Part 1 General

INTENT

.1 Test, adjust and balance mechanical equipment and systems so that entire system produces the results for which it was designed.

1.2 RELATED SECTIONS

.1	Testing, Adjusting and Balancing:	Division 01.
.2	Contractor Start-Up Report Forms:	Division 01.
.3	Mechanical Operation and Maintenance Data:	Division 01.
.4	Mechanical Operation and Maintenance Manual:	Division 01.
.5	General Mechanical Starting and Testing Requirements:	Section 23 08 13.
.6	Mechanical Equipment Starting and Testing:	Section 23 08 23.
.7	Mechanical Systems Starting and Testing:	Section 23 08 33.
.8	EMCS Start-up and Testing:	Division 25.

1.3 TESTING/ADJUSTING/BALANCING REPORT DATA

.1 Organize balancing data in accordance with AABC - Associated Air Balancing Council, report format. Report data in SI units.

.2 Air Systems: Include both specified and measured data.

.1 Air Handling Equipment:

.1 Maximum air flow volume.

.2 Fan total pressure.

.3 Motor volts, amps and power.

.4 Minimum outside air volume.

.5 Fan rotational speed.

.6 Fan Power, calculate fan efficiency.

.7 Inlet and outlet dry and wet bulb temperatures.

.8 Equipment static pressure profile.

.2 Duct Air Quantities - Mains and Branches:

.1 Duct size.

.2 Number of pressure/velocity readings per traverse.

.3 Sum of velocity measurements.

.4 Average velocity.

.5 Duct air flow volume.

.6 Barometric pressure and duct air temperature.

.3 Air Outlets:

.1 Outlet location and designation.

.2 Manufacturers catalogue identification and type.

.3 Air outlet flow factors. Use 1.0 when flowhood is used.

.4 Air flow volumes.

.5 Deflector vane or diffuser cone settings.

.3 Hydronic Systems: Include both specified and measured data.

.1 Pumps:

.1 Discharge and suction pressures, at design flow and no flow.

.2 Fluid flow rate. Calculate from pump curves if metering not provided.

.3 Motor volts, amps, power.

.2 Heating Equipment:

.1 Equipment type, location and designation.

.2 Fluid used. Identify fluid used; water.

.3 Fluid flow rate.

.4 Fluid Specific Heat, at mean temperature.

.5 Fluid Specific Gravity, at mean temperature.

.6 Fluid entering and leaving temperatures and pressures

.7 Heat transfer rate.

.3 Air Heating Coils:

.1 Coil type and identification, location and designation.

.2 Entering and leaving air dry and wet bulb temperatures.

.3 Air static pressure drop.

.4 Air flow volume.

.5 Barometric pressure.

.6 Air side heat transfer rate.

.7 Fluid used. Identify fluid used; water.

.8 Fluid flow rate.

.9 Fluid Specific Heat, at mean temperature.

.10 Fluid Specific Gravity, at mean temperature.

.11 Fluid entering and leaving temperatures and pressures.

.12 Fluid side heat transfer rate.

.4 Sound Pressure Level Data:

.1 Overall A-weighted Sound Pressure Level readings.

.2 When required, plot octave-band frequency, 63 to 8000 Hz, sound pressure readings on Noise Criteria graph paper to show relationship between measured level and specified NC level.

.3 For outdoor equipment or community noise measurements provide a diagram or description of relationship of sound source to measuring instrument.

Part 2 Products - Not Used

Part 3 Execution

3.1 BALANCING AND ADJUSTING PREPARATION

.1 Perform testing, adjusting and balancing work after equipment and systems starting procedures have been properly completed in accordance with Sections 23 08 23 and 23 08 33.

.2 Perform balancing during heating and cooling season of first year of operation, and at times when directed by Minister, to ensure proper settings of controls under both summer and winter peak load conditions.

.3 Vary load to verify operation of system under partial load conditions. Test start-up, shut-down, emergency conditions, safety controls operation and automatic and manual resets and interlocks.

.4 Perform work using measuring instrumentation conforming to requirements specified in Section 23 08 13.

3.2 GENERAL PROCEDURES

.1 Perform balancing to following accuracy:

.1	Air - terminal outlets	± 10%
.2	Air - central equipment	± 5%
.3	Hydronic - terminal outlets	± 10%
.4	Hydronic - pumps and central equipment	± 5%

.2 Permanently mark settings on splitters, valves, dampers or other adjustment devices.

.3 Subsequent to correcting work, take measurements to verify balance has not been disrupted or that any such disruption has been rectified.

