SECTION 23 05 93 – system testing, adjusting, and balancing for hvac

1. GENERAL
	* + 1. RELATED DOCUMENTS
				1. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
				2. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.
			2. SUMMARY
				1. Testing, adjusting, and balancing (TAB) of the air conditioning systems and related ancillary equipment will be performed by a technically qualified TAB Firm. TAB Firm must have a current JCI Controller Configuration Tool (CCT) software subscription and be capable of using it to support their TAB effort. If TAB contractor is not capable or doesn't have a subscription, they must hire the BAS Provider to provide TAB support.
				2. TAB Firm shall be capable of performing the TAB services as specified in accordance with the Contract Documents, including the preparation and submittal of a detailed report of the actual TAB Work performed.
				3. TAB Firm shall check, adjust, and balance components of the air conditioning system which will result in optimal noise, temperature, and airflow conditions in the conditioned spaces of the building while the system equipment is operating economically and efficiently. This is intended to be accomplished after the system components are installed and operating as specified in the Contract Documents. It is the responsibility of the Contractor to place the equipment into service. Variable air volume systems shall be balanced in accordance with AABC Standard, Latest Edition or NEBB Standards for Testing, Adjusting, Balancing of Environmental Systems (Latest Edition).
				4. TAB Firm shall check, adjust, and balance all hydronic systems including pumps, water distribution systems, chillers, cooling towers, boilers, heat exchangers, coils, and related equipment.
				5. Liaison and Early Field Inspection:

TAB Firm shall act as a liaison between the Owner, Architect and Contractor(s). TAB Firm shall perform the following reviews (observations) and tests:

During construction, review all HVAC submittals such as control diagrams, air handling devices, etc., that pertain to the ability to satisfactorily balance systems.

Test at least one or at least 10 percent of the single and fan-powered terminal units if the number of units are greater then twenty (20), for casing and damper leakage when the shipment arrives at the Project Site. All testing (except for the initial terminal units) shall be performed at the Project Site.

Test one (1) lab configuration including fume hood with air valve, general exhaust air with air valve and supply air with air valve for performance capability through a full range of inlet pressures. The tracking capability of the exhaust air versus the supply air will be with the submitted hood sash fully open and as the sash is closed in 2 inch increments until fully closed. Track the valves’ response time in relation to sash movement and the lab differential.

During the balancing process, as the TAB Firm discovers abnormalities and malfunctions of equipment or components, the TAB Firm shall advise the Contractor in writing so that the condition can be corrected by the Contractor prior to finishing the TAB scope of Work. Data from malfunctioning equipment shall not be recorded in the final TAB report.

* + - 1. REFERENCE STANDARDS
				1. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.
				2. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.
				3. All materials, installation and workmanship shall comply with the applicable requirements and standards addressed within the following references:

AABC - National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems.

NEBB - National Environmental Balancing Bureau, Procedural Standards for Testing, Adjusting, Balancing of Environmental Systems.

ASHRAE HVAC Applications Chapter 37: Testing, Adjusting and Balancing.

ANSI/ASHRAE Standard 111: Practices for Measurement, Testing, Adjusting and Balancing of Buildings, Heating, Ventilation, Air Conditioning and Refrigeration Systems.

CTI - Cooling Technology Institute CODE ATC-105.

