

**SECTION 23 05 93**  
**TESTING, ADJUSTING, AND BALANCING FOR HVAC**

**PART 1 - GENERAL**

**1.1 DESCRIPTION**

A. Testing, adjusting, and balancing (TAB) of heating, ventilating and air conditioning (HVAC) systems. TAB includes the following:

1. Planning systematic TAB procedures.
2. Design Review Report.
3. Systems Inspection report.
4. Duct Air Leakage test report.
5. Systems Readiness Report.
6. Balancing air and water distribution systems; adjustment of total system to provide design performance; and testing performance of equipment and automatic controls.
7. Vibration and sound measurements.
8. Recording and reporting results.

B. Definitions:

1. Basic TAB used in this Section: Chapter 37, "Testing, Adjusting and Balancing" of ASHRAE Handbook, "HVAC Applications".
2. TAB: Testing, Adjusting and Balancing; the process of checking and adjusting HVAC systems to meet design objectives.
3. AABC: Associated Air Balance Council.
4. NEBB: National Environmental Balancing Bureau.
5. Hydronic Systems: Includes chilled water, heating hot water.
6. Air Systems: Includes all outside air, supply air, return air, exhaust air and relief air systems.
7. Flow rate tolerance: The allowable percentage variation, minus to plus, of actual flowrate from values (design) in the contract documents.

## C. TAB SPECIFIC REQUIREMENTS:

## 1. CHILLED WATER &amp; REHEAT WATER SYSTEMS

- a. Building no 1 chilled water & reheat water central system shall be completely rebalanced prior the final project acceptance as herein requested.
- b. In general:
  - i. Existing chilled water system is composed of 47 AHUs, 3 primary pumps, 3 secondary pumps, three chillers. The system has an overall capacity of 2700 tons and 6480 gpm. Pumps have variable frequency drives that modulate to control a constant differential pressure. (A schedule of design values will be provided prior system balancing to the selected contractor.
  - ii. Existing reheat water system is composed of two Heat Transfer Packages (HTPs) with spare pumps each, connected to the same header. Currently, there is only one heat transfer unit in operation. The system has an overall capacity of 715 tons and 858 gpm. There are an approximate amount of 800 reheat coils. (A schedule of HTPs will be provided to the selected contractor prior performing balancing services)
    - a. HTPs pumps are constant flow.
  - iii. For new AHUs & Cooling Coils schedules and new Reheat Coils schedules, see contract drawings.
- c. A revised set of HVAC reference drawings is being prepared and an electronic copy on Auto Cad and on pdf will be provided to the TAB subcontractor thru the General Contractor as soon is completed which shall be within two months after the award.
- d. This set of reference drawings will include existing AHUs, Pumps and Chillers, VAVs, Reheat Coils, ect Schedules; piping routes, Existing AHUs location, existing chilled water and reheat water distribution drawings, existing ductwork layouts and air flow distribution.
- e. This set of reference drawings will not be 100% accurate, especially the reheat piping distribution. Contractor shall be responsible of field verify existing HVAC units, piping and duct

work routes in order to complete the rebalancing work of the new units and of the existing affected AHUs, EFs and chilled water system.

- f. Costs for these TAB field verification works shall be included in the cost of this contract.
- g. The TAB field verification works shall be done prior to perform any work that might affect the existing HVAC systems normal operations.
- h. TAB subcontractor shall:
  - i.* Submit a field verification report of existing main chilled water system prior the performance of any modification on this system.
  - ii.* Submit a field verification report of existing reheat water system prior the performance of any modification on this system.
  - iii.* Submit a field verification report existing AHU distribution systems that might be affected during the first floor major renovation work (New Canteen and Urology areas) prior the performance of any modification on these systems.
- i. Testing, Adjusting and Balance of existing and/or new systems shall be done in accordance with the project approved construction phasing and/or as approved by the RE Office.
- j. Proposed Chilled Water balancing procedure:
  - i. Stage A (New Differential pressure transmitters - DPTs)
    - a. Locate DPT to be installed prior the Bed tower demolition. (This DPT shall be connected at the CHW lines of the pipe rack running on 2<sup>nd</sup> floor, just before the AHU-22 (Clinical Laboratory unit), see contract drawings)
      - 1) Refer to paragraph C.3 "New Differential Pressure Switch".
      - 2) Differential pressure transmitters can be installed using a hot tap installation; otherwise the contractor shall carefully coordinate when to close 2<sup>nd</sup> floor roof CHW distribution and install the DPTs.

