SECTION 23 05 93 - TESTING ADJUSTING AND BALANCING FOR HVAC

[Note to PSC: Existing System Coordination –

When connecting to an existing system, it is the PSC's Responsibility to examine existing documents, field verify existing conditions, perform thorough calculations, and confirm that the proposed systems will be adequately served by the existing systems attached to and adjacent tp systems affected. "pre-testing" of the existing systems may be required including evaluation of available trend data and consultation of a testing, adjusting, and balancing (TAB) professional.

1. *Verify Adequate Capacity – As a rule of thumb, modifications affecting less than +/-10% requires TAB for the proposed components, the primary existing components (ie. heat exchangers, fans, pumps, etc.), and the main branches (eg. at each floor, building wing, etc.). Alterations affecting greater than +/-10% may require major or complete re-balance (PSC to confirm and advise requirements).*
2. *Coordinate With Adjacent Systems – Additions and alterations shall not adversely affect adjacent existing systems. A complete evaluation of airflow conditions shall be performed to ensure appropriate air pressurization relationships. Partitions and adjacencies shall be included in the proposed system load calculations.*
3. *Matching existing – Balancing Devices - For consistency, the PSC shall investigate the existing system attached to and at a minimum match the balancing device type and location (eg. volume dampers, calibrated balancing valves, etc.). Additional quality may be considered (PSC to propose value added modifications).*
4. *Matching Existing – Control Devices - For consistency, the PSC shall investigate the existing system attached to and at a minimum match the control devices used (3-way valve, 2-way valve, pressure independent, etc.) type and location. Existing differential pressure, static pressure, temperature, and other control, alarm, and monitoring devices shall be confirmed for adequate location and functionality. PSC shall propose relocation or additional devices as appropriate. Additional quality may be considered (PSC to propose value added modifications).*

PART I - GENERAL

1.1 WORK INCLUDES

A. Heating Contractor provides:
   1. Testing, adjusting, and balancing of heating systems.
   2. Testing, adjusting, and balancing of cooling systems.
   3. Measurement of final operating condition of HVAC systems.
   4. Participation in commissioning process.

B. Ventilation Contractor provides:
   1. Testing, adjusting, and balancing of air systems.
   2. Measurement of final operating condition of HVAC systems.
   3. Participation in commissioning process.

1.2 REFERENCES

A. AABC - National Standards for Total System Balance.

B. AMCA – Publication 203-90; Field Performance Measurement of Fan Systems.

C. ASHRAE - HVAC Applications Handbook; Testing, Adjusting and Balancing.

D. ASHRAE/ANSI - Practices for Measurement, Testing, Adjusting and Balancing of Building HVAC&R Systems.

E. NEBB - Procedural Standards for Testing, Adjusting and Balancing of Environmental Systems.

F. SMACNA - HVAC Systems; Testing, Adjusting and Balancing.

G. TABB – International Standards for Environmental Systems Balance.

1.3 SUBMITTALS

A. Submit hardcopy and electronic copies of report forms, balancing procedures, TAB Plan and the name and qualifications of testing and balancing agency for approval within 30 days after award of Contract.

B. Identify as “Draft copy of Balancing and Testing Report - for Approval” on Transmittal with relevant numbering as required on Project Submittals. Include all items from (A) and all requirements from this Specification, related sections including but not limited to 01 93 23 - General Commissioning Requirements, 23 08 00 - Commissioning of HVAC, and 23 09 23 -Building Automation System (BAS) for HVAC.

1. Upon approval from both the Owner and PSC - Submit electronic and four (4) certified copies of test Final report to the PSC 3-ring binder manuals, with cover identification. Include index page and indexing tabs. Identify as “Balancing and Testing Report - Approved Final” on Transmittal with relevant numbering as required on Project Submittals.

C. Note - Final Witnessing by the Owner during Functional Testing of related Systems occurs after successful completion of A & B. The Owner reserves the right to require the TAB Contractor(s) to help resolve discrepancies and / or missing work products discovered during Functional Testing and as necessary have the TAB(s) retest affected work at no additional charge should the PSC determine discrepancies were related to this work.

1.4 REPORT FORMS

A. Submit reports on AABC, SMACNA or NEBB forms. Use custom forms approved by the PSC when needed to supply specified information.

B. Include in the final report a schematic drawing showing each system component, including balancing devices, for each system. Each drawing shall be included with the test reports required for that system. The schematic drawings shall identify all testing points and cross-reference these points to the report forms and procedures.

