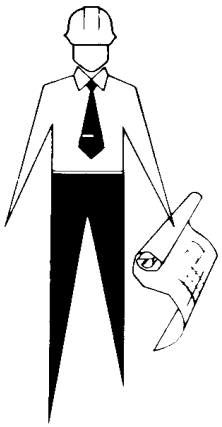
PROCEDURAL STANDARDS FOR MEASUREMENT OF SOUND AND VIBRATION



2006 – SECOND EDITION

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PROCEDURAL STANDARD FOR MEASUREMENT OF SOUND AND VIBRATION

FIRST EDITION – JANUARY 1977	***PROCEDURAL STANDARDS FOR MEASURING SOUND AND VIBRATION***
FIRST EDITION - JANUARY 1994	***PROCEDURAL STANDARDS FOR THE MEASUREMENT AND ASSESSMENT OF SOUND AND VIBRATION***
SECOND EDITION – SEPTEMBER 2006	***PROCEDURAL STANDARDS FOR MEASUREMENT OF SOUND AND VIBRATION***

These Procedural Standards were developed using reliable engineering principles and research plus consultation with, and information obtained from, manufacturers, users, testing laboratories and others having specialized experience. They are subject to revision as further experience and investigation may show is necessary or desirable. Sound and vibration measurements and reporting, which complies with these Procedural Standards, will not necessarily be acceptable, if when examined and tested, it is found to have other features that impair the result intended by these standards. The National Environmental Balancing Bureau assumes no responsibility and has no liability for the application of the principles or techniques contained in these Procedural Standards. Authorities considering adoption of these Procedural Standards should review all Federal, State, local and contract regulations applicable to the specific installation.

FOREWORD

The purpose of the NEBB *Procedural Standards for Measurement of Sound and Vibration* is to establish a uniform and systematic set of criteria for the performance of the sound and vibration testing of environmental and building operations.

Today's buildings provide highly controlled indoor environments. These conditions could not exist without sophisticated mechanical systems created by a team of skilled professionals. A key member of this team is the NEBB Certified Sound and Vibration (S&V) Firm.

This publication is identified as the "Second Edition". In fact, this is the third Procedural Standards that NEBB has produced for the Sound and Vibration program. The first publication (1977) focused on the measurement and reporting of sound and vibration levels. The second publication (1994) added the dimension of assessment to the S&V firm's responsibility. This publication (2006) returns the focus of the discipline back to its foundation; measurement and reporting of S&V data.

This Second Edition represents a departure from past editions in other ways. It is divided into two distinct Parts: S*tandards* and *Procedures*. These S&V procedural standards have been developed using language defined by **"*Shall, Should, and May*"** as it relates to the standards and procedures described in this manual. It is important to note these particular words throughout this manual and how they pertain to the NEBB standards and procedures.

These standards and procedures are intended as the minimum NEBB requirements that a NEBB Certified S&V Firm shall follow when performing sound and vibration measurements and reporting the results. Contract documents may supercede the NEBB requirements. These S&V Procedural Standards have been carefully compiled and reviewed by the NEBB Technical Committees.

Part 1 STANDARDS
Part 1, STANDARDS, covers the requirements for Quality Control and Compliance, Instrumentation Requirements, and S&V Reports. Revised requirements for sound and vibration instrumentation and reports are identified. The new report requirements allow the NEBB Certified Firm more flexibility in designing their reports by prescribing sets of information that ***"Shall, Should*** and/or ***May"*** be required to complete an S&V Report.

Part 2 PROCEDURES
Part 2, PROCEDURES, covers measurement procedures of sound and vibration testing for building systems.

APPENDICES
The Appendices includes both a long form and a short form suggested NEBB S&V specifications, and sample report forms, and an overview of the instrumentation requirements.

This Edition of the S&V Procedural Standards, when used by NEBB Certified S&V Firms, will assure the building owner of standard accurate reporting of sound and vibration levels for their facilities.

Andrew P. Nolfo, P.E.
NEBB Technical Director

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SECTION 1 DEFINITIONS

These procedural standards have been developed using language defined by "Shall, Should, and May" as it relates to the standards and procedures described in this publication. It is important to note these particular words throughout this publication and how they pertain to NEBB standards and procedures.

A-Weighting (A-scale or dB(A)): Frequency response of sound levels at different frequencies as defined in ASNI S3.14. Adjusts the levels of a frequency spectrum in the same way the human ear does when exposed to low levels of sound.

Acceleration: The vector quantity that specifies the time rate of change of velocity.

Accelerometer (Transducer): A device which converts shock or vibratory motion into an optical, mechanical, or electrical signal that is proportional to a parameter of the experienced motion.

Accuracy: The *accuracy* of an instrument is the capability of that instrument to indicate the true value of a measured quantity.

AHJ: The local governing **A**uthority **H**aving **J**urisdiction over the installation.

Airborne Noise (sound): Sound that arrives at a point of interest by propagation through the air.

Ambient Noise (sound): All encompassing noise associated with a given environment at a given time, including noise from the sound source of interest.

Attenuation: The decrease in the sound level between the source and the receiver from various mechanisms, such as geometrical divergence, atmospheric absorption, building structures, etc.

Axial Axis of Measurement (z-axis): An axis of measurement along or parallel to the rotating axis of a piece of equipment.

Background Noise (sound): Total noise from all sources other than a particular sound that is of interest; e.g. other than noise from the sound source of interest.

C-Weighting (C-scale or dB(C)): Frequency response of sound levels at different frequencies as defined in ASNI S3.14. Adjusts the levels of a frequency spectrum in the same way the human ear does when exposed to high levels of sound.

Calibrate: The act of comparing an instrument of unknown accuracy with a standard of known accuracy to detect, correlate, report, or eliminate by adjustment any variation in the accuracy of the tested instrument.

Contract Document Evaluation: A NEBB Certified S&V Firm evaluation of the contract plans and specifications is limited to determining the scope of responsibilities and reporting.

Decibel: The unit of level which denotes the logarithmic ratio between two quantities that are proportional to power; the number of decibels is 10 times the logarithmic (base10) of this ratio.

Deficiency: Any circumstance or operation that affects the measurement results as compared to the design criteria required by the contract documents.

Displacement: The vector quantity that specifies the change of position of a body or particle, with respect to a mean position or position at rest.

Direct Sound (Direct Sound Field): Sound which reaches a given location in a direct line from the source, without any reflections.

Far Field: The portion of the sound field of a sound source in which the sound pressure level decrease by 6 dB for each doubling of distance from the source.

Fast Time Constant (response): Exponential averaging of the measured sound levels with a 0.125 second time constant.

Flat Weighting (dB(Flat) or dB(Linear)): DOES NOT adjust frequency response of sound levels at different frequencies. DOES NOT adjust the level of a frequency spectrum for either high or low levels of sound.

Free Sound Field (Free Field): A sound field in which the effects of boundaries are negligible over the frequency range of interest.

Frequency: The number of times a quantity (sound wave) repeats itself in 1 second.

Frequency Spectrum: The amplitude of sound or vibration at various frequencies or band of frequencies.

Function: For the purposes of this NEBB Standard, *function* refers to the specific type of data measurement specified in Section 4, *Standards for Instrumentation and Calibration.*

Harmonics: A sinusoidal component that is a whole number multiple of the fundamental frequency.

Horizontal Axis of Measurement (x-axis): An axis of measurement that is parallel to the mounting base of a piece of equipment or the building foundation.

May: The word **may** is used to indicate a course of action that is permissible as determined by the NEBB Certified S&V Firm.

Mil: A unit of measure. In Inch-Pounds units, 1 mil equals one-thousandth of an inch (0.001 inch). In metric units, it is expressed in micrometers, where 1 micrometer equals one-thousandth of a millimeter (0.001 millimeter).

N/A: *Not Available, Not Applicable, or Not Accessible.* The simple notation "N/A" without definition is not allowed.

Near Field: The sound field close to a sound source (between the source and the far field) where the instantaneous sound pressure and particle velocity are not in phase.

NEBB Certified S&V Firm: A *NEBB Certified S&V Firm* is a firm that has met and maintains all the requirements of the National Environmental Balancing Bureau for firm certification in Sound & Vibration Measurement and is currently certified by NEBB. A NEBB Certified S&V Firm shall employ at least one NEBB Qualified S&V Supervisor in a full time management position.

NEBB Certified S&V Report: The data presented in a NEBB Certified S&V Report accurately represents system measurements obtained in accordance with the current edition of the NEBB *Procedural Standards for Measurement of Sound and Vibration.* A NEBB Certified S&V Report does not necessarily guarantee that systems measured conform to the design requirements or stated guidelines. The report is an accurate representation of the measured results only.

NEBB Qualified S&V Supervisor: A *NEBB Qualified S&V Supervisor* is a full time employee of the firm in a management position who has successfully passed the supervisor level written and practical qualification examinations and maintains the Supervisor re-qualification requirements of NEBB.

Noise: Any disagreeable or undesired sound.

Noise Criteria Curve (NC Curve): A series of curves of octave-band sound spectra in a system for rating the noisiness of an occupied indoor space; an actual octave-band spectrum is compared with this set of curves to determine the NC level of the space.

Octave: The frequency interval between two sounds whose frequency ratio is 2.

Octave Band (1/1-octave or full-octave) Sound Pressure Level: The sound pressure level of sound at all frequencies contained within that band.

Peak-to-Peak vibration value (p-p): The total distance traveled by the vibrating part, from one extreme limit of travel to the other extreme limit of travel, usually expressed in mils.

Precision: *Precision* is the ability of an instrument to produce repeatable readings of the same quantity under the same conditions. The precision of an instrument refers to its ability to produce a tightly grouped set of values around the mean value of the measured quantity.

Procedure: A *Procedure* is defined as the approach to and execution of a sequence of work operations to yield a repeatable and defined result.

Pure Tone: A sound wave which is at a single frequency.

Range: *Range* is the upper and lower limits of an instrument's ability to measure the value of a quantity for which the instrument is calibrated.

Resolution: *Resolution* is the smallest change in a measured variable that an instrument can detect.

Room Criterion Curve (RC Curve): A series of curves of octave-band sound spectra in a system for rating the noisiness of an occupied indoor space; an actual octave-band spectrum is compared with this set of curves to determine the RC level of the space.

Root Mean Square (RMS): This is the square root of the time average of the sound (vibration) wave(s).

