Dufferin-Peel Catholic District School Board

STANDARD TEXT GUIDELINE FOR

Testing, Adjusting and Balancing

for

SECONDARY AND ELEMENTARSCHOOLS

Prepared by the Plant Department

Formatted by the Design Department

1. GENERAL

1.1. GUIDELINE

1.1.1. This is not a specification. It is a Guideline to be followed by the Consultants in the development Testing, Adjusting & Balancing of Mechanical Systems for the Dufferin-Peel Catholic District School Board's Elementary and Secondary Schools.

1.1.2. It is the Consultant's responsibility to insure that the Guidelines as listed below, are incorporated within the Contract Documents, in the appropriate sections.

1.2. GENERAL CONDITIONS

1.2.1. The following notes should be included in the General Conditions:

1.2.1.1. Mechanical General Requirements, Section 15000 shall form an integral part of this Section.

1.2.1.2. Review Project Status and completion schedule with the General Contractor and co-ordinate the scheduling of TAB work. Proposed Substantial completion date is XXXXXXX.

1.3. TENDER AWARD

1.3.1. The Architect will review Tenders with the Board and Mechanical Engineer and will direct award of a contract, based on the tendered amount, qualifications and experience of Balancing Company. *Price alone will NOT be the sole criterion for selection of the Balancing Company*.

1.4. QUALIFICATIONS

1.4.1. An independent Balancing Company that specializes in, and whose business is limited to only this type of work, shall be allowed to bid.

1.4.2. The Company shall be incorporated under the laws of Canada or one of its Provinces, carry personal and liability insurance, and shall prove that it has recognized experience in performing all the specified tests, adjustment and balancing detailed herein.

1.4.3. The Company must be a certified member of AABC or NEBB of current date.

1.4.4. To perform the required professional services, the Balancing Company shall have on staff, a minimum of one test and balance engineer, certified by AABC or NEBB.

1.4.5. This certified test and balance engineer shall be responsible for the supervision of all other test-and balance personnel and for certification of the total work herein specified. The personnel shall not be changed or substituted without consent of the Board.

1.4.6. The Balancing Company shall submit records of experience in the field of air and hydronic system balancing or any other data as requested by the Board. The supervisory personnel for the Balancing Company shall have at least five (5) years of experience. All other employees used on this project shall be qualified technicians in this specific field.

1.4.7. The Balancing Company shall furnish all necessary calibrated instrumentation to adequately perform the specified services. An inventory of all instruments and devices in possession of the Balancing Company shall be enclosed with the Tender, to determine the Balancing Company's performance capability.

1.4.8. The Balancing Company must have operated for a minimum of three (3) years under its current name.

1.5. DOCUMENTS

1.5.1. The Architect shall provide the Balancing Company with one (1) copy of the following documents:

1.5.1.1. Project drawings and specifications

1.5.1.2. Approved construction revisions pertaining to the HVAC systems including all addenda, bulletins, and change orders relating to air and water systems.

1.5.1.3. The following documents will be available, at site, for review:

1.5.1.4. Approved submittal data for all HVAC equipment and systems to be installed by the Mechanical Subcontractor.

1.5.1.5. Approved HVAC shop drawings.

1.5.1.6. Approved HVAC wiring diagrams, control diagrams, and equipment brochures, as appropriate.

1.6. CO-ORDINATION

1.6.1. The Balancing Company shall perform its services in close co-ordination with the Mechanical Contractor.

1.6.2. The plans and specifications have indicated the location and quantity of meters, valves, dampers and other devices for the purpose of adjusting the system(s) to obtain optimum operating conditions. It shall be the responsibility of the Mechanical Subcontractor to install these devices in a manner that will leave them accessible and readily adjustable. The Balancing Company shall provide guidance if the location of a control or balancing device is not certain.

1.6.3. The General Contractor, Mechanical Subcontractor, Automatic Temperature Control Subcontractor, and the suppliers of the HVAC equipment shall all co-operate with the Balancing Company to provide all necessary data on the design and proper application of the system components. In addition, they shall furnish all labour and materials required in correcting and eliminating any system deficiencies.

1.7. SUBMITTALS

1.7.1. Submit an estimated time schedule for the following:

1.7.1.1. Site visits.

1.7.1.2. Air balances.

1.7.1.3. Hydronic balances.

1.7.1.4. Performance tests of automatic temperature control sequence of operation for heating and cooling seasons for all systems.

1.7.1.5. Typed reports, six copies, interim and final.

Note: TENDERS NOT INCLUDING THE ABOVE INFORMATION AND BREAKDOWN WILL BE REJECTED.

1.7.2. Prior to the commencement of the work, submit to the Mechanical Engineer (Board) a copy of test report forms for each test to be performed, two (2) weeks prior to commencement of any tests, for approval.

