter design conditions to accurately reflect specified conditions.

1.7 WARRANTY:

A. For a period of 90 days after the acceptance of the balancing report, the TAB contractor shall recheck or reset any part of any system to meet the Owner's needs, where these variations are within the capabilities of the equipment.

PART 2 - PRODUCTS

2.1 NOT APPLICABLE.

PART 3 - EXECUTION:

3.1 PREPARATION

A. Pre-Balancing Conference: Prior to the pre-balance conference, inspect system readiness for testing, adjusting, and balancing (TAB). Prepare and submit a list of system deficiencies. Afterwards, meet with the Project Engineer, Commissioner and contractors to resolve system deficiencies, to verify TAB procedures and system readiness for TAB, and to coordinate TAB activities and schedule.

B. Coordinate testing, adjusting and balancing of fume hood exhaust systems with U-M OSEH.

C. Phased Construction: Coordinate TAB procedures with any phased construction requirements for the project so that usable increments of finished work may be accepted for beneficial occupancy. Systems serving partially occupied phases of the project may require balancing for each phase prior to final balancing.

D. Scheduling: Identify to the contractor anticipated durations for TAB work, and what items must be complete prior to proceeding with TAB work. Allow sufficient time in the construction schedule for TAB prior to final project inspection.

E. Conduct final TAB after system has been completed and is in full working order. Prior to completing balancing, inspect and test systems and components to verify proper installation and operation, including but not be limited to:

1. Verify strainers and filters are installed and clean.
2. Verify motor and equipment rotation, lubrication and alignment.
3. Align belts and pulleys. Adjust tension.
4. Check operation of all automatic valves and dampers.
5. Check position of isolation valves and dampers.
6. Verify air has been vented from hydronic systems.

F. In cooperation with other contractors, correct deficiencies.

3.2 TESTING, ADJUSTING AND BALANCING - GENERAL REQUIREMENTS:

A. Notify Commissioner and / or University Project Engineer when testing and balancing activities are commencing.

B. Immediately notify the Commissioner and University Project Engineer when any deficiencies are detected, whether associated with design, installation, or equipment.

C. Properly repair any damage to mechanical systems resulting from TAB procedures, e.g. patch duct test holes, repair pipe insulation, etc.

D. TAB contractor shall provide all required tools and equipment necessary to perform TAB services. Take measurements with certified and calibrated devices. Do not use field installed sensors and gauges.

1. Exception: Magnetic flow meters may be utilized for flow measurements when available. However, the TAB contractor shall make secondary checks such as pump pressure readings and shall indicate the results of those tests in the TAB report.

E. Take air and hydronic measurements on equipment at the same time, e.g. take air handler coil water flow data at the same time as air handler air side data.

F. Measure the total air and water flow rate of each system and each major system component.

G. Coordinate work with the building controls contractor(s).

H. Measure motor and equipment speed (RPM) with strobe tachometer. Record full load and part load slippage, and calculate motor brake horsepower (BHP) using BHP= nameplate HP x (part load slip / full load slip).

3.3 AIR BALANCING - GENERAL REQUIREMENTS:

A. Place systems in operation with filters installed and control systems complete and operating. Temporarily block filters to simulate dirty filter pressure drop (obtain dirty filter pressure drop from drawing schedules. If not stated, contact design engineer to obtain). Balance systems to design ratings. Adjust each air terminal unit, inlet and outlet to 100% - 110% of design requirements, but total air for each system shall be not less than shown.

B. Check flow rates for all factory set air terminal units and reset if not correct.

C. Adjust fan speeds by adjusting or replacing sheaves and belts. If replacement is required, follow project change order procedures and obtain authorization prior to proceeding.

D. Set supply fan static pressure as low as practicable while maintaining required pressure at the most aerodynamically remote terminal units.

E. Record pressure drop readings across all major system components and significant drops within duct systems.

F. Verify the calibration of air flow measuring stations by taking traverse readings across associated ducts.

G. For fans equipped with variable speed drives, set the drive to 60 hertz and measure motor and fan RPM to validate that, at the maximum drive speed setting, the fan rotates at the maximum design fan speed. The maximum design fan speed shall be as indicated on the approved fan curve. Assure that running the fan at maximum design speed will not cause any damage prior to making this test.

H. Label all diffusers, chilled beams, registers and grilles with clear plastic adhesive labels indicating air flow rate, terminal unit number and outlet number corresponding to the balance report. Similarly label VAV boxes with terminal unit number and min./max. CFM, affixing label to ceiling grid or access panel at box location. Use nominal 3/16” high black block-style font.

