.6 When permanent systems are used for temporary heat, provide alarm indicating system failure.

.7 Where pumps are used for temporary heating, replace mechanical seals, regardless of condition, with new mechanical seals.

1.27 Temporary or Trial Usage

.1 Temporary or trial usage by the Owner or Engineer of mechanical equipment supplied under contract shall not represent acceptance.

.2 Repair or replace permanent equipment used temporarily.

.3 Repair or otherwise rectify damage caused by defective materials or workmanship during temporary or trial usage.

.4 Avoid thermal shock to heating system by coordination with the Owner during planning, construction and operation of temporary heating system.

.5 Return condensate to the heating plant. Meter equipment is not required.

1.28 Substantial and Total Performance

.1 Refer to Division 1.

.2 Prior to requesting an inspection for Substantial Performance, provide a complete list of items which are deficient.

.3 A certificate of Substantial Performance will not be granted unless the following items are completed:

.1 Heating air conditioning, plumbing and fire protection systems have been commissioned and are capable of operation with alarm controls functional and automatic controls in operation. Commissioning checklists must be submitted prior to the request by the contractor to have a substantial completion inspection.

.2 The necessary tests on equipment and systems including those required by authorities have been completed with certificates of approval.

.3 Air and water systems have been balanced with draft report submitted to Engineer.

.4 Valve tagging and equipment identification is complete.

.5 Warranty forms have been mailed to the manufacturer. Provide copy of original warranty for equipment which has warranty period longer than one year.

.6 Systems have been chemically cleaned. Flush and initiate water treatment. Provide report from manufacturer's representative to confirm status of treatment.

.7 Draft Operating/Maintenance Manuals have been submitted.

.8 Operating and Maintenance demonstrations have been provided to the Owner.

.9 Written inspection report by manufacturer's representative has been submitted for noise and vibration control devices and flexible connections.

.10 Record drawings have been submitted.

.11 Fan plenums have been cleaned, and temporary filters have been replaced with permanent filters.

.12 All previously identified deficiencies have been corrected.

.4 The following shall be an outline checklist of the minimum requirements to be met by the contractor prior to the Engineers' Substantial Performance by the contractor.

Inspection:

- ☐ Complete Commissioning Checklists
- ☐ Final Plumbing Inspection Certificate from local plumbing inspector
- ☐ Fire alarm test certificate (via DIV.16)
- ☐ Fire Stopping and Fire Damper test letter
- ☐ Seismic Engineers inspection of all Seismic restraints and schedule C letters of assurance
- ☐ Chemical Treatment supplies final inspection and test certificate
- ☐ Major equipment – suppliers start-up test sheets and letters certifying start up. (pumps, fan, packaged air handling equipment)
- ☐ Final As-Built Drawings ready for review
- ☐ Maintenance and operation manuals, ready for review

.5 Prior to Total Performance Inspection provide declaration in writing that deficiencies noted at time of substantial performance inspection have been corrected and the following items completed prior to the total performance inspection:

.1 Submit find air and water balance reports.

.2 Submit final operating and maintenance manuals.

.3 Complete final calibration.

.6 The Contractor shall provide qualified personnel in appropriate numbers to operate the facility until substantial performance is declared.

1.29 Acceptable Manufacturers

.1 The following listed manufacturers are acceptable for their ability to meet the general design intent, quality and performance characteristics of the specified product. The list does not endorse the acceptability of all products available from the listed manufacturers/suppliers.

.2 It remains the responsibility of the contractor to ensure the products supplied are equal to the specified products in every respect, operate as intended, and meet the performance specifications and physical dimensions of the specified product.

.3 The contractor shall be fully responsible for any additional work or materials, to accommodate the use of equipment from the acceptable manufacturers and suppliers list.

.4 Submit within fourteen (14) days of contract award a copy of the list underlining the name of the manufacturer whose price was carried in the tender. If no manufacturers names are submitted, it will be assumed that the price carried in the tender was that of the specified manufacturer or where the specified product is generic, the first acceptable manufacturer listed for each item and equipment.