Root-Mean-Square (RMS) (Velocity measurement): This term is often used when vibrations are random or consist of a number of sinusoidal vibrations of different frequencies. The RMS value is a measure of the effective energy used to produce the vibration of the machine. For a sinusoidal motion the RMS value is .707 x peak.

Shall: The word **shall** is used to indicate mandatory requirements to be followed strictly in order to conform to the standards and procedures and from which no deviation is permitted. Note: In the event unique circumstances prevent a required action from being fulfilled, a notation shall be included in the S&V report explaining the exception. For example, such notation could be one of the following: *Not Available, Not Applicable, or Not Accessible.* The simple notation "N/A" without definition is not allowed.

Seismic Vibration: For NEBB vibration measurements this refers to vibration in and of a building structure.

Should: The word **should** is used to indicate that a certain course of action is preferred but not necessarily required.

Slow Time Constant: Exponential averaging of the measured sound levels with a 0.125 second time constant.

Sound: A physical disturbance in air (or another medium) that is capable of being detected by the human ear.

Sound Power Level (L_w): Ten times the logarithm (to the base 10) of the ratio of a given sound power to a reference sound power of 1 picowatt (1 picowatt = 10^{-12} watts).

Sound Pressure Level (L_p): In air, 20 times the logarithm (to the base 10) of a given sound pressure to a reference sound pressure of 20 micropascals (20 * 10^{-6} pacals, 1 pascal = 1 Newton/m^2).

Standard: A *Standard* is defined as a required qualification, action, or result for S&V work.

Structure Borne Noise: Sound that arrives at a point of interest by propagation through a solid structure.

System Effect: A phenomenon that can create undesired or unpredicted conditions that may cause increased sound and vibration levels. System Effect can also reduce performance capacities in all or part of a system.

Testing: *Testing* is the use of specialized and calibrated instruments to measure sound and vibration levels, temperatures, pressures, rotational speeds, electrical characteristics, velocities, and fluid quantities.

Testing, Adjusting, and Balancing (TAB): TAB is a systematic process or service applied to heating, ventilating and air-conditioning (HVAC) systems and other environmental systems to achieve and document air and hydronic flow rates. The standards and procedures for providing these services are addressed in the NEBB *"PROCEDURAL STANDARDS FOR THE TESTING, ADJUSTING AND BALANCING OF ENVIRONMENTAL SYSTEMS",* 7TH Edition, 2005.

Third Octave Band (1/3-octave) Sound Pressure Level: The sound pressure level of sound at all frequencies contained within that band.

Velocity: The vector quantity that specifies the time rate of change of displacement.

Vertical Axis of Measurement (y-axis): An axis of measurement perpendicular to the horizontal and axial axes of measurement of a piece of equipment but not necessarily in the horizontal plane.

Wavelength: The *wavelength* of a periodic wave in an isotropic medium is the perpendicular distance between two wave fronts in which the displacements have a difference in phase of one complete period or cycle.

Vibration: An oscillation wherein the quantity is a parameter that defines the motion of a mechanical (physical) system. The term is usually used to mean an objectionable movement.

SECTION 2 NEBB PROGRAM, QUALITY CONTROL AND COMPLIANCE

2.1 NEBB PROGRAMS

The National Environmental Balancing Bureau (NEBB) is a not-for-profit organization founded in 1971 to:

a) develop standards, procedures and programs for the performance of testing, balancing and commissioning of building systems,
b) promote advancement of the industry through technical training and development,
c) operate programs to certify firms and qualify individuals who meet and maintain NEBB standards with integrity.

Additional information on NEBB Programs is available at www.nebb.org.

2.1.1 NEBB DISCIPLINES

NEBB establishes and maintains standards, procedures, and specifications for work in its various disciplines, which include:

a) Testing-Adjusting-Balancing (TAB) -- Air and Hydronic Systems
b) Sound and Vibration (S&V) Measurement
c) Cleanroom Performance Testing (CPT)
d) Building Systems Commissioning (BSC)

Each discipline is anchored by a NEBB Procedural Standards manual that provides guidelines for work to be performed. NEBB also has created technical manuals, training materials and programs, and seminars to enhance and support each discipline.

2.1.2 FIRM CERTIFICATION

NEBB certifies firms that meet certain criteria, ensuring strict conformance to its high standards and procedures. Among other requirements, NEBB Certified Firms must document a record of responsible performance, own, or have access to, a complete set of instruments required for the sophisticated techniques and procedures necessary to take and report sound and vibration measurements, and have a NEBB Qualified S&V Supervisor as a full-time employee.

2.1.3 SUPERVISOR QUALIFICATION

NEBB also establishes professional qualifications for the supervision and performance of work in its various disciplines. NEBB Qualified S&V Supervisors must have extensive experience, and they must pass appropriate, college-level written examinations and demonstrate certain practical working knowledge and proficiency in the use of instruments required for the various disciplines.

2.1.4 RECERTIFICATION REQUIREMENTS

Through the recertification procedures, the firm must verify that its NEBB Qualified S&V Supervisor is still on staff and that it continues to own, or have access to, a complete set of instruments that are in current calibration. In addition, the firm's NEBB Qualified S&V Supervisor renews his or her qualification. Among other requirements, Supervisors must keep abreast of developments in their discipline by successfully completing continuing education requirements annually.

2.2 QUALITY ASSURANCE PROGRAM - CONFORMANCE CERTIFICATION

The credibility of NEBB is built by maintaining integrity through high standards, quality programs, and demonstrated capabilities of its certified firms. As further assurance, NEBB offers a Quality Assurance Program to guarantee that the work will be accomplished in accordance with its standards. The NEBB Certificate of Conformance Certification is an integral element of the program. It assures that the NEBB Certified Firm will perform specified services in conformity with the current applicable NEBB Procedural Standards.

2.2.1 PROGRAM ADVANTAGES

The NEBB Quality Assurance Program affords building owners, architects, engineers and other agents a reliable basis for specifying work within the various disciplines of NEBB. The program promotes proper execution of projects by ensuring compliance with NEBB standards and procedures.

2.2.2 NEBB QUALITY ASSURANCE PROGRAM CERTIFICATE

The NEBB Certified S&V Firm shall make application to the NEBB Office for a Certificate of Conformance Certification if specified in the contract documents. The NEBB Quality Assurance Program Conformance Certification is also available for any project.

2.3 QUALITY CONTROL AND COMPLIANCE

Building owners are entitled to a professional service by every NEBB Certified Firm on every project, whether the job is NEBB-specified or not. It is the responsibility of the NEBB Certified Firm and its NEBB Qualified S&V Supervisor to establish and maintain procedures and practices that will assure a consistent pattern of high quality work on all projects. This point cannot be overemphasized.

2.3.1 S&V WORK COMPLIANCE

The scope of work shall be performed as specified in the Sound and Vibration (S&V) specifications, the Test, Adjust, and Balance (TAB) specifications or as contractually amended. Each relevant or applicable item as identified in the contract documents by description, or by reference, shall be performed and recorded in the S&V report. Data presented in the S&V report shall provide an accurate quantitative record of system measurements and information.

The design professional should adequately define the scope of the S&V services. Many of today's contract documents do not define the actual scope of S&V services to be performed on the project. Contract documents may reference desired procedures and may include statements such as "…the work will be performed in accordance to NEBB Standards…" or, the contract documents may refer to NEBB and that sound and vibration work "…shall be done in accordance with the reference standard…" or, merely allude to the NEBB organization and make reference to sound and vibration measurements.

When contract documents do not clearly identify the exact scope of S&V services, the NEBB Qualified S&V Supervisor shall make every attempt to have the design professional dictate the actual scope through the addendum process. If the design professional still does not adequately define the scope of S&V measurement, the scope requirements for S&V services for that project shall be in accordance with the minimum NEBB requirements as stated in Section 7 and Section 8.

Regardless of what is specified, in all cases the process by which the data is acquired shall conform to the current edition of the NEBB *Procedural Standards for Measurement of Sound and Vibration*.

2.4 S&V SUPERVISOR RESPONSIBILITIES

It is the responsibility of the NEBB Qualified S&V Supervisor to control the quality of the S&V work. This means that the NEBB Certified S&V Firm, through its NEBB Qualified S&V Supervisor, shall satisfy the contract obligations set forth in the drawings and applicable specifications.

2.4.1 EXECUTION OF S&V PROCEDURES

The NEBB Qualified S&V Supervisor shall have project responsibility, which includes authority to represent the NEBB Certified S&V Firm. Examples of project responsibility may include labor decisions, negotiating change orders, committing to contract interpretations and implementing changes in job schedules.

The NEBB Qualified S&V Supervisor has the responsibility to assure that the measurements of sound and vibration have been performed in accordance with these Procedural Standards and the contract documents to assure the accuracy of all data included in the final S&V report. Factors such as instrument use, coordination / supervision, work instructions, and project communication play a critical role in achieving this requirement.

2.4.2 TECHNICIAN TRAINING

The NEBB Qualified S&V Supervisor has a responsibility to assure that technicians performing the work are properly trained and possess sufficient skills. Areas that should be stressed are S&V procedures, instrument use and maintenance, coordination and supervision, and project communication.

2.4.3 S&V PROCEDURES TRAINING

NEBB Qualified S&V Supervisors must be prepared to completely measure and record data in the manner specified. It is mandatory that NEBB Qualified S&V Supervisors possess the ability to perform the specific tasks and procedures required for each project. An understanding of building system fundamentals and operating characteristics is important, and technicians should possess rudimentary knowledge of all related systems and procedural considerations. This may require periodic training to promote knowledge and skill development as well as to facilitate the transfer of knowledge and basic skills in the use of new technology.

2.4.4 INSTRUMENT USE AND MAINTENANCE

NEBB Qualified S&V Supervisors shall possess knowledge and skill in the proper use and care of instruments required to perform the work. This shall include a thorough understanding of the operating principles and use of S&V equipment and instruments. Considerations for the delicate nature of many of the S&V instruments typically used, as well as the adverse effects of dirt, shock, jarring movements and exceeding rated capacities, shall be addressed along with the proper methods for storing and transporting the instruments.

2.4.5 COORDINATION / SUPERVISION

The NEBB Qualified S&V Supervisor shall be responsible for directing technicians in performing the work. Instructions may delineate items such as the scope of work, location, type and quantity of measurements, etc. so that field personnel may know exactly what to do and what is required of them.