1.5 QUALITY ASSURANCE

A. Agency shall be a company specializing in the adjusting and balancing of systems specified in this section with minimum three years experience. Perform work under supervision of AABC Certified Test and Balance Engineer, NEBB Certified Testing, Balancing and Adjusting Supervisor, SMARTA Certified Air and Hydronic Balancer, or TABB Certified Supervisor.

B. Work shall be performed in accordance with this Specification, the requirements of the references listed at the start of this section, other identified or related Sections, and Div 1.

1.6 WARRANTY/GUARANTEE

A. The TAB Contractor shall include an extended warranty of 90 days after Using Agency receipt of a completed balancing report, during which time the Using Agency may request a recheck of terminals, or resetting of any outlet, coil, or device listed in the test report. This warranty shall provide a minimum of 40 manhours of on site service time. If it is determined that the new test results are not within the design criteria, the balancer shall rebalance the system according to design criteria.

B. Warranty/Guarantee must meet one of the following programs: TABB International Quality Assurance Program, AABC National Project Performance Guarantee, NEBB's Conformance Certification.

1.7 SCHEDULING

A. Coordinate schedule with other trades. Provide a minimum of seven days notice to all trades and the PSC prior to performing each test.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

A. Title Page:
   1. Project name
   2. Project location
   3. Project Architect
   4. Project Engineer
   5. Project General Contractor
   6. TAB Company name, address, phone number
   7. TAB Supervisor's name and certification number
   8. TAB Supervisor's signature and date
   9. Report date

B. Report Index

C. General Information:
   1. Test conditions
   2. Nomenclature used throughout report
   3. Notable system characteristics/discrepancies from design.
   4. Test standards followed
   5. Any deficiencies noted
   6. Quality assurance statement

D. Instrument List:
   1. Instrument
   2. Manufacturer, model, and serial number
   3. Range
   4. Copy of actual NIST level Certificate of Calibration with Calibration date from the manufacturer of the instrument.

2.2 AIR SYSTEMS

A. Duct Leakage Test:
   1. Air system and fan
   2. Leakage class
   3. Test pressure
   4. Construction pressure
   5. Flow rate (cfm): specified and actual

6. Leakage *[Note to PSC: Include a referenced Section 23 31 00 in the specifications*]: specified and actual.
7. Statement that fire dampers, reheat coils and other accessories were included in the test.
8. Pass or Fail
9. Test performed by
10. Test witnessed by

B. Air Moving Equipment:
1. Drawing symbol
2. Location
3. Manufacturer, model, arrangement, class, discharge
4. Supply flow rate (cfm): specified and actual
5. Return flow rate (cfm): specified and actual
6. Outside flow rate (cfm): specified and actual
7. Exhaust flow rate (cfm): specified and actual
8. Filter pressure drop: specified and actual
9. Total static pressure: specified and actual. (Indicate if across fan or external to unit).
10. Inlet pressure
11. Discharge pressure
12. Fan RPM
13. Multiple RPM fan curve with operating point marked. (Obtain from equipment supplier)

C. Fan Data:
1. Drawing symbol
2. Location
3. Manufacturer and model
4. Flow rate (cfm): specified and actual
5. Total static pressure: specified and actual. (Indicate measurement locations).
6. Inlet pressure
7. Discharge pressure
8. Fan RPM

D. Electric Motors:
1. Drawing symbol of equipment served
2. Manufacturer, Model, Frame
3. Nameplate: HP, phase, service factor, RPM, operating amps, efficiency.
4. Measured: Amps in each phase

E. Duct Traverse:
1. System zone/branch/location
2. Duct size
3. Free area

4. Velocity: specified and actual
5. Flow rate (cfm): specified and actual
6. Duct static pressure
7. Air temperature
8. Air correction factor

F. Air Terminal (Inlet or Outlet):
1. Drawing symbol
2. Room number/location
3. Terminal type and size
4. Velocity: specified and actual
5. Flow rate (cfm): specified and actual
6. Percent of design flow rate

G. Air Terminal Unit (Terminal Air Box) Data:
1. Drawing symbol
2. Location
3. Manufacturer and model
4. Size
5. Type: constant, variable, single, dual duct
6. Inlet static pressure during testing (maximum and minimum).
7. Coil air pressure drop: specified and actual
8. Cooling maximum flow rate (cfm): specified and actual.
9. Heating maximum flow rate (cfm): specified and actual.
10. Minimum flow rate (cfm): specified and actual.
11. Entering air temperature: specified and actual.
12. Leaving air temperature (in heating mode): specified and actual.