3.4 AIR BALANCING - CONSTANT VOLUME SYSTEMS:

A. Adjust fan speed to minimize wasted horsepower and noise at throttled balancing dampers.

B. Verify each CAV box or zone for proper control: normally open or normally closed position, and type of control.

3.5 AIR BALANCING - VARIABLE VOLUME SYSTEMS (INCLUDING CAV AND VAV BOXES):

A. Balance systems to minimize throttling loses and to optimize (reduce to lowest possible) end-of-line (E-O-L) differential pressure set points. Prior to beginning balancing, meet with the project Commissioner and agree to the exact procedures to be followed. Set static pressure set points to ensure the most hydraulically remote terminal unit can achieve design flow. Measure flow at each terminal unit individually to verify scheduled design flow is achieved at the lowest possible differential pressure set point. Reset E-O-L set point and re-measure flow at each terminal unit until the lowest E-O-L set point is achieved. For DDC systems, coordinate with DDC programmer to optimize E-O-L set point where the sum of the loads exceeds system capacity, the ratio of capacity/loads is defined as the system diversity factor. Calculate diversity factor and indicate calculated diversity factor in the balance report. Adjust belts and sheaves to achieve design flow. Test maximum equipment capacity with all boxes forced open to design maximum CFM. Document design diversity, actual diversity, E-O-L set point, and fan volume. Show all calculations

B. Verify each VAV box for proper control: normally open or normally closed position, and type of control.

C. Check each individual VAV box for minimum and maximum flow. Calibrate boxes as required to meet design CFMs. For electronically controlled boxes, check and correct correction factor at each box. Coordinate with the DDC programmer.

D. Check supply and return fan tracking and assure compliance with design requirements.

3.6 AIR BALANCING - ROOM PRESSURIZATION VERIFICATION:

A. Perform room pressurization verification on all systems where drawings indicate a pressure relationship between rooms based on a differential in supply, return and exhaust cfm. Test systems in each operational mode (e.g. close fume hood sashes, change room temperature set point, etc.) and verify that correct air flow direction at doorways and correct CFM offset between terminal units is maintained in any mode. Indicate if the room “passed” in the air balance report. In all cases, record room pressurization in cfm differential. Verify that all architectural patching of penetrations has been completed. Conduct final testing and balancing with all doors closed. Coordinate work with Laboratory Controls Contractor.

1. For room pressurization designed with cfm offset:
   a. Balance air flow to all terminal units.

b. Verify the room pressure relationships implied by scheduled cfm. Smoke stick test all rooms and record results.

2. For room pressurization designed with controlled differential pressure offset:
   a. Balance air flow to all terminal units.
   b. Verify room pressure relationships. Document offset achieved in inches w.c. at design set points.
3. For room pressurization systems with adjustable or reversible controls: Verify room pressure relationships with controls set in both the positive and the negative direction. Test at maximum offsets and document offsets achieved in inches w.c. Set at design offset (if indicated) and document offset achieved in inches w.c.
4. For room pressurization designed with visual indicators (Ping-Pong balls or similar devices): Verify correct function of the visual indicators in each operational mode.

3.7 AIR BALANCING - AIR HANDLING EQUIPMENT AND SYSTEMS:

A. Test air handling units, exhaust and return fans, and associated automatic dampers in all modes of operation. Determine the most restrictive operating mode and balance systems in this mode.

B. In addition to values listed in ASHRAE Standard 111-1988, the following shall also be measured and reported:

1. Minimum and maximum outdoor air quantities. (Include setting minimum outside air where applicable.)
2. Power factor or watts for motors larger than 10 HP
3. Component air pressure drops, including across open dampers.

C. Record actual motor amps, volts, and rpm, and fan flow, static pressure and rpm.

D. Check all equipment motors, belts, drives, bearings, filters.

E. Check supply and return fan tracking/offset by traverse duct measurements and validate compliance with design requirements.

F. For new air handling units, fan coils, or any other air handling equipment equipped with a condensate drain: In conjunction with the commissioner, test cooling coil condensate drain and trap performance. Artificially load filters to simulate dirty filter conditions. Verify drain pan does not overflow, and air does not blow by trap.

G. Units equipped with air-to-air heat exchangers: Take measurements up and downstream of heat exchangers and calculate the leakage rate between the supply and exhaust/return sides of the unit to validate that leakage rates do not exceed design values. Measure leakage rates at design air flow volumes (producing corresponding pressure differentials), with filters blocked to simulate dirty filter pressure drop. For rotary heat exchangers, take air flow measurements with rotor rotating at maxumim speed. Take air flow measurements after duct leak testing has successfully passed, as close to units as possible to limit impacts from duct leakage, but at locations that allow accurate measurement.