1.7.3. Submit a list of the instruments to be used for each type of test. The list should contain the following for each instrument to be used:

1.7.3.1. Names of instrument manufacturer.

1.7.3.2. Instrument model and serial number.

1.7.3.3. Scales and full-scale accuracy.

1.7.3.4. Dates of last calibration test verifying instrument accuracy and name of testing organization or company.

1.7.4. Submit lists of A_k factors to be used in calculation of air velocity and volume for grilles and diffusers.

1.7.5. Submit all test reports in triplicate to the Mechanical Engineer (Board) for his review and records.

2. RESPONSIBILITIES OF THE MECHANICAL SUBCONTRACTOR

2.1.1. The Mechanical Subcontractor shall complete the installation in accordance with the Contract Documents and start-up all HVAC systems to ensure they are working properly, and shall perform all other items as described hereinafter to assist the Balancing Company in performing the testing, adjusting, and balancing of the HVAC systems.

2.2. AIR DISTRIBUTION SYSTEMS

2.2.1. Verify installation for conformity to design.

2.2.2. Terminate all supply, return, exhaust ducts and pressure test them for leakage, as required by specification.

2.2.3. Ensure that all splitter, volume, and smoke and fire dampers are properly located and functional. Dampers serving requirements of minimum and maximum outside, return, relief, and exhaust air shall provide tight closure and full opening, with a smooth and free operation.

2.2.4. Verify that all supply, return, exhaust, transfer grilles; registers; diffusers; and terminal units are installed and operational

2.2.5. Ensure that air handling systems, units, and associated apparatus, such as heating, and cooling coils, filter sections, access doors, etc., are blanked and/or sealed to eliminate excessive bypass or leakage of air.

2.2.6. Ensure that all fans (supply, return, relief, and exhaust) are operating and free of vibration. All fans and drives shall be checked for proper fan rotation and belt tension. Overload protection shall be of proper size and rating. A record of motor current and voltage shall be made to verify that the motors do not exceed nameplate rating.

2.2.7. Make any necessary changes to the sheaves, belts, and dampers, as required by the Balancing Company, at no additional cost to the Mechanical Engineer (Board).

2.2.8. Install clean filters.

2.3. HYDRONIC SYSTEMS.

2.3.1. Verify installation for conformity to design.

2.3.2. Check pumps to verify pump alignment and rotation.

2.3.3. Ensure that all systems are clean, with the proper strainer screens installed for normal operation.

2.3.4. Ensure that the correct concentration of anti-freeze solution has been added, where necessary, and note specific gravity of system solution.

2.3.5. Check all pump motors for current and voltage, to ensure that motors do not exceed nameplate rating.

2.3.6. Provide overload protection of proper size and rating.

2.3.7. Ensure that all hydronic systems shall be full and free of air; that expansion tanks are set for proper water level; and that all air vents were installed at high points of systems and are operating.

2.3.8. Check and set operating temperatures of heat exchangers to design requirements.

3. RESPONSIBILITIES OF AUTOMATIC TEMPERATURE CONTROL SUBCONTRACTOR.

3.1.1. The automatic temperature control subcontractor shall complete the installation of the automatic temperature control system, and operate and test all control systems to ensure they are functioning properly as designed. The automatic temperature control subcontractor shall assist the Balancing Company in testing, adjusting, and balancing the HVAC systems, as follows:

3.1.1.1. Verify that all control components are installed in accordance with project requirements and are functional, including all electrical interlocks, damper sequences, air and water reset, and fire and freeze stats.

3.1.1.2. Verify that all controlling instruments are calibrated and set for design operating conditions.

3.1.1.3. Calibrate room thermostats after installation, and before the thermostat control verification test are performed. The balancing Company shall prove accuracy of final settings by taking temperature readings. The readings shall be in a typical conditioned space for each separately controlled zone.

3.1.1.4. The automatic temperature control subcontractor shall allow sufficient time in the project to provide assistance and instruction to the Balancing Company in the proper use and setting of control components such as, but not limited to, computers, static pressure controllers, or any other device that may need set points changed so that testing, adjusting and balancing work can be performed.

4. RESPONSIBILITIES OF THE BALANCING COMPANY

4.1. SCOPE

4.1.1. In accordance with the project drawings and specifications and as specified herein, the Balancing Company shall provide all supervision, personnel, instruments, calibration equipment, and all other materials and services necessary to perform all testing, adjusting, and balancing of the HVAC systems. All test data including all pertinent calculations shall be reported on appropriate forms.

4.2. GENERAL

4.2.1. The testing, adjusting, and balancing of the HVAC systems shall be performed by an independent Balancing Company approved by the Mechanical Engineer (Board). The Balancing Company shall have a minimum of five 5) years experience in air and hydronic system balancing, and possess calibrated instruments, qualified test, adjust, and balance engineers, and skilled technicians to perform all required tests.

4.2.2. The tests shall demonstrate the specified capacities and operation of all equipment and materials comprising the systems. The balancing shall make available to the Mechanical Engineer (Board's) representative such instruments and technicians as are required for spot checks of the system.

4.2.3. The Balancing Company shall not instruct or direct the Mechanical subcontractor in any of the work, or any proposed changes, or revisions in the work without submitting, in writing, such instructions or directions to the Architect. The Architect shall, in co-ordination with the Engineer, process the proposal as appropriate.