H. Air Flow Measuring Station:
1. Drawing symbol
2. Service
3. Location
4. Manufacturer and model
5. Size
6. Flow rate (cfm): specified and actual
7. Pressure drop: specified and actual

I. Fire, Smoke, and Fire/Smoke Dampers:
1. Damper ID #
2. System identification
3. Type
4. Size

5. U.L. assembly number
6. Location of damper and access door
7. Fusible link temperature rating
8. Manufacturer and model
9. Operation pass/fail/reset

2.3 HEATING SYSTEMS

A. Pump Data:
   1. Drawing symbol
   2. Service
   3. Manufacturer, size, and model
   4. Impeller size: specified, actual, and final (if trimmed)
   5. Flow Rate (gpm): specified and actual
   6. Pump Head: specified, operating and shut-off
   7. Suction Pressure: Operating and shut-off
   8. Discharge Pressure: Operating and shut-off
   9. Final frequency of motor at maximum flow rate. (On pumps driven by VFD.)

B. Electric Motors:
   1. Drawing symbol of equipment served
   2. Manufacturer, Model, Frame
   3. Nameplate: HP, phase, service factor, RPM, operating amps, efficiency.
   4. Measured: Amps in each phase

C. Heat Exchangers (not all items apply to all units):
   1. Drawing symbol
   2. Service
   3. Location
   4. Manufacturer and model
   5. Steam pressure in exchanger: specified and actual Flow rate (cfm): specified and actual.
   6. Secondary water entering temperature: specified and actual.
   7. Secondary water leaving temperature: specified and actual.
   8. Secondary water flow: specified and actual.
   9. Secondary water pressure drop: specified and actual.
   10. Secondary water Btuh (gpm x temperature rise x 500).

D. AHU Heating Coils:
   1. Drawing symbol
   2. Service
   3. Location
   4. Manufacturer and model

5. Size
6. Flow rate (cfm): specified and actual
7. Entering air temperature: specified and actual
8. Leaving air temperature: specified and actual
9. Air pressure drop: specified and actual
10. Steam pressure after valve: specified and actual
11. Water pressure drop: specified and actual
12. Entering water temperature: specified and actual
13. Leaving water temperature: specified and actual
14. Air Btuh (cfm x temp rise x 1.09)
15. Water Btuh (gpm x temp drop x 500). Repeat tests if not within 10% of air Btuh.

E. Terminal Heat Transfer Units (Note: Terminal equipment does not include balancing valves. Refer to drawing for additional information):
1. Drawing symbol
2. Location
3. Manufacturer and model
4. Flow rate (cfm): specified and actual
5. Entering air temperature: specified and actual
6. Leaving air temperature: specified and actual
7. Include air data only for forced air units

2.4 COOLING SYSTEMS

A. Electric Motors:
1. Drawing symbol of equipment served
2. Manufacturer, Model, Frame
3. Nameplate: HP, phase, service factor, RPM, operating amps, efficiency
4. Measured: Amps for each phase

B. AHU Cooling Coils:
1. Drawing symbol
2. Service
3. Location
4. Size
5. Manufacturer and model
6. Flow rate (cfm): specified and actual
7. Entering air DB temperature: specified and actual
8. Entering air WB temperature: specified and actual
9. Leaving air DB temperature: specified and actual
10. Leaving air WB temperature: specified and actual
11. Air pressure drop: specified and actual

12. Water pressure drop: specified and actual
13. Entering water temperature: specified and actual
14. Leaving water temperature: specified and actual
15. Air Btuh (cfm x enthalpy change x 4.5)
16. Water Btuh (gpm x temperature drop x 500). Repeat tests if not within 10% of air Btuh

C. Terminal Heat Transfer Units (Note: Terminal equipment does not include balancing valves. Refer to drawing for additional information):
   1. Drawing symbol
   2. Location
   3. Manufacturer and model
   4. Flow rate (cfm): specified and actual
   5. Entering air DB temperature: specified and actual
   6. Leaving air DB temperature: specified and actual
   7. Include air data only for forced air units

2.5 ENERGY RECOVERY SYSTEMS

A. Air Systems - Air energy recovery devices shall be tested at ambient temperatures of less than 40˚F or greater than 85˚F.
   1. Energy Recovery Wheel:
      a. Drawing Symbol
      b. Location
      c. Primary Entering Air Temperature
      d. Primary Leaving Air Temperature
      e. Primary Air Pressure Drop
      f. Primary Air Flow Rate (cfm)
      g. Secondary Entering Air Temperature
      h. Secondary Leaving Air Temperature
      i. Secondary Air Pressure Drop
      j. Secondary Air Flow Rate (cfm)
      k. Wheel RPM

PART 3 - EXECUTION

3.1 GENERAL REQUIREMENTS

A. All procedures must conform to a published standard listed in Part 1 of this Section. All equipment shall be adjusted in accordance with the manufacturer's recommendations. Any system not listed in this specification but installed under the Contract Documents shall be balanced using a procedure from a published standard listed in Part 1 of this Section.