- ii. Stage B (Systems As-is and Rebalance)
  - a. The contractor shall measure the flow to all air handling units.
    - 1) This shall be coordinated with the engineering control center to position all valves in open position. Water flows shall be measured in each unit.
  - b. Immediately after completing the As-is measurements, the TAB contractor shall balance the units as per original design schedules or values given by the VA.
  - c. The TAB report shall generated a TAB report showing the as-found conditions and the balanced conditions.
  - d. The TAB contractor shall provide the recommended values for a DPT located on the Bed Tower for interim operation prior Bed tower is disconnected form the CHW.
- iii. Stage C: (Balancing of existing units after disconnection of the Bed Tower CHW distribution system)
  - a. Locate the valves that that serve the riser and that need to be closed in order to perform the work.
    - 1) Coordinate with the RE office to close the valves that serve that riser.
    - 2) Mechanical contractor shall follow contract drawings instructions to CAP lines and perform the demolition work
  - b. The TAB contractor shall balance all existing units not serving the Bed tower to the values set on Stage B.
- iv. Stage D: (New Urology clinic Air Handling Unit)
  - a. The new unit shall be provided with pressure independent valves; therefore this unit does not need to be rebalanced. The unit maximum flow shall be measured with all units control valves in 100%.

- 1) The contractor shall use ultrasound flow meters to confirm that the flow to the different air handling units lines flow remain near or equal to the TAB report on Stage C.
  - a. If flows of the new unit or the flow to any branch is under parameters, the increase VFDs speed manually. Any other typical balancing procedures shall be applied to obtain the required water flows. Provide recommended value for DPT after completing the water balanced adjustments.
- v. Stage D:(Installation of Renovation Phase II, AHUs)
  - a. New DPT at Fourth floor level (At the 8 inches CHW lines at the Penthouse #4) and at the CHW lines at the mechanical room C-32 shall be installed as requested by contract drawings. These shall be monitored together with the DPT installed on Stage A.
  - b. The new units shall be provided with pressure independent valves; therefore this unit does not need to be rebalanced. The unit maximum flow shall be measured with all units control valves in 100%.
  - c. All other existing units shall be balanced when completing the total new AHUs installation.
  - d. The new control sequence will maintain the minimum pressure differential of several DPTs. This is established on the contract drawings sequence of operation. The TAB contractor shall provide the recommended values of these set points after adjusting the VFDs and completing the water balanced.
- k. Proposed Reheat Water balancing procedure:
  - a) Stage A: The contractor shall use several ultrasonic flow meters and measure the main branches of the reheat

water distribution. This activity shall be done during the night.

- a. The TAB contractor shall record water flows for each branch.
  - b. The contractor shall assume a minimum of 15 main branches to measure. (A drawing showing the proposed measurements points shall be provided during the construction prior the balancing work.)
- b) Stage B: After performing the first set of readings, the TAB contractor shall balance the reheat water system to obtain approximate values found on the Stage B plus design values of approximately 100 reheat coils on critical areas. It will be acceptable to use isolation valves to balance branches. The reheat coils to be balanced shall be adjusted at the circuit setters.
- a. In this case the position shall be marked and informed on the TAB report tagging the valves and refer them on tables and drawings.
  - b. The Reheat coils that served critical areas and are to be balanced to design values with the circuit setters are serving the following areas:
    - 1) SPD and SPD support areas.
    - 2) Surgery.
    - 3) Lockers Surgery.
    - 4) Recovery.
    - 5) Clinical LAB.
    - 6) SICU
    - 7) Morgue
- c) Stage C: After closing reheat lines serving the Bed Tower, the same reheat coils and branches balanced on stage shall be balanced to the values accepted on stage B.
- d) Stage D: (New Urology clinic Air Handling Unit)
- a. New reheat control valves are pressure independent. The TAB contractor shall confirmed that the valves maximum flow is achieve at maximum

open position. This shall be some during the night period.