4.3. SERVICES

4.3.1. During construction, the Balancing Company shall inspect the installation of piping systems, sheet metal work, automatic temperature controls, and other component parts of the HVAC systems to ensure that all systems are being installed satisfactorily for all future testing, adjusting, and balancing with respect to the number, location, and accessibility of balancing and testing devices, openings and all other aspects pertinent to the work.

4.3.2. The inspections shall be performed periodically as the work progresses. A minimum of two (2) inspections are required as follows:

4.3.2.1. When 60 percent of the ductwork is installed, and

4.3.2.2. When 90 percent of the equipment is installed.

4.3.2.3. The Balancing Company shall submit a brief written report of each inspection to the Mechanical Engineer (Board).

4.3.3. Testing, adjusting, and balancing shall commence only after all system installation has been completed, any known deficiencies corrected and system has been put into continuous operation by the Mechanical Subcontractor. The Balancing Company shall test, adjust and balance the system components to obtain optimum conditions in each conditioned space in the building.

4.3.4. If construction deficiencies are still encountered that preclude obtaining optimum conditions, and the deficiencies cannot be corrected by the Mechanical Subcontractor within a reasonable period of time, the Balancing Company shall cease testing, adjusting, and balancing services, and advise the Mechanical Engineer (Board) in writing of the deficiencies.

5. NOTIFICATION FOR TAB WORK TO COMMENCE

5.1.1. The General Contractor shall liaise with the Balancing Company and shall notify the Balancing Company in writing when all HVAC systems are complete and ready for testing, adjusting and balancing. The Mechanical Subcontractor and Automatic Temperature Control Subcontractor shall confirm in writing that they have completed all items described in Sections

regarding *Responsibilities of the Mechanical Subcontractor*, and *Responsibilities of the Automatic Temperature Control Subcontractor*.

5.1.2. If, upon commencing the work, the Balancing Company finds that the systems are not ready, or if a dispute occurs as to the readiness of the systems, the Balancing Company shall request an inspection to be made by the Mechanical Engineer. This inspection shall establish to the satisfaction of the represented parties whether or not the systems meet the basic requirements for testing, adjusting, and balancing.

5.1.3. Should the inspection reveal the notification to have been premature, all costs for the inspection and work previously accomplished by the Balancing Company shall be paid for by the General Contractor. Furthermore, such items that are not ready for testing, adjusting, and balancing shall be completed and placed in operational readiness before testing, adjusting, and balancing services are recommenced.

6. ADDITIONAL REQUIREMENTS

6.1. QUANTITIES

6.1.1. In all cases where a device, operation, procedure, tool, equipment, or part of the equipment is herein referred to in the singular number, it is intended that such reference shall apply to as many such devices as are required to complete the testing, adjusting, and balancing specified herein.

6.2. STORAGE

6.2.1. In co-ordination with the General Contractor, the Balancing Company shall arrange for an area of ample size and convenient location for storage of tools, equipment, and other items as required.

6.3. UTILITIES

6.3.1. The Balancing Company shall not be responsible in whole or in part for any expense for utilities, or expense of any nature relating to the building or other contractor's work.

7. BALANCING

7.1.1. The Balancing Company shall carry the following instruments as a minimum requirement for carrying out the air and hydronic testing, adjusting and balancing:

7.2. AIR BALANCING

7.2.1. Micro manometer calibrated in 0.0005" w.g. divisions,

7.2.2. Combination inclined and vertical manometer (0 to 10in of water),

7.2.3. Pitot tubes in various lengths, as required,

7.2.4. Tachometer, direct contact, self-timing type or strobe light,

7.2.5. Multi-purpose electric meter to measure Volts, Amps, KVA, KW, Power Factor,

7.2.6. Deflecting vane anemometer,

7.2.7. Rotating vane anemometer,

7.2.8. Flow hood,

7.2.9. Dial thermometers (2' diameter minimum and 1^{o}F graduations minimum) and glass stem thermometers (1^{o}F graduations minimum),

7.2.10. Velometer.

7.3. HYDRONIC BALANCING (COMBINATION OF THE FOLLOWING)

7.3.1. Manometers, differential pressure gauges (either analog of digital),

7.3.2. Portable digital meter to measure flow and pressure drop, Pressure differential gauges and manufacturer's factory certified flow vs. pressure drop curves,

7.3.3. Test pressure taps, pressure gauges, thermometers,

7.3.4. System components used as flow meters (terminal coils, chillers, heat exchangers or control valves if using manufacturer's factory certified flow vs. drop curves),

7.3.5. Flow limiting or regulating devices (to add a variable load to the pump head),

7.3.6. Pumps with factory - certified pump curves,

7.3.7. Control valves with factory flow coefficient C_v of flow vs. pressure drop tables,

7.3.8. Balancing valve with a factory rated coefficient C_v a flow vs. hand wheel position and pressure drop tables, or a slide rule calculator.

8. TEST REPORT DATA AND FORMS

8.1.1. The test, adjust and balance report shall be complete with logs, data, and records as required herein. All logs, data, and records shall be typed on white bond paper bound. The report shall be certified accurate and complete by the Balancing Company's certified balancing engineer.