* + - 1. QUALIty assurance
				1. TAB Firm shall have operated a minimum of five (5) years under TAB Firm’s current name.
				2. TAB Firm’s personnel performing Work at the Project Site shall be either professional engineers or certified air and water balance technicians, who shall have been permanent, full time employees of the TAB Firm for a minimum of six (6) months prior to the start of Work for this Project.
				3. TAB firm shall have a background record of at least five (5) years of specialized experience in the field of air and hydronic system balancing in hospital and medical facilities and shall possess properly calibrated instrumentation.
			2. submittals
				1. The activities described in this Section shall culminate in a report to be provided in quadruplicate (4), individually bound and also provided electronically to the Contractor to be presented to the Owner. Neatly type and arrange data. Include with the data, the dates tested, personnel present, weather conditions, nameplate record of test instrument and list all measurements taken after all corrections are made to the system. Record all failures and corrective action taken to remedy incorrect situation. The intent of the report is to provide a reference of actual operating conditions for the Owner's operations personnel.
				2. All measurements and recorded readings (of air, water, electricity, etc.) that appear in the report must have been made at the Project Site by the permanently employed technicians or engineers of the TAB Firm.
				3. At the Owner’s option, all data sheets tabulated each day by TAB Firm personnel shall be submitted for review and sign-off by the Owner’s Construction Inspector. Those data sheets, as initialed by Owner’s Construction Inspector, shall be presented as a supplement to the final TAB report.
				4. Submit reports on electronic forms approved by the Owner and Architect/Engineer which will include the following information as a minimum:

Title Page:

Company name.

Company address.

Company telephone number.

Project name.

Project location.

Project Manager.

Project Engineer.

Project Contractor.

Project identification number.

Certifications

TAB firm certifications.

Personnel certifications.

Instrument List:

Instrument.

Manufacturer.

Model.

Serial number.

Range.

Calibration date.

Test for which instrument was used..

Fan Data (Supply and Exhaust):

Identification and location.

Manufacturer.

Model.

Air flow, specified and actual.

Total static pressure (total external), specified and actual.

Inlet pressure.

Discharge pressure.

Fan RPM.

Air Handler Return Air/Outside Air Data (If fans are used, provide fan data as noted above):

Identification and location.

Design return air flow.

Actual return air flow.

Design outside air flow.

Return air temperature.

Outside air temperature.

Required mixed air temperature.

Actual mixed air temperature.

Electric Motors:

Manufacturer.

Horsepower/brake horsepower.

Phase, voltage, amperage, nameplate, actual.

RPM.

Service factor.

Starter size, heater elements, rating.

V-Belt Drive:

Identification and location.

Required driven RPM.

Driven sheave, diameter and RPM.

Belt, size and quantity.

Motor sheave, diameter and RPM.

Center-to-center distance, maximum, minimum and actual.

Duct Traverse:

System zone/branch.

Duct size.

Area.

Design velocity.

Design air flow.

Test velocity.

Test air flow.

Duct static pressure.

Air temperature.

Air correction factor.

Air Monitoring Station Data:

Identification and location.

System.

Size.

Area.

Design velocity.

Design air flow.

Test velocity.

Test air flow.

Variable or Constant Volume Terminal Unit Test Sheet:

Identification number.

Room number/location.

Terminal type (FP if fan powered) and / or (SDVV, SDCV, DDVV, DDCV), and (HWRH or ERH if reheat coil is used).

Terminal size.

Area factor.

Design velocity.

Design maximum and minimum air flow.

Test (final) velocity.

Test (final) maximum and minimum air flow.

For DDC instrumentation: Measure and record computer readout and calibration factor at the final measurement conditions.

Air dry bulb temperature at the discharge of the terminal unit.

Pump Data:

Identification and location.

Manufacturer.

Size/model.

Impeller size.

Service (CTW, CHW, CDW, HW, etc.).

Developed head pressure and BHP at design flow rate.

Developed head pressure and BHP at actual flow rate.

Pump discharge pressure.

Pump suction pressure.

Total operating head pressure at final balance.

Shut off, discharge and suction pressure.

Shut off, total head pressure.

Pressure differential settings.

Fluid temperature.

Cooling Coil Data:

Identification number.

Location.

Service.

Manufacturer.

Entering air DB temperature, design and actual.

Entering air WB temperature, design and actual.

Leaving air DB temperature, design and actual.

Leaving air WB temperature, design and actual.

Water pressure flow, design and actual.

Water pressure drop, design and actual.

Pressure independent control valve water pressure drop, design and actual.

Entering water temperature, design and actual.

Leaving water temperature, design and actual.

Air quantity CFM design, and CFM actual.