3.8 AIR BALANCING - LABORATORY SYSTEMS:

A. Test, adjust and balance laboratory air systems, including all laboratory terminal airflow units, fume hoods, bio-safety cabinets (exhausted, or partially exhausted type), snorkels, chemical cabinets, canopy hoods, etc.

1. All adjustments to Lab Terminal Airflow Units (LTAUs) shall be done by the Laboratory Controls Contractor, not the TAB contractor. TAB contractor shall take flow readings to verify the accuracy of these devices, only.

B. Test supply and exhaust tracking through full system performance range. Record room pressurization in cfm differential. Correlate to room air balancing plan.

1. Verify the LTAU air flow against that reported by the LTAU controller at the following points: design minimum and maximum CFM.
2. Measure differential pressure across the LTAU during each CFM verification measurement.
3. Record air flow measured, air flow reported by LTAU controller, and differential pressure across the LTAU, for each verification point. In heavy black permanent marker, mark this data on the LTAU near the mfr.'s data.

C. Fume Hoods: In conjunction with U-M OSEH and the laboratory air flow controls contractor:

1. Adjust the fume hood terminal air flow unit to achieve the design fume hood face velocity with the sash set at the sash stop position.
2. Measure the face velocity at sash stop position and at the fully open sash position.
3. Verify operation of the fume hood alarm monitor (sash at sash stop position) by temporarily reducing air flow through the hood until the alarm set point indicated on the design drawings is achieved.
4. Measure the hood face dimensions (sash at sash stop) and include this info along with the calculated face area and calculated face velocity in the balance report.

D. Lab Exhaust Fans:

1. Test operation of bleed-in dampers.
2. Measure total exhaust air flow from the building to each exhaust fan/fan plenum.
3. Test every fan on plenumized fan systems.

E. Gas Cabinets:

1. Balance exhaust to achieve an average face velocity at the face of gas cabinet access ports or windows (while open) of not less than 200 FPM, and a minimum velocity of 150 FPM at any point at the face of the access port or window.

3.9 HYDRONIC BALANCE - GENERAL REQUIREMENTS

A. Perform final hydronic balance after all systems have been flushed, cleaned, and filled.

B. Test hydronic systems in all modes of operation. In general, balance systems in the most restrictive operating mode.

C. Hydronic balance includes performance readings (flow, pressures, temperatures) on all pumps, coils, heat exchangers, and flow measuring devices. For coils 3 gpm or less at terminal units, record flows only. Adjust pump flows to actual system heads by adjusting balancing valves (constant volume systems). Flow measuring devices take precedence over pump head readings. Record discrepancies for evaluation. Provide pump head and flow (i.e. flow determined from shut off head, operating head and pump curve) and flow measuring device data.

D. Report pressure drop readings across all major system components both for flow determination and for deviations between actual and design values.

E. Record the pressure drop across water filtering devices.

F. Where Y or basket strainers are equipped with inlet and outlet pressure gauges, record the pressure drop.

G. Record (on flow diagrams) the flows and pressures obtained in each of the various circuits and modes of operation. Measure flows in parallel pumping systems when operating independently and jointly.

H. Adjust and set the memory stop for each balancing valve.

I. For auto-balancing valves, record differential pressure with auto-balancing valve throttling against maximum flow mode. .

J. For 3-way control valves, balance “bypass” flow to match “through” flow.

K. In general, balance variable flow systems to achieve design flow at all units simultaneously. Where the sum of the loads exceeds system capacity, the ratio of capacity/loads is defined as the system diversity factor. Calculate diversity factor and indicate calculated diversity factor in the balance report. Balance variable flow systems to minimize throttling loses and to optimize (reduce to lowest possible) differential pressure set points. Prior to beginning balancing, meet with the project Commissioner and agree to the exact procedures to be followed. Set static pressure set points to ensure the most hydraulically remote load can achieve design flow. Measure flow at each load individually to verify scheduled design flow is achieved at the lowest possible differential pressure set point. Reset and re-measure flow at each load until the lowest differential pressure set point is achieved. Verify that no control valve “lifts” at the final differential pressure set point, by closing all other control valves, allowing the controls to settle to the differential pressure set point, and then verifying the valve remains fully closed. Record the final differential pressure set point in the TAB report. Throttle balance valves at loads only as required to obtain accurate flow data; generally balance valves should otherwise be left fully open. (Exception: throttle balance valves at stacked coil sections (or similar arrangements)to provide equal flow to each coil in the stack.)For DDC systems, coordinate with DDC programmer to optimize differential set point.

