3.4 American National Standards for noise emission measurements

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William Murphy is co-leader of the Hearing Loss Prevention Team in the NIOSH Division of Applied Research and Technology in Cincinnati. He provided a two-part summary on noise standards,[13] first discussing American National Standards Institute (ANSI) standards for sound power determination and then how to use sound power standards for product labeling.

The Structure of the American National Standards Program

The Acoustical Society of America manages the American National Standards Institute (ANSI) standards program for the following committees, S1 for Acoustics, S2 for Vibration, S3 for Bioacoustics and S12 for Noise. Susan Blaeser is the Manager of the ASA's standards efforts,[14] the Director for Standards is Paul Schomer. Rich Peppin is the chair of S1, Ali Herfat is the chair of S2 for Vibration standards, Chris Struck is the chair of S3 and William J. Murphy is chair of S12 for Noise. Under these committees, the United States has opportunities to participate in the International Organization for Standardization (ISO). The United States has one vote on international standards which requires more cooperation if important issues are going to be settled. The official representatives to the ISO Technical Committees are Walter Madigosky for TC 108, and Paul Schomer for TC 43 and TC 43 Subcommittee SC1. American National Standards for the determination of noise emissions of equipment are developed by S12. Descriptions of these standards may be found on the Internet.[15] Maling[16] has listed the international noise emission standards.

Standards for the Determination of Noise Emissions

When determining sound power, three different room designs are described in the standards: *anechoic* (meaning free from echo), *hemi-anechoic*, and *reverberant*.

A typical *anechoic* room is rectangular and has wedges on the six interior walls and a mesh trampoline to permit positioning the device being tested in the center of the volume of the room. In a *hemi-anechoic* room the floor is a reflective surface meant to simulate what might happen during outdoor measurements, in quiet without any reflections except for the ground. A *reverberant* room is designed to be highly reflective with non-parallel walls and diffusers on the walls to prevent the development of standing wave modes that are characteristic of rectangular rooms.

For measuring in the three types of rooms, several measurement methods exist. Perhaps the most common is the *pressure-over-area* method. In this configuration, a set of microphones sample the sound level at a prescribed distance from the source outside of the near field of the device under test (see Figure 3.4-1). The microphones are distributed over an imaginary surface that encompasses the device under test (DUT), and the pressure over a given area is used to determine that average power output of the DUT. The pressure over area method requires that

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[13] Please note that the opinions presented in this talk are his own and should not be interpreted as any official policy of the Centers for Disease Control and Prevention, the National Institute for Occupational Safety and Health or the US Environmental Protection Agency. Any products mentioned in this paper are not endorsed or promoted by NIOSH, CDC or EPA.

[14] The names in this paragraph were current at the time the workshop was held.

[15] http://acousticalsociety.org/standards/ansi/s12

[16] Maling, G.C. Jr., International standards for specifying noise emissions, *Sound&Vibration*, **47**(12), 13-16, December, 2013.

the noise be coming from the source and that there not be other sources which are acting as sources outside the imaginary volume.

For instance ANSI S12.55 is used to measure sound power in fully anechoic spaces and in hemi-anechoic spaces. ANSI S12.54 and S12.56 are used in hemi-anechoic environments, and ANSI S12.51 and S12.53 are used to determine sound power in reverberant environments. The different standards reflect varying degrees of precision involved in conducting the measurements. The NIOSH sound power laboratories in Pittsburgh and Cincinnati conduct measurements at the Engineering grade, ±2 dB. To achieve Precision grade, ±1 dB, requires greater control of temperature and humidity.

Figure 3.4-1 *An IBM server surrounded by microphones at the IBM Acoustics Laboratory, Poughkeepsie, New York.*

In the *substitution,* or *comparison, method,* a calibrated reference sound source is tested in the space to establish the room constant and understand how the sound might be absorbed by the space. The substitution or comparison method can be conducted in just about any space, the most satisfactory being a *reverberation room.* The sound absorptive characteristics of the space affects the sustained sound pressure level of the reference sound source when it produces a continuous noise in the room.

The sound source is tested in the room with the other equipment turned off. The device of interest is turned on and the sound source is turned off. The sustained level in the room while the device under test (DUT) is running is a function of the sound power of the DUT and the room constant. By measuring the room constant with a known source, the sound power can be determined.

More sound absorption equates to less build up of sound energy in the space. Once the reference sound source has been measured, the microphones are kept in the same position and the DUT is operated and assessed. From the two measurements, the sound power of the DUT can be determined. When a product is purchased that has a Noise Declaration provided, the validity of that declaration can be tested after the product has been installed.

Finally, the *sound intensity method* is best suited for *in situ* sound power measurement because it can be performed in any environment. It relies upon making measurements over a measurement surface enclosing the DUT with a pair of phase- and amplitude-matched microphones. The sound intensity is determined as the product of the average pressure of the point between the microphones and the derived particle velocity estimated by the difference between the microphones.

Why Measure Sound Power?

There are several reasons for measuring sound power. Sound power is an inherent property of the device under test. The sound pressure is affected by the room acoustics—the absorptive effects of the ceiling tiles, the panels on the wall, the number of people in the room, and the location of the listener relative to the device under test. That's the difference between sound pressure and sound power.

With sound power, it is possible to develop acoustic models that can be used to predict the noise levels in various environments. Using the geometry of the room, the sound power of various sources, the absorption coefficients of the surfaces in the room, accurate models[17] can be developed to predict the distributions of sound in the room.

Sound pressure, on the other hand, does not permit modeling in a generalized manner. Sound power is an inherent quantity of the source, precisely the quantity that should be used when attempting to provide informative labeling for noise emissions.

In summary:

- Sound power is an inherent property of the source
- It can be used to develop acoustic models of noise distributions and noise exposures
- Sound pressure levels depend on:
  - Room acoustics
  - Receiver distance from the source
  - Receiver orientation to the source
- Sound power is the appropriate metric for labeling

How Might Noise Emission Labels Be Implemented?

Matt Nobile from the IBM Hudson Valley Acoustics Laboratory in Poughkeepsie, New York has been working on developing labeling standards for products. In a presentation at the National Institute for Occupational Safety and Health in November 2011, Nobile presented some concepts that could lead to standardized declarations for a variety of products (Figure 3.4-2).

On the left of Figure 3.4-2 is the *comparative declaration label*. The unit associated with the product noise rating (PNR) is the decibel, but the unit is notably absent. In a way, this is a concession to the lack of the public