.5 List of acceptable Manufacturers:

• Access Doors	Maxam, Acudor, Milcor, Can.Aqua, Mifab
• Air Handling Units (Heat Recovery) - Indoor Pre-manufactured	Engineered Air, Haakon, Venmar
• Air Separators, Relief Valves	Armstrong, Bell & Gossett, Taco, Wheatley
• Air Terminals - Grilles Registers, Diffusers	E.H. Price, Titus, Anemostat, Nailor
• Air Vents	Hoffman, Maid-O-Mist, Taco
• Backdraft Dampers	Airolite, Vent-Aire, Penn, T.A. Morrison
• Backflow Preventers	Febco, Watts, Hersey, Singer, Ames
• Balancing Dampers	Maxam, Ruskin
• CO and Combustible Gas Detector	MSA, ACME, Armstrong, Critical Environment Technology
• Coils - Heating and Cooling	Trane, Aerofin, Engineered Air, Colmac, Heatcraft
• Dampers - Control, Backdraft	Ruskin, Tamco
• Dampers - Smoke-Fire Combination	Ruskin, Controlled Air, Prefco

• Drains - Floor, Cleanouts, Trap Primers, Water Hammer Arrestors	Zurn, Ancon, PPP, J.R. Smith
• Expansion Compensators	Flexonics, Tube Turn, Hyspan, Hydroflex, Metraflex, United Flexible, Mason
• Expansion Joints	Flexonics, Hyspan, Hydroflex, Metraflex, United Flexible, Mason
• Fans - Centrifugal	Buffalo, Twin City, Trane, Chicago, Barry Blower, Northern
• Fans - In-Line Centrifugal	Greenheck, Jenn Air, Ammerman, ILG, Cook, Penn, Twin-City, Carnes
• Fans - Roof and Wall Mounted	Greenheck, Ammerman, Powerline, ACME, Loren Cook, Penn, Jenn Fan, ILG, Carnes, Twin City
• Filters	Cambridge, AAF, Pacific, FARR
• Fire Dampers	Controlled Air, Ruskin, Canadian Advanced Air, Maxam, Nailor
• Flexible Connectors - Ducting	Thermaflex, G.I. Industries Type IHP
• Flexible Connectors - Piping	Flexonics, Tube Turn, Atlantic, Hyspan, Hydroflex, Metraflex, United Flexible, Mason
• Flow Meter - Venturi	Gerand, Presco
• Gauges - Air	Dwyer, Magnehelic
• Hose Bibbs	Jenkins, Dahl, Crane, Toyo, Kitz, Mifab
• Insulation - Piping and Duct	Fibreglass Canada, Manson, Knauf Fibreglass, Plasti-Fab, Manville
• Louvres	Airolite, Penn, Airstream, West Vent. Nailor, Ruskin
• Pipe Restraints	Trelleborg
• Piping Hangers and Saddles	Grinnell, Myatt
• Plug Cocks	DeZurik, Newman-Milliken
• Plumbing: Floor Drains, Roof Drains, Hose Bibbs	Mifab, Zurn, Smith
• Pumps - Vertical In-Line and Base Mounted	Armstrong, B & G, Taco, Leitch, Grundfos
• Radiation - Wall Fin	Engineered Air, Rosemex, Heatcraft
• Strainers	Armstrong, Sarco, Mueller, Toyo, Anderson, Metraflex, Yarway
• Tank - Diaphragm Type Expansion	Amtrol, Hamlet and Garneau Inc.

