**SECTION 23 05 93**

**TESTING, ADJUSTING, AND BALANCING FOR HVAC**

**BASED ON DFD MASTER SPECIFICATION DATED 4/3/2023**

***This section has been written to cover most (but not all) situations that you will encounter. Depending on the requirements of your specific project, you may have to add material, delete items, or modify what is currently written. The Division of Facilities Development expects changes and comments from you.***

**P A R T 1 - G E N E R A L**

**SCOPE**

This section includes air and water testing, adjusting and balancing for the entire project. Included are the following topics:

PART 1 - GENERAL

 Scope

 Related Work

 Reference

 Reference Standards

 Description

 Pre-Installation Meeting and Scheduling

 Pre-Balance Conference

 Submittals

PART 2 - PRODUCTS

 Instrumentation

PART 3 - EXECUTION

 Preliminary Procedures

 Existing Equipment

 Performing Testing, Adjusting and Balancing

 Deficiencies

**RELATED WORK**

Section 01 91 01 or 01 91 02 – Commissioning Process

Section 23 05 00 Common Work Results for HVAC

Section 23 07 00 HVAC Insulation

Section 23 08 00 – Commissioning of HVAC

Section 23 09 14 Pneumatic and Electric Instrumentation and Control Devices for HVAC

Section 23 09 23 Direct Digital Control System for HVAC

Section 23 09 24 Direct Digital Control System for HVAC (Informational Purposes Only)

Section 23 09 25 Direct Digital Control System for HVAC Integrated Terminal Units

***The A/E must indicate all balancing information on the bidding documents and any proposed changes that develop during the course of the project. If the project involves additions or extensions of any kind to an existing system, the documents must show that system to the extent necessary so that it is balanced at the completion of the project. If the project is phased, the documents must indicate the phasing requirements and a description given as to how the phasing affects the Testing and Balancing and operation of the systems during each phase. Specific data to be identified include (but are not limited to) the following:***

***1. Air and water flows required of new and existing systems;***

***2. Capacities and location of all equipment that requires testing, adjusting, or balancing, including existing equipment;***

***3. Critical air pressure relationships that must be maintained;***

***4. Building static pressure to be maintained;***

***5. Motors of sufficient horsepower for air and hydronic systems to allow the specified flow rates to be achieved;***

***6. Any other information needed for a proper balance to be performed.***

***7. The location and capacity of existing systems that are being extended. The test and balance agency will be required to verify this information during their work. Add flow-measuring devices as may be necessary to accomplish this work.***

***8. When the existing capacity of equipment proposed to be modified or extended is not known or the A/E is not sure that the equipment is performing in accordance with its original design, arrange for measurements to be taken with /DFD Project Manager approval. The cost of this work will be charged back to the project.***

**REFERENCE**

Applicable provisions of the General Conditions, Supplementary General Conditions and General Requirements in Division 1 govern work under this section.

**REFERENCE STANDARDS**

AABC National Standards for Total System Balance, Sixth Edition, 2002.

ASHRAE ASHRAE Handbook, 2007 HVAC Applications, Chapter 37, Testing Adjusting and Balancing.

NEBB Procedural Standards for Testing Adjusting Balancing of Environmental Systems, Seventh Edition, 2005.

TABB Tab Procedural Guide, First Edition, 2003.

**DESCRIPTION**

The Contractor will separately contract with an independent test and balance agency to perform all testing, adjusting, and balancing of air and hydronic systems required for this project. Work related to the testing, adjusting, and balancing that must be performed by the installing mechanical contractor is specified in other section of these specifications.

Provide total mechanical systems testing, adjusting and balancing. Requirements include the balance of air and water distribution, adjustment of new and existing systems and equipment to provide design requirements indicated on the drawings, electrical measurement and verification of performance of all mechanical equipment, all in accordance with standards published by AABC, NEBB, or TABB.

Test, adjust and balance all air and hydronic systems so that each room, piece of equipment or terminal device meets the design requirements indicated on the drawings and in the specifications.

Accomplish testing, adjusting and balancing work in a timely manner that allows partial occupancy of major buildings, occupancy of one building when the project involves many buildings, and completion of the entire project in the time stated in the Instruction to Bidders and in accordance with the completion schedule established for this project.

Verify that provisions are being made to accomplish the specified testing, adjusting and balancing work. If problems are found, handle as specified in Part 3 under Deficiencies.

**QUALITY ASSURANCE**

**Qualifications**

An independent Firm specializing in the Testing and Balancing of HVAC systems for a minimum of 3 years. A Firm not engaged in the commerce of furnishing or providing equipment or material generally related to HVAC work other than that specifically related to installing Testing and Balancing components necessary for work in this section such as, but not limited to sheaves, pulleys, and balancing dampers.