- b. Main branches only shall be rebalanced as needed to previous values of stage C. Some adjustments shall be made to the branch serving the actual area to be remodeled as the Urology clinic. This shall be coordinated with the Resident engineer and the A/E.

e) Stage E: (Renovation Phase II, all remaining new units)

- a. New reheat control valves are pressure independent. The TAB contractor shall confirmed that the valves maximum flow is achieve at maximum open position. This shall be some during the night period.
- b. Main branches and critical reheat coils balanced on stage C shall be rebalanced. Some adjustments shall be made to the branch serving the actual areas to be remodeled by the Renovation Phase II. This shall be coordinated with the Resident engineer and the A/E.

### 3. EXISTING AIR DISTRIBUTION SYSTEMS

1. Existing ductwork that currently serve the areas where the new Urology and canteen Services are going to be located are to be cut and capped and therefore the AHU servicing these areas will need to be properly rebalance.
2. Contractor shall, prior to cut the ductwork, measure the air flow and static pressure at the point of the tie-in and measure the supply air and static of the AHU servicing such area and rebalance such AHU in order for the unit to supply less air thru the main ductwork that served the affected area.

### 4. New Differential Pressure Transmitters:

The TAB contractor shall review the installation of the DPTs and verify that automatic air vents are installed to eliminate air at the DPTs.

**1.2 RELATED WORK**

- A. Section 23 05 11, COMMON WORK RESULTS FOR HVAC: General Mechanical Requirements.
- B. Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT: Noise and Vibration Requirements.
- C. Section 23 07 11, HVAC, PLUMBING, AND BOILER PLANT INSULATION: Piping and Equipment Insulation.
- D. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS
- E. Section 23 36 00, AIR TERMINAL UNITS: Terminal Units Performance.
- F. Section 23 31 00, HVAC DUCTS AND CASINGS: Duct Leakage.
- G. Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC: Controls and Instrumentation Settings.
- H. Section 23 82 16, AIR COILS
- I. Section 23 73 00, INDOOR CENTRAL-STATION AIR-HANDLING UNITS
- J. Section 23 34 00, HVAC FANS
- K. Section 23 21 23, HYDRONIC PUMPS
- L. Section 23 37 00, AIR OUTLETS AND INLETS
- M. Section 23 21 13, HYDRONIC PIPING
- N. Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC AND STEAM GENERATION EQUIPMENT

**1.3 QUALITY ASSURANCE**

- A. Refer to Articles, Quality Assurance and Submittals, in Section 23 05 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION.
- B. Qualifications:
  - 1. TAB Agency: The TAB agency shall be a subcontractor of the General Contractor and shall report to and be paid by the General Contractor.
  - 2. The TAB agency shall be either a certified member of AABC or certified by the NEBB to perform TAB service for HVAC, water balancing and vibrations and sound testing of equipment. The certification shall be maintained for the entire duration of duties specified herein. If, for any reason, the agency loses subject certification during this period, the General Contractor shall immediately notify the Resident Engineer and submit another TAB firm for approval. Any agency that has been the subject of disciplinary action by either the AABC or the NEBB within the five years preceding Contract Award shall not be eligible to perform any work