• Thermometers	Trerice, Marsh, Ashcroft, Winters
• Unit Heaters - Cabinet	Engineered Air, Rosemex, Trane, Heatcraft
• Unit Heaters - HW	Engineered Air, Trane, Rosemex, Heatcraft
• Valves - Butterfly	Jenkins, Keystone, DeZurik, Centreline, Monotight, Dresser, Lunkenheimer, Crane, Bray, Toyo, Grinnell
• Valves - Circuit Balancing	Armstrong, B & G, Wheatley, Tour & Anderson
• Valves - Drain, Radiator	Jenkins,Dahl, Crane, Toyo, Kitz
• Valves - Eccentric Plug	DeZurik, Homestead
• Valves - Gate, Globe, Swing, Check, Ball	Jenkins, Toyo, Crane, Kitz, Milwaukee
• Valves - Plumbing Flush	Crane, Sloan, Teck
• Valves - Pressure Balanced Mixing	Symmons
• Valves - Pressure Reducing	Armstrong, Bell & Gossett, Taco
• Valves - Relief	Armstrong, Bell & Gossett, Taco, Wheatley
• Valves - Silent Check	Val-matic, APCO, StreamFlo
• Valves - Suction Diffusers Combination Check and Balance	Armstrong, B&G, Taco
• Valves - Thermostatic Mixing	Symmons, Powers, Lawler
• Valves - Water Pressure Reducing	Watts, Clayton, Singer, Zurn. Wilkins, BCA, Cash Acme, Braukman
• Vent Caps	Jenn-Air, Penn Ventilator
• Vent Sets	Greenheck, Trane, Sheldons, Buffalo, New York, Brundage, Loren Cook, Lau
• Vibration Isolation	Mason, Vibro Acoustic

1.30 Equipment Supplied By Others

.1 Scope

.1 Provide rough-in for and make all connections to equipment supplied by others process equipment.

.2 Related Work in Other Sections

.1 Refer to drawings and other specification sections to complete list of equipment supplied by others.

.3 Installation

.1 Make all mechanical connections to equipment supplied by others under this contract. This shall include all water, drain, exhaust, traps, ductwork and similar connections required. Provide isolation valves, unions, flanges and traps as required for a complete installation.

.2 Change to rough-in of services or final equipment connections due to a change in the make of equipment from that specified shall be made at no extra cost to the Owner, provided that proper shop drawings are available for rough-in. Prior to commencing installation of rough-in for the equipment, coordinate with the final reviewed equipment shop drawings and with the manufacturer.

.3 Exposed piping shall be painted as per Architect's instructions.

.4 Arrange piping connections to allow for equipment removal.

.5 Equipment supplied by others and requiring hook-up is as follows:

2. PRODUCTS

.1 Not Applicable.

3. EXECUTION

.1 Not Applicable.

END OF SECTION

BALANCING

1. GENERAL

1.1 Scope

.1 Balance, adjust, and test air and water systems and equipment and submit reports in identical units to those shown on contract documents.

.2 Contractor shall prepare the facility for balancing.

1.2 Quality Assurance

.1 Work specified in this section shall be performed by an Independent Agency specialising in this type of work, and paid by the Contractor.

.2 Balancing (of both air and water systems) and sound level readings shall be performed by the same agency.

.3 Balancing procedures shall be in accordance with the latest, current requirements NEBB, SMACNA and ASHRAE Standards.

1.3 Site Visits

.1 Minimum of one site visit shall be made during construction to correspond with the general monthly site meetings held by the Contractor. After each site visit, a written report shall be submitted to the Contractor and Engineer. Site visits shall commence after the start of air and water distribution work and be spread over the construction period to the start of the balancing work.

.2 A review of the installation shall be made at the specified site visit and any additional dampers or valves required for proper balance shall be reviewed with the Engineer and the Contractors.

.3 Allow one visit to site to adjust systems for seasonal changes and to check and reset fans and outlets during warranty. Co-ordinate time of visit with the Owner. Submit reports to Engineer.

.4 Begin balancing after balancing preparation and after systems have been completed and are in full working order. Place systems and equipment into full operation and continue operation during each working day of balancing.

1.4 Balance Report

.1 Submit two (2) copies of balancing reports to Engineer prior to final acceptance of project.

.2 Provide six (6) copies of final reports to Contractor for inserting in owner's Operating and Maintenance Manuals as described in Section 01730 Operation and Maintenance Manuals.

.3 Include types, serial number and dates of calibration of instruments in the reports.

1.5 System Data

.1 The following information shall be provided:

.1 Air Handling Equipment
Design Data:
Total air flow rate;
Fan total static pressure;
System static pressure;
Motor kW, r/min, amps, volts, phase;
Outside air flow rate L/s;
Fan r/min;
Fan kW;
Inlet and outlet, dry and wet bulb temperatures.

Installation Data:

Manufacturer and model;
Size;
Arrangement discharge and class;
Motor type, kW, r/min, voltage, phase, cycles, and load amperage;
Location and local identification data.