2.4.6 PROJECT COMMUNICATION

The NEBB Qualified S&V Supervisor shall report on progress made toward work completion, when required, as well as report and address problems if encountered. When a problem exists, the NEBB Qualified S&V Supervisor should notify the appropriate project personnel.

2.4.7 WORK COMPLETION

The NEBB Qualified S&V Supervisor shall determine when the sound and vibration measurements have been completed, and when to submit the S&V report. Generally, the specified S&V field work is complete when:

a) All Sound and Vibration measurements for building systems are completed;

or

b) Reasonable efforts within the extent of testing for S&V Measurements have been performed in an effort to complete all required measurements. The NEBB Qualified S&V Supervisor shall notify the appropriate project personnel of any significant system deficiencies preventing S&V Measurements from being performed before the final report is submitted.

2.4.8 COMPILATION AND SUBMISSION OF FINAL S&V REPORTS

Reports shall include information and data to provide an accurate quantitative record of system measurements and information. Reports also shall include notes and comments, as appropriate, to provide the reviewer with additional details related to the test procedure, system operation and results. Reports shall meet the criteria listed in Sections 5.

The certification page shall bear the stamp of the NEBB Qualified S&V Supervisor. The stamp on the certification page shall be signed as evidence that the NEBB Qualified TAB Supervisor has personally reviewed and accepted the report. *Signature stamps are specifically prohibited.*

SECTION 3 RESPONSIBILITIES

3.1 INTRODUCTION

Many approaches can be taken to deliver a successful S&V project. In order to maximize value and benefits from sound and vibration testing, it is important to understand that design professionals and other construction team members have responsibilities that will affect the outcome of the S&V process.

3.2 DESIGN AND CONSTRUCTION TEAM RESPONSIBILITIES

3.2.1 DESIGN PROFESSIONAL'S RESPONSIBILITIES

It is recommended that the contract documents shall:

a) Specify the equipment and systems to be measured for sound and vibration. NEBB standards and procedures define industry best practices to perform the measurements.

b) Define who retains the services of the NEBB Certified S&V Firm and require that the NEBB Certified S&V Firm be retained early in the construction process.

c) Clearly define on the contract documents all sound and vibration design criteria.

d) Clearly identify on the contract documents all locations where sound and vibration measurements are to be performed.

e) Specify that the building, mechanical, electrical and all work is to be completed prior to performing S&V measurements.

f) Specify that all building, mechanical, electrical, and other systems are completely operational, under control and performing according to the design intent prior to performing sound and vibration measurements. This would include that all building automation / controls are installed, operational, calibrated and functioning properly and that the TAB work is completed. Sound and vibration measurements made prior to completion of these activities should be avoided. Actual final measurements may differ from measurements taken prior to the completion of the work.

g) Provide adequate access to all equipment and components required in the S&V process.

3.2.2 CONSTRUCTION TEAM RESPONSIBILITIES

It is recommended that the construction team shall:

a) Provide the NEBB Certified S&V Firm with a conformed set of contract documents (drawings, specifications, and approved submittals), including all current approved change orders and contract modifications.

b) Develop a project schedule, with the input of the NEBB Certified S&V Firm that coordinates the work of other disciplines and provides *adequate* time in the construction process to allow successful completion of the S&V work.

c) Notify the NEBB Certified S&V Firm of ***all*** schedule changes.

d) Ensure that the building enclosure is complete, including but not limited to: all structural components; windows and doors installed; door hardware complete; floor and ceilings complete; stair, elevator and mechanical shafts complete; roof systems complete, all plenums sealed; etc.

e) Ensure that all necessary building systems are complete and are operating in a safe manner.

f) Complete the installation of permanent electrical power systems serving the building systems. Such electrical systems shall be properly installed in accordance with all applicable codes to ensure the safety of all construction personnel.

g) Perform start up of all building systems in accordance with manufacturers' recommendations.

h) 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 all building control work.

i) Complete all TAB related work.

3.2.3 NEBB CERTIFIED S&V FIRM RESPONSIBILITIES

The NEBB Certified S&V Firm shall:

a) Follow the current NEBB standards and procedures when performing the S&V work.

b) Communicate on a regular basis, through proper channels, items pertaining to design, installation or function that prevent the NEBB Certified S&V Firm from achieving completion of the S&V work in accordance with the current edition of the NEBB *Procedural Standards for Measurement of Sound and Vibration.*

c) Perform the required S&V measurements.

d) Publish a NEBB Certified S&V Report of final conditions that accurately reflects the sound and vibration measurements taken on the required building systems.

SECTION 4 STANDARDS FOR INSTRUMENTATION AND CALIBRATION

4.1 MINIMUM INSTRUMENTATION

A NEBB Certified S&V Firm will use a variety of instrumentation to perform the specified S&V measurements on a project. It is the responsibility of the NEBB Certified S&V Firm to provide appropriate instrumentation that meets the minimum requirements for use on a project. Instrumentation used on a NEBB project shall be in proper operating condition and shall be applied in accordance with the manufacturer's recommendations. TABLE 4-1 lists the minimum instrumentation specifications that a NEBB Certified S&V firm shall utilize in the performance of all sound and vibration measurements. The NEBB Certified S&V Firm has two options relating to equipment and instrumentation requirements; 1) they shall either own and maintain the required instruments, or 2) they shall have access to the required instruments. In either case, the actual instruments used to perform all S&V work and measurements shall conform to the requirements of Table 4-1.

Instruments shall be used in accordance with manufacturer's recommendations. The most suitable instrument, or combination of instruments, should be employed for a particular measurement or reading.

Some of the instrumentation identified in TABLE 4-1 is redundant for different applications, not all of these instruments are required to be owned / leased. The instrumentation required shall be based on each project's requirements and shall be determined by the NEBB S&V Supervisor. The minimum instrumentation required to perform either sound or vibration measurements is as follows,

Sound Level Measurements – the minimum instrumentation required to perform sound level measurements is:

a. A traditional sound level meter with a full or third octave filter set, AND an acoustic calibrator.
b. A real time analyzer with third and full octave capability, AND an acoustic calibrator.

Vibration measurements – can be performed with a number of different instrument configurations, such as;

a. A Sound Level Meter with a third octave filter set, a vibration integrator matched to that sound level meter, and an accelerometer.
b. A Real Time Analyzer with third octave and/or narrow band FFT capability AND input capability for an accelerometer, and an accelerometer.
c. A Vibration Meter and an accelerometer.
d. A Spectrum Analyzer and an accelerometer.

4.2 RANGE AND ACCURACY

Calibration requirements for each instrument are specified in table 4-1 and shall be met.

4.3 CALIBRATION

Annual Calibration – ALL S&V instrumentation shall be maintained with a current annual calibration certificate, traceable to the National Institute of Standards and Technology (NIST), or equivalent organizations in other countries, and to the ANSI specifications listed in Table 4.1 or manufacturers specifications, whichever is more stringent.

Field Calibration (Sound) – All sound instrumentation shall be field calibrated with an acoustic calibrator meeting the minimum requirements set forth in Table 4.1, at the beginning and the end of each day of use. Field calibration levels, times, and dates shall be documented in test reports.

Field Calibration (Vibration) – All vibration instrumentation shall be field calibrated per manufacturer's recommendations, and/or with a vibration calibrator meeting the minimum requirements set forth in Table 4.1. Calibration shall be performed before and after each instrument use. Field calibration levels, times, and dates shall be documented in test reports.

Firms with multiple sets of instrumentation shall comply with *either* of the following conditions as a minimum requirement for NEBB certification:

a) Calibrate all instrumentation used by the firm on S&V projects in accordance with Table 4-1.

Or

b) Maintain a complete set of calibrated instrumentation used for comparison with regularly used instrumentation. Periodic checking of regularly used instrumentation against the calibrated set shall be performed. ***Acceptance criteria for the results of the comparisons are the responsibility of the NEBB Qualified S&V Supervisor.***

Supervisors must understand the importance of using accurate instrumentation in the field, and shall be prepared to have witnesses verify their work with the Firm's calibrated set of instrumentation. Results of the data verification shall validate the accuracy of the instrumentation used to perform the work.

TABLE 4-1 NEBB S&V INSTRUMENTATION SPECIFICATIONS

Instrumentation Type	Measurement Type	Specifications	Calibration Interval
Sound Level Meters (SLM's)	Sound Pressure Measurements	Shall meet the Type 1 or Type 2 requirements specified in the most current version of *ANSI S1.4 American National Standard Specification for Sound Level Meters*	12 Months
Full and Third Octave Filters	Sound Pressure Measurements	Shall meet the requirements specified in the most current version of *ANSI S1.11 American National Standard Specification for Octave-Band and Fractional-Octave-Band Analog and Digital Filters*	12 Months
Real Time Analyzers	Sound Pressure Measurements	Shall meet the minimum requirements as specified in ANSI S1.4 and S1.11 and, Lines of resolution ≥ 400 Frequency range capability = 0 – 20,000 Hz True dynamic range ≥ 70 dB Sum and exponential averaging Peak hold function Memory for storage of measurements	12 Months
Vibration Integrators for Sound Level Meters	Vibration Measurements	Shall meet the minimum requirements as specified below: Displacement – 0.1 to 100 mils, Velocity – 0.005 to 100 in/sec Acceleration – 0.01 to 100 G's Frequency Range – 1 to 10,000 Hz Frequency Resolution 1/3-Octave – 12.5 to 20,000 Hz,	12 Months
Vibration Meters	Vibration Measurements	Shall meet the minimum requirements as specified below: Displacement – 0.1 to 100 mils, Velocity – 0.005 to 100 in/sec Acceleration – 0.01 to 100 G's Frequency Range – 1 to 200 Hz (0 to 12,000 CPM) Frequency Resolution Narrowband – 1 Hz	12 Months
Accelerometers / Transducer	Vibration Measurements	Shall have the following minimum specifications: Sensitivity (± 10 %) ≥ 100 mV/G Measurement Range = ± 50 G peak Frequency Range = 1 to 1000 Hz at ± 5 % Mounted Natural Frequency ≥ 30,000 Hz	12 Months
Acoustic Calibrators	Sound Pressure Calibration	Shall meet the requirements specified in the most current version of *ANSI S1.40-1984 (R2001) American National Standard Specification for Acoustical Calibrators*	12 Months
Vibration Calibrators	Vibration Calibration	Shall have the following minimum specifications: Operating Frequency = 159.2 Hz Acceleration Output = 1.00 G rms ± 3% Distortion (with 0 to 100 gram load) ≤ 3%	12 Months

SECTION 5 STANDARDS FOR REPORTS AND FORMS

5.1 REPORTS

The NEBB *Procedural Standards for Measurement of Sound and Vibration* establishes minimum requirements of a NEBB Certified S&V Report. The standards have been developed and written using **"Shall, Should, and May"** language. It is important to note these particular words throughout this document and how they pertain to NEBB Procedural Standards.