- related to the TAB. All work performed in this Section and in other related Sections by the TAB agency shall be considered invalid if the TAB agency loses its certification prior to Contract completion, and the successor agency's review shows unsatisfactory work performed by the predecessor agency.
3. TAB Specialist: The TAB specialist shall be either a member of AABC or an experienced technician of the Agency certified by NEBB. The certification shall be maintained for the entire duration of duties specified herein. If, for any reason, the Specialist loses subject certification during this period, the General Contractor shall immediately notify the Resident Engineer and submit another TAB Specialist for approval. Any individual that has been the subject of disciplinary action by either the AABC or the NEBB within the five years preceding Contract Award shall not be eligible to perform any duties related to the HVAC systems, including TAB. All work specified in this Section and in other related Sections performed by the TAB specialist shall be considered invalid if the TAB Specialist loses its certification prior to Contract completion and must be performed by an approved successor.
  4. TAB Specialist shall be identified by the General Contractor within 60 days after the notice to proceed. The TAB specialist will be coordinating, scheduling and reporting all TAB work and related activities and will provide necessary information as required by the Resident Engineer. The responsibilities would specifically include:
    - a. Shall directly supervise all TAB work.
    - b. Shall sign the TAB reports that bear the seal of the TAB standard. The reports shall be accompanied by report forms and schematic drawings required by the TAB standard, AABC or NEBB.
    - c. Would follow all TAB work through its satisfactory completion.
    - d. Shall provide final markings of settings of all HVAC adjustment devices.
    - e. Permanently mark location of duct test ports.
  5. All TAB technicians performing actual TAB work shall be experienced and must have done satisfactory work on a minimum of 3 projects comparable in size and complexity to this project. Qualifications must be certified by the TAB agency in writing.

C. Test Equipment Criteria: The instrumentation shall meet the accuracy/calibration requirements established by AABC National Standards or by NEBB Procedural Standards for Testing, Adjusting and Balancing of Environmental Systems and instrument manufacturer. Provide calibration history of the instruments to be used for test and balance purpose.

D. Tab Criteria:

1. One or more of the applicable AABC, NEBB or SMACNA publications, supplemented by ASHRAE Handbook "HVAC Applications" Chapter 36, and requirements stated herein shall be the basis for planning, procedures, and reports.
2. Flow rate tolerance: Following tolerances are allowed. For tolerances not mentioned herein follow ASHRAE Handbook "HVAC Applications", Chapter 36, as a guideline. Air Filter resistance during tests, artificially imposed if necessary, shall be at least 90 percent of final values for pre-filters and after-filters:
  - a. Air handling unit and all other fans, cubic meters/min (cubic feet per minute): Minus 0 percent to plus 10 percent.
  - b. Air terminal units (maximum values): Minus 2 percent to plus 10 percent.
  - c. Exhaust hoods/cabinets: 0 percent to plus 10 percent.
  - d. Minimum outside air: 0 percent to plus 10 percent.
  - e. Individual room air outlets and inlets, and air flow rates not mentioned above: Minus 2 percent to plus 10 percent except if the air to a space is 100 CFM or less the tolerance would be 0 to plus 5 percent.
  - f. Heating hot water pumps and hot water coils: Minus 5 percent to plus 5 percent.
  - g. Chilled water and condenser water pumps: 0 percent to plus 5 percent.
  - h. Chilled water coils: 0 percent to plus 5 percent.
3. Systems shall be adjusted for energy efficient operation as described in PART 3.
4. Typical TAB procedures and results shall be demonstrated to the Resident Engineer for one air distribution system (including all fans, three terminal units, three rooms) and one hydronic system (pumps and three coils) as follows:

- a. When field TAB work begins.
- b. During each partial final inspection and the final inspection for the project if requested by VA.

#### **1.4 SUBMITTALS**

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- B. Submit names and qualifications of TAB agency and TAB specialists within 60 days after the notice to proceed. Submit information on three recently completed projects and a list of proposed test equipment.
- C. For use by the Resident Engineer staff, submit one complete set of applicable AABC or NEBB publications that will be the basis of TAB work.
- D. Submit Following for Review and Approval:
  - 1. Submit a field verification report of existing main chilled water system prior the performance of any modification on this system.
  - 2. Submit a field verification report of existing reheat water system prior the performance of any modification on this system.
  - 3. Submit a field verification report existing AHU distribution systems that might be affected during the first floor major renovation work (New Canteen and Urology areas) prior the performance of any modification on these systems.
  - 4. Submit the Design Review Report within 14 Calendar days, for conventional design projects, after the contractor's ductwork and piping layout and shop drawings be properly submitted. Refer to Section 23 05 11 for coordination, layout and shop drawings submission requirements.
  - 5. Systems inspection report on equipment and installation for conformance with design.
  - 6. Duct Air Leakage Test Report.
  - 7. Systems Readiness Report.
  - 8. Intermediate TAB reports.
  - 9. Final TAB reports covering flow balance and adjustments, performance tests, vibration tests and sound tests performed on every project stage or project phasing.
  - 10. Include in final reports uncorrected installation deficiencies noted during TAB and applicable explanatory comments on test results that differ from design requirements.