Recorded Data:
Air flow rate;
Fan total static pressure;
System static pressure;
Fan r/min;
Motor operating amperage;
Inlet and outlet, dry and wet bulb temperatures.

.2 Duct Air Quantities: All mains supplying more than 10% of Volume, outside air and exhaust (maximum and minimum) major return air openings back to duct shafts.

Duct sizes;
Number of pressure readings;
Sum of velocity measurements;
Average velocity;
Duct recorded air flow rate;
Duct design air flow rate.

.3 Air Inlet and Outlets
Outlet identification location and designation;
Manufacturers catalogue identification and type;

Application factors;
Design and recorded velocities;
Design and recorded air flow rates;
Deflector vane or diffuser cone settings.

.4 Pumps

Design Data:

Fluid flow rate;
Total head;
kW, r/min, amps, volts, phase.

Installation Data:

Manufacturer and model;
Size;
Type drive;
Motor type, kW, r/min, voltage, phase, and full load amperage.

Recorded Data:
Discharge and suction pressures (full flow and no flow);
Operating head;
Operating water flow rate (from pump curves if metering not provided);
Motor operating amps (full flow and no flow);
R/min.

.5 Expansion Tank

Design Data:

Size;
Capacity;
Pressure rating.
Installation Data:

Manufacturer, size, capacity;
Pressure reducing valve setting;
Pressure relief valve setting

.6 Heating Equipment (Baseboards, Unit Heaters, etc.)

Design Data:

Heat transfer rate;
Fluid flow rate;
Entering and leaving fluid temperatures;

Fluid pressure drop.

Installation Data:

Manufacturer, model, type;
Entering and leaving fluid temperatures;
Capacity;
Pressure drops;
Flow rates.

Recorded Data:

Element type and identification (location and designation);
Entering and leaving fluid temp (for varying outdoor temperatures);
Fluid pressure drop;
Fluid flow rate;
Pressure relief valve setting.

.7 Air Heating and Cooling Equipment

Design Data:

Heat transfer rate;
Liquid and air flow rates;
Liquid pressure drop;
Air static pressure drop;
Entering and leaving liquid temperatures;
Entering and leaving air dry and wet bulb temperatures.

Installation Data:

Manufacturer, model, type;
Entering and leaving fluid flow and temperatures;
Entering and leaving air flow and temperatures;
Fluid and air side pressure drops.

Recorded Data:

Element type and identification (location and designation);
Entering and leaving air dry and wet bulb temperatures;
Entering and leaving water temperatures;
Water pressure drop;
Air static pressure drop;
Air and water flow rates;
Adjusted temperature rise or drop.

.8 Sound Level Data

Diagram or description of relationship of sound source and measuring instrument;
"A" scale reading;
Reading at each octave band frequency.

2. PRODUCTS

2.1 Instruments

.1 Provide calibration histories for each instrument. Recalibration or use of other instruments may be requested when accuracy of readings is questionable.

3. EXECUTION

3.1 General Procedure

.1 Permanently mark, by stick-on labels, settings on valves, splitters, dampers, and other adjustment devices.

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

.3 Balancing shall be performed to the following accuracies:

• Air	terminal outlets	±10%
• Air	central equipment	±5%
• Hydronic	terminal outlets	±10%
• Hydronic	pumps and central	±5%

3.2 Air System Procedure

.1 Perform balancing, adjusting and testing with building doors and windows in their normal operation position.

.2 The following procedure shall be adopted for central systems:

- Ensure dampers or volume control devices are in fully open position.
- Balance central apparatus to ±10% air flow.
- Balance branches, mains to ±10% air flow.
- Recheck central apparatus.
- Balance all terminal air outlets to ±10%.
- Rebalance central apparatus to ±5%.
- Recheck all air outlets.

- Perform acoustical measurements.

- Perform building pressurisation tests and measurements at minimum and maximum outdoor air damper positions of the main air unit(s).

.3 When balancing air outlets:

.1 Rough balance furthest outlets and then balance sequentially back to source.

.2 Fine balance furthest outlet back to source.

.4 Take static pressure readings and air supply temperature readings at 10 points on each air system.

