Facility Design Guidelines: Workplace, Architecture & Engineering

System Testing, Adjusting and Balancing
MasterFormat Section 23-02-00

The guidelines described herein shall be used on all projects, unless USAA’s Project Variance Request process has been used to secure an approved, project-specific variance.

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1.00 SUMMARY

A. Testing, adjusting and balancing (TAB) of air and water for the air conditioning systems and related ancillary equipment will be performed by an impartial technically qualified TAB firm selected and employed by the General Contractor as part of the construction contract.

B. The firm shall be capable of performing the services specified at the location of the facility described within the time specified, of preparing and submitting the detailed report of the actual field work performed and following up the basic work as may be required.

1.02 QUALIFICATIONS

A. The Firm shall be one which is organized to provide professional services of this specified type in the State where construction is being performed and shall have one (1) professional engineer licensed in the State where construction is occurring, with current registration, to oversee and or perform such professional services. This engineer shall be responsible for developing the job site data as required in the test procedures outlined in these Guidelines.

B. The Firm shall have operated a minimum of five (5) years under its current Firm name.

C. All personnel used on the job site shall be either professional engineers or engineering technicians, who shall have been permanent, full time employees of the firm for a minimum of six (6) months prior to the start of work for this specific project.

D. The TAB firm shall submit biographical data on the Engineer and/or the individual proposed who will directly supervise the TAB work, as well as other personnel scheduled to perform the technical work under the contract. It shall also submit a background record of at least five years of specialized experience in the field of air, hydronic system balancing, and shall possess properly calibrated instrumentation. The supervisory personnel for the TAB firm shall be registered engineers in the mechanical field and all of the employees used in the TAB firm shall be permanent, full-time employees of the firm.
1.03 REFERENCES


1.04 RESPONSIBILITIES OF THE TAB FIRM

A. The TAB personnel shall check, adjust, and balance the 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 equipment of the system is operating economically. This is intended to be accomplished after the system components are installed and operating as provided for in the contract documents. It is the responsibility of the Mechanical Contractor to place the equipment into service. Variable air volume systems shall be balanced in accordance with AABC 2002 Standard, Sixth Edition.

B. Liaison and Early Inspection:

1. The TAB firm personnel on the job shall act as liaison between the Owner, Architect and Contractor. The following reviews (observations) and tests shall be performed by the TAB Agency:

   a. During construction, review all HVAC submittals such as control diagrams, air handling devices, etc., that pertain to commissioning work and balanceability.

   b. Allow for a fixed number of trips to the project site, over and above those required for testing and balancing for inspection of installation of the mechanical piping systems, sheet metal work, temperature controls and other component parts of the heating, air conditioning and ventilating systems during the construction stage. These inspections shall be made prior to and/or at the above ceiling inspection. Commentary will be provided to the General Contractor of each observation.

2. During the balancing process, as abnormalities and malfunctions of equipment or components are discovered by the TAB personnel, the General Contractor shall be advised in writing so that the condition can be corrected by the Mechanical Contractor. The written document need not be formal but must be understandable and legible. Data from malfunctioning equipment shall not be recorded in the final TAB report.
1.05 FINAL AIR BALANCE

General: When systems are complete and ready for operation, the TAB Consultant will perform a final 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 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 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. The general scope of balancing by the TAB Consultant will include, but is not limited to, the following:

1. **Filters:** Check air filters and filter media and balance only system with essentially clean filters and filter media. The Division 23 Contractor shall install new filters and filter media prior to the final air balance.

2. **Blower Speed:** Measure RPM at each fan or blower to design requirements. Where a speed adjustment is required, the Division 23 Contractor shall make any required changes.

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

4. **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.

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

6. **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 HVAC 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).

7. **Zone Air Flow:** Adjust each zone of multizone units, each HVAC terminal unit and air handling unit for design CFM.

8. **Outlet Air Flow:** Adjust each exhaust inlet and supply diffuser, register and grille to design air CFM. Include all terminal points of air supply and all points of exhaust.