Air pressure drop, design and actual.

Sensible Btu/hr design, and actual.

Total Btu/hr design, and actual.

Heating Coil Data:

Identification number.

Location.

Service.

Manufacturer.

Air flow, design and actual.

Water flow (gpm) or Steam mass flow rate (lbs per hour) design and actual.

Pressure drop water (feet w.g.) or steam (psid), design and actual.

Pressure independent control valve water pressure drop, design and actual.

Entering water or steam temperature, design and actual.

Leaving water or steam temperature, design and actual.

Entering air temperature, design and actual.

Leaving air temperature, design and actual.

Air quantity CFM design, and CFM actual.

Air pressure drop, design and actual.

Sensible Btu/hr design, and actual.

Electric heat kW, number of stages, kW per stage – specified and actual (if applicable).

Heat Exchanger Data:

Identification and location.

Service.

Manufacturer.

Steam flow rate, design and actual.

Water flow rate, design and actual.

Water pressure drop, design and actual.

Pressure independent control valve water pressure drop, design and actual.

Entering steam temperature and pressure, design and actual.

Entering water temperature, design and actual.

Leaving water temperature, design and actual.

Electric heat, full load kW, number of stages, kW per stage – specified and actual (if applicable).

Chiller:

Identification and location.

Manufacturer and model number.

Condenser cooling medium (water or air cooled).

Number of compressor types and number of stages.

Chilled water entering and leaving temperature - specified and actual - one hour log.

Condenser water entering and leaving temperature - specified and actual - one hour log.

Evaporator section and condenser section water side pressure drop - specified and actual.

Air cooled condenser entering and leaving dry bulb temperatures.

Compressors full load amperage - specified and actual.

Voltage, phase, and cycle - specified and actual.

Ambient temperature, DB/WB, time of day, and weather conditions at time of test.

Cooler tons, condenser tons, and measured operating kW / ton compared to factory certified performance test data.

Cooling Tower:

Identification and location.

Manufacturer.

Model number.

Size and serial number.

Motor horsepower and RPM.

Voltage, phase, hertz.

Full load amps.

Running amps.

Cooling tower water flow rate through the tower.

Cooling water flow rate through the bypass piping.

Air entering and leaving wet bulb temperatures.

Record airflow velocities and rates at the tower air inlets.

Specified and actual tons capacity at design conditions.

Hot Water Boiler or Steam Boiler:

Identification and location.

Unit manufacturer and model number.

Heating water flow gpm - specified and actual (if applicable).

Steam capacity lbs per hour - specified and actual (if applicable).

Steam temperature and pressure - specified and actual.

MBtuh Input / output - specified and actual.

MBtuh output - specified and actual.

Gas / Fuel oil burner CFH / gpm.

Gas / Fuel oil inlet pressure, in water / psig.

Blower motor horsepower and FLA.

Fire rate - gas, therm. / oil, btu per lbm.

High fire set point(s).

Low fire set point(s).

NOx measurement

Sound Level Report:

Location (Location established by the Engineer).

Baseline background NC curve for eight (8) bands – with equipment off.

Operating NC curve for eight (8) bands – with equipment on.

Vibration Test on equipment having 10 horsepower motors or greater:

Location of points:

Fan bearing, drive end.

Fan bearing, opposite end.

Motor bearing, center (if applicable).

Motor bearing, drive end.

Motor bearing, opposite end.

Casing (bottom or top).

Casing (side).

Duct after flexible connection (discharge outlet).

Duct after flexible connection (suction inlet).

Test readings:

Horizontal, velocity and displacement.

Vertical, velocity and displacement.

Axial, velocity and displacement.

Normally acceptable readings, velocity and acceleration.

Unusual conditions at time of test.

Vibration source (if non-complying).

Control verification indicating date performed and any abnormalities identified:

Point Location/Description.

EMS Readout (Setpoint and Actual).

Actual Readout.

Interlocks.

Safeties:

VSD Normal Operation.

