

HVAC Systems Sound and Vibration Procedural Guide, First Edition

Sheet Metal and Air-Conditioning Contractors'
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The primary Sheet Metal and Air-Conditioning Contractors' National Association (SMACNA) markets include commercial, industrial, institutional, and residential facilities that have design requirements for human occupancy. This "Guide" addresses these design requirements. This review includes a summary of the Guide's contents and concludes with some cautionary items.

The target readership for the Guide is a sheet-metal contractor seeking "compliance" with performance criteria such as room criteria (RC) and noise criteria (NC), which are promulgated by ASHRAE. These criteria are a function of room type or use, and they establish the "allowable upper limit" for sound and vibration levels due to heating ventilating and air-conditioning (HVAC) equipment within a room. Representative starting points, to best apply the technical methodology of this Guide, include a working knowledge of impact insulation, noise control, room acoustics, sound transmission and vibration isolation. The "work" undertaken by a sheet metal contractor is for the installation of HVAC equipment.

The two construction-industry associations that are most pertinent to the SMACNA membership of Contractors include the American Construction Standards Institute (CSI) and the Construction Specifications Canada (CSC) association. The CSI and CSC jointly produce the MasterFormat® classification scheme that defines the format of specifications within contract documents. Further reference is made within the Guide to the Testing Adjusting and Balancing Bureau (TABB). The TABB is a certifying agency that is described for selecting sound and vibration testing technicians.

The Foreword, self-authored by SMACNA, emphasizes the market value of achieving compliance with criteria that quantitatively define what "quiet" is for a given room type. However, SMACNA does not seek to impose criteria of their own making but makes clear and recurring reference to the RC and NC criteria. These criteria are published separately for reference within the ASHRAE Handbook's chapter on "Sound and Vibration Control."

Subsequent to the Foreword, there are seven chapters, an appendix, and a glossary. All of the text is easy to read when a person is familiar with the beginner/technician methodology and MasterFormat® classification scheme. All of the written material of the Guide is aimed at a beginner/technician that may well be qualified to conduct sound and vibration testing.

Chapter 1: Introduction frames the scope, purpose, and use of the Guide, for providing the "minimum testing requirements and procedures that will result in repeatable and accurate measurements". The scope, purpose and use could benefit from editorial changes that more narrowly focus onto the compliance-testing mission. Then the Guide would be more effective at establishing the underlying "quality assurance" qualifications of certified suppliers of testing services and elucidating the methods and procedures that are essential to obtaining the accurate and repeatable measurement data that are essential to the SMACNA vision.

Chapter 2: Standards for Instrumentation provides information for configuration of instrumentation. For a sound level meter (SLM), the information includes differentiation between ANSI Type 1 and Type 2 accuracy, frequency-domain filtering using A/B/C networks, 1/1-octave and 1/3-octave band filter sets, acceptable microphone diameter (0.5-inch and 1-inch) and "wind screens." The Guide errs when recommending the use of a 1-inch diameter microphone since these are not generally suitable for measurements at frequencies above about 10,000 Hz and, as a result, cannot be used to obtain accurate sound levels within either of the 8000 Hz octave band or 10,000 Hz third-octave band. For a vibration meter, the information includes reference to both proportional-bandwidth and fixed-resolution measurement, fast Fourier transform (FFT), and calibration history that is "traceable" via a paper trail to the National Institute of Standards and Technology (NIST). There is a stipulation for accelerometer with mass at, "...1/10th the weight of the [HVAC] equipment to which it is being attached. . ." which could use further explanation. There is also a fixed-resolution requirement for having at least 400 frequency bins without a description of the ancillary frequency resolution, time-domain filter selection or resulting bandwidth.

Chapter 3: Preliminary Sound and Vibration Testing Procedures provides a description of methods and procedures for measurement that are to be applied in the absence of a predetermined requirement from the "contract documents". These descriptions cover the who, what, where, when, why and how of testing using a listing of questions that must be answered to achieve the Guide's vision for accurate and repeatable measurement data. Most of these questions are provided within answers by the Guide, but not all. For example, the Guide asks, "Are highest allowable vibration levels defined by [HVAC] equipment type?". An excellent question, and the Guide recommends allowable vibration levels at bearing caps elsewhere within the Guide, but does not generalize by [HVAC] equipment type.

Chapter 4: Sound Measurement Procedures discusses the positioning of testing instrumentation for

both “indoor and outdoor” sound measurements. The procedures for indoor testing include the operating conditions of HVAC equipment; positioning of microphones relative to floors, walls and ceilings; repetition of testing with HVAC equipment either on or off; doors and windows open or closed; and the problematic intrusion of background sounds for measurement. The importance of field “calibration” of testing instrumentation is also discussed, as a requirement over and above proper laboratory calibration. The Guide would benefit from citation to the ASHRAE Handbook where technical information is already presented, such as a method for considering background sounds when evaluating RC and NC, where, for example, the RC are known to require measurement data for the 16 Hz octave band and the curve-fitting procedures are discussed with exacting detail. The procedures for outdoor testing allude to “. . .local municipal, city, and county ordinances. . .” that are unique to each regulatory region, and considers a limitation on outdoor wind speeds of 20 to 25 mph (30 to 40 km/h). The discussion of wind speeds would be improved by citation of standards where allowable wind speeds (such as “calm” conditions) and acceptable wind speeds of ± 1 m/s are described.