.4 As a prerequisite to the Minister's acceptance of balance report demonstrate random points in balance selected by the Commissioning Facilitator. The Commissioning Facilitator will witness these checks.

3.3 FIRE DAMPER/FIRE STOP FLAP VERIFICATION

.1 Visually inspect all fire dampers/fire stop flaps to verify that:

.1 Installation is straight and level.

.2 Wall angles are properly installed.

.3 Duct has break away connection.

.4 Fire stopping material, where used, is properly installed.

.5 Access is adequate.

.6 Adequate clearance exists between sleeve and wall.

.7 ULC label is visible.

.8 Blades are out of air stream.

.9 Temperature rating of linkages are correct.

.2 Inspect and clean all fire damper blades and tracks prior to function test.

.3 Function test each damper, by detaching fusible link chain. Verify that damper blade drops properly and is tightly sealed within frame. Reset each damper.

.4 If fire damper does not close properly, repair installation and retest.

.5 All fire damper tests shall be witnessed by two parties, certified by Mechanical Sub-Contractor and endorsed by testing personnel.

.6 Write to authority having jurisdiction prior to testing dampers. Invite authority to witness tests as required.

3.4 AIRFLOW MEASURING STATIONS

.1 Measure air flow by duct traverse at five different air volumes equally spaced between design minimum and maximum for each station.

.2 Use EMCS trend logs to record air volume flow during time that each duct traverse is performed. Average trend log readings over this time period.

.3 Compare duct traverse and averaged trend log readings for each of the five air volume measurements taken. Calculate calibration correction equation.

.4 Document each calibration on Minister approved Mechanical Sub-Contractor Start-up Program “Flow Measuring Station Calibration” sheets.

3.5 AIR SYSTEM PROCEDURE

.1 Perform testing, adjusting and balancing only after all suspended ceilings and partitions are complete, with doors and windows in place and closed.

.2 In consultation with the Commissioning Facilitator select duct traverse locations acceptable to all parties. Same transverse locations shall be used for Work of this Section and for Performance Testing by the Commissioning Facilitator.

.3 Compare accuracy of balancing instrumentation with Commissioning Facilitator’s Performance Testing instruments before starting balancing, as follows:

.1 Temperature: bench test temperature instruments at two reference temperatures.

.2 Velocity Pressure: bench test velocity pressure instruments against an inclined manometer, at five readings over range to be used.

.3 Air Velocity: compare readings between instruments at the same five locations in one or more air systems.

.4 Pressure: compare both instruments simultaneously on a common header at five reference pressures over range of pressures to be measured.

.5 Humidity: compare both instruments simultaneously at ambient humidity.

.6 Tachometer: compare both instruments at the driving and driven pulleys on two fans.

.4 Adopt following procedures for central systems:

.1 Test drop and reset all fire dampers.

.2 Verify that dampers and volume control devices are in fully open position.

.3 Initially balance central plant to ± 10% air flow.

.4 Calibrate air flow measuring stations.

.5 Balance mains and branches to ± 10% air flow.

.6 Recheck central plant.

.7 Balance all terminal air outlets to ± 10%.

.8 Rebalance central plant to ± 5%.

.9 Recheck all air outlets.

.10 Measure performance of coils and humidifier.

.11 Measure air pressure change across each component of central plant.

.12 Take sound pressure level readings.

.5 Take air flow measurements in ducts by "Pitot Tube" traverse of entire cross sectional area. Take the number of readings as set out in ASHRAE Fundamentals Chapter 13 "Measurement and Instruments". If readings are inconsistent across duct, relocate by two duct diameters / widths and redo traverse.

.6 Following precedence applies to air flow measuring devices and methodology:

.1 Pitot tube traverses in straight sections of duct have precedence over anemometer or velometer traverses of filters, coils, ducts, etc.

.2 Micromanometer flowhood measurements at air outlets have precedence over anemometer or velometer readings at air outlets.

.3 A pitot tube traverse in a straight duct section at inlet to a variable volume box has precedence over a box air flow sensor reading.

.4 Variable volume box air flow sensor may be used to set up box maximum and minimum air volumes but, unless otherwise agreed with the Minister, the sum of micromanometer flowhood readings at all air outlets has precedence over a box flow sensor reading.

.7 Use volume control devices at air outlets to regulate air quantities only to extent that adjustments do not create objectionable air motion or noise. Effect volume control primarily by duct internal devices such as dampers and splitters.

.8 Vary total system air quantities by adjustment of fan speeds. Vary branch air quantities by damper regulation.