VSD Bypass Operation.

Alarms.

Sequences of Operation.

Include in the appendix all submittals for air handling units, pumps, fans, heat exchangers, energy recovery units control system, etc.

1. PRODUCTS

 Not used.

1. EXECUTION
	* + 1. AIR BALANCE
				1. When systems are installed and ready for operation, the TAB Firm shall perform an air balance for all air systems and record the results. The outside, supply, exhaust and return air volume for each air handling unit, supply fan and exhaust fan and the supply, exhaust or return air volume for each distribution device shall be adjusted to within +/- 5 percent of the value shown on the Drawings. Air handling unit and fan volumes shall be adjusted by changing fan speed and adjusting volume dampers associated with the unit. Air distribution device volume shall be adjusted using the spin-in tap damper for flexible duct connected devices and the device opposed blade damper (OBD) for duct connected devices. Air distribution devices shall be balanced with air patterns as specified. Duct volume dampers shall be adjusted to provide air volume to branch ducts where such dampers are shown.
				2. The general scope of balancing by the TAB Firm shall include, but is not limited to, the following:

Filters: Check air filters and filter media and balance only systems with essentially clean filters and filter media. The Contractor shall install new filters and filter media prior to the final air balance.

Blower Speed: Measure RPM at each fan or blower to design requirements. Where a speed adjustment is required, the Contractor shall make any required changes.

Ampere Readings: Measure and record full load amperes for motors.

Static Pressure: Static pressure gains or losses shall be measured across each supply fan, cooling coil, heating coil, return air fan, air handling unit filter and exhaust fan. These readings shall be measured and recorded for this report at the furthest air device or terminal unit from the air handler supplying that device. Static pressure readings shall also be provided for systems, which do not perform as designed.

Equipment Air Flow: Adjust and record exhaust, return, outside and supply air CFM(s) and temperatures, as applicable, at each fan, blower and coil.

Coil Temperatures: Set controls for full cooling and for full heating loads. Read and record entering and leaving dry bulb and wet bulb temperatures (cooling only) at each cooling coil, heating coil and reheat coil at each VAV terminal unit. At the time of reading record water flow and entering and leaving water temperatures (In variable flow systems adjust the water flow to design for all the above readings).

Zone Air Flow: Adjust each HVAC VAV terminal unit and VAV air handling unit for design CFM.

Outlet Air Flow: Adjust each exhaust inlet and supply diffuser, register and grille to within + 5 percent of design air CFM. Include all terminal points of air supply and all points of exhaust. Note: For Labs and rooms that are negative exhaust air flow shall be set to design + 10 percent and supply to design - 5 percent. Positive areas will have opposite tolerances.

Pitot Tube Traverses: For use in future troubleshooting by Owner, all exhaust ducts, main supply ducts and return ducts shall have air velocity and volume measured and recorded by the traverse method. Locations of these traverse test stations shall be described on the sheet containing the data.

Maximum and minimum air flow on terminal units.

* + - 1. HYDRONIC SYSTEM BALANCE
				1. When systems are installed and ready for operation, the TAB Firm shall perform water balance for each chilled and heating hot water system.
				2. The general scope of balancing by the TAB Firm shall include, but not be limited to, the following:

Adjusted System Tests: Adjust pressure independent control valves at each coil and heat exchanger for design flow, +/- 5 percent, in accordance with valve manufacturer’s published commissioning procedure. Pressure independent valve manufacturer will provide service tool and/or service software for use in this commissioning process, and provide training in its use. Adjust balancing valves at pumps to obtain design water flow. Record pressure rise across pumps and GPM flow from pump curve. Permanently mark the balanced position for each valve. (Note: If discharge valves on the pumps are used for balancing record the head being restricted by the valves).

Temperature Readings: Read and record entering and leaving water temperature at each water coil, converter and heat exchanger. Adjust as necessary to design conditions. Provide final readings at all thermometer well locations.

Test cooling towers in accordance with CTI Code ATC – 105.

