

SOUND MEASUREMENT & VIBRATION
MEASUREMENT FOR HVAC**PART 1. GENERAL****1.1 DESCRIPTION OF WORK**

- A. Sound measurement of equipment operating conditions.
- B. Vibration measurement of equipment operating conditions.

1.2 SUBMITTALS

- A. Preliminary:
 - 1) Submit electronic copies of documentation to confirm compliance with Quality Assurance provisions:
 - (a) Organizations Certified Professional, Certified Technician, and other trained in the discipline of Sound Measurement & Vibration Measurement
 - (b) Sample copy of each of the report forms proposed for use
- B. Final:
 - 1) Submit electronic copies of Final Reports for Sound Measurement and Vibration Measurement.
 - 2) Form of Final Reports:
 - (a) The final S&V Report must bear the name, signature and NEBB Stamp of the S&V Certified Professional of the S&V Firm.
 - (b) Each individual final reporting form must bear the name of person who recorded the data.
 - (c) When more than one certified organization performs services, the firm performing the particular service shall make the submittal of work performed.

1.3 QUALITY ASSURANCE

- A. Sound and vibration measurement services shall be performed by a NEBB Certified Sound Measurement and Vibration Measurement Firm. The NEBB Certified Sound Measurement and Vibration Measurement Firm shall have a proven record of doing Sound Measurement and Vibration Measurement work and be in Good Standing with NEBB. At the Owners request, references may be requested from the S&V Firm.
- B. Submit evidence that personnel who perform sound measurement and vibration measurement of project systems are qualified personnel; for review and approval by Owner prior to performing work.
- C. If the design parameters cannot be achieved due to faulty installation, provide an S&V Deficiency Report listing the items that do not meet the design parameters to the Engineer of Record. Upon the S&V Firm receiving a change order for retesting, perform retesting after corrective measures are completed by the installing contractors. If the design parameters cannot be achieved, issue the Final S&V Report with the outstanding Deficiencies List.
- D. Qualified personnel are:
 - 1) S&V personnel shall be certified NEBB.
 - 2) S&V Work performed by the NEBB Certified S&V Firm shall be under direct supervision of a NEBB S&V Certified Professional who is a full-time employee of the NEBB Certified S&V Firm. Technicians performing S&V Work must be NEBB Certified Technicians and full-time employees of the NEBB Certified S&V Firm.
- E. Should separate NEBB Certified firms perform services for sound and vibration portions, each

firm is required to submit their own NEBB Certified sound measurement or vibration measurement Report.

- F. Comply with applicable procedures and standards of NEBB, unless more stringent requirements are specified in this Section.
 - 1) Current issue of "Procedural Standards for Measurement of Sound and Vibration" published by NEBB.
- G. Calibrate and maintain test instruments in accordance with requirements of referenced standards. Calibrate instruments used in performance of S&V Work within twelve (12) months preceding date of usage. Instruments shall meet the instrument requirements found on www.nebb.org.
 - 1) Sound meter shall be Class 1 or Class 2.
 - (a) Smartphones used as sound meters do not meet requirements.
 - (b) Sound meter shall have octave band filters and be capable of time averaging.
 - 2) Overall vibration level meters do not meet instrument requirements.

1.4 COORDINATION AND COOPERATION

- A. Testing and Balancing of Mechanical Systems to be provided by TAB Contractor per 23 0593 section.
- B. Enlist aid of Installing Contractor or equipment suppliers, at no additional cost, whenever such aid is required for timely and proper performance of S&V Work.
- C. Cooperate with Installing Contractor to allow smooth coordination of S&V Work with Construction Schedule.
- D. Vibration testing shall be performed after HVAC Test and Balance of air and water systems have been satisfactorily completed, and with all systems operating at normal conditions. Vibration testing shall be completed and reported prior to sound testing.
- E. Sound testing shall be performed after HVAC Test and Balance of air and water systems have been satisfactorily completed, with all systems operating at normal conditions, and with all spaces completed and finished for occupancy. All other building mechanical and electrical systems must be operational that may affect sound readings.
- F. Provide the S&V Firm with a conformed set of contract documents (drawings, specifications, and approved submittals), including all current approved change orders and contract modifications. Failure to do so may result in a change order for rebuilding of the S&V Report Forms and marked up drawings.
- G. Develop a project schedule with the input of the S&V Firm that coordinates the work of other disciplines, providing adequate time in the construction process for successful completion of the S&V work.
- H. Notify the S&V Firm of all schedule changes.
- I. Ensure that the building enclosure is complete, including structural components, window and door installation, door hardware, ceilings, stairs, elevator/mechanical shafts and roof systems. All plenums and chases must be sealed.
- J. The Installing Contractors shall ensure that all necessary mechanical and HVAC work is complete and is safe to operate including TAB Work completion. This includes, but is not limited to mechanical, electrical, and control safeties, duct air leakage testing (DALT), hydrostatic testing; piping system flushing, filling, venting, and chemical treating. All strainers should be cleaned, and the correct screens installed. For additional requirements, see the current edition of NEBB Procedural Standards for Measurement of Sound and Vibration.
- K. The Installing Contractors shall complete the installation, programming (including design parameters and graphics), calibration and startup of all building control systems. Verify that the building control system provider has commissioned and documented their work before S&V work begins.

