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.
E. NEBB - Procedural Standards for Testing, Adjusting and Balancing of Environmental Systems.
F. SMACNA - HVAC Systems; Testing, Adjusting and Balancing.

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 AE - Submit electronic and four (4) certified copies of test Final report to the AE 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 AE 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 AE 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 AE 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 AE: 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
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
7. Secondary water leaving temperature: 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 AE.

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 AE 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.

3.4 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.

3.5 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.

3.6 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 AE, 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.