Chapter 5: Vibration Inspection Procedures describes a series of inspection activities that are prudently completed before initiating any vibration testing. These inspection activities are of value to a contractor since excessive vibration at a source, such as a rotating fan, can also produce excessive sound and vibration within rooms. These inspection activities are to occur prior to vibration testing and could also prudently occur prior to sound testing. Many of the inspection activities that are described are generally accepted “commissioning” activities that include “testing and balancing” of rotating HVAC equipment. When making use of the Guide, many a sheet-metal contractor may want to emphasize, for their own purposes, that “approval” of the work by the “consultant” is not tantamount to “acceptance” of the work by the “owner” of a project.

Chapter 6: Vibration Measurement Procedures discusses the positioning of testing instrumentation for vibration measurement. The testing considerations that are discussed include the expected operating conditions for HVAC equipment, along with the positioning, use and abuse of accelerometers and the field calibration of vibration instrumentation. A vibration calibrator that works at a frequency of 159 Hz is often used. A single vibration-velocity limit of 0.2 in/s for each axis is presented by SMACNA as an acceptable upper limit for time-domain evaluations. For circumstances where the rotational speed is 900, 1800 or 3600 RPM, the fundamental frequency would be 15, 30 or 60 Hz,

respectively, along with harmonics of those frequencies that will differ for each type of HVAC equipment. For this reason, SMACNA could have recommended additional compliance testing using frequency-domain analysis that recognizes the potential for having vibrations propagating to rooms where components of both audible sound and perceptible vibrations can be problematic. The RC as promulgated by ASHRAE do recognize the importance of low frequency noise and vibration by making use of octave-band measurement data for noise at a low frequency of 16 Hz.

Chapter 7: Sound and Vibration Forms are an essential set of submittals that support the purposes of the Guide. The essential forms that are provided within the Guide include: (1) sound and vibration report with administrative content; (2) equipment broadband vibration levels; (3) instrument calibration report; (4) octave band sound measurements; (5) noise criteria curves and (6) vibration isolation inspection report. The forms represent a fairly comprehensive means of documenting sound and vibration conditions at a technical level, as is consistent with the requirements of the people and organizations that comprise the SMACNA membership.

Appendix A: Sound and Vibration Specification presents a conceptual format of a new specification section (§ 23 XX XX) that is based appropriately on the MasterFormat[®] classification scheme. The most-interesting subsections include “Quality Assurance” where a requirement is provided for the use of a Testing and Balancing Bureau (TABB) certified technician as a supplier of sound and vibration testing services. The “Products” subsection is left blank, and this could and should be modified to include the configuration requirements for instrumentation in their entirety. This would ensure that certain technical issues are properly and fully addressed, such as ensuring that the instrument is actually capable of measuring vibrations at frequencies where the HVAC equipment is known to produce them (e.g., 15 Hz). Similarly, a vibration-isolation base with springs will have a resonance at a relatively low frequency, such as 4 Hz, and it may be prudent to ensure that accurate measurement data are obtained for frequencies above and below that resonant frequency. The conceptual specification does not allow for this evaluation.

The concluding Glossary is segregated from the Guide as an “information only” section. There are definitions for thirty-two technical terms that are used within the Guide. Some of them are not comprehensive, for example, “Peak to Peak” is applied only to displacement, when it can be generalized for application to velocity and acceleration. So there are some items where improvement could be made. To further the objectives of making the Guide, there could be added

some more specific definitions for words that are contractually significant, such as could, should, shall, must and may.

The Guide addresses the target readership with a broad overview of the perils and pitfalls of sound and vibration testing for compliance. There is also an important assertion within the Guide that, “. . .there are some [sound and vibration] S&V problems that cannot be resolved after construction,” and concerns expressed about whether or not the measurement data are “admissible” as evidence during a litigation over problematic sound and vibration conditions. However, this reviewer cannot clearly endorse the methods and procedures of the Guide for the purposes of litigation. The information of the Guide represents a well-presented and broad-based starting point, but the reader must apply supplement professional expertise before sallying forth into the potential fracas of the legal system.

In conclusion, the existence of the Guide itself reflects well on the decades of effort made by organizations, such as ASHRAE and ANSI, whose work product includes performance criteria for evaluating sound and vibration conditions and the eventual standardization of those criteria. By creating this Guide, SMACNA is clearly acting in response to the ascending market value of those criteria when they are adopted within further laws, ordinances, regulations, and standards that could include indoor environmental quality (IEQ), LEED™ “Green Building Rating Systems” and sustainability initiatives for both of the design and construction industries.

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