- L. The control system firm shall provide S&V access to hardware, software and onsite technical support as required at no cost to the S&V Firm. The Installing Contractors shall provide S&V Firm with a controlled environment (steady states of flow, pressure, control, temperature) to perform S&V measurement. The S&V Firm must be consulted during scheduling to identify what controlled environment is required to provide successful S&V. proper measurement conditions. To create a controlled environment, in addition to mechanical systems being complete and under control, other variables must be considered such as building envelope (i.e.; windows, doors, door sweeps, gaskets, etc.), other trade activities, etc.
- M. The Installing Contractors shall make corrections reported in the S&V Deficiency List in a timely manner and provide written notice when complete.

1.5 PROCEDURES

- A. Review the requirements of the S&V Work from the Engineer of Record before starting any field S&V Work.
- B. When potential or developing problems are discovered relating to materials, equipment or methods being used in Work, and where such problems may adversely affect S&V Work, immediately report these findings in writing to the Engineer of Record.

1.6 WARRANTY AND CONTRACT CLOSEOUT

- A. Warranty: The Quality Assurance Program guarantee from NEBB applicable for the S&V Work applies to all NEBB Certified S&V Firms
- B. Contract Closeout:
 - 1) Submit reports for:
 - (a) Vibration measurements.
 - (b) Sound measurements.

PART 2. EXECUTION

2.1 GENERAL

- A. The Installing Contractor shall examine HVAC equipment to ensure that clean filters have been installed, bearings are greased, belts are aligned and tight, and equipment with functioning controls are ready for operation, prior to S&V.
- B. The Installing Contractor to examine strainers for clean screens and proper perforations, prior to S&V.
- C. Testing, Adjusting and Balancing to be performed, and report to be provided to S&V firm, prior to S&V field measurements.
- D. Controls contractor and/or installing contractor to aid S&V firm to provide system conditions required for testing.
- E. The Installing Contractor shall provide access to areas and equipment for S&V measurement.
- F. Vibration measurements to be taken on system components and building locations required per spec.
- G. Following vibration measurements, report any deficient items to the Construction Manager who shall coordinate required corrections. Send a copy of report to Owner's Representative, Engineer of Record and Construction Manager.
- H. Retesting of deficient equipment to be performed following resolution, with resubmittal of report. If separate NEBB firm performing sound measurement, final vibration measurement report to be submitted to sound firm prior to sound measurement.
- I. Perform sound measurement of air handling systems with finished ceilings and partitions in place, and doors closed.
- J. Sound measurements to be completed onsite in locations indicated by spec or contract

requirements.

- K. Following sound measurements, report any deficient items to the Construction Manager who shall coordinate required corrections. Send a copy of report to Owner's Representative, Engineer of Record and Construction Manager.
- L. Retesting of deficient sound areas to be performed following resolution, with resubmittal of report.