NEBB does not require the use of NEBB produced forms. Customized forms are acceptable based on the data acquisition requirements of this section. Where contract document data reporting requirements exceed the minimum requirements of NEBB, the NEBB Certified S&V Firm is responsible to meet the requirements of the contract documents. There are sample S&V Forms included in the Appendix. These sample forms are available to NEBB Certified S&V Firms from the NEBB Website at www.nebb.org.

NEBB Sound and Vibration Reports shall include the following information:

A. REPORT TITLE

B. REPORT CERTIFICATION

C. TABLE OF CONTENTS

D. REPORT SUMMARY / REMARKS

E. APPROPRIATE FORMS

F. INSTRUMENT CALIBRATION

G. ABBREVIATIONS

5.2 REQUIRED FORMS

Listed below are the **requirements** for each NEBB Certified S&V Report in **Shall, Should, and May** language.

5.2.1 REPORT TITLE

Shall Data: The heading: "Certified Sound and Vibration Report"; Project Name / Address, Engineer Name; HVAC Contractor Name; NEBB Certified S&V Firm Name / Address / Certification Number.

May Data: Architect Name; Architect Address / Contact Numbers; Engineer Address / Contact Numbers; HVAC Contractor Address / Contact Numbers.

5.2.2 REPORT CERTIFICATION

THE CERTIFICATION PAGE SHALL BEAR THE STAMP OF THE NEBB QUALIFIED S&V SUPERVISOR. THE STAMP ON THE CERTIFICATION PAGE SHALL BE SIGNED AS EVIDENCE THAT THE NEBB SUPERVISOR HAS REVIEWED AND ACCEPTED THE REPORT. ***SIGNATURE STAMPS ARE SPECIFICALLY PROHIBITED.***

Shall Data: Project Name; Certifying NEBB Qualified S&V Supervisor's Name; Firm Name; Certification Number; Expiration Date; Certifying NEBB Qualified S&V Supervisor's NEBB Stamp (signed & dated); and the following exact verbiage:

"THE DATA PRESENTED IN THIS REPORT IS A RECORD OF THE SOUND AND VIBRATION MEASUREMENTS OBTAINED IN ACCORDANCE WITH THE CURRENT EDITION OF THE NEBB *PROCEDURAL STANDARDS FOR MEASUREMENT OF SOUND AND VIBRATION*. ANY VARIANCES FROM DESIGN / OR INDUSTRY STANDARDS WHICH EXCEED THE LIMITS SET BY THE CONTRACT DOCUMENTS ARE NOTED THROUGHOUT THIS REPORT AND / OR IN THE REPORT PROJECT SUMMARY."

(This data may be included on the report title page or on a separate certification page.)

5.2.3 TABLE OF CONTENTS

The table of contents shall serve as a guide to the organization of the S&V report.

Shall Data: Page numbers of system and component information in the report.

5.2.4 REPORT SUMMARY / REMARKS

A NEBB Certified S&V Report includes a narrative description of system set-up conditions established prior to testing. The narrative should explain the rational for system parameters, such as to establish a full load condition, and the steps taken to achieve the desired set-up.

This section also includes a listing of deficiencies in the summary and identifies the appropriate pages in the report.

Shall Data: Summary of all items that exceed Contract Document tolerances or any other items that require discussion / explanation.

5.2.5 ALL REPORT PAGES

All tested items included in the NEBB S&V Report shall be clearly identified with a unique designation. The method of identification may use schematic diagrams, mechanical plans where permissible, or a narrative description. Each data form supplied in a NEBB S&V Report shall include the name of the responsible technician / NEBB Qualified S&V Supervisor who reported the information, and the time period the data was collected.

Shall Data: Project name. All pages shall be numbered consecutively.

May Data: Remarks section to record any information pertinent to the data reported on the data sheet.

5.2.6 INSTRUMENT CALIBRATION

This is a listing of the instruments that will be used to verify the reported data.

Shall Data:

Instrument type
Instrument manufacturer
Instrument model Number
Instrument serial Number
Date of Instrument Calibration
Due Date of Instrument Calibration
Dates of use

5.2.7 ABBREVIATIONS

This is a list of definitions of the relevant abbreviations used in the report.

Shall Data: A listing of all abbreviations and their definition as used in the report.

5.2.8 VIBRATION MEASUREMENT REPORT FORMS

Vibration measurements shall be presented in graphical or tabular format for each measurement plane and location and the data shall be reported on the appropriate vibration measurement reporting form(s).

Shall Data:

Date of test
Time of test
Equipment designation
Motor Horsepower
Location and Axis of Measurements
Equipment operational parameters – speed/frequency at time of measurements
Measured vibration levels,
Acceleration (in one of the following units: g's, inches/sec², meters/sec²) and/or,
Velocity (in one of the following units: inches/sec, meters/sec) and/or,
Displacement peak-to-peak (in one of the following units: inches, meters),
or units requested by the engineer of record.

5.2.9 SOUND MEASUREMENT REPORT FORMS

Sound measurements shall be recorded on appropriate test forms, indicating the decibel levels measured for both background and operating building system readings. Each tested location shall be recorded on appropriate NC, RC, or dB(A) forms. The following information shall also be recorded:

Shall Data:

Date of test
Time of test
Equipment operational parameters – speed/frequency at time of measurements
dB level of background noise
dB level of operating system
Indication of measurement locations that exceed design criteria
Indoor measurements – space location within building including floor level and room / space number.
Outdoor measurements – location identifier such as location relative to equipment, location relative to building, location relative to property line, etc.

PART 2 - PROCEDURES

SECTION 6 PRELIMINARY SOUND & VIBRATION PROCEDURES

6.1 INTRODUCTION

For sound and vibration measurements to be meaningful and the data to be reported accurately, advance preparations must be completed. The NEBB Qualified S&V Supervisor shall examine the contract documents, examine the approved equipment submittals, and inspect the equipment installation prior to taking any field measurements. This point cannot be overstressed.

6.2 EXAMINATION OF CONTRACT DOCUMENTS

The purpose of the Contract Document examination is to become familiar with the Project requirements and conditions that may preclude proper S&V testing of systems and equipment.

6.2.1 SPECIFICATION EXAMINATION

The noise and vibration criteria established for a project are usually found in either the Architectural or Mechanical Specifications. This information may be found in the Architectural or Mechanical Drawings or some other part of the Contract Documents. The specifications shall be examined for the following items:

a) NC, RC, dB(A), and any other sound or vibration criteria.
b) List of any rooms or spaces noted in the specifications that require low noise and/or vibration levels.
c) Schedule of equipment to be vibration isolated. (This schedule may be in either the Mechanical Specification or on the Mechanical Equipment Schedule Drawing).
d) Description, approved manufacturers, etc., of the equipment bases and vibration isolators.

6.2.2 DRAWING EXAMINATION

The contract drawings shall be examined for any information deemed necessary to perform the sound and vibration measurements.

6.3 SUBMITTAL DRAWINGS EXAMINATION

Examine submittals for vibration isolators, machinery bases and all other sound control equipment to verify whether the equipment furnished to the job is in accordance with the manufacturer's submittals.

6.4 CONSTRUCTION FIELD INSPECTION VERFICATIONS

The purpose of the construction inspections is to become familiar with the actual Project installation and to discover conditions in the system design that may preclude proper S&V testing of systems and equipment. A second purpose of the field inspections is to verify that the installed applications match the designed parameters.

6.4.1 INSPECTION CHECK LIST

All vibration isolated machinery must be inspected to examination installation conditions before startup. The following items should be checked:

a) Verify that all isolators are installed in accordance with manufacturer's recommendations
b) 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.
c) Steel isolation bases must be inspected for cracked welds, excessive bending or twisting of steel members.
d) 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.
e) Elastomer 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.
f) 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.
g) 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.
h) 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.
i) 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.
j) Seismic restraints shall not prevent the proper functioning of vibration isolation system.
k) 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.
l) Carefully inspect the space under all isolated bases to assure that these spaces are clean and free of debris to prevent short-circuiting.
m) Check to ensure that all shipping bolts associated with spring isolators have been removed.
n) 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.

o) Inspect all electrical and control connections to ensure that they do not restrain the movement of the vibration isolated equipment.
p) Inspect all fabric connections between fans and ductwork to ensure that a fabric "bellows" exists when the fans are operating.
q) 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.
r) 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.

Report deficiencies as discovered to the appropriate parties.

6.4.2 CONSTRUCTION READINESS

As previously stated, most construction activities should be completed prior to sound & vibration testing. The building should be in a state of near occupancy conditions. Any item that will effect the sound and vibration measurements should be completed.

From a general construction standpoint, this means that the building exterior is complete, interior partitions complete, ceiling installed, carpeting installed, etc. Items such as painting, hard surfaces flooring, etc. is not required. See Section 6.5 and 6.6 for additional details.

From a building operating systems standpoint, this means all mechanical/electrical systems have been started, are operational and completely under functional control. Testing, adjusting and balancing activities shall be completed. See Section 6.5 and 6.6 for additional details.

6.4.3 CONSTRUCTION READINESS REPORT

Prepare a report identifying all issues that would preclude proper S&V testing of systems and equipment.

6.5 CONDITIONS REQUIRED FOR VIBRATION MEASUREMENTS

A check should be made to determine that all building construction equipment is either removed from the building or is not operating. If the building is subject to vibration forces other than the building systems, such as railroad or vehicle traffic, a time should be chosen when the effects of other vibration sources can be minimized and will not influence measurements of equipment being measured. Restrict people from occupying areas where activities may affect the accuracy of the measurements. The mechanical systems shall be properly balanced, and the inspection of vibration isolation systems completed. Vibration measuring equipment shall be calibrated as outlined in Section 4.

Building environmental systems shall be complete, including all specified vibration isolation, and fully operational with air and water flow components tested and balanced. Before starting vibration measurements, check to determine the operating conditions of the building environmental systems. All of the subsystems must be operating within the ranges specified by the contract documents and manufacturer's recommendations.