.5 Make air quantity measurements in ducts by "Pitot Tube" traverse of entire cross sectional area. If readings are inconsistent across duct, relocate to two duct diameters and re-do traverse.

.6 Use volume control devices to regulate air quantities only to extent that adjustments do not create objectionable air motion or sound levels. Effect volume control only by duct internal devices such as dampers.

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

.8 Where modulating dampers are provided, take measurements and balance at extreme conditions.

.9 The final balanced condition of each area shall include testing and adjusting of pressure conditions. Test and record building pressurisation levels in variable volume systems throughout full range of fan delivery rates, under both heating and cooling conditions. Full multi-storey building test pressure conditions at ground and upper levels. Front doors, exits, should be checked for air flow so that exterior conditions do not cause excessive or abnormal pressure conditions. Document abnormal building leakage conditions noted.

.10 Complete balancing to achieve positive building pressure unless otherwise instructed. A positive pressure relative to outside of 10 Pa minimum and 20 Pa maximum shall be achieved, measured with negligible outside wind velocity.

3.3 Balancing of Hydronic Systems

.1 Open all (excepting pressure bypass must be closed) valves to fully open position including balancing valves, isolation valves, and control valves.

.2 Execute air balance prior to initiating hydronic balance (if coils are provided).

.3 Set pumps to deliver 10% excess flow if possible.

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

.5 Check and adjust flows and temperatures at inlet side of coils.

.6 Position and mark all automatic valves, hand valves and balancing cocks for design flow through all coils, connectors and all items in system requiring circulation of glycol.

.7 Upon completion of flow readings and coil adjustments, mark setting and record data.

.8 Co-ordinate shaving of impellor to operating condition on pumps larger than 1.5 kW.

.9 Ensure all bypass valves are tightly closed.

.10 After making all terminal unit adjustments, re-check settings at pumps. Re-adjust as required.

.11 Calibrate all pressure and temperature gauges.

.12 Install pressure gauges on each coil then read pressure drop through coil and set flow rate on call for full flow through coil. Set pressure drop across bypass valve to match coil full flow pressure drop.

.13 For all parallel pumping systems, check all flows through boiler, heat exchanger, and pumps under the following situations.

- With two pumps operating.
- With one pump operating - repeat for each pump.
- With controls demanding no heating.

.14 For each pump, plot maximum and minimum flows on curve.

.15 Verify pressure drops and flows through pressure control bypass valves at full operating range.

3.4 Balancing Report

.1 Submit draft copies of reports prior to final acceptance of project.

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

.3 Record test data on a sepia made from the latest available revised set of mechanical drawings and submit four (4) copies upon completion of the balancing contract for inclusion in equipment and maintenance manuals.

.4 Install at each piece of mechanical equipment a "Data Register" showing significant operating temperatures, pressures, amperes, voltage, brake horsepower. "Data Register" to be enclosed in a plastic holder securely attached to the equipment or to a wall in the adjacent area.

.5 Submit with report, fan and pump curves with operating conditions plotted. Submit grille and diffuser shop drawings and diffusion factors.

.6 Report shall be indexed as follows:

Air
Summary
Procedure
Instrumentation
Drawings
Equipment Summary
Fan Sheets
Fan Curves
Fan Profile Data
Static Data
Air Monitoring Station Data
Traverse Data and Schedule
Terminal Unit Summary
Outlet Data Summary and Schematics (per system)
Building Pressurisation Data Diagnostic

Water
Summary
Procedure
Instrumentation
Drawings
Pump Data
Pump Curves
Flow Stations
Coils
Equipment Data
Element Data Summary and Schematics (per system)
Diagnostic

3.5 Bring the work to an operating state and ready for balancing, including:

.1 Clean equipment and ductwork.

.2 Install air terminal devices.

.3 Provide temporary filters in air handling equipment and carry out a rough air balance to ensure all equipment performs required function.

.4 Replace filters with specified filters prior to balancing.

.5 Verify lubrication of equipment.

.6 Install permanent instrumentation.

.7 Clean piping systems and strainers, clean systems as per Section 15090, drain and fill with clean heat exchange fluid.