8.1.2. Three (3) copies of the testing, adjusting and balancing report are required and shall be submitted to the **Mechanical Engineer (Board).**

8.1.3. The report shall contain the following general data in a format selected by the Balancing Company:

8.1.3.1. Project number

8.1.3.2. Contract number

8.1.3.3. Project title

8.1.3.4. Project location

8.1.3.5. Name of Project Architect

8.1.3.6. Name of Project Mechanical Engineer

8.1.3.7. Name of Testing, adjusting, and balancing company

8.1.3.8. Name of Testing, adjusting, and balancing engineer

8.1.3.9. Name of General Contractor

8.1.3.10. Name of Mechanical Subcontractor

8.1.3.11. Date tests were performed

8.1.3.12. Certification

9. TEST ADJUST AND BALANCE REPORT

9.1.1. The test, adjust, and balance report shall be recorded on report forms supplied by the Mechanical Engineer (Board) or approved forms supplied by the Balancing Company. At a minimum the report shall include the following:

9.2. PREFACE

9.2.1. A general discussion of the system, any abnormalities and/or problems encountered.

9.3. INSTRUMENTATION LIST

9.3.1. The list of instruments including type, model, manufacturer, serial number, and calibration dates.

9.4. SYSTEM IDENTIFICATION

9.4.1. In each report, VAV boxes, zones, supply, return, and exhaust openings, and Pitot tube traverse points identified on system schematics or drawings shall be numbered and/or lettered to correspond to the numbers and letters used on the report data sheets.

9.5. AIR HANDLING EQUIPMENT TEST REPORT FORMS

9.5.1. Record the data in accordance with the procedures outlined in AMCA Publication 203 Field Performance Measurements for the air handling/fan configuration under consideration, on forms approved by the Mechanical Engineer (Board). Carry out and record all necessary Pitot tube traverses readings to establish total fan performance, including all necessary calculations relating to System Effect Factor - all corrections for barometric pressure and density.

9.6. OTHER INFORMATION

9.6.1. Other information shall include but not limited to:

9.6.1.1. Manufacturer, model number, and serial number

9.6.1.2. All design and manufacturer-rated data

9.6.1.3. Suction and discharge static pressure of each fan, as applicable

9.6.1.4. Outside air and return air total cfm

9.6.1.5. Fan and motor sheave manufacturer, model, size, number of grooves, and centre distance

9.6.1.6. Belt size and quantity

10. PUMP TEST REPORT

10.1.1. Submit pump performance curve indicating design, operating, and no-flow points of operation.

10.2. OTHER INFORMATION

10.2.1. Other information shall include but not limited to:

10.2.1.1. Manufacturer, model number, and serial number

10.2.1.2. All design and manufacturer-rated data

10.2.1.3. Pump operating suction and discharge pressure and final total dynamic head

10.2.1.4. No flow (pump discharge valve closed) suction and discharge pressure and corresponding total dynamic head to determine actual impeller size.

10.2.1.5. Rated and actual operating current, voltage, and brake horsepower of each pump motor.

11. CHILLER TEST FORMS

11.1.1. Record the following information on the forms provided; this information shall include but not limited to:

11.1.1.1. Manufacturer, model number, and serial number

11.1.1.2. All design and manufacturer-rated data

11.1.1.3. Rated and actual pressure drop across evaporator, condenser, and related gpm

11.1.1.4. Entering and leaving water temperatures

12. HEAT EXCHANGER TEST FORMS

12.1.1. Record the following information on the forms provided; this information shall include but not limited to:

12.1.1.1. Manufacturer, model number, and serial number

12.1.1.2. All design and manufacturer-rated data

12.1.1.3. Service and location

12.1.1.4. Actual pressure drop and related GPM or steam pressure, primary side

12.1.1.5. Primary side entering and leaving temperatures

12.1.1.6. Secondary side entering and leaving temperatures

12.1.1.7. Temperature control setting

13. HEATING AND COOLING COIL TEST FORMS

13.1.1. Record the following information on the forms provided; this information shall include but not limited to:

13.1.1.1. Manufacturer, model number, and serial number

13.1.1.2. All design and manufacturer-rated data

13.1.1.3. Rated and actual water pressure drop through each coil and related GPM

13.1.1.4. Rated and actual static pressure drop across each coil

13.1.1.5. Entering and leaving water temperatures

13.1.1.6. Wet bulb and dry bulb temperatures entering and leaving each cooling coil; dry bulb temperatures entering and leaving each heating coil.

14. ELECTRIC HEATING COIL/DUCT HEATER TEST FORMS

14.1.1. Record the following information on the forms provided; this information shall include but not limited to:

14.1.1.1. Manufacturer, model number, and serial number

14.1.1.2. All design and manufacturer-rated data

14.1.1.3. Coil identification number.

15. AIR SYSTEMS

15.1. SYSTEM PREPARATION

15.1.1. Prior to commencing air system testing , adjusting, and balancing, obtain and verify the following:

15.1.1.1. Updated construction drawings, specifications, approved shop drawings, addenda, bulletins change orders and any other pertinent information effecting the air systems.