In addition, all mechanical equipment rooms (MER) should be completely enclosed, as called for by the contract documents, and all building environment system equipment in the mechanical equipment room should be operating.

Measurements can be performed after notification from the mechanical contractor (or responsible party) that the building systems are complete and ready for measurement.

All equipment to be tested must be safely accessible.

6.6 CONDITIONS REQUIRED FOR SOUND MEASUREMENTS

6.6.1 INTERIOR

Sound measurements in interior acoustical environments of a building cannot be made unless the rooms, and preferably the entire building, are acoustically sealed from exterior noise: windows glazed, doors hung complete with hardware, etc. Construction activities must be completed or the measurements must be made after working hours. Exterior noise, such as traffic, aircraft, etc., and interior construction noise will substantially affect the measurements. If the building has been completed and is occupied, measurements must not be made if office equipment, computers, printers, copiers, etc. or voice signals are audible. When this is the case, sound measurements must be made during non-working hours.

The interior surfaces of the spaces must be reasonably complete: suspended acoustical ceilings installed and all carpeting in place. These are sound absorptive surfaces and will have a significant effect on the sound measurements. On the other hand, work that does not substantially change the acoustical characteristics of the room, such as painting of walls, installation of vinyl or asphalt tile, installation of desks and thinly upholstered chairs, need not be completed before starting sound tests.

6.6.2 EXTERIOR

Sound measurements at the exterior of a building are usually made to determine whether mechanical/electrical equipment located at the exterior of the building or which are discharging noise to the exterior will increase the noise level in the building or in adjacent buildings.

Before making exterior sound measurements, all construction activities must stop; noise from construction equipment, hoists, etc., will affect the measurements. If nearby aircraft or vehicle traffic activity increases noise levels in the vicinity of the building, it may be necessary to make the measurements at night when such activities are at a minimum in order to accurately measure the noise output of the building/mechanical/electrical equipment.

Exterior measurements may also be required to address municipal code requirements for the locality of the project. Often times such codes require noise measurements be carried out for period of 24 hours or longer or during different times of day to address specific code restrictions. Also codes have provisions for tonal conditions that refer to equipment generating noise at discrete frequencies that typically tend to be more intrusive than broadband noise. All these aspects of exterior noise tend to be project specific and would need to be addressed on a case-by-case basis.

Environmental equipment servicing the building should be fully operational. Cooling towers should be operating with all fans at design speeds and water flow at normal operating rates. All fans connected to intake or discharge louvers should be operating with damper settings at design fresh air intake or exterior discharge. All outdoor unitary equipment should be operating under load, assuring that the compressor is on and all the condenser fans are operating. In essence operating conditions should be

representative of project design condition(s) or clearly stated prior to any noise testing to ensure that noise data reflects a meaningful operating condition for the project.

The building site need not be completely landscaped. Trees, bushes, and grass do not substantially attenuate sound transmission over a reasonably short distance, such as 100 feet (30 m), between the noise source and the point of measurement. Grading, however, should be reasonably complete to the extent that a temporary soil storage pile must not obscure the line of sight between a noise source and point of measurement. This applies also to temporary buildings and solid fences.

Avoid taking exterior sound measurements in the presence of more than one inch of snow on the ground. Additionally, exterior sound measurements should not be taken when wind speed exceed 10 mph, or during rain.

6.6.3 ENVIRONMENTAL SYSTEMS

Building environmental systems should be fully operational with air and water flow components tested and balanced. Before starting sound measurements, check to determine the operating conditions of the building environmental systems. All of the subsystems should be operating within the ranges specified by the contract documents and manufacturer's recommendations.

In addition, all mechanical equipment rooms (MER) should be completely enclosed, as called for by the contract documents, and all building environment system equipment in the mechanical equipment room should be operating.

SECTION 7 VIBRATION MEASUREMENT PROCEDURES

7.1 EQUIPMENT STARTUP

Prior to taking vibration measurements, construction inspections shall be done in accordance with the requirements of Section 6.

7.2 VIBRATION SOURCES

The NEBB S&V Firm is responsible to perform vibration measurements and report the data in accordance with the requirements of the current edition of the NEBB *PROCEDURAL STANDARDS FOR MEASUREMENT OF SOUND AND VIBRATION.*

Vibration measurements are made to determine whether the vibration of rotating equipment may be in excess of specifications. This can result in vibration in other areas of a building that may be annoying to building occupants or that may cause problems with sensitive instruments.

Vibration measurements are typically reported in terms of acceleration, velocity, and / or displacement.

7.3 VIBRATION SCOPE

7.3.1 VIBRATION SCOPE METHODS

The scope of vibration measurement services can be defined by three distinct contractual methods: engineering contract documents, minimum NEBB requirements, or a negotiated contract.

7.3.2 ENGINEERING CONTRACT DOCUMENTS

The contract documents should specify the scope of vibration measurement services to be performed for the project. A defined scope of vibration measurement services will always take precedence over the minimum NEBB requirements.

7.3.3 MINIMUM NEBB REQUIREMENTS

Some contract documents do not define the scope of vibration measurement services. When the scope of vibration measurement services are not adequately defined in the Engineering Contract Documents, then the scope of vibration measurements for the project shall conform to the minimum NEBB requirements. ***The minimum NEBB requirements SHALL automatically become the scope of S&V services on all contract document projects where the exact scope of S&V services has not been determined by the Design Professional (See 7.3.1.1). The NEBB Certified S&V Firm shall be bound contractually to these minimum NEBB requirements unless specifically stated otherwise in their proposal.***

The minimum NEBB requirements for these types of projects are as follows:

All pumps and fans over 3 Hp (2.2 kW), and
All chillers/compressors over 5 Hp (3.7 kW).

7.3.4 NEGOTIATED CONTRACT

The scope of vibration measurement services shall be determined by the NEBB Certified S&V Firm and agreed upon by the Owner, or owner's appointed representative.

7.4 MEASUREMENT PROCEDURES

7.4.1 MEASUREMENT PROCEDURES

Regardless of the scope of vibration measurement services, the procedures by which all vibration measurements are to be made, shall conform to the procedures contained in this section.

7.4.2 OTHER SOURCES THAT MAY AFFECT MEASUREMENTS RESULTS

Perform vibration measurements when other building systems/conditions and exterior vibration sources are at a minimum level and will not influence measurements of equipment being tested. In order to minimize other vibration sources, the following suggestions should be implemented:

A. Turn off equipment in the building that might interfere with testing.
B. Restrict people from occupying areas where human activity may affect accuracy of measurements.
C. Measurements should be performed when exterior vibration sources (trains, roadway traffic, adjacent construction activities, etc.) are at a minimum level.

In certain situations, it may be impossible to shut down building systems in order to obtain vibration measurements. In all situations, the NEBB Qualified S&V Supervisor shall contact the appropriate personnel before shutting down any building systems.

7.4.3 LOCATION AND ATTACHMENT OF ACCELEROMETER (TRANSDUCER)

The method of attaching an accelerometer can seriously affect its performance. Accelerometers should be attached to vibrating surfaces according to the accelerometer manufacturer's instructions. The accelerometer shall be mounted to surfaces that are flat and clean. If vibration measurements must be made on vibrating machinery which appears to have exceptionally large vibration amplitudes, it may be necessary to attach the accelerometer to the machine by means of threaded metal studs.

Heavy accelerometers may affect the accuracy of vibration levels obtained from small or lightweight systems or equipment. Accelerometer weight shall be no more than 10% of the equipment to be tested.

It is recommended that the same mounting method be used for all measurements made on any individual piece of equipment and similar pieces of equipment.

The hierarchy of mounting an accelerometer, based on accuracy of repeatable results is: stud

mount, adhesive mount, magnetic base, bees wax, and hand-held probe. The magnetic base is the most common method of attachment.

The following mounting methods generally can be used for vibration measurements in which the upper frequency limit of the measurements does not exceed 1,000 Hz.

7.4.3.1 Magnetic Base

A magnet can be used to attach accelerometers to ferrous metal vibrating surfaces. Attach the accelerometer to a magnetic base (usually by means of a small threaded stud) and then place the magnetic base on the vibrating metal surface.

7.4.3.2 Bees Wax or Petroleum Wax

Accelerometers may be attached with Bees Wax. Place a thin layer of Bees Wax on the mounting surface of the accelerometer and then press the accelerometer onto a vibrating surface. It must be noted that a firm mounting must be achieved for the transducer to read properly.

7.4.3.3 Adhesive Attachment

Use epoxy cement or methyl cyanoacrylate cement. Place a thin layer of the cement on the mounting surface of the accelerometer and then press the accelerometer onto the vibrating surface. Care should be exercised in the use of cement to ensure that the accelerometer is not damaged when it is removed from the surface. This form of attachment is normally used with a ¼ turn quick connect for the transducer with the mounting plate left attached to the measurement surface.

7.4.3.4 Threaded Stud Mounted

Accelerometers may be mounted with a threaded metal stud. Two methods are commonly available: a drilled and tapped hole into the mounting surface, or by use an existing grease fitting tap. Apply an oil film or a thin layer of beeswax between the accelerometer and the surface to which it is mounted.

7.4.3.5 Hand-held Probe

Another method for making vibration measurements entails attaching an accelerometer to either a short or long pointed metal probe. The pointed end of the probe is then pressed against vibration surfaces. This method can generally be used for vibration measurements in which the upper frequency limit of the measurements does not exceed 200 Hz. ***NOTE: In some instances safety concerns may require the use of hand-held probes. Use of hand-held probes is not a preferred method and can lead to inconsistent and non-repeatable measurements.***

7.5 DATA MEASUREMENTS

Vibration measurements shall be recorded and reported in one of two methods: at discrete frequencies or in 1/3 octave bands as follows:

1. Discrete vibration levels: from 1 to 200 Hz in 1 Hz increments, or
2. In each 1/3 octave band: from 12.5 Hz to 200 Hz.

NOTES:

a. Vibration measurements with an FFT analyzer, require definition of other measurement parameters; such as type of averaging and measurement duration, maximum versus average level, type of windowing and setup for narrowband. This should be included in contract specifications but if this is not the case they need to be agreed upon and confirmed prior to taking any vibration readings.

b. Oftentimes building vibration requires seismic grade, high sensitivity (10,000 or 1,000 mV/G) accelerometers capable of measuring low levels and down to low frequencies(1 to 2 Hz). A general purpose accelerometer with a sensitivity of 100 mV/g or less, may be insufficient for building floor vibration measurements of low vibration amplitude. Refer to Table 4.1 in Section 4 for proper selection of vibration transducers for low level vibration measurements.