B. Recorded data shall represent actual measured or observed conditions.

C. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary to allow adequate performance of procedures. After testing and balancing is complete, close probe holes and patch insulation with new materials as specified. Restore vapor barrier and finish as specified.

D. Permanently mark setting of valves, dampers, and other adjustment devices allowing for settings to be restored. Set and lock memory stops.

E. Leave systems in proper working order, replacing belt guards, closing access doors, closing doors to electrical switch boxes, plugging test holes, and restoring thermostats to specified settings.

F. The Balancing Contractor shall measure terminal air box air flow, and the BAS Contractor shall adjust DDC readout to match. Refer to *Section 23 09 23* for additional information.

3.2 EXAMINATION

A. Before beginning work, verify that systems are complete and operable. Ensure the following:

1. Equipment is safe to operate and in normal condition.
2. Equipment with moving parts is properly lubricated.
3. Temperature control systems are complete and operable.
4. Proper thermal overload protection is in place for electrical equipment.
5. All filters are clean and in place. If required, install temporary media.
6. Duct systems are clean and free of debris.
7. Direction of rotation of all fans and pumps is correct.
8. Fire/smoke and manual volume dampers are in place, functional and open.
9. Coil fins have been cleaned and combed.
10. Access doors are closed and end caps are in place.
11. Air outlets are installed and connected.
12. Duct system leakage has been minimized.
13. Hydronic systems have been cleaned, filled, and vented.
14. Strainer screens are clean and in place.
15. Shut-off, throttling and balancing valves are open.

B. Report any defects or deficiencies to PSC.

C. Promptly report items that are abnormal or prevent proper balancing.

D. If, for design reasons, system cannot be properly balanced, report as soon as observed.

E. Beginning of work means acceptance of existing conditions.

F. Indicate if flow measuring devices are installed correctly such that accurate measurements can be made.

3.3 PREPARATION

A. Provide instruments required for testing, adjusting, and balancing operations. Make instruments available to the PSC for spot checks during testing.

B. Instruments shall be calibrated within six months of testing performed for project, or more recently if recommended by the instrument manufacturer. Provide a copy of the actual Certificate of Calibration with Calibration date from the instrument manufacturer with the Plan, Preliminary Report and Final Report.

C. Prepare a TAB plan that includes strategies and step-by-step procedures.

D. Complete system-readiness checks and prepare reports. Verify the following:

1. Permanent electrical-power wiring is complete.

2. Hydronic systems are filled, clean, and free of air.
3. Automatic temperature-control systems are operational.
4. Equipment and duct access doors are securely closed.
5. Balance, smoke, and fire dampers are open.
6. Isolating and balancing valves are open and control valves are operational.
7. Ceilings are installed in critical areas where air-pattern adjustments are required and access to balancing devices is provided.
8. Windows and doors can be closed so indicated conditions for system operations can be met.

3.4 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.

B. Prepare schematic diagrams of systems' "as-built" duct layouts.

C. For variable-air-volume systems, develop a plan to simulate diversity.

D. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.

E. Check airflow patterns from the outdoor-air louvers and dampers and the return- and exhaust-air dampers through the supply-fan discharge and mixing dampers.

F. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

G. Verify that motor starters are equipped with properly sized thermal protection.

H. Check dampers for proper position to achieve desired airflow path.

I. Check for airflow blockages.

J. Check condensate drains for proper connections and functioning.

K. Check for proper sealing of air-handling-unit components.

L. Verify that air duct system is sealed as specified in Division 23 Section "Metal Ducts."

3.5 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.

1. Measure total airflow.

a. Where sufficient space in ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow.

2. Measure fan static pressures as follows to determine actual static pressure:

a. Measure outlet static pressure as far downstream from the fan as practical and upstream from restrictions in ducts such as elbows and transitions.

b. Measure static pressure directly at the fan outlet or through the flexible connection.

c. Measure inlet static pressure of single-inlet fans in the inlet duct as near the fan as possible, upstream from the flexible connection, and downstream from duct restrictions.

d. Measure inlet static pressure of double-inlet fans through the wall of the plenum that houses the fan.