A certified member of AABC or certified by NEBB or TABB in the specific area of work performed. Maintain certification for the entire duration of the project. If certification of firm or any staff performing work is terminated or expires during the duration of the project, contact DFD immediately.

Technicians on this project must have satisfactorily completed work on a minimum of (3) three projects of at least 50% in size, and of similar complexity. Size is defined as the quantity of each specific individual item requiring testing and balancing such as, but not limited to, equipment, devices, terminal devices, and grilles and diffusers.

Submit Qualifications of firm and project staff to DFD upon requested.

**PRE-INSTALLATION MEETING AND SCHEDULING**

The test and balance agency is required to attend a pre-installation meeting with all other project contractors before the construction process is started. The test and balance agency shall give the Mechanical Contractor a detailed schedule of testing and balancing tasks for incorporation into the project schedule.

**PRE-BALANCE CONFERENCE**

90 days prior to beginning testing, adjusting and balancing, schedule and conduct a conference with the Architect/Engineer, DFD's Project Representative and the mechanical system and temperature control system installing Contractors. Provide AE and Commissioning Provider (CxP) with a complete copy of the TAB plan for the project. The objective is final coordination and verification of system operation and readiness for testing, adjusting and balancing procedures and scheduling procedures with the above mentioned parties. Indicate work required to be completed prior to testing, adjusting, and balancing and identify the party responsible for completion of that work.

**SUBMITTALS**

Refer to division 1, General Conditions, Submittals. See also Related Work in this section.

Submit testing, adjusting and balancing reports bearing the seal and signature of the NEBB, AABC or TABB Certified Test and Balance Supervisor. The reports certify that the systems have been tested, adjusted and balanced in accordance with the referenced standards; are an accurate representation of how the systems have been installed and are operating; and are an accurate record of all final quantities measured to establish normal operating values of the systems.

Submission:

Distribute electronic copies of the Report to the DFD Project Representative, the Agency Contact, the Prime A/E, the DFD Project Manager, John Chapman (John.Chapman@wisconsin.gov), and Mike Casper ([Mike.Casper@wisconsin.gov](Mike.Casper%40wisconsin.gov)).

One A/E copy should be retained by the A/E for his/her use. Since the A/E is responsible for the system design, as reflected in the contract documents, the A/E will be expected to review, evaluate and comment on the contents of the report and to assist in the correction of any problems encountered.

***The A/E is responsible for the system design, as reflected in the contract documents, the A/E will be expected to review, evaluate and comment on the contents of the report and to assist in the correction of any problems encountered. The final TB report shall be uploaded to the DFDM SharePoint site as a separate document by the AE as part of the project close-out requirements.***

Format: Cover page identifying project name, project number and descriptive title of contents. Divide the contents of the report into the below listed divisions:

1. General Information
2. Summary
3. Air Systems
4. Hydronic Systems
5. Special Systems

Contents: Provide the following minimum information, forms and data:

General Information: Inside cover sheet identifying Test and Balance Agency, Contractor, Architect, Engineer, Project Name and Project Number. Include addresses, contact names and telephone numbers. Also include a certification sheet containing the seal and signature of the Test and Balance Supervisor.

Summary: Provide summary sheet describing mechanical system deficiencies. Describe objectionable noise or drafts found during testing, adjusting and balancing. Provide recommendations for correcting unsatisfactory performances and indicate whether modifications required are within the scope of the contract, are design related or installation related. List instrumentation used during testing, adjusting and balancing procedures.

The remainder of the report to contain the appropriate standard NEBB, AABC, or TABB forms for each respective item and system. Fill out forms completely. Where information cannot be obtained or is not applicable indicate same.

**P A R T 2 - P R O D U C T S**

**INSTRUMENTATION**

Provide all required instrumentation to obtain proper measurements. Application of instruments and accuracy of instruments and measurements to be in accordance with the requirements of NEBB, AABC, or TABB Standards and instrument manufacturer's specifications.

All instruments used for measurements shall be accurate, and calibration histories for each instrument to be available for examination by DD upon request. Calibration and maintenance of all instruments to be in accordance with the requirements of NEBB, AABC, or TABB Standards

**P A R T 3 - E X E C U T I O N**

**DAILY REPORTS**

Submit to DFD's Project Representative daily work activity reports for each day on which testing and balancing work is performed. Reports shall include description of day's activities and description of any system deficiencies.

**PRELIMINARY PROCEDURES**

Review preconstruction meeting report, applicable construction bulletins, applicable change orders and approved shop drawings of equipment, outlets/inlets and temperature controls.

Check filters for cleanliness, dampers and valves for correct positioning, equipment for proper rotation and belt tension, temperature controls for completion of installation and hydronic systems for proper charge and purging of air.