7.6 MEASUREMENT LOCATIONS

Measure and record vibration levels at all required equipment, equipment bases and on building structure adjacent to the equipment. Record vibration acceleration, velocity, and/or displacement; in the vertical (radial), horizontal (transverse) and axial (longitudinal) axes (with respect to the equipment axis of rotation), or as per contract specifications.

7.6.1 MEASUREMENTS ON EQUIPMENT

Perform vibration measurements at equipment and record vibration levels in the vertical, horizontal, and axial axes, where measurements can be performed safely. If direct access to the bearing is not available, then measurements shall be taken as close as possible to the shaft center line at the housing. Measurements shall be taken as indicated in the following table:

Equipment	Item	Location
Pumps	Pump Bearing	Drive end and opposite end
Pumps	Motor bearing	Drive end and opposite end
Fans and HVAC Equipment with Fans	Fan Bearing	Drive end and opposite end
Fans and HVAC Equipment with Fans	Motor Bearing	Drive end and opposite end
Chillers and HVAC Equipment with Compressors	Compressor Bearing	Drive end and opposite end
Chillers and HVAC Equipment with Compressors	Motor Bearing	Drive end and opposite end

7.6.2 MEASUREMENTS ON EQUIPMENT BASES

Perform vibration measurements at equipment bases on both sides (equipment side and floor side) of the isolator and record vibration levels in the vertical, horizontal, and axial axes, where measurements can be performed safely as indicated in the following table:

Equipment Bases	Location
Pumps	Within 6” of each isolator
Fans and HVAC Equipment with Fans	Within 6” of each isolator
Chillers and HVAC Equipment with Compressors	Within 6” of each isolator

7.6.3 MEASUREMENTS ON BUILDING STRUCTURE

Perform vibration measurements at building structure adjacent to equipment and record vibration levels in the vertical, horizontal, and axial axes (where possible), where measurements can be performed safely as indicated in the following table:

Equipment	Floor Location
Pumps	Within 6” of equipment
Fans and HVAC Equipment with Fans	Within 6” of equipment
Chillers and HVAC Equipment with Compressors	Within 6” of equipment

SECTION 8 SOUND MEASUREMENT PROCEDURES

8.1 EQUIPMENT STARTUP

Prior to taking sound measurements, construction inspections shall be done in accordance with the requirements of Section 6.

8.2 SOUND SOURCES

The NEBB S&V Firm is responsible to perform sound level measurements and report the data in accordance with the requirements of the current edition of the NEBB *PROCEDURAL STANDARDS FOR MEASUREMENT OF SOUND AND VIBRATION.*

Sound level measurements are made to determine whether noise from mechanical and some electrical equipment or rotating equipment may be in excess of specifications. This can result in sound in other areas of a building that may be annoying to building occupants or that may cause problems with sensitive instruments. Sound level measurements may also be required to demonstrate project noise compliance with municipal codes at property boundary or neighboring properties as stipulated by such codes or project conditions of approval.

Sound levels measurements are typically reported in terms of dB(Flat or Linear), dB(A), Noise Criteria (NC) or Room Criteria (RC).

8.3 SOUND SCOPE

8.3.1 SOUND SCOPE METHODS

The scope of sound level measurement services can be defined by three distinct contractual methods: engineering contract documents, minimum NEBB requirements, or a negotiated contract.

8.3.2 ENGINEERING CONTRACT DOCUMENTS

The contract documents should specify the scope of sound level measurement services to be performed for the project. A defined scope of sound level measurement services will always take precedence over the minimum NEBB requirements.

8.3.3 MINIMUM NEBB REQUIREMENTS

Some contract documents do not define the scope of sound level measurement services. When the scope of sound level measurement services are not adequately defined in the Engineering Contract Documents, then the scope of sound level measurements for the project shall conform to the minimum NEBB requirements. ***The minimum NEBB requirements***

SHALL automatically become the scope of S&V services on all contract document projects where the exact scope of S&V services has not been determined by the Design Professional (See 8.3.1.1). The NEBB Certified S&V Firm shall be bound contractually to these minimum NEBB requirements unless specifically stated otherwise in their proposal.

The minimum NEBB requirements for these types of projects are as follows:

a. Perform sound testing in all occupied space horizontally and vertically adjacent to all mechanical equipment rooms and all mechanical chases.

b. 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)

c. Perform sound testing in all spaces with design criterion of NC or RC 25 or less.

8.3.4 NEGOTIATED CONTRACT

Scope of sound level measurement services shall be determined by the NEBB Certified S&V Firm and agreed upon by the Owner, or owner's appointed representative.

8.4 MEASUREMENT PROCEDURES

8.4.1 MEASUREMENT PROCEDURES

Regardless of the scope of sound level measurement services, the procedures by which all sound measurements are to be made, shall conform to the procedures contained in this section.

8.4.2 OTHER SOURCES

Perform sound measurements when other building systems/conditions and exterior sound sources are at a minimum level and will not influence measurements of equipment being tested. In order to minimize other sound sources, the following suggestions should be implemented:

A. Close ALL windows and doors to the space.
B. Turn off equipment in the building that might interfere with testing.

C. 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.
D. 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.
E. Measurements should be performed when exterior vibration sources (trains, roadway traffic, adjacent construction activities, etc.) are at a minimum level.

8.4.3 FIELD CALIBRATION OF INSTRUMENTATION

Prior to making any sound level measurements verify that all instruments have a current calibration certificate as specified in Section 4. A field calibration shall be performed in accordance with Section 4.3.

8.4.4 BACKGROUND SOUND LEVELS

Take sound measurements with the building systems "OFF" to establish the background levels and take sound measurements with the building systems operating. Calculate the difference between measurements. Apply a correction factor depending on the difference and adjust measurements. In certain situations, it may be impossible to shut down building systems in order to obtain background sound levels. Under these conditions, background sound levels can not be measured. In all situations, the NEBB Qualified S&V Supervisor shall contact the appropriate personnel before shutting down any building systems.

8.5 DATA MEASUREMENTS

Unless specified otherwise in contract documents, sound level measurements shall be recorded and reported in one or both of the following two methods: overall sound levels or in octave bands as follows:

1. Overall dB(Flat or Linear) or dB(A) levels.
2. The sound level meter shall be set to the Slow time constant.
3. In each 1/1(Full) octave band, from 31.5 to 8,000 Hz.

8.6 MEASUREMENT LOCATIONS

Measure and record sound levels in all spaces as specified in Section 8.3.

Position sound level instrument to achieve a direct line-of-sight between the sound source and the sound-level meter.

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.

APPENDICES

APPENDIX A SAMPLE S&V SPECIFICATION – LONG FORM

(This recommended S&V specification is available from www.nebb.org)

NEBB has provided two distinct sample specifications. The document in Appendix A is meant to be utilized as self-contained, free-standing sound and vibration specification identifying requirements such as the scope of work, submittals, reporting forms, qualifications, etc. The document in Appendix B is a short form specification that is meant to be inserted into a standard TAB specification. This shorter form only includes the sound and vibration scope of work.

SECTION 15xxx (23xxx) – SOUND AND VIBRATION TESTING

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

This Section includes measurement and reporting of sound and vibration levels.

1.3 DEFINITIONS

(To be added as per Section 1 of the S&V PS)

1.4 SUBMITTALS

A. Qualification Data: Within __ days from Contractor's Notice to Proceed, submit __ copies of evidence that S & V firm and this Project's S & V team members meet the qualifications specified "QUALITY ASSURANCE" (Part 1, Section 1.5 below).

B. Contract Document Examination Report: Within ___days from Contractor's Notice to Proceed, submit __ copies of the Contract review report as specified in Part 3.

C. Tasks and Procedures Plan: Within __ days from Contractor's Notice to Proceed, submit __ copies of S & V tasks as specified in Section 3.1 - "Examination". Include a complete set of report forms intended for use on this Project.

D. Certified S&V Reports: Submit __ copies of report prepared, as specified in this Section, on approved forms by the NEBB Certified S&V firm.

1.5 QUALITY ASSURANCE

A. S&V Firm Qualifications: Engage a NEBB Certified Sound & Vibration Firm.

B. S&V Conference: Meet with Owner's and Engineer's representatives on approval of S&V strategies and procedures; plan to develop a mutual understanding of the details. Ensure the participation of S&V team members and other support personnel. Provide __ days advanced notice of scheduled meeting time and location.

C. Certification of S&V Reports: Review field data reports to validate accuracy of data and to prepare certified S&V reports. The Certified Report shall be prepared in accordance with the requirements of Part 3, Section 3.4 and the latest edition of the *NEBB Procedural Standards for Measurement of Sound and Vibration.*

D. S&V Report Forms shall include, at a minimum, all information required in Part 3, Section 3.5 and the latest edition of the *NEBB Procedural Standards for Measurement of Sound and Vibration*.

E. Instrumentation Type, Quantity, Accuracy and Calibration shall meet the requirements of the latest edition of the *NEBB Procedural Standards for Measurement of Sound and Vibration*.

F. Field calibration prior to instrument use shall meet the requirements of the latest edition of the *NEBB Procedural Standards for Measurement of Sound and Vibration*.

1.6 PROJECT CONDITIONS

A. 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.

B. 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.

PART 2 - PRODUCTS (Not Applicable)

PART 3 – EXECUTION

3.1 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.

1. Inspect Contract Documents defined in the General and Supplementary Conditions of the Contract.
2. Verify that sound and vibration isolating devices are required by the Contract Documents. Verify that the quantities and locations of these isolating devices are accessible and appropriate for testing.

B. Examine approved submittal data of final installed HVAC systems and equipment, provided by the mechanical/general contractor, or building owner's representative.

C. Examine appropriate system and equipment test reports, for systems and equipment requiring factory start-up.

D. Verify that all system and equipment installations are complete and that testing, adjusting, and balancing specified in the contract documents have been performed.

E. All vibration isolated machinery must be inspected to examination installation conditions before startup. The following items should be checked:

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. Elastomer 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.

Report deficiencies as discovered to the appropriate parties.

3.2 PROCEDURES FOR VIBRATION MEASUREMENTS

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.
   3. Exterior vibration sources; i.e. trains, roadway traffic, adjacent construction activities, etc.