15.1.1.2. Prepare all field data sheets for recording all testing, adjusting and balancing procedures used in the testing, adjusting, and balancing process.

15.1.1.3. Obtain air system leakage rate where duct leakage testing is specified.

15.1.1.4. Verify that all equipment is installed correctly, rotating correctly, controlled to supply the required airflow rate, and that all installation lubrication and safety requirements are met.

15.1.1.5. Check for clean filters.

15.1.1.6. Verify that all fire, smoke, automatic, and manual volume control dampers are operable, accessible and are in an open or normal position.

15.1.1.7. Controls are operable and calibrated.

15.1.1.8. All boxes and/or terminal devices are installed, operable, and accessible.

15.1.1.9. All access doors are installed and secured.

15.1.2. Perform the following before commencing air system testing, adjusting, and balancing:

15.1.2.1. Verify that all dampers are in an open or normal position and all boxes and/or automatic air volume control devices are in an acceptable mode.

15.1.2.2. Verify that all air terminal air pattern devices are in the correct position when using A_k factors to determine airflow rate.

15.1.2.3. Verify that all automatic controls in the system are set in the testing mode.

16. AIR SYSTEM TESTING AND ADJUSTING

16.1.1. Perform the following tests and adjustments before beginning the air system balancing:

16.1.1.1. Record the data in accordance with the procedures outlined in AMCA Publication 203 Field Performance Measurements for the air handling/fan configuration under consideration, on the forms provided by the Mechanical Engineer (Board).

16.1.1.2. Set system in the minimum outdoor mode, and carry out and record all necessary Pitot tube traverses readings to establish total fan performance, including all necessary calculations relating to System Effect Factor; including all corrections for barometric pressure and density.

16.1.1.3. Verify minimum outside air volume and return air volume with Pitot tube traverses, where possible, alternatively use the temperature method after establishing the total air flow for the supply fan under test; adjust minimum outside air, return and relief air dampers to suit.

16.1.1.4. Adjust fan speed for total design supply and return airflow rates. Total design flow must include estimated duct leakage previously determined by procedures outlined in the SMACNA AHVAC Duct Leakage Test Manuals latest edition, plus 5% of system total to allow for balancing effects. Maintain minimum outdoor air quantities during all system modes.

16.1.1.5. Measure and record the static pressure resistance of the duct system and the static pressure drop across coils, filters, etc., in the cabinet or out in the duct system.

16.1.1.6. Measure and record the pressures at the fan suction and discharge per the pressure rating required, either static or total.

16.1.1.7. Repeat test, using maximum outside air. If motor overloads or airflow rates are excessive, adjust fan RPM to suit.

16.1.1.8. In conjunction with Clause .6 above, after balancing the return air system and associated supply air system, the return air damper

shall be closed; the interlocked relief/exhaust damper shall be opened and the return air fan performance checked again. If it is necessary to increase the system static pressure and thereby reduce the total return fan volume, adjust the exhaust air damper to a maximum position less than 100% open.

17. AIR SYSTEM BALANCING

17.1. GENERAL

17.1.1. After each air system has been prepared for balancing in accordance with the procedures outlined in Clause 3.2 above, perform the balance on the supply and/or return air system by the procedures set forth below:

17.2. PROPORTIONING OF AIRFLOW TO OUTLETS

17.2.1. Commence with the outlets on the branch duct served by the main air duct determined to have the highest resistance to design airflow. Measure the airflow to each outlet.

17.2.2. Compare the ratio of the measured to design flow for each outlet.

17.2.3. Determine the outlet with the lowest measured-to-design flow ratio; this is outlet #1. Adjust the outlet damper for the outlet where the measured- to-design flow ratio is *second* lowest until the ratio for this outlet equals that of the *first* outlet with the lowest ratio. (DO NOT ADJUST THE FIRST OUTLET WITH LOWEST RATIO OF MEASURED-TO-DESIGN FLOW).

17.2.4. Re-measure the airflow to the outlet with the lowest ratio again and recalculate the ratio for this outlet. Readjust the outlet with the second lowest ratio again until these ratios are equal.

17.2.5. Proceed to the outlet with the next (third) lowest ratio and repeat the procedure outlined in steps .3 and .4 above, always comparing to the first outlet. *Do not* adjust the outlets that have previously been adjusted. Repeat steps .3, .4, and .5 until all outlets on this branch have been adjusted to their proper proportion of airflow. The actual airflow of the lowest ratio outlet and subsequent balance outlets will increase as each additional outlet is balanced.

17.2.6. Repeat steps .1 through .5 using the next lowest ratio until the outlets on all branches of each main duct run have been proportioned.

17.3. PROPORTIONING OF AIR TO BRANCH DUCTS

17.3.1. Ensure that all thermostats controlling any volume control device are set to allow maximum airflow to each branch of the sub-main being balanced.