.8 Complete the "start-up" of equipment.

.9 Adjust stuffing boxes and packing glands on pumps and valves.

.10 Check rotation and alignment of rotating equipment and tension of belted drives.

.11 Verify ratings of overload heaters in motor starters.

.12 Set control points of automatic apparatus, check-out sequence of operation.

.13 Make available control diagrams and sequence of operation.

.14 Clean work, remove temporary tags, stickers, and coverings.

.15 Make available one (1) copy of Maintenance Manuals especially for use in balancing.

.16 Provide Balancing Agency a complete set of mechanical drawings and specifications.

3.6 Co-operate with the Balancing Agency as follows:

.1 Make corrections as required by Balancing Agency.

.2 Allow Balancing Agency free access to site during construction phase. Inform Balancing Agency of any major changes made to systems during construction and provide a complete set of record drawings for their use.

.3 Operate automatic control system and verify set points during balancing.

3.7 Balancing Valves and Dampers

.1 Provide and install balancing valves, dampers, and other materials requested by the Balancing Agency and/or necessary to properly adjust or correct the systems to design flows, without additional cost to Owner.

3.8 Pulleys and Sheaves

.1 Provide and install pulleys and sheaves for rotating equipment, as required to properly balance the systems to design flows, without additional cost to Owner.

3.9 Shaving of Pump Impellers

.1 Allow in the contract price shaving of impellers as required to balance the pumps to design flow at operating condition.

END OF SECTION

1. GENERAL

1.1 Scope

.1 Test domestic water piping.

.2 Test effluent water piping.

.3 Test sanitary sewer piping.

.4 Test fuel oil piping.

.5 Test low velocity ducts.

.6 Test glycol heating piping.

.7 Performance testing of equipment.

.8 Manufacturer's start-up of equipment.

1.2 Quality Assurance

.1 Test equipment and material where required by specification or authority having jurisdiction to demonstrate its proper and safe operation.

.2 Test procedures in accordance with the current applicable portions of ASME, ASHRAE, and other recognised test codes as far as field conditions permit.

.3 Perform tests on site to the satisfaction of the Consultant.

.4 Piping, fixtures or equipment shall not be concealed or covered until inspected and approved by the Engineer. Provide ample written notice (two working days) to the Consultant before tests.

.5 Co-ordinate with Consultant at start of project, those tests that will require witnessing by the Consultant.

.6 Use factory trained representatives and submit manufacturer's check sheets for starting the following specialty equipment.

- Air handling units
- Pumps
- Control components
- Chemical cleaning and treatment

.7 Prior to starting, testing, balancing, adjusting and cleaning processes, verify with Engineer any tests required to be witnessed. Provide sufficient notice to Engineer prior to commencement of procedures.

.8 Engineer shall be allowed to witness any testing, adjusting, starting, balancing and cleaning procedures.

.9 Assume all costs associated with starting and testing, including the supply of testing or cleaning medium.

.10 Prior to starting equipment or systems, secure and review manufacturer's installation, operation and starting instructions. Read in conjunction with procedures defined herein.

.11 Use manufacturer's or supplier's starting personnel where required to ensure integrity of manufacturer's warranty.

.12 Compare installations to published manufacturer's data and record discrepancies. Items proving detrimental to equipment performance shall be corrected prior to equipment starting.

.13 Some processes involved in starting procedures defined in this section may be duplications of authorities' verification. To facilitate expedient completion of project, arrange for authorities to assist or witness these procedures.

.14 All starting, testing procedures shall be in accordance with applicable portions of the latest, current ASME, ASHRAE, AABC, CSA, NFPA, SMACNA, ASTM and ASPE codes and standards.

.15 Personnel involved in starting, testing, balancing and adjusting procedures shall be experienced in the design and operation of mechanical equipment and systems being checked and shall be able to interpret results of the reading and tests.

.16 Assume all liabilities associated with starting, testing and balancing procedures.

1.3 Submittals

.1 Obtain certificates of approval, acceptance, and comply with current rules and regulations from authorities having jurisdiction and include in Operating and Maintenance Manuals.