B. Attach and secure the vibration transducer in accordance with the latest edition of the *NEBB Procedural Standards for Measurement of Sound and Vibration.*

C. Measure and record, on all pumps and fans over 3 hp, and all chillers and compressors over 5 hp, at discrete frequencies or in 1/3 octave bands as follows:

   1. Discrete vibration levels from 1 to 200 Hz in 1 Hz increments, or
   2. In each 1/3 octave band from 12.5 Hz to 200 Hz.

D. Measure and record equipment vibration, bearing vibration, equipment base vibration, and on building structure adjacent to equipment. Record velocity and displacement readings in the radial vertical, radial horizontal and axial planes, where measurements can be performed safely.

1. Pumps:

    a. Pump Bearing: Drive end and opposite end.
    b. Motor bearing: Drive and opposite end.
    c. Pump Base: Top and side, within 6” of each isolator.
    d. Building: Floor adjacent to pump/motor, within 6” of each isolator.

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 each isolator.
    d. Building: Floor adjacent to fan/motor, within 6” of each isolator.

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 each isolator.
    d. Building: Floor adjacent to equipment, within 6” of each isolator.

3.3 PROCEDURES FOR SOUND LEVEL MEASUREMENTS

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 sound level instrument 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 slow time constant, in the octave bands from 31.5 to 8000 Hz.

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.

3.4 REPORTING

A. Provide appropriate deficiency information to the construction team as S&V work progresses. Deficiency information shall be sufficient to facilitate contractor's dispatch of appropriate personnel to resolve items noted prior to final S&V work.

3.5 FINAL REPORT

A. The final report shall be typewritten or computer printout in letter-quality font, on standard bond paper. It shall be bound, tabulated and divided into sections.

B. The final report shall be in accordance with the requirements of the current edition of the NEBB *Procedural Standards for Measurement of Sound and Vibration.* The final certified repot shall include, but not limited to the following:

1. Report Title page indicating the Project name, Project location, Engineer's name, Contractor's name, NEBB Certified S&V Firm's name, address, and certification number.
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. Abbreviations page shall include a listing of all abbreviations and their definition as used in the report.
6. Data sheets on Sound and Vibration measurements as described below.
7. 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.

8. Other information relative to equipment performance at time of testing that is deemed appropriate by the NEBB Certified S&V Firm.

C. Vibration Measurement Report Forms: For each measurement location, record vibration measurements on appropriate test forms, indicating the following information:

1. Date and time of test.
2. Equipment designation, location, motor horsepower and equipment operational parameters (speed/ frequency) at time of measurements.
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).

D. 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.

APPENDIX B SAMPLE S&V SPECIFICATION – SHORT FORM

SECTION 15xxx (23xxx) – SOUND AND VIBRATION TESTING

PART 1 – GENERAL

1.1 SUMMARY

This Section includes measurement and reporting of sound and vibration levels.

PART 2 - PRODUCTS (Not Applicable)

PART 3 – EXECUTION

PART 3 – EXECUTION

3.1 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.

1. Inspect Contract Documents defined in the General and Supplementary Conditions of the Contract.
2. Verify that sound and vibration isolating devices are required by the Contract Documents. Verify that the quantities and locations of these isolating devices are accessible and appropriate for testing.

B. Examine approved submittal data of final installed HVAC systems and equipment, provided by the mechanical/general contractor, or building owner's representative.

C. Examine appropriate system and equipment test reports, for systems and equipment requiring factory start-up.

D. Verify that all system and equipment installations are complete and that testing, adjusting, and balancing specified in the contract documents have been performed.

E. All vibration isolated machinery must be inspected to examination installation conditions before startup. The following items should be checked:

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. Elastomer 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.

Report deficiencies as discovered to the appropriate parties.

3.2 PROCEDURES FOR VIBRATION MEASUREMENTS

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.

3. Exterior vibration sources; i.e. trains, roadway traffic, adjacent construction activities, etc.

B. Attach and secure the vibration transducer in accordance with the latest edition of the *NEBB Procedural Standards for Measurement of Sound and Vibration.*

C. Measure and record, on all pumps and fans over 3 hp, and all chillers and compressors over 5 hp, at discrete frequencies or in 1/3 octave bands as follows:

1. Discrete vibration levels from 1 to 200 Hz in 1 Hz increments, or
2. In each 1/3 octave band from 12.5 Hz to 200 Hz.

D. Measure and record equipment vibration, bearing vibration, equipment base vibration, and on building structure adjacent to equipment. Record velocity and displacement readings in the radial vertical, radial horizontal and axial planes, where measurements can be performed safely.

1. Pumps:

a. Pump Bearing: Drive end and opposite end.
b. Motor bearing: Drive and opposite end.
c. Pump Base: Top and side, within 6" of each isolator.
d. Building: Floor adjacent to pump/motor, within 6" of each isolator.

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 each isolator.
d. Building: Floor adjacent to fan/motor, within 6" of each isolator.

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 each isolator.
d. Building: Floor adjacent to equipment, within 6" of each isolator.

E. Vibration Measurement Reports:

1. Date and time of test.
2. Equipment designation, location, equipment speed, motor speed and motor horsepower.
3. Measured acceleration (in units of g's, inches/sec^2, meters/sec^2, 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).

3.3 PROCEDURES FOR SOUND LEVEL MEASUREMENTS

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 sound level instrument 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 slow time constant, in the octave bands from 31.5 to 8000 Hz.

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).
    11. Perform sound testing in all spaces with a design criterion of NC or RC 25 or less.

J. 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.

4. Outdoor measurements – location identifier such as location relative to equipment, building, or property line.
5. Indicate where measurements meet or exceed design criteria.

3.4 FINAL REPORT

A. The final report shall be in accordance with the requirements of the current edition of the NEBB *Procedural Standards for Measurement of Sound and Vibration.*

APPENDIX C SAMPLE S&V REPORT FORMS

SOUND AND VIBRATION REPORT

REPORT DATE: _____

PROJECT:

NAME: _____

ADDRESS: _____

_____

DESIGN ENGINEERING FIRM:

NAME: _____

ADDRESS: _____

_____

HVAC CONTRACTOR:

NAME: _____

ADDRESS: _____

_____

NEBB S&V FIRM:

NAME: _____

ADDRESS: _____

_____

S&V CERTIFICATION NUMBER: _____

CERTIFICATION

PROJECT: _____

_____

THE DATA PRESENTED IN THIS REPORT IS AN EXACT RECORD OF THE SOUND AND VIBRATION MEASUREMENTS OBTAINED IN ACCORDANCE WITH THE CURRENT EDITION OF THE NEBB PROCEDURAL STANDARDS FOR MEASUREMENT OF SOUND AND VIBRATION. ANY VARIANCES FROM DESIGN WHICH EXCEED THE LIMITS SET BY THE CONTRACT DOCUMENTS ARE NOTED THROUGHOUT THIS REPORT AND / OR IN THE REPORT PROJECT SUMMARY.

THE SOUND AND VIBRATION LEVELS ALLOWANCES OF THE AIR AND HYDRONIC DISTRIBUTION SYSTEMS HAVE BEEN MEASURED IN ACCORDANCE WITH THE CURRENT EDITION OF THE NEBB *PROCEDURAL STANDARDS FOR MEASUREMENT OF SOUND AND VIBRATION* AND THE PROJECT SPECIFICATIONS.

SUBMITTED & CERTIFIED BY

NEBB QUALIFIED S&V SUPERVISOR (Print Name):_____

NEBB QUALIFIED S&V SUPERVISOR (Signature): _____

NEBB CERTIFIED S&V FIRM NAME: _____

CERTIFICATION NO: _____ CERTIFICATION EXPIRATION DATE: _____

REPORT DATE: _____

SEAL

INSTRUMENT CALIBRATION REPORT

PROJECT:_____

INSTRUMENT TYPE	MANUFACTURER	MODEL NUMBER	SERIAL NUMBER	CALIBRATION DATE	DATES OF USE

VIBRATION ISOLATION INSPECTION REPORT – FREEDOM OF MOVEMENT

PROJECT: _____
LOCATION (Mechanical Equipment Room): _____
EQUIPMENT NO. IDENTIFICATION: _____
TYPE: _____
SYSTEM: _____
SERVICE: _____
EQUIPMENT TEST REF. (from NEBB reports): _____

INSPECTIONS TO BE CONDUCTED WHILE EQUIPMENT IS NOT OPERATING

		Yes	No
FREEDOM OF MOVEMENT	Isolator Loaded Height		
	Equipment moves freely when rocked		
	Space between inertia base and slab clear of debris		
BOLTS	Loose bolts		
	Missing bolts		
	Missing lock screws		
RESTRAINS	No restraint from control wiring		
	No restraint from power wiring		
	No restraint from piping connections		
	No restraint from duct connections		
	All isolator restraint devices inoperative		
HANGERS	Hanger isolator rods not short circuited		
SPRING ISOLATORS	Overloading of housed springs		
	Clearance		
	Tilted or cocked springs		
	High frequency isolation pad		
RUBBER ISOLATORS	Cracks in rubber		
	Loose bond between rubber and steel components		
	Clearance between bolts and rubber		
PNEUMATIC ISOLATORS	Overload		
	Air pressure in operation pressure range		
	Height regulator in operation		
	Potential damage – sharp objects, etc.		