- E. Twenty (20) calendar dates prior to request for Final or Partial Final inspection, submit completed/final Test and Balance report for the area, for review and approval. Final or Partial Final inspection will not be performed without the TAB report approval.
- F. Include in the final TAB report the flow diagrams of the Chilled Water, reheat water and AHUs showing actual & design air and water flows.

### **1.5 APPLICABLE PUBLICATIONS**

- A. The following publications form a part of this specification to the extent indicated by the reference thereto. In text the publications are referenced to by the acronym of the organization.
- B. American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc. (ASHRAE):  
2003.....HVAC Applications ASHRAE Handbook, Chapter 37,  
Testing, Adjusting, and Balancing and Chapter  
47, Sound and Vibration Control
- C. Associated Air Balance Council (AABC):  
2002.....AABC National Standards for Total System  
Balance
- D. National Environmental Balancing Bureau (NEBB):  
7<sup>th</sup> Edition 2005 .....Procedural Standards for Testing, Adjusting,  
Balancing of Environmental Systems  
1<sup>st</sup> Edition 1994 .....Procedural Standards for the Measurement and  
Assessment of Sound and Vibration
- E. Sheet Metal and Air Conditioning Contractors National Association  
(SMACNA):  
3<sup>rd</sup> Edition 2002 .....HVAC SYSTEMS-Testing, Adjusting and Balancing

## **PART 2 - PRODUCTS**

### **2.1 PLUGS**

Provide plastic plugs to seal holes drilled in ductwork for test purposes.

### **2.2 INSULATION REPAIR MATERIAL**

See Section 23 07 11, HVAC, PLUMBING, AND BOILER PLANT INSULATION. Provide for repair of insulation removed or damaged for TAB work.

## **PART 3 - EXECUTION**

### **3.1 GENERAL**

- A. Refer to TAB Criteria in Article, Quality Assurance.

- B. Obtain applicable contract documents and copies of approved submittals for HVAC equipment and automatic control systems.

### **3.2 DESIGN REVIEW REPORT**

- A. The TAB Specialist shall review the Contract Plans and specifications and advise the Resident Engineer of any design deficiencies that would prevent the HVAC systems from effectively operating in accordance with the sequence of operation specified or prevent the effective and accurate TAB of the system. The TAB Specialist shall provide a report individually listing each deficiency and the corresponding proposed corrective action necessary for proper system operation.
- B. The TAB Specialist shall verify that all required balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, manual volume dampers and other devices or equipment such as fire or smoke dampers, sound attenuators, etc. that are included on the ductwork and piping coordination shop drawings. The TAB Specialist shall verify that quantities and locations of these balancing devices are accessible and appropriate for effective balancing and for efficient system and equipment operation.

### **3.3 SYSTEMS INSPECTION REPORT**

- A. Inspect equipment and installation for conformance with design.
- B. The inspection and report is to be done after air distribution equipment is on site and duct installation has begun, but well in advance of performance testing and balancing work. The purpose of the inspection is to identify and report deviations from design and ensure that systems will be ready for TAB at the appropriate time.
- C. Reports: Follow check list format developed by AABC, NEBB or SMACNA, supplemented by narrative comments, with emphasis on air handling units and fans. Check for conformance with submittals. Verify that diffuser and register sizes are correct. Check air terminal unit installation including their duct sizes and routing.
- D. Examine system and equipment installations to verify that they are complete.
- E. Revise individual equipment or units (AHUs, Pumps, Chillers, Cooling Towers, etc) start-up reports. Attached the start-up