17.3.2. When the airflow quantity cannot be obtained by Pitot tube traverse, the sum of the outlet air quantities shall be used as the total airflow for that branch. If a Pitot tube traverse is not performed, the reason why shall be noted on the test, adjust and balance report sheets

17.3.3. Commencing at the far end of the sub-main duct with the lowest measured -to-design airflow, adjust all branch dampers until the ratio of measured -to- design airflow for each branch on that sub-main duct system is the same, always comparing to the first branch which is not readjusted.

17.3.4. Repeat steps .1 through .3, commencing with the next sub-main duct with the lowest measured to design airflow, for each sub-main duct.

17.4. PROPORTIONING AIRFLOW TO SUB-MAIN DUCTS

17.4.1. Determine the airflow through each sub-main being balanced using a Pitot tube traverse.

17.4.2. Commencing with the sub-main duct with the lowest measured to design airflow, adjust all sub-main dampers until the ratio of measured to design airflow for each sub-main the same, always comparing to the first sub-main which is not readjusted.

18. AIR SYSTEM FINAL ADJUSTING AND BALANCING

18.1.1. After completing all of the above procedures obtain final measurements as follows:

18.1.1.1. Perform a final check of air flows in each branch commencing with the sub-main duct with the lowest measured to design airflow. If the ratio for any branch of a sub-main duct is greater than 10% higher than the ratio of the lowest branch, adjust the highest branch until the 10% tolerance is achieved.

18.1.1.2. Repeat the procedure in .1 above for all sub-main ducts and adjust accordingly.

18.1.1.3. Adjust the fan speed or volume control to obtain the total design airflow in the system. This shall be achieved by Pitot tube traverse of the main duct or sub-main ducts to obtain a measured to design ratio of 1. Since the system has been proportionately adjusted, the

measured-to-design-ratio throughout the system will be approximately 1, and the airflow from each outlet will be the design airflow rate.

18.1.1.4. At least one outlet damper shall be fully open on every branch duct, and at least one branch duct balancing damper shall be fully open.

18.1.1.5. Measure and record the data for the procedures as specified above for system operating with minimum and maximum outside air.

18.1.1.6. Reset all controls for normal operation.

19. HYDRONIC SYSTEMS

19.1. SYSTEM PREPARATION

19.1.1. Prior to commencing hydronic system testing, adjusting, and balancing, obtain and verify the following:

19.1.1.1. Updated construction drawings, specifications, approved shop drawings, addenda, bulletins change orders and any other pertinent information effecting the hydronic systems.

19.1.1.2. Prepare all field balancing data sheets or report forms with all pertinent design data and number in sequence starting at pump to end of system. Check sum of branch circuit flows against approved pump flow rate. If variation exceeds 5%, correct as instructed.

19.1.1.3. Prepare schematic layouts of systems to be balanced and show number on sketch that will correspond to number on balancing data sheet in report.

19.1.1.4. Carry out site inspection to ensure system can be balanced and that appropriate balancing stations including flow measuring devices, temperature wells, pressure taps and balancing devices are installed in accordance with contract drawings and manufacturer's recommendations.

19.1.1.5. Check that all systems have been cleaned, flushed, refilled and vented and any construction debris removed.

19.1.1.6. Check that all manual valves are fully open for maximum flow.

19.1.1.7. Check that all strainers are clean and have the correct mesh for system fluid.

19.1.1.8. Check pump rotation is correct.

19.1.1.9. Check liquid level in expansion tank.

19.1.1.10. Check make-up water pressure gauge to ensure adequate pressure for venting at the highest point.

19.1.1.11. Check that all flow control valves for specified sequence of operation and set for design flow conditions.

19.1.1.12. If a differential pressure control valve is installed, set valve to specified differential pressure. Do not set at a fully closed position when pump is a positive displacement type unless several terminal valves remain in the open position.

19.1.1.13. Adjust system controls to ensure automatic valves to heat exchangers are fully open.

19.1.1.14. Check pump motor load. If motor is overloaded, throttle main flow balancing device so that nameplate rating is not exceeded.

19.1.1.15. Check all air vents for positive pressure. Ensure all air is expelled with continuous liquid flow from all vents when manually operated.

20. HYDRONIC SYSTEM TESTING AND ADJUSTING

20.1. GENERAL

20.1.1. Perform the following tests and adjustments before beginning the hydronic system balancing:

20.1.1.1. Check to ensure that pressure gauges reinstalled correctly. If there are no pump gauge tappings, then the gauges shall be connected to suction and discharge pipes of pump. These connections shall be placed as close as possible to the pump with NO fittings between the pump and the gauge connections.

20.1.1.2. Check that an isolation cock and snubber is installed directly ahead of each gauge to dampen pulsations to obtain a steady accurate reading.

20.1.1.3. Check that gauges are mounted at the same level. If mounted at different levels, the readings must be corrected for the head

difference between the gauge readings. After taking a set of readings, the gauges shall be interchanged and read again for comparison with the first set of readings unless one gauge is a compound gauge.

20.1.1.4. Record the system static pressure with the pumps off.

20.2. VERIFYING IMPELLER SIZE

20.2.1. With the pump running, close the pump discharge valve and read and record pressure differential across the pump correcting for any difference in gauge heights.