REMARKS: _____
_____

INSPECTION DATES: _____
MEASUREMENTS BY: _____
CERTIFIED BY: _____ Page _____ of _____

VIBRATION ISOLATION INSPECTION REPORT – FLEXIBLE PIPING

EQUIPMENT NO. IDENTIFICATION: _____

SYSTEM: _____

SERVICE: _____

LOCATION (Mechanical Equipment Room): _____

EQUIPMENT TEST REF. (from NEBB reports): _____

INSPECTION OF FLEXIBLE PIPING INSTALLED

Type of flexible piping: Rubber_____Braid_____Bellows_____
Rubber with control cables_____

	Specified/Submitted	Actual
Diameter		
Length (Including elongation)		

REMARKS: _____

_____

INSPECTION DATES: _____

MEASUREMENTS BY: _____

CERTIFIED BY: _____Page _____ of _____

VIBRATION ANAYLSIS DATA SHEET (VM)

PROJECT: _____

EQUIPMENT DESCRIPTION: _____

_____

AXIS OF MEASUREMENT: _____

REMARKS: _____

_____

_____

INSPECTION DATES: _____

MEASUREMENTS BY: _____

CERTIFIED BY: _____ Page _____ of _____

VIBRATION ANAYLSIS DATA SHEET (SLM)

PROJECT: _____

EQUIPMENT DESCRIPTION: _____

_____

AXIS OF MEASUREMENT: _____

1/3-Octave Centerband Frequency	Acceleration		Velocity		Displacement		Remarks
	L_a, dB	m/sec²	L_v, dB	m/sec	L_d, dB	m	
12.5							
16							
20							
25							
31.5							
40							
50							
63							
80							
100							
125							
160							
200							

REMARKS: _____

_____

_____

INSPECTION DATES: _____

MEASUREMENTS BY: _____

CERTIFIED BY: _____ Page _____ of _____

MEASUREMENT SCHEMATIC, DESCRIPTION AND OTHER CONDITIONS

PROJECT: _____ SYSTEM: _____

LOCATION: _____

LOCATION DESCRIPTION: _____

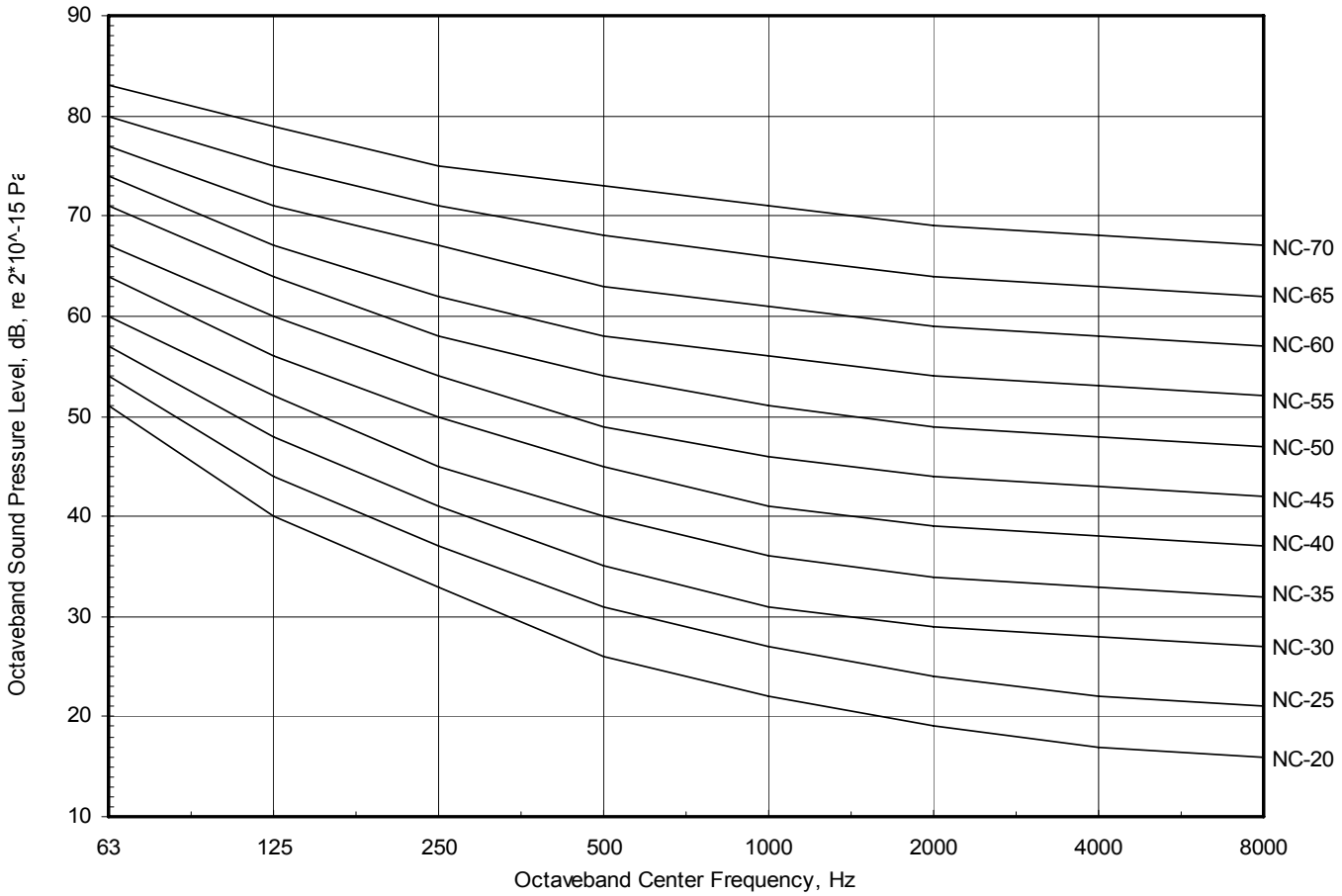
Page _____ of _____

NOISE CRITERIA (NC) REPORT

PROJECT: _____ SYSTEM: _____
LOCATION: _____

SOUND MEASUREMENTS OF: _____

	Full – Octave Band Center Frequency, Hz							
	63	125	250	500	1000	2000	4000	8000
Measured Level								



REMARKS: _____

_____

INSPECTION DATES: _____

MEASUREMENTS BY: _____

CERTIFIED BY: _____ Page _____ of _____

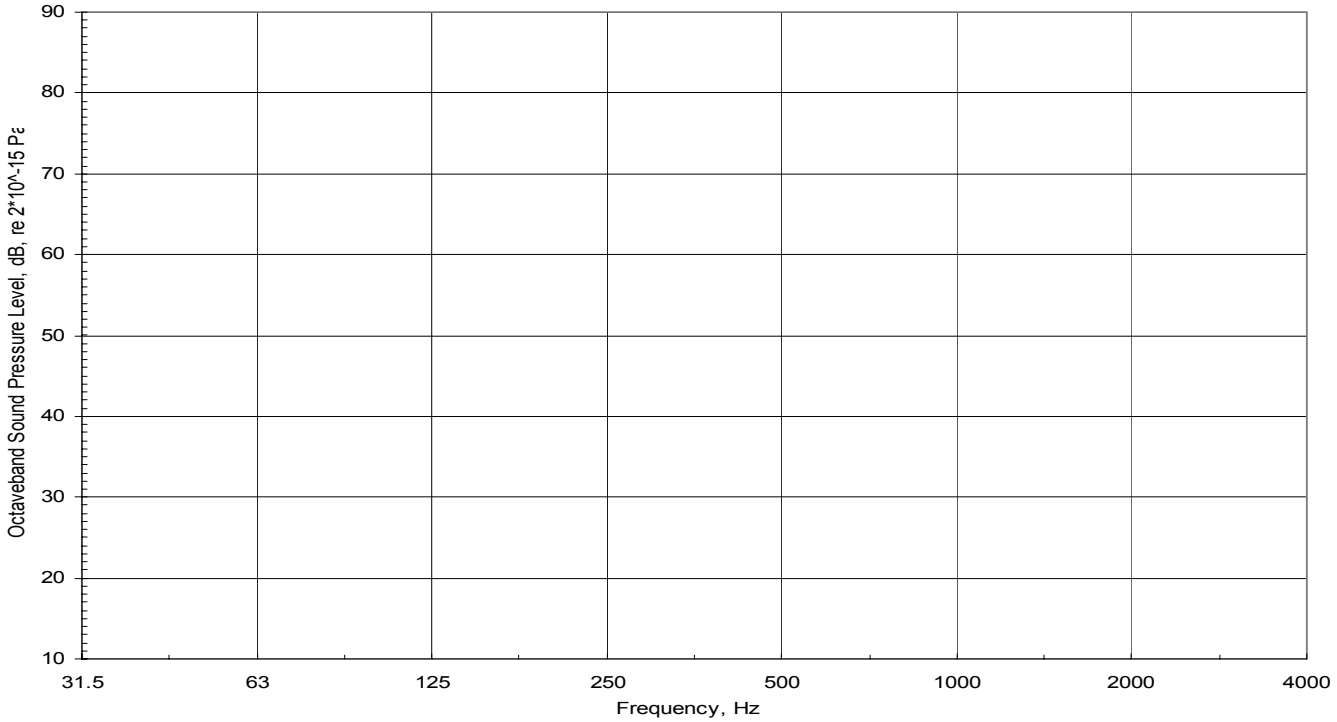
ROOM CRITERION (RC) REPORT

PROJECT: _____ SYSTEM: _____

LOCATION: _____

SOUND MEASUREMENTS OF: _____

	Full – Octave Band Center Frequency, Hz							
	31.5	63	125	250	500	1000	2000	4000
Measured Level								
PSIL Value								



REMARKS: _____

_____

INSPECTION DATES: _____

MEASUREMENTS BY: _____

CERTIFIED BY: _____ Page _____ of _____

EXTERIOR NOISE MEASUREMENT REPORT

PROJECT: _____

LOCATION: _____

DESCRIPTION OF ENVIRONMENTAL CONDITIONS:
TEMPERATURE: _____
RELATIVE HUMIDITY: _____
BAROMETRIC PRESSURE: _____
WIND SPEED (WIND SPEED SHOULD BE LESS THAN 5 MPH): _____
WIND DIRECTION: _____
CLOUD COVER: _____

DESCRIPTION AND DISTANCE OF NOISE SOURCES:

Equipment Description	Distance, feet
Mechanical Equipment Room Louvers	
Cooling Tower(s)	
Transformer(s)	
Compressor(s)	
Chiller(s)	
Other	

BACKGROUND NOISE SOURCES AND DISTANCE TO NOISE SOURCES:

Equipment Description	Distance, feet
Roadway(s)	
Mechanical Equipment on Other Buildings	
Construction Sites	

DISTANCE AND DIRECTION TO NEAREST BUILDING(S):

Building #	Distance, feet
#1	
#2	
#3	

EXTERIOR NOISE MEASUREMENT REPORT

SOUND PRESSURE LEVELS FROM SOURCES:

Description	Full – Octave Band Center Frequency, Hz									dB(A)
	31.5	63	125	250	500	1000	2000	4000	8000	
Source #1										
Source #2										
Source #3										
Source #4										

SKETCH OF MEASUREMENT SITE:

REMARKS: _____

_____

INSPECTION DATES: _____

MEASUREMENTS BY: _____

CERTIFIED BY: _____ Page _____ of _____

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