Notify DFD's Project Representative on a daily basis during balancing. Identify deficiencies preventing completion of testing, adjusting and balancing procedures. Do not proceed until systems are fully operational with all components necessary for complete testing, adjusting and balancing. Installing Contractors are required to provide personnel to check and verify system completion, readiness for balancing and assist Balancing Agency in providing specified system performance.

**EXISTING EQUIPMENT**

***A/E may delete this portion of the specification on new construction projects. However, on remodeling or renovation projects, DFD expects any systems that are extended or modified in any way to be balanced as if they were installed as part of this project. This may mean that additional balancing or flow measuring devices have to be added.***

***In this paragraph, the A/E should indicate any special characteristics of existing equipment or systems that have to be tested, adjusted or balanced when that information is not fully described on the drawings. For example, it may be necessary to describe the components of an existing air handling unit if that information is not clear from the plans.***

**PERFORMING TESTING, ADJUSTING AND BALANCING**

Perform testing, adjusting and balancing procedures on each system identified, in accordance with the detailed procedures outlined in the referenced standards except as may be modified below.

Unless specifically instructed in writing, all work in this specification section is to be performed during the normal workday.

***If the project has special requirements that will cause work of the section to be performed at night or on weekends, indicate those requirements here.***

In areas containing ceilings, remove ceiling tile to accomplish balancing work; replace tile when work is complete and provide new tile for any tile that are damaged by this procedure. If the ceiling construction is such that access panels are required for the work of this section and the panels have not been provided, inform the owner's project representative.

***The A/E is expected to have properly sized access panels located in inaccessible ceilings as part of the bidding and contract documents.***

Cut insulation, ductwork and piping for installation of test probes to the minimum extent necessary for adequate performance of procedures. Patch using materials identical to those removed, maintaining vapor barrier integrity and pressure rating of systems.

In air systems employing filters, blank off sufficient filter area to simulate a pressure drop that is midway between that of a clean filter and that of a dirty filter.

Measure and record system measurements at the fan and/or pump to determine total flow. Adjust equipment as required to yield specified total flow at terminals. Proceed taking measurements in mains and branches as required for final terminal balancing. Perform terminal balancing to specified flows balancing branch dampers, deflectors, extractors and valves prior to adjustment of terminals.

Measure and record static air pressure conditions across fans, coils and filters. Indicate in report if cooling coil measurements were made on a wet or dry coil and if filter measurements were made on a clean or dirty filter. Spot check static air pressure conditions directly ahead of terminal units.

Adjust outside air, return air and relief air dampers for design conditions at both the minimum and maximum settings and record both sets of data. Balance modulating dampers at extreme conditions and record both sets of data. Balance variable air volume systems at maximum air flow rate, full cooling, and minimum flow rate, full heating; record all data.

Adjust register, grille and diffuser vanes and accessories to achieve proper air distribution patterns and uniform space temperatures free from objectionable noise and drafts within the capabilities of the installed system.

Provide fan and motor drive sheave adjustments necessary to obtain design performance. Provide drive changes specifically noted on drawings, if any. If work of this section indicates that any drive or motor is inadequate for the application, advise the owner's project representative by giving the representative properly sized motor/drive information (in accordance with manufacturers original service factor and installed motor horsepower requirements); Confirm any change will keep the duct/piping system within its design limitations with respect to speed of the device and pressure classification of the distribution system. Required motor/drive changes not specifically noted on drawings or in specifications will be considered an extra cost and will require an itemized cost breakdown submitted to owner's project representative. Prior authorization is needed before this work is started.

Areas or rooms designed to maintain positive, negative or balanced air pressures with respect to adjacent spaces, as indicated by the design air quantities, require special attention. Adjust fan drives, distribution dampers, terminals and controls to maintain indicated pressure relationship.

Final air system measurements to be within the following range of specified cfm:

Fans 0% to +10%

Supply grilles, registers, diffusers 0% to +10%

Return/exhaust grilles, registers 0% to -10%

Room pressurization air -5% to +5%

Final water system measurements must be within the following range of specified gpm:

Heating flow rates 0% to -10%

Cooling flow rates -5% to +5%

Contact the temperature control Contractor for assistance in operation and adjustment of controls during testing, adjusting and balancing procedures. Cycle controls and verify proper operation and setpoints. Include in report description of temperature control operation and any deficiencies found.

Permanently mark equipment settings, including damper and valve positions, control settings, and similar devices allowing settings to be restored. Set and lock memory stops.

Leave systems in proper working order, replacing belt guards, closing access doors and electrical boxes, and restoring temperature controls to normal operating settings.

Coordinate and assist CxP with all verification activities defined within section (01 91 01, 02) including providing all required sampling date necessary for the commissioning process.