.2 Perform tests as specified and upon completion of mechanical installation. Provide certification of tests with detailed data as required. Itemise each test as to time performed and personnel responsible. Include in Operating and Maintenance Manuals.

1.4 Liability

.1 Take charge of plant during tests, assume responsibility for damages in event of injury to personnel, building or equipment and bear costs for liability, repairs, and restoration in this connection.

2. PRODUCTS

Not Applicable.

3. EXECUTION

3.1 Pressure Tests

.1 Provide equipment, materials and labour for tests and pay expenses. Use test instruments from approved laboratory or manufacturer and furnish certificate showing degree of accuracy. Install permanent gauges and thermometers used for tests just prior to tests to avoid possible changes in calibration.

.2 Carry out tests for eight-hour period and maintain pressure with no appreciable pressure drop. Where leakage occurs, repair and re-test and pay necessary costs for re-witnessing.

.3 Drainage Systems: Test by filling with water to produce water pressure to 30 kPa minimum and 62 kPa maximum.

.4 Water (domestic and final effluent) Piping: Test to 1-1/2 times maximum working pressure or 1033 kPa, whichever is greater, water pressure measured at system low point.

.5 Fuel Oil Piping: Test as required by current edition of CSA B139, and authority having jurisdiction.

.6 Ducts: Test ducts as per current edition of SMACNA Manual.

.7 Check systems during application of test pressure including visual check for leakage of water test medium, soap bubble test for air.

.8 During heating piping system tests, check linear expansion at elbows, U bends, expansion joints and offsets for proper clearance.

.9 When using water as test medium for system not using water, evacuate and dehydrate the piping and certify the lines are dry. Use agency specialising in this type of work.

.10 Should tests indicate defective work or variance with specified requirements, make changes immediately to correct the defects. Correct leaks by re-making joints in screwed fittings, cutting out and re-welding welded joints, re-making joints in copper lines. Do not caulk.

3.2 Testing Of Soldered Copper Joints

.1 Submit two (2) sample soldered copper pipe joints prepared by each tradesmen to be used on the project, to the Consultant within two (2) months of contract award. These samples may be subjected to radiographic testing to verify quality of workmanship.

.2 Remove ten (10) samples of soldered copper pipe joints on heating system during construction as selected by the Consultant and remake joints removed. Arrange and pay for radiographic testing of removed joints to verify quality of workmanship.

.3 Rejection of a sample will require re-test of adjacent joints at the Contractor's expense.

.4 Failure of more than 75% of the above removed samples will necessitate removal and replacement of all joints completed up to the time of test, at Contractor's expense.

3.3 General

.1 Conduct performance tests to demonstrate equipment and systems meet specified requirements after mechanical installations are completed and pressure tested. Conduct tests as soon as conditions permit. Make changes, repairs, and adjustments required prior to operating tests.

.2 Meet with Division 16 manufacturers, suppliers, and other specialists as required to ensure all phases of work are properly co-ordinated prior to the commencement of each particular testing procedure. Establish all necessary manpower requirements.

.3 Operate and test motors and speed switches for correct wiring and sequences and direction of rotation. Check and record overload heaters in motor starters.

.4 Confirm voltages and operating amperages at full load.

.5 Failure to follow instruction pertaining to correct starting procedures may result in re-evaluation of equipment by an Independent Testing Agency selected by Owner at Contractor's expense. Should results reveal equipment has not been properly started, equipment may be rejected, removed from site, and replaced. Replacement equipment shall also be subject to full starting procedures, using same procedures specified on the originally installed equipment.

3.4 Procedures

.1 Procedures shall be identified in the following five (5) distinct phases:

.1 Pre-Starting: Visual inspection.

.2 Starting: Actual starting procedure.

.3 Post-Starting: Operational testing adjusting or balancing, and equipment run-in phase.

.4 Pre-Interim Acceptance of the Work: Final cleaning, re-testing, balancing and adjusting, and necessary maintenance.

.5 Post-Interim Acceptance of the Work: Repeat tests and fine-tuning resulting from corrective action of deficiency clean-up.

.2 Check specified and shop drawing data against installed data.

.3 Check the installation is as defined by contract documents and as per manufacturer's recommendations including manufacturer's installation check sheets.

END OF SECTION