3. Measure static pressure across each component that makes up an air-handling unit, rooftop unit, and other air-handling and -treating equipment.

    a. Report the cleanliness status of filters and the time static pressures are measured.

4. Measure static pressures entering and leaving other devices, such as sound traps, heat-recovery equipment, and air washers, under final balanced conditions.

5. Review Record Documents to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.

6. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload will occur. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.

B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows within specified tolerances.

1. Measure airflow of submain and branch ducts.

    a. Where sufficient space in submain and branch ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow for that zone.

2. Measure static pressure at a point downstream from the balancing damper, and adjust volume dampers until the proper static pressure is achieved.

3. Re-measure each submain and branch duct after all have been adjusted. Continue to adjust submain and branch ducts to indicated airflows within specified tolerances.

C. Measure air outlets and inlets without making adjustments.

1. Measure terminal outlets using a direct-reading hood or outlet manufacturer's written instructions and calculating factors.

D. Adjust air outlets and inlets for each space to indicated airflows within specified tolerances of indicated values. Make adjustments using branch volume dampers rather than extractors and the dampers at air terminals.

1. Adjust each outlet in same room or space to within specified tolerances of indicated quantities without generating noise levels above the limitations prescribed by the Contract Documents.

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

3.6 PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS

A. Compensating for Diversity: When the total airflow of all terminal units is more than the indicated airflow of the fan, place a selected number of terminal units at a minimum set-point airflow with the remainder at maximum-airflow condition until the total airflow of the terminal units equals the indicated airflow of the fan. Select the reduced-airflow terminal units so they are distributed evenly among the branch ducts.

B. Pressure-Independent, Variable-Air-Volume Systems: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:

1. Set outdoor-air dampers at minimum, and set return- and exhaust-air dampers at a position that simulates full-cooling load.

2. Select the terminal unit that is most critical to the supply-fan airflow and static pressure. Measure static pressure. Adjust system static pressure so the entering static pressure for the critical terminal unit is not less than the sum of the terminal-unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge system losses.

3. Measure total system airflow. Adjust to within indicated airflow.

4. Set terminal units at maximum airflow and adjust controller or regulator to deliver the designed maximum airflow. Use terminal-unit manufacturer's written instructions to make this adjustment. When total airflow is correct, balance the air outlets downstream from terminal units the same as described for constant-volume air systems.

5. Set terminal units at minimum airflow and adjust controller or regulator to deliver the designed minimum airflow. Check air outlets for a proportional reduction in airflow the same as described for constant-volume air systems.

    a. If air outlets are out of balance at minimum airflow, report the condition but leave outlets balanced for maximum airflow.

6. Remeasure the return airflow to the fan while operating at maximum return airflow and minimum outdoor airflow.

    b. Adjust the fan and balance the return-air ducts and inlets the same as described for constant-volume air systems.

7. Measure static pressure at the most critical terminal unit and adjust the static-pressure controller at the main supply-air sensing station to ensure that adequate static pressure is maintained at the most critical unit.

8. Record final fan-performance data.

3.7 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS

A. Prepare test reports with pertinent design data, and number in sequence starting at pump to end of system. Check the sum of branch-circuit flows against the approved pump flow rate. Correct variations that exceed plus or minus 5 percent.

B. Prepare schematic diagrams of systems' "as-built" piping layouts.

C. Prepare hydronic systems for testing and balancing according to the following, in addition to the general preparation procedures specified above:

1. Open all manual valves for maximum flow.

2. Check liquid level in expansion tank.

3. Check for adequate pressure for highest vent.

4. Check flow-control valves for specified sequence of operation, and set at indicated flow.

5. Set differential-pressure control valves at the specified differential pressure. Do not set at fully closed position when pump is positive-displacement type unless several terminal valves are kept open.

6. Set system controls so automatic valves are wide open to heat exchangers.

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

8. Check air vents for a forceful liquid flow exiting from vents when manually operated.

3.8 PROCEDURES FOR CONSTANT-FLOW HYDRONIC SYSTEMS

A. Measure water flow at pumps. Use the following procedures except for positive-displacement pumps:

1. Verify impeller size by operating the pump with the discharge valve closed. Read pressure differential across the pump. Convert pressure to head and correct for differences in gage heights. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.

    a. Refer to adjustments section below for pump impeller trim to final duty requirements.