9. **Pitot Tube Traverses:** For use in future troubleshooting by maintenance personnel, 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.
10. Maximum and minimum air flow on terminal boxes.

1.06 FINAL CHILLED AND HEATING HOT WATER BALANCE

General: When systems are completed and ready for operation, the TAB Consultant will perform a final water balance for each chilled and hot water system. The general scope of balancing by the TAB Consultant will include, but not be limited to, the following:

1. **Adjusted System Tests:** Adjust balancing valves at each coil and heat exchanger for design flow. 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).

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

3. **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 valves until the rated pressure drops across each coil is obtained and total water flow is verified by flow measuring status. 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.

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

1.07 SOUND VIBRATION AND ALIGNMENT

A. **Sound:** Read and record sound levels at up to 15 locations in the building designated by the Engineer. All measurements shall be made using an Octave Band Analyzer. All tests shall be conducted when the building is quiet in the presence of the Engineer, if he so desires.

B. **Vibration:** Read and record vibration for all water circulating pumps, air handling units, and fans which have motors larger than 10 HP. Include equipment vibration, bearing housing vibration, foundation vibration, building structure vibration, and other tests as directed by the 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 1 mil on fans and 1 mil on pumps unless otherwise specified. Equipment manufacturers shall rectify all systems exceeding vibration tolerances.

1.08 TESTING OF TEMPERATURE CONTROL SYSTEMS
A. In the process of performing the TAB work, the TAB Agency shall:

1. Work with the temperature control contractor to ensure the most effective total system operation within the design limitations, and to obtain mutual understanding of intended control performance.

2. Verify that all control devices are properly connected.

3. Verify that all dampers, valves and other controlled devices are operated by the intended controller.

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

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

6. Observe that all valves are properly installed in the piping system in relation to direction of flow and location.

7. Observe the calibration of all controllers.

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

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

10. 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. Control Contractor will relocate as deemed necessary by the TAB Agency.

11. Verify that the sequence of operation for any control mode is in accordance with approved shop drawings and specifications. Verify that no simultaneous heating and cooling occurs.

12. Verify that all controller setpoints meet the design intent.

13. Check all dampers for free travel.

14. Verify the operation of all interlock systems.

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

B. A systematic listing of the above testing and verification shall be included in the final TAB report.
1.09 STAIRWELL PRESSURIZATION SYSTEMS

A. With all doors closed, measure the door pull to determine that the opening force is below required #/ft.

B. With all doors closed, measure the pressure differential across each door to verify the pressure differentials at each floor.

C. Measure the air flow 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, measure air flow at each outlet.

D. Verify with smoke that the smoke detector in the stair pressurization fan inlet shuts the fan down.

1.10 REPORTS

A. The activities described in this section shall culminate in a report to be provided in quadruplicate (4) individually bound to the General Contractor and electronic. Neatly type and arrange data. Include with the data the date 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 final report is to provide a reference of actual operating conditions for USAA’s operations personnel.

B. All measurements and recorded readings (of air, water, electricity, etc.) that appear in the reports must have been made onsite by the permanently employed technicians or engineers of the firm.

C. At the option of the General Contractor, all data sheets tabulated each day by TAB personnel shall be submitted for initial by the Construction Inspector. Those work sheets so initialed, or copies thereof, shall be presented as a supplement to the final TAB report.

D. Submit reports on forms approved by the Owner & Engineer which will include the following information as a minimum:

1. Title Page
   a) Company Name
   b) Company Address
   c) Company telephone number
   d) Project name
   e) Project location
   f) Project Manager
   g) Project Engineer
   h) Project Contractor
   i) Project Identification Number
2. Instrument List
   a) Instrument
   b) Manufacturer
   c) Model
   d) Serial Number
   e) Range
   f) Calibration date
   g) What test instrument was used for

3. Fan Data (Supply and Exhaust)
   a) Location
   b) Manufacturer
   c) Model
   d) Air flow, specified and actual
   e) Total static pressure (total external), specified and actual
   f) Inlet pressure
   g) Discharge pressure
   h) Fan RPM