2.2 EXAMINATION

- A. Examine the Contract Documents to become familiar with the Project requirements and to discover conditions in the system design that may preclude proper S&V testing of systems and equipment.
- B. Verify that the mechanical contractor performed, completed, and provided written documentation that a field inspection of all vibration isolators and that all vibration isolators have been installed and adjusted properly. Vibration isolator compliance includes,
 - 1) Verify that all isolators are installed in accordance with manufacturer's recommendations.
 - 2) Verify that piping, duct, and conduit penetrations through mechanical equipment room envelope are sealed, and if required, rigid contact with building structure does not exist.
 - 3) Steel isolation bases must be inspected for cracked welds, excessive bending or twisting of steel members.
 - 4) Concrete isolation bases must be examined for cracked concrete. Isolator retainer brackets must be checked for looseness. The concrete base must be flat and true in plane.
 - 5) Elastomeric isolators must be examined for cracks in the rubber and for loose bonds between the rubber and steel plates or other steel components. Adequate clearance must be provided between bolts and the side of the bolt holes to prevent short circuiting.
 - 6) Steel spring isolators must be examined for loose or missing bolts, nuts or lock washers. Check for spring overloading or underloading, completely collapsed spring coils, and cocked springs. Note if rubber or glass fiber pad between the bottom plate of the steel spring and the concrete slab or supporting structure is present.
 - 7) Housed steel springs must be examined for proper centering of the springs, clearance between the cast housing and rubber snubber, and the steel spring for tilted or cocked springs.
 - 8) When the specifications require that the isolators be bolted to the concrete slab or other supporting structure, the bolts may be isolated by means of rubber bushings and rubber washers.
 - 9) Inspect isolators with restraint devices to make sure that all shims have been removed and supportive nuts have been properly adjusted to allow for free floating of the isolated system.
 - 10) Seismic restraints shall not prevent the proper functioning of vibration isolation system.
 - 11) Pneumatic isolators must be inspected for overload or underload by checking the air pressure gauge against manufacturer's submittals or catalog. The pneumatic isolator system should include the isolator, strainer, oil separator, height regulator, and air pressure gauge. Inspect the vicinity of the isolator. Note if the isolator is exposed to damage from vehicle or other traffic.
 - 12) Carefully inspect the space under all isolated bases to assure that these spaces are clean and free of debris to prevent short-circuiting.
 - 13) Check to ensure that all shipping bolts associated with spring isolators have been removed.
 - 14) Inspect all flexible piping, hoses, and expansion joints as to type, length and location as called for by the specifications. Examine flexible hose for excessive elongation.
 - 15) Inspect all electrical and control connections to ensure that they do not restrain the movement of the vibration isolated equipment.
 - 16) Inspect all fabric connections between fans and ductwork to ensure that a fabric "bellows" exists when the fans are operating.
 - 17) Each piece of vibration isolated machinery must be free of any structural tie or rigid connection that may "short circuit" the isolation system. All limit stops, shipping bolts, and leveling bolts on all isolators must be inspected to ensure that they are not "short circuiting" the isolation system.
 - 18) Hanger isolators should be free of misalignment and over / underloading. Under no circumstances the isolator rod should be allowed to make rigid contact with the hanger housing.

- C. Report deficiencies as discovered to the appropriate parties.

2.3 VIBRATION PROCEDURES

- A. Perform vibration measurements when other building and outdoor vibration sources are at a minimum level and will not influence measurements of equipment being tested.
 - 1) Turn off equipment in the building that might interfere with testing.
 - 2) Restrict people from occupying areas where human activity may affect accuracy of measurements. Measurements should be performed when exterior vibration sources (trains, roadway 1065 traffic, adjacent construction activities, etc.) are at a minimum level.
- B. Attach and secure the vibration transducer in accordance with the latest edition of the NEBB S&V Procedural Standard for Measurement of Sound and Vibration.
- C. Measure and record, on all pumps and fans over 3 Hp, and all chillers and compressors over 5HP, vibration levels in at least 1.25 Hz increments over a minimum frequency range of 5 to 1000 Hz or as specified by contract documents.
- D. Measure and record acceleration and/or velocity and/or displacement readings on equipment, bearing and equipment base in the vertical, horizontal and axial planes, or as per contract specifications, where measurements can be performed safely.
 - 1) Pumps:
 - (a) Pump Bearing: Drive end and opposite end.
 - (b) Motor bearing: Drive and opposite end, one each isolator.
 - (c) Equipment Base: Top and side, within 6" of one isolator.
 - (d) Building: Floor adjacent to pump/motor, within 6" of one isolator, vertical axis only.
 - 2) Fans and HVAC Equipment with Fans:
 - (a) Fan Bearing: Drive end and opposite end.
 - (b) Motor Bearing: Drive and opposite end.
 - (c) Equipment Base: Top and side, within 6" of one isolator.
 - (d) Building: Floor adjacent to pump/motor, within 6" of one isolator, vertical axis only.
 - 3) Chillers and HVAC Equipment with Compressors:
 - (a) Compressor Bearing: Drive end and opposite end.
 - (b) Motor Bearing: Drive end and opposite end.
 - (c) Equipment Base: Top and side, within 6" of one isolator.
 - (d) Building: Floor adjacent to pump/motor, within 6" of one isolator, vertical axis only.
- E. FFT Analyzer Settings (Typical or as specified in contract documents):
 - 1) Windowing – Hanning
 - 2) Averages – at least two
 - 3) Frequency Range – 5 to 1,000 Hz (300 to 60,000 rpm)
 - 4) Frequency Resolution – at least 1.25 Hz (75 rpm)
 - 5) Line of Resolution – at least 800.
 - 6) Detection – Peak or Peak-to-Peak or RMS
 - 7) Averaging – Exponential

2.4 SOUND PROCEDURES

- A. Close windows and doors to the space.
- B. Perform measurements when the space is not occupied, or when the occupant noise levels from other spaces in the building and outside are at a minimum, or do not affect sound readings.
- C. Clear the space of temporary sound sources so unrelated disturbances will not be measured. Turn off all sound sources (personal computers, printers, fax machines, etc.) in the space that may affect sound readings.
- D. Position testing personnel during measurements to achieve a direct line-of-sight between the sound source and the sound-level meter.
- E. Take sound measurements at a height approximately 48 inches above the floor and at least 36

inches from a wall, column, or any other large surface capable of altering the measurements.