3.10 VIBRATION TESTING

A. Perform vibration measurements for all rotating equipment 1/2 horsepower and larger, including compressors, pumps, fans and motors.

B. Inspect vibration isolation system and alignment and report deficiencies.

C. Allowable Vibration Tolerances: Self-excited, vibration maximum velocity shall not exceed the following limits, measured in inches per second RMS (not in mils peak to peak), filter in. Measure vibration at bearing caps of machine in vertical, horizontal and axial directions or at equipment mounting feet if bearings are concealed.

1. Except where noted otherwise: 0.20
2. Pumps: 0.13
3. Centrifugal Compressors: 0.13
4. Fans: 0.09

D. For variable speed equipment, inspect at full range of speeds. Verify the maximum safe speed the system can be run at before beginning tests. Modulate speed from minimum to maximum to test for possible harmonic vibrations. Record vibration at maximum operating speed and at any speed displaying harmonic vibration.

E. Include in the report a summary sheet indicating pass / fail for each unit. For each unit of equipment, record detailed initial measurements, corrections made, retest measurements, and suggested course of action for equipment that still fails limits after contractor correction.

3.11 ACOUSTIC TESTING

A. Conduct acoustic testing with a calibrated sound level meter and octave band analyzer of the accuracy required by AABC or NEBB. Include dBA and individual octave readings. Use current ASHRAE manuals for reference levels, formulas and coefficients.

B. Record sound pressure readings by octave and in weighted dBA scale. Plot dB by octave and calculate RC and NC values. Compare against specified levels indicated on drawings or in specifications.

1. Conduct sound pressure testing:
   a. In six rooms, designated by the Owner/Engineer.
   b. Where RC/NC criteria appears on the drawings.

3.12 PERFORMANCE TESTING

A. Equipment Performance Testing: For the equipment listed, test performance and verify that it meets scheduled capacity. Develop a system specific testing plan for review by the Architect / Engineer and the commissioner. Document all testing procedures, and corrections due to variations in actual testing condition versus scheduled performance.

B. Seasonal Performance Testing: For the systems listed, conduct testing at or near design outdoor conditions. Test, adjust, and balance air conditioning systems during summer season and heating systems during winter season, including at least a period of operation at outside conditions within 5 deg F wet bulb temperature of maximum summer design condition, and within 10 deg F dry bulb temperature of minimum winter design condition. Take final temperature readings during seasonal operation.

3.13 COMPLETION SERVICES

A. Final Check: Make final checks and complete any testing as directed.

B. Acceptance: Final acceptance of the project will not be made until a satisfactory report is received. Owner reserves the right to spot check the report by field verification prior to final acceptance.

3.14 TESTING, ADJUSTING, AND BALANCING REPORT

A. Submit TAB reports in compliance with specifications and the requirements listed below.

B. Submit progress TAB reports within 3 days of balancing *each* air, hydronic, and plumbing system, and more frequently if requested by the project Commissioner. Submit the final TAB report within one week of completing all testing, adjusting and balancing

C. Report all data in inch/pound units.

D. Provide date and time all readings were taken.

E. Include brief system descriptions, deficiencies, corrections made, unresolved problems, and recommendations.

F. Provide as-built schematic sketches for each system indicating all equipment, balancing related components, terminal devices, diffusers, grilles, registers, and valves. Use equipment nomenclature as defined in construction documents. Indicate room numbers, and correlate all devices to the balance report data.

G. Include a list of all testing equipment and devices used, including type, accuracy, manufacturer, model number, serial number, and calibration date.

H. Include definition of all abbreviations and acronyms, and all formulas used in calculations.

I. Provide the outside air dry bulb and wet bulb temperature at the beginning and end of each TAB day, correlated to the day's TAB work.

J. Number all report pages. Tab major sections of the report and provide a report table of contents.

K. Include complete nameplate data for all equipment.

L. Include flows and pressures in all operating modes. Indicate final E-O-L differential pressure set points, and the results of all tests (e.g. smoke stick tests, etc.)

M. Describe TAB procedures used; including procedure used in establishing differential pressure set point for variable speed drive controlled systems.

N. Include performance data for all major equipment, including providing copies of the approved fan curves, pump curves, coil data sheets, flow element curves, and Cv characteristics. This is not required for terminal units 2000 cfm or less.

END OF SECTION 230593