Verify and record, in the T&B Report, “K” factors for all VAV air terminal devices and air flow stations.

Verify and record, in the T&B Report, values of damper positions and fan speeds for all characterization curves required in the 23 09 93 control sequences.

Coordinate air handling unit minimum outside air set points with the Temperature Control Contractor.

Coordinate Fume Hood Monitor calibration with the Fume Hood Manufacturer.

LABORATORY FUME HOODS

Adjust airflow from fume hoods to the scheduled airflow by measuring the airflow in the duct connected to the fume hood and adjusting the air terminal device as needed. Then measure the fume hood face velocity with the sash wide open. If the wide open sash face velocity is below 50 fpm then adjust airflow to be at 50 fpm. After this balancing is complete and the other air balancing in the space containing the hood is complete, the fume hood supplier will calibrate the fume hood monitor and perform an “as installed” ASHRAE 110 test to verify that hood is properly containing fumes.

LABORATORY BIOLOGICAL SAFETY CABINETS (BSC)

Adjust airflow from BSC by measuring the airflow in the duct connected to the BSC and adjusting the air terminal device as needed. After this balancing is complete and the other air balancing in the space containing the BSC is complete, the University will test and certify the BSC. Adjust the BSC airflow as directed by the University staff during the certification process.

VAV SUPPLY AND EXHAUST DUCT SYSTEM STATIC PRESSURE SET POINT

For VAV supply and exhaust systems with VAV air terminal devices, determine the minimum required duct static pressure at the DDC static pressure sensor location(s) needed to insure that all VAV air terminals are operating at their design airflows with the most demanding VAV terminal wide open. Provide these static pressure numbers to the DDC temperature controls contractor and record them in the T&B report for each system.

HYDRONIC SYSTEM DIFFERENTIAL PRESSURE CONTROL SET POINT

For hydronic systems with variable speed pumping, determine the minimum required system differential pressure set point needed to insure that all terminal devices are operating at their design water flows with the most demanding terminals device control valve wide open. Provide the differential control setting set point to the DDC temperature control contractor and record them in the T&B report for each system.

CRITICAL ROOM PRESSURE RELATIONSHIPS

For the following rooms the pressure relationship between the room and the adjacent space or corridor is critical. After the air balancing in the room is complete, measure and record in the T&B report the static pressure between the room listed and the adjacent corridor/room. Inform the AE of all instances where the pressure relationship does not match what is indicated in this schedule.

***Insert a schedule of all rooms that have space differential pressure requirements to the adjacent space or corridor. Include if it is + or – and identify the adjacent space (IE “corridor” or “room 112”). Examples include laboratories and vivariums. As an option the schedule can be located on the hvac drawings if it is properly referenced and coordinated.***

PUMPS

For HVAC pumps 10 horsepower or less, valve throttling alone may be used for hydronic system balancing.

Throttling of triple-duty valves shall not exceed 50% closed.  Where additional throttling would be necessary to achieve the system design flow the impellor shall be trimmed.

Verify Triple duty valve utilized on systems with Variable Frequency Drives are 100% open when balancing work is complete.

The pressure drop across triple duty valves shall not exceed 25 ft. w.g.  Where additional throttling would be necessary to achieve the system design flow the impellor shall be trimmed.

For HVAC pumps greater than 10 horsepower through 60 horsepower, trim the impellor where valve throttling will result in a draw that exceeds 3 horsepower.

For HVAC pumps larger than 60 horsepower, trim the impellor where valve throttling results in a horsepower draw that exceeds 5% of the pump motor horsepower rating.

Future fouling of an open piping system may be considered when determining impellor trim requirements.

BUTTERFLY VALVES

Verify butterfly valves utilized for hydronic system balancing are provided with position-lock operators (memory stops) in accordance with Section 23 05 23. The adjustment and marking of lever-lock operators that use throttling notches will not be accepted.  Lock all memory stops so the valves can be reopened to their balanced positions if they are used for isolation purposes.

**DEFICIENCIES**

Division 23 00 00 contractor to correct any installation deficiencies found by the test and balance agency that were specified and/or shown on the Contract Documents to be performed as part of that division of work. Test and balance agency will notify the DFD's Project Representative of these items and instructions will be issued to the Division 23 00 00 contractor for correction of the deficient work. All corrective work to be done at no cost to the State of Wisconsin. Retest mechanical systems, equipment, and devices once corrective work is complete as specified.

**FUNCTIONAL PERFORMANCE TESTING**

Contractor is responsible for utilizing the functional performance test forms supplied under specification Section 23 08 00 Commissioning of HVAC in accordance with the procedures defined for functional performance testing in Section 01 91 01 or 01 91 02. Notify the A/E and commissioning provider 5 business days prior to performing functional performance testing so that they may witness.

END OF SECTION