Pressure Readings: Water pressure shall be recorded at all gauge connections. Pressure readings at coils and pumps shall be related to coil and pump curves in terms of GPM flow through flow measuring status, if provided and installed, at each air handler. The flow of water through all water coils shall be adjusted by manipulating pressure independent control valves, in accordance with valve manufacturer’s published commissioning procedures until the rated pressure drops across each coil is obtained and total water flow is verified by flow measuring status. Verify required pressure drop across each pressure independent control valve. For coils equipped with 3-way valves, the rated pressure drop shall first be adjusted through the coils. The bypass valve shall then be adjusted on each coil until an equal pressure drop between supply and return connections is the same as with the flow through the coil.

Ampere Readings: Reading and record full load amperes for each pump motor.

* + - 1. SOUND VIBRATION AND ALIGNMENT
				1. Sound: Read and record sound levels at up to fifteen (15) locations per floor in the building as designated by the Architect/Engineer. All measurements shall be made using an Octave Band Analyzer. All tests shall be conducted when the building is quiet and in the presence of the Architect/Engineer, at the Architect/Engineer’s option.
				2. Vibration: Read and record vibration for all water circulating pumps, air handling units, and fans which have motors larger than 10 horsepower Include equipment vibration, bearing housing vibration, foundation vibration, building structure vibration, and other tests as directed by the Architect/Engineer. Readings will be made using portable IRD (or approved equal) equipment capable of filtering out various unwanted frequencies and standard reporting forms. Maximum vibration at any point listed above, or specified, shall not exceed one mil on fans and one mil on pumps unless otherwise specified. Equipment manufacturer shall rectify all systems exceeding vibration tolerances.
			2. BUILDING AUTOMATION SYSTEMS
				1. In the process of performing the TAB Work, the Contractor shall:

Work with the Building Automation System (BAS) Provider and Owner to ensure the most effective total system operation within the design limitations, and to obtain mutual understanding of intended control performance.

Verify that all control devices are properly connected.

Verify that the intended controllers operate all dampers, valves and other controlled devices.

Verify that all dampers and valves are in the position indicated by the controller; open, closed, or modulating.

Verify the integrity of valves and dampers in terms of tightness of close-off and full-open positions. This includes all duct-mounted dampers, dampers in terminal units, and fire/smoke dampers.

Observe that all valves are properly installed in the piping system in relation to direction of flow and location. Observe that all pressure independent control valves are properly installed in accordance with manufacturer’s published installation instructions.

Observe the calibration and operation of all controllers.

Verify the proper application of all normally opened and normally closed valves.

Observe the locations of all thermostats and humidistats for potential erratic operation from outside influences such as sunlight, drafts, or cold walls.

Observe the locations of all sensors to determine whether their position will allow them to sense only the intended temperatures or pressures of the media. BAS Provider will relocate sensors as deemed necessary by the TAB Firm or Contractor.

Verify that the sequence of operation for any control mode is in accordance with approved Shop Drawings and Specifications. Verify that no demand for simultaneous heating and cooling occurs at the terminal units.

Verify that all controller setpoints meet the Contract Documents.

Check all dampers for free travel.

Verify the operation of all interlock systems.

Perform variable volume system verification to assure the system and system components track with changes from full flow to minimum flow.

* + - 1. STAIRWELL PRESSURIZATION SYSTEMS
				1. With all doors closed, measure the door pull to determine that the opening force required is less than or no greater than 30 pound-force.
				2. With all doors closed, measure the pressure differential across each door to verify the pressure differentials at each floor. Pressure differential shall not exceed 0.15 inches w.g. and shall be greater than 0.05 inches w.g.
				3. Measure the airflow in the stairwell with the maximum number of doors fully open by pitot tube traverse, if traverse locations are available. If traverse locations are not available, TAB Firm shall measure air flow at each outlet.
				4. Verify with smoke that the smoke detector in the stair pressurization fan inlet shuts down the fan.

END OF SECTION 23 05 93