.9 Balance air systems at design minimum supply air temperature.

.10 When balancing constant volume systems:

.1 Rough balance furthest outlet and then balance sequentially back to source,

.2 Fine balance furthest outlet back to source.

.11 Upon completion of balancing, recheck and record data from central Air Handling Unit (refer to Section 23 08 23) including following:

.1 Motor data.

.2 Coil, filter data.

.3 Static pressure profile across all components.

.4 Damper controls.

.12 Final balanced condition of each area shall include testing and adjusting of pressure conditions. Test, adjust and record building and zone pressurization levels. For variable volume systems check pressurization throughout full range of fan delivery for both heating and cooling conditions. Check front doors, exits and elevator shafts for air flow so that exterior conditions do not cause excessive or abnormal pressures. Document abnormal building leakage conditions noted.

.13 Complete balancing to achieve positive building pressure unless otherwise instructed.

.14 Replace sheaves and belts on all air systems to suit the maximum balanced air flows.

3.6 MISCELLANEOUS AIR HANDLING DEVICES

.1 Motorized Smoke and Gravity/Barometric Dampers:

.1 Review installation to ensure:

.1 No cracks around damper frame.

.2 Blades close and seals engage completely.

.3 Damper strokes fully open to fully closed with no binding of blades at any part of stroke.

.4 Suitable access and identification.

.2 Air Outlets:

.1 Review installation to ensure:

.1 Air outlet is clean.

.2 Air outlet is located as shown on drawings.

.3 Balancing Dampers:

.1 Check installation to ensure:

.1 Damper can open and close fully.

.2 Access is clearly marked.

.3 Damper is not located in a turbulent air stream.

3.7 COMBUSTION AIR

.1 With all heating appliances, within the boiler room, operating on high fire, measure:

.1 Combustion air volume entering boiler room from outside.

.2 Differential pressure to:

.1 Outside

.2 Adjacent areas of the building.

.2 With all heating appliances on high fire, check each natural draft appliance diverter for any back draft.

3.8 ACOUSTIC MEASUREMENTS

.1 Acoustic Measurement Procedure:

.1 Use Sound Level Meter and octave band filter set as specified in Section 23 08 13.

.2 Calibrate microphone and sound level meter before use.

.3 Hold Sound Level Meter in front of body of observer and as far away as is practicable or attach instrument to a tripod stand.

.4 Height of measuring microphone from floor shall be 1200 mm ±50 mm unless otherwise noted.

.5 Measurement locations shall be minimum of one metre away from any large vertical or horizontal surface, ie. walls, columns, floors.

.6 Take measurements with meter on “SLOW” response or follow manufacturer’s instructions for L_{eq} “equivalent energy level” averaging.

.7 Do not take readings until noise created by extraneous equipment, people or other sources, which would interfere with specific acoustic measurements, have ceased.

.2 HVAC Noise Inside Building:

.1 The objective is to measure Sound Pressure Level within each **occupied** room created by entire HVAC system and to evaluate these in terms of the recommended maximum background noise levels for each type or area. Investigate areas found to be in excess of recommended maximum levels and take corrective action.

.2 Follow testing procedures specified under "Acoustic Measurement Procedure".

.3 Measure overall, A-weighted Sound Pressure Level in most cases. In more critical areas determine NC - Noise Criteria level.

.4 Take minimum of one reading per 30 m^2 of floor area, but no less than one reading in any one enclosed room or open area which will be occupied.

.5 Take measurements with system operating in its loudest normal condition which is typically the summer mode.

.6 Measure sound pressure levels in rooms directly beneath roof top towers, condensers, furnaces, etc. with units running at maximum speed or capacity.

.7 Compare results with following maximum noise criteria:

.1 Bedroom: NC30

.8 Determine NC levels for any areas found to be in excess of recommended maximum A-weighted noise level or where any unusually loud or distinct noises,

rumble, hiss, tone, ballast hum, etc., are heard. In these areas measure unweighted octave band sound pressure levels from 31.5 Hz to 8000 Hz. Plot this data on NC curve charts.

.3 Community Noise:

.1 Community noise measurements are taken to ensure compliance with local noise by-laws and to minimize annoyance to nearby residents.

.2 Follow testing procedures specified under "Acoustic Measurement Procedure".

.3 Measure overall, A-weighted Sound Pressure Level.

.4 Take measurements when ambient noise is at lowest, typically at nighttime, 23:00 - 6:00. Do not take measurements when there is significant interference due to wind, rain, etc.