4. Return Air/Outside Air Data (If fans are used, same data as for 3 above)
   a) Identification/location
   b) Design return air flow
   c) Actual return air flow
   d) Design outside air flow
   e) Return air temperature
   f) Outside air temperature
   g) Required mixed air temperature
   h) Actual mixed air temperature

5. Electric Motors
   a) Manufacturer
   b) HP/BHP
   c) Phase, voltage, amperage, nameplate, actual
   d) RPM
   e) Service factor
   f) Starter size, heater elements, rating

6. V-Belt Drive
   a) Identification/location
   b) Required driven RPM
   c) Driven sheave, diameter and RPM
   d) Belt, size and quantity
   e) Motor sheave, diameter and RPM
f) Center-to-center distance, maximum, minimum and actual

7. Duct Traverse
   a) System zone/branch
   b) Duct size
   c) Area
   d) Design velocity
   e) Design air flow
   f) Test velocity
   g) Test air flow
   h) Duct static pressure
   i) Air temperature
   j) Air correction factor

8. Air Monitoring Station Data
   a) Identification/location
   b) System
   c) Size
   d) Area
   e) Design velocity
   f) Design air flow
   g) Test velocity
   h) Test air flow

9. Air Distribution Test Sheet
   a) Air terminal number
   b) Room number/location
   c) Terminal type
   d) Terminal size
   e) Area factor
   f) Design velocity
   g) Design air flow
   h) Test (final) velocity
   i) Test (final) air flow

10. Pump Data
    a) Identification/number
    b) Manufacturer
    c) Size/model
    d) Impeller
    e) Service
    f) Design flow rate, pressure drop, BHP
    g) Actual flow rate, pressure drop, BHP
    h) Discharge pressure
i) Suction pressure
j) Total operating head pressure
k) Shut off, discharge and suction pressure
l) Shut off, total head pressure
m) Pressure differential settings

11. Cooling Coil Data

a) Identification/number
b) Location
c) Service
d) Manufacturer
e) Entering air DB temperature, design and actual
f) Entering air WB temperature, design and actual
g) Leaving air DB temperature, design and actual
h) Leaving air WB temperature, design and actual
i) Water pressure flow, design and actual
j) Water pressure drop, design and actual
k) Entering water temperature, design and actual
l) Leaving water temperature, design and actual
m) Air pressure drop, design and actual
n) Leaving water temperature, design and actual

12. Heating Coil Data

a) Identification/number
b) Location
c) Service
d) Manufacturer
e) Air flow, design and actual
f) Water flow, design and actual
g) Water pressure drop, design and actual
h) Entering water or steam temperature, design and actual
i) Leaving water temperature, design and actual
j) Entering air temperature, design and actual
k) Leaving air temperature, design and actual
l) Air pressure drop, design and actual

13. Sound Level Report

a) Location (Location established by the design engineer)
b) NC curve for eight (8) bands - equipment off
c) NC curve for eight (8) bands - equipment on

14. Vibration Test on equipment having 10 HP motors or above

a) Location of points:
   1) Fan bearing, drive end
2) Fan bearing, opposite end  
3) Motor bearing, center (if applicable)  
4) Motor bearing, drive end  
5) Motor bearing, opposite end  
6) Casing (bottom or top)  
7) Casing (side)  
8) Duct after flexible connection (discharge)  
9) Duct after flexible connection (suction)

b) Test readings:

1) Horizontal, velocity and displacement  
2) Vertical, velocity and displacement  
3) Axial, velocity and displacement

c) Normally acceptable readings, velocity and acceleration

d) Unusual conditions at time of test

e) Vibration source (if non-complying)

15. Control verification indicating date performed and any abnormalities identified.

a) Point Location/Description  
b) BAS Readout (Setpoint and Actual)  
c) Actual Readout  
d) Interlocks  
e) Safeties  
1) VSD Normal Operation  
2) VSD Bypass Operation  
f) Alarms  
g) Sequences of Operation

END OF SECTION