- reports to the system inspection report.
- F. Examine HVAC system and equipment installations to verify that indicated balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers are properly installed and their locations are accessible and appropriate for effective balancing and for efficient system and equipment operation.
  - G. Examine the installation of pipe systems, sheet metal work, temperature controls, insulation and other component parts of the HVAC systems.
  - H. Examine air-handling equipment to ensure clean filters have been installed, bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.
  - I. Examine terminal units, such as variable-air-volume boxes and mixing boxes, to verify that they are accessible and their controls are connected and functioning.
  - J. Examine strainers for clean screens and proper perforations.
  - K. Examine control valves for proper installation for their intended function of diverting or mixing fluid flows.
  - L. Examine heat-transfer coils for correct piping connections and for clean and straight fins.
  - M. Examine open-piping-system pumps to ensure absence of entrained air in the suction piping. Verify if air vents are properly installed.
  - N. Examine equipment for installation and for properly operating safety interlocks and controls.
  - O. Examine automatic temperature system components to verify that sequence of operation for control modes is according to the Contract Documents.
  - P. Examine Fire and Smoke dampers installation.
  - Q. Examine the installation of equipment, piping and ductworks' supports, vibration isolation, flexible connections, and any HVAC installation work that might affect the rooms NCs, noise and/or vibration transmission through connections, piping, ductwork, foundations, and/or walls.
  - R. Provide detail report prior to start with the testing and

balancing procedures.

### **3.4 DUCT AIR LEAKAGE TEST REPORT**

See paragraphs "Duct leakage Tests and Repairs" in Section 23 31 00, HVAC DUCTS AND CASINGS for TAB agency's role and responsibilities in witnessing, recording and reporting of deficiencies.

### **3.5 SYSTEM READINESS REPORT**

- A. Inspect each System to ensure that it is complete including installation and operation of controls.
- B. Verify that all items such as ductwork piping, ports, terminals, connectors, etc., that is required for TAB are installed. Provide a report to the Resident Engineer.

### **3.6 TAB REPORTS**

- A. Submit an intermediate report for 50 percent of systems and equipment tested and balanced to establish satisfactory test results.
- B. The TAB contractor shall provide raw data immediately in writing to the Resident Engineer if there is a problem in achieving intended results before submitting a formal report.
- C. If over 45 percent of readings in the intermediate report fall outside the acceptable range, the TAB report shall be considered invalid and all contract TAB work shall be repeated and re-submitted for approval.
- D. Do not proceed with the remaining systems until intermediate report is approved by the Resident Engineer.

### **3.7 TAB PROCEDURES**

- A. Tab shall be performed in accordance with the requirement of the Standard under which TAB agency is certified by either AABC or NEBB.
- B. General: During TAB all related system components shall be in full operation. Fan and pump rotation, motor loads and equipment vibration shall be checked and corrected as necessary before proceeding with TAB. Set controls and/or block off parts of distribution systems to simulate design operation of variable volume air or water systems for test and balance work.
- C. Coordinate TAB procedures with any phased construction completion requirements for the project. Provide TAB reports for each phase of the project prior to partial final inspections of each phase of the project.
- D. Allow sufficient time in construction schedule for TAB and submission of all reports for an organized and timely correction of deficiencies.

E. Air Balance and Equipment Test: Include air handling units, fans, fan coil units, room diffusers/outlets/inlets:

1. Artificially load air filters by partial blanking to produce air pressure drop of at least 90 percent of the design final pressure drop.
2. Adjust fan speeds to provide design air flow. V-belt drives, including fixed pitch pulley requirements, are specified in Section 23 05 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION.
3. Test and balance systems in all specified modes of operation, including variable volume, economizer, and fire emergency modes. Verify that dampers and other controls function properly.
4. Variable Air Volume (VAV) Systems:
  - a. Coordinate TAB, including system volumetric controls, with Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.
  - b. Section 23 36 00, AIR TERMINAL UNITS, specifies that maximum and minimum flow rates for air terminal units (ATU) be factory set. Check and readjust ATU flow rates if necessary. Balance air distribution from ATU on full cooling maximum scheduled cubic meters per minute (cubic feet per minute). Reset room thermostats and check ATU operation from maximum to minimum cooling, to the heating mode, and back to cooling. Record and report the heating coil leaving air temperature when the ATU is in the maximum heating mode.
5. Record final measurements for air handling equipment performance data sheets.