20.2.2. Record the point on the pump curve at zero flow; this is the shut off head.

20.2.3. Using the shut-off head, compare this reading with the manufacturer's submittal data curves. If the test point does not fall on the design curve, calculate and plot a new curve parallel with the other curves on the chart from zero to maximum flow. With this data the pump curve fitting this data at no flow represents the impeller size. Verify with pump manufacturer if this procedure is applicable for the pump under consideration.

20.2.4. Determine the revised pump impeller size.

20.3. SYSTEM FLOW AND RESISTANCE

20.3.1. With all system valves open in the correct position, slowly open the valve on the pump discharge fully and record the suction and discharge pressures and total head.

20.3.2. Using the total head, read the system water flow from the manufacturer's pump curve or from the pump curve established in clause .2 above.

20.3.3. If the system is installed with a flow measuring device at the discharge of the pump, measure the pressure differential across the device and compare with the manufacturer's factory certified flow vs. pressure drop curves.

20.3.4. Compare the readings obtained in .2 and .3. above. If the flow reading obtained using the flow measuring device and the flow reading obtained using the total head and pump curve do not correlate carry out the following:

20.3.4.1. If the reading obtained from the flow measuring device indicates a flow greater than the reading obtained using the total head, throttle the flow measuring device until the correct pressure differential for

the desired flow rate, corresponding with manufacturer's certified flow vs. pressure drop curves and valve setting is obtained **without** any change in overall pump total head.

20.3.4.2. If the total head is less than design, water flow will be greater. Increase the pump discharge pressure by partially closing the balancing valve until the system water flow is approximately 105% of design. (Adjust flow measuring device accordingly to correspond with revised flow rate).

20.3.4.3. If the total head is greater than design, system water flow will be lower than design. Check to ensure that all system valves and automatic control valves are in the correct position and fully open. Check to ensure that any flow measuring device at a terminal unit is fully adjusted for revised flow rate for mode of operation.

20.3.4.4. If the flow is not within 5% of design, consult with Engineer to arrange a change of impeller size, approval to throttle or change of design flow rate.

20.3.4.5. If the deficiency cannot be rectified, proceed to balance proportionately.

20.3.4.6. Set any calibrated flow measuring devices, if installed, at calculated pre-setting.

20.3.4.7. Measure and record readings at all flow measuring devices and adjust where necessary to obtain preliminary balance.

21. HYDRONIC SYSTEM BALANCING

21.1. GENERAL

21.1.1. After each hydronic system has been prepared for balancing in accordance with the procedures outlined in Clause 3.5 above, perform the balance on hydronic system by the procedures set forth below:

21.2. SELECTING THE RISER OR SUB-MAIN WITH THE HIGHEST FLOW RATIO

21.2.1. Ensure that all control valves and flow measuring devices are fully open.

21.2.2. Ensure that total pump flow is between 100 and 105% of design flow or at amended flow rate agreed with Mechanical Engineer (Board).

21.2.3. Measure and record in all risers or sub- mains, the measured-to- design flow rate.

21.2.4. Identify the riser or sub-main with the highest flow ratio, commence balancing at this point and continuing with the next highest flow ratio.

21.2.5. If it is found that the flow is higher in favoured circuits and lower in un-favoured circuits to the extent that the flow cannot be measured, return to these risers or sub-mains only after all other risers or sub-mains have been balanced.

21.3. SELECTING THE BRANCH WITH THE HIGHEST FLOW RATIO

21.3.1. Measure and record the flow in all branches and calculate the measured-to- design flow ratio for each branch.

21.3.2. If it is ascertained that the flow in certain branches is greater than 130 to 150% of design flow, adjust the flow measuring devices in these branches to reduce the branch flow to approximately 110% of design flow.

21.3.3. Repeat step .1 above.

21.3.4. Commence balancing in branches with a flow ratio greater than or equal to 1. Commence with the branch having the highest flow ratio.

21.4. PROPORTIONING OF FLOW TO BRANCH TERMINAL UNITS

21.4.1. Measure and record the flow in all terminal units on the selected branch, with the riser or sub-main flow measuring device fully open.

21.4.2. Determine and compare the ratio of the measured flow to design flow for each terminal unit.

21.4.3. Determine the terminal unit with the lowest measured-to-design flow ratio; this is terminal unit #1 or reference unit. Adjust the flow measuring device for the terminal unit where the measured- to- design flow ratio is *second* lowest until the ratio for this terminal unit equals that of the *reference* unit with the lowest ratio. (DO NOT ADJUST THE REFERENCE UNIT WITH LOWEST RATIO OF MEASURED-TO-DESIGN FLOW).

21.4.4. Re-measure the flow to the terminal unit with the lowest ratio again and recalculate the ratio for this terminal unit. Readjust the terminal unit with the *second* lowest ratio again until these ratios are equal.

21.4.5. Proceed to the terminal unit with the next (third) lowest ratio and repeat the procedure outlined in steps .3 and .4 above, always comparing to the

reference terminal unit. *Do not* adjust the terminal units that have previously been adjusted. Repeat steps .3, .4, and .5 until all terminal units on this branch have been adjusted to their proper proportion of flow. The actual flow of the lowest ratio terminal unit and subsequent balanced terminal units will increase as each additional terminal unit is balanced.

21.4.6. Repeat steps .1 through .5 using the next lowest ratio until the terminal units on all branches of each riser or sub-main have been proportioned.

21.5. PROPORTIONING OF FLOW TO BRANCHES ON SUB-MAIN OR RISER

21.5.1. When the terminal units on all branches are balanced, the branches shall be balanced using a similar procedure to above.

21.5.2. Check that the flow-measuring device on the riser or sub-main is fully open.

21.5.3. Measure and record the flow in all branches; determine and compare the ratio of the measured-to-design flow for each branch and identify the branch with the lowest measured-to-design flow ratio.

21.5.4. The branch with the flow measuring device which is furthest from the pump on this riser or sub-main and with the lowest measured-to- design flow ratio obtained in .3 above becomes the *Reference valve* and is locked at this setting.

21.5.5. Adjust the flow- measuring device on the branch with the next lowest measured-to-design flow ratio to equal the *Reference valve* setting. This changes the reading at the *Reference valve*. Readjust the setting so that it equals the flow ratio at the *Reference valve* and lock the flow-measuring device at this setting.

21.5.6. Proceed to adjust each branch, with the next lowest measured-to-design flow ratio, in accordance with the reading obtained at the *Reference valve* and readjust the setting so that it equals the flow ratio at the *Reference valve* and lock the flow measuring device at this setting. Continue process until all branches on riser or sub-main are complete.

21.6. PROPORTIONING OF FLOW TO EACH SUB-MAIN OR RISER FROM A MAIN

21.6.1. When the branches on all risers or sub-mains are balanced, the risers or sub-mains shall be balanced using a similar procedure to above.

21.6.2. Check that the flow measuring device on each riser or sub-main is fully open.

21.6.3. Measure and record the flow in all risers or sub-mains; determine and compare the ratio of the measured-to-design flow for each riser or sub-main and identify the riser or sub-main with the lowest measured-to-design flow ratio.

21.6.4. The riser or sub-main with the flow measuring device which is furthest from the pump and with the lowest measured-to-design flow ratio obtained in .3 above, becomes the *Reference valve* and is locked at this setting.

21.6.5. Adjust the flow measuring device on the riser or sub-main with the next lowest measured-to-design flow ratio to equal the *Reference valve* setting. This changes the reading at the *Reference valve*. Readjust the setting so that it equals the flow ratio at the *Reference valve* and lock the flow measuring device at this setting.

21.6.6. Proceed to adjust each riser or sub-main, with the next lowest measured-to-design flow ratio, in accordance with the reading obtained at the *Reference valve* and readjust the setting so that it equals the flow ratio at the *Reference valve* and lock the flow measuring device at this setting. Continue process until all risers or sub-mains have been balanced.

21.6.7. Finally, adjust the flow measuring device in the main to obtain a flow ratio at the *Reference valve* equal to 1.

21.7. VARIABLE PRIMARY FLOW AND CONSTANT SECONDARY FLOW

21.7.1. This applies to three-way valves in combination with a circulating pump serving a heating or cooling coil.

21.7.2. The three-way valve is supplied by a primary differential pressure between the primary flow and return mains. This pressure may disturb the function of the three-way valve. The water flow in the by-pass may reverse and eliminate the mixing function of the control valve.

21.7.3. To prevent this, a balancing valve is installed between the by-pass connection and the primary return.

21.7.4. A balancing valve is also installed in the secondary return from the coil between the coil and by-pass connection to the three-way valve.

21.7.5. Close the three-way valve to primary flow.

21.7.6. Adjust the balancing valve in the secondary return to design flow.

21.7.7. Open the three-way valve to primary flow.

21.7.8. Continue to measure the flow at the balancing valve in the secondary low. Adjust the balancing valve, as described in .3 above, to obtain the same flow as described in .6 above.

21.7.9. Do this as part of the balancing procedure for the entire primary system.

21.8. CONSTANT PRIMARY FLOW AND VARIABLE SECONDARY FLOW.

21.8.1. This applies to a three-way mixing valve in a by-pass application circuit that can supply the coil at variable flow and constant water temperature, while keeping primary flow constant and eliminating interactivity between circuits on the primary side.

21.8.2. Open the three-way valve to flow through the coil.

21.8.3. To prevent this, a balancing valve is installed in the common return from the three-way valve and the primary return.

21.8.4. A balancing valve is also installed in the by-pass from the primary flow to three-way valve.

21.8.5. Open the three-way valve to flow through the coil.

21.8.6. Adjust the balancing valve, as described in .3 above, to design flow. Do this as part of the balancing procedure for the entire primary system.

21.8.7. Close the three-way valve to flow through the coil.

21.8.8. Measure the flow through the balancing valve, as described in .3 above. Adjust the balancing valve, as described in .4 above, to obtain the same design flow through the balancing valve as described in .3 above.

END OF TESTING, ADJUSTING & BALANCING GUIDELINE

LATEST REVISION IN GREEN FONT

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