2. Check system resistance. With all valves open, read pressure differential across the pump and mark pump manufacturer's head-capacity curve. Adjust pump discharge valve until indicated water flow is achieved.

    b. Monitor motor performance during procedures and do not operate motors in overload conditions.

3. Verify pump-motor brake horsepower. Calculate the intended brake horsepower for the system based on pump manufacturer's performance data. Compare calculated brake horsepower with nameplate data on the pump motor. Report conditions where actual amperage exceeds motor nameplate amperage.

4. Report flow rates that are not within plus or minus 10 percent of design.

B. Measure flow at all automatic flow control valves to verify that valves are functioning as designed.

C. Measure flow at all pressure-independent characterized control valves, with valves in fully open position, to verify that valves are functioning as designed.

D. Set calibrated balancing valves, if installed, at calculated presettings.

E. Measure flow at all stations and adjust, where necessary, to obtain first balance.

1. System components that have Cv rating or an accurately cataloged flow-pressure-drop relationship may be used as a flow-indicating device.

F. Measure flow at main balancing station and set main balancing device to achieve flow that is 5 percent greater than indicated flow.

G. Adjust balancing stations to within specified tolerances of indicated flow rate as follows:

1. Determine the balancing station with the highest percentage over indicated flow.

2. Adjust each station in turn, beginning with the station with the highest percentage over indicated flow and proceeding to the station with the lowest percentage over indicated flow.

3. Record settings and mark balancing devices.

H. Measure pump flow rate and make final measurements of pump amperage, voltage, rpm, pump heads, and systems' pressures and temperatures including outdoor-air temperature.

I. Measure the differential-pressure-control-valve settings existing at the conclusion of balancing.

J. Check settings and operation of each safety valve. Record settings.

3.9 PROCEDURES FOR VARIABLE-FLOW HYDRONIC SYSTEMS

A. Balance systems with automatic two- and three-way control valves by setting systems at maximum flow through heat-exchange terminals and proceed as specified above for hydronic systems.

3.10 PROCEDURES FOR STEAM SYSTEMS

A. Retain this article if using steam systems.

B. Measure and record upstream and downstream pressure of each piece of equipment.

C. Measure and record upstream and downstream steam pressure of pressure-reducing valves.

D. Check settings and operation of automatic temperature-control valves, self-contained control valves, and pressure-reducing valves. Record final settings.

E. Check settings and operation of each safety valve. Record settings.

F. Verify the operation of each steam trap.

3.11 INSTALLATION TOLERANCES

A. Adjust supply, return, and exhaust air-handling systems to +10% / -5% of scheduled values.

B. Adjust outdoor air intakes to within + 5% of scheduled values.

C. Adjust air inlets and outlets to ± 10% of scheduled values.

D. Adjust supply and exhaust air-handling systems for space pressurization to ± 5% of scheduled values, and to provide proper pressurization.

E. Adjust piping systems to ± 10% of design values.

3.12 ADJUSTING

A. After adjustment, take measurements to verify balance has not been disrupted or that disruption has been rectified.

B. Once balancing of systems is complete, at least one damper or valve must be 90% open.

C. After testing, adjusting and balancing are complete, operate each system and randomly check measurements to verify system is operating as reported in the report. Document any discrepancies.

D. Contractor responsible for each motor shall also be responsible for replacement sheaves. Coordinate with contractor.

E. Contractor responsible for pump shall trim impeller to final duty point as instructed by this contractor on all pumps not driven by a VFD. Coordinate with contractor.

F. Participate in commissioning process. Refer to *Section 23 08 00 – Commissioning of HVAC* and Division 1.

3.13 SUBMISSION OF REPORTS

A. Fill in test results on appropriate forms.

B. Provide required data and Documentation including but not limited to Submittals of tested equipment components/Systems previously approved by the PSC, Schematics and all forms per the paragraph entitled “Report Forms” in Part 1 of this section.

C. Provide BAS Trend Reports, TC “Commissioning Tool” Report or other coincident data capture validating TAB data for flow, pressure, temperature, enthalpy, etc.

D. Provide overview of findings, calibrations, tolerances, flow and BTU Capacity balances, rates of same as being on track (part load or design conditions when tested), remaining issues, and delayed balancing and testing scheduled but as yet completed.

E. Provide Sound and Vibration measurements as defined within referenced Sections and Schedules.

END OF SECTION 23 05 93

This section of the *U of I Facilities Standards* establishes minimum requirements only.
It should not be used as a complete specification.