### 3.8 VIBRATION TESTING

- A. Furnish instruments and perform vibration measurements as specified in Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT. Field vibration balancing is specified in Section 23 05 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION. Provide measurements for all rotating HVAC equipment of 373 watts (1/2 horsepower) and larger, including, pumps, fans and motors.
- B. Record initial measurements for each unit of equipment on test forms and submit a report to the Resident Engineer. Where vibration readings exceed the allowable tolerance Contractor shall be directed to correct the problem. The TAB agency shall verify that the corrections are done and submit a final report to the Resident Engineer.



**3.9 SOUND TESTING**

- A. Perform and record required sound measurements in accordance with Paragraph, QUALITY ASSURANCE in Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT:
1. Take readings in all rooms. The Resident Engineer may designate the specific rooms to be tested.
- B. Take measurements with a calibrated sound level meter and octave band analyzer of the accuracy required by AABC or NEBB.
- C. Sound reference levels, formulas and coefficients shall be according to ASHRAE Handbook, "HVAC Applications", Chapter 46, SOUND AND VIBRATION CONTROL.
- D. Determine compliance with specifications as follows:
1. When sound pressure levels are specified, including the NC Criteria in Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT:
    - a. Reduce the background noise as much as possible by shutting off unrelated audible equipment.
    - b. Measure octave band sound pressure levels with specified equipment "off."
    - c. Measure octave band sound pressure levels with specified equipment "on."
    - d. Use the DIFFERENCE in corresponding readings to determine the sound pressure due to equipment:

DIFFERENCE:	0	1	2	3	4	5 to 9	10 or More
FACTOR:	10	7	4	3	2	1	0

Sound pressure level due to equipment equals sound pressure level with equipment "on" minus FACTOR.

- e. Plot octave bands of sound pressure level due to equipment for typical rooms on a graph which also shows noise criteria (NC) curves.
2. When sound power levels are specified:
    - a. Perform steps 1.a. thru 1.d., as above.
    - b. For indoor equipment: Determine room attenuating effect, i.e., difference between sound power level and sound pressure level. Determined sound power level will be the sum of sound pressure level due to equipment plus the room attenuating effect.

- c. For outdoor equipment: Use directivity factor and distance from noise source to determine distance factor, i.e., difference between sound power level and sound pressure level. Measured sound power level will be the sum of sound pressure level due to equipment plus the distance factor. Use 10 meters (30 feet) for sound level location.
- 3. Where sound pressure levels are specified in terms of dB(A), measure sound levels using the "A" scale of meter. Single value readings will be used instead of octave band analysis.
- E. Where measured sound levels exceed specified level, the installing contractor or equipment manufacturer shall take remedial action approved by the Resident Engineer and the necessary sound tests shall be repeated.

### **3.10 MARKING OF SETTINGS**

Following approval of Tab final Report, the setting of all HVAC adjustment devices including valves, splitters and dampers shall be permanently marked by the TAB Specialist so that adjustment can be restored if disturbed at any time. Style and colors used for markings shall be coordinated with the Resident Engineer.

### **3.11 IDENTIFICATION OF TEST PORTS**

The TAB Specialist shall permanently and legibly identify the location points of duct test ports. If the ductwork has exterior insulation, the identification shall be made on the exterior side of the insulation. All penetrations through ductwork and ductwork insulation shall be sealed to prevent air leaks and maintain integrity of vapor barrier.

### **3.12 PHASING**

- A. Phased Projects: Testing and Balancing Work to follow project with areas shall be completed per the project phasing. Upon completion of the project all areas shall have been tested and balanced per the contract documents.

### **3.13 COMMISSIONING**

- A. Provide commissioning documentation in accordance with the requirements of Section 23 08 00 - COMMISSIONING OF HVAC SYSTEMS for all inspection, start up, and contractor testing required above and required by the System Readiness Checklist provided by the Commissioning Agent.
- B. Components provided under this section of the specification will be tested as part of a larger system. Refer to Section 23 08 00 -

COMMISSIONING OF HVAC SYSTEMS and related sections for contractor responsibilities for system commissioning.

- - - E N D - - -