.5 Measure at adjoining property boundaries closest to mechanical equipment on all sides of building.

.6 Take following measurements at every position:

.1 Measure ambient noise level with no relevant mechanical equipment in building operating.

.2 Measure noise in the summer with all appropriate seasonal equipment at their nighttime maximum outputs.

.7 Measurements shall not exceed 45 dB(A) or they shall not increase existing ambient level by more than 2 dB(A) whichever is greatest.

.8 Documentation:

.1 Provide a site plan indicating building[s], adjacent properties, and test locations.

.2 Provide night time ambient noise levels with equipment on and off in the summer. Submit data in tabular format.

.3 Provide a list of mechanical equipment operating in these conditions as well as their operating levels.

.4 Provide any subjective comments that may be useful.

.4 Outdoor Equipment Noise:

.1 This equipment includes Air-Cooled Condenser Units, Cooling Towers, Rooftop Chillers and Packaged Rooftop Heating/Cooling Units.

.2 Follow testing procedures specified under "Acoustic Measurement Procedure".

.3 Measure Sound Pressure levels in a manner consistent with manufacturer's data. If no such data is available then measure overall, A-weighted Sound Pressure Level.

.4 Orient observer and measuring microphone sideways to source.

.5 Note distance between measuring microphone and equipment. Choose a distance coinciding with closest measurements published by equipment manufacturer whenever possible. When this is not possible, take measurement 1500 mm from sides of equipment or from intake and exhaust louvers.

.6 Perform Sound Pressure Level measurements on all accessible sides of equipment and note measurement distance.

.7 Provide a plan indicating equipment location and measurement locations.

.8 Compare measurements with manufacturer's published data.

3.9 BALANCING OF HYDRONIC SYSTEMS

.1 Fully open all valves, except the pressure bypass valve which must be closed, including balancing valves, isolation valves and control valves.

.2 Measure and record pump flows.

.3 Adjust flows through each boiler to ensure equal flow.

.4 Install pressure gauges across each coil or use balancing valve pressure tappings if provided. Read pressure drop through coil or balancing valve and set flow rate for full flow through coil. Set pressure drop across bypass valve at full flow to bypass to match coil full flow pressure drop.

.5 Distribute flow through radiation using circuit balancing valve pressure drop to apportion flow to each zone, and temperature drop to apportion flow through each run of radiation.

.6 Terminal reheat coils of constant volume systems can not be hydronically balanced, by the method of air side temperature rise across the coil, until after air balance has been completed.

.7 Position and lock all balancing valves and mark all hand valves for design flow through all coils, coil by-passes, branch circuits, etc. Record flow measurement data for all major circuits and each terminal device.

.8 After making all coil and terminal unit adjustments remeasure flow and head for each pump, for both single and parallel operation.

.9 For each pump, plot maximum and minimum flows on curve for both single and parallel operation.

.10 Verify pressure drops and flows through pressure control by-pass valves over full operating range.

.11 Calibrate all pressure and temperature gauges.

3.10 BALANCING AND ADJUSTING OF DOMESTIC WATER SYSTEMS

.1 Adjust PRV on main line to 570 kPa maximum.

.2 Balance domestic hot water circulating system piping to ensure flow from all points in system. Ensure all hot and cold supply shut off valves are fully open.

3.11 BALANCING REPORT

.1 Submit draft copies of final reports prior to Interim Acceptance of the Work. Provide four copies of final report for inclusion in Operation and Maintenance Manual.

.2 Include types, serial number and dates of calibration of instruments.

.3 Submit with report, fan and pump curves with operating conditions plotted. Submit grille and diffuser shop drawings and manufacturer's flow factors.

.4 Organize report as follows:

Air Systems

.1 Summary

.2 Procedure

.3 Instrumentation

.4 Drawings

.5 Equipment Summary

.6 Fan Data Sheets

.7 Fan Curves

.8 Air Handling Unit Profile Data

.9 Traverse Data and Schedule

.10 Terminal Unit Summary

.11 Outlet Data Summary and Schematic, per system

.12 Building Pressurization Data

.13 Diagnostic

Hydronic Systems

.1 Summary

.2 Procedure

.3 Instrumentation

.4 Drawings

.5 Equipment Summary

.6 Pump Data Sheets

.7 Pump Curves

.8 Pump Profile Data

.9 Terminal Unit Summary

.10 Diagnostic

Acoustics

.1 Summary

.2 Procedure

.3 Instrumentation

.4 Drawings

.5 Sound Pressure Level Data

.6 NC curve plot of Sound Pressure Level

END OF SECTION