- F. Take sound measurements in dB (linear or flat), with the fast time constant, in the octave bands from 31.5 to 8000 Hz, time averaging over a minimum of 60 seconds.
- G. Take sound measurements with the HVAC systems off to establish the background levels and take sound measurements with the HVAC systems operating. Calculate the difference between measurements. Apply a correction factor depending on the difference and adjust measurements.
- H. Perform sound testing in all occupied space horizontally and vertically adjacent to all mechanical equipment rooms and all mechanical chases.
- I. Perform sound testing at 10% of locations on the project for each type of the following spaces. For each space type tested, select a measurement location that has the greatest anticipated sound level. If testing multiple locations for each space type, select at least one location that is near and at least one location that is remote from the predominant sound source.
 - 1) Private office.
 - 2) Open office area.
 - 3) Conference room.
 - 4) Auditorium/large meeting room/lecture hall.
 - 5) Classroom/training room.
 - 6) Patient room/exam room.
 - 7) Sound or vibration sensitive laboratory.
 - 8) Hotel room/apartment.
 - 9) Library open space.
 - 10) Public areas (such as, lobbies, hallways, break rooms).
- J. Perform sound testing in all spaces with design criterion of NC or RC 25 or less
- K. Sound Measurement Reports: Record sound measurements on appropriate test forms, indicating the decibel levels measured in for both “background” and “HVAC system operating” readings. Record each tested location on a separate NC or RC chart. Record the following on the forms.
 - 1) Date and time of test.
 - 2) Equipment operational parameters - speed / frequency at time of measurements.
 - 3) Indoor measurements - space location within building including floor level and room / space number

2.5 FINAL REPORT

- A. The final report shall be in accordance with the requirements of the current edition of the NEBB Procedural Standard for Measurement of Sound and Vibration. The final certified report shall include, but not limited to the following:
 - 1) Report Title page indicating: “Certified Sound and Vibration Report”; Project Name, names of the project Architect, Engineer, HVAC Contractor and NEBB Certified S&V Firm with names, addresses and telephone numbers.
 - 2) Report Certification Page indicating the Project name, Certifying NEBB Qualified Supervisor’s name, Firm name, Certification number, Expiration date, Certifying NEBB Qualified Supervisor’s NEBB Stamp (signed & dated). The Certification page shall also contain the required certification statement.
 - 3) Table of contents with the total number of pages defined for each section of the report. Number each page in the report.
 - 4) Report Summary / Remarks including a narrative description of system set-up conditions, results and deficiencies.
 - 5) Instrument Calibration page indicating a list of the instruments to be used to verify the reported data. The page shall contain the name/type of each instrument, the manufacturer, model number, serial number, calibration date and dates of use.
 - 6) Data sheets on Sound and Vibration measurements as described below.

- 7) Other information relative to equipment performance at time of testing that is deemed appropriate by the NEBB Certified S&V Firm.
- B. Vibration Measurement Report Forms: For each measurement location, record vibration measurements on appropriate test forms, indicating the following information:
- 1) Date of test.
 - 2) Equipment designation, location, motor horsepower and equipment operational parameters (speed/ frequency) at time
 - 3) Measured acceleration (in units of g's, inches/sec², meters/sec², or units requested by the engineer of record), and/or, measured velocity (in units of inches/sec, meters/sec or units requested by the engineer of record) and/or, measured displacement (in units of inches, mils, millimeters, or units requested by the engineer of record) of measurements.
 - 4) Vibration level plot of vibration amplitude versus frequency for each measurement location.
- C. Sound Measurement Report Forms: Record sound measurements on appropriate test forms, indicating the decibel levels measured in for both "background" and "building system operating" readings. Record each tested location on a separate NC or RC chart. Record the following on the forms.
- 1) Date and time of test.
 - 2) Equipment operational parameters – speed / frequency at time of measurements.
 - 3) Indoor measurements – space location within the building including floor level and room space number.
 - 4) Outdoor measurements – location identifier such as location relative to equipment, building, or property line.
 - 5) Indicate where measurements meet or exceed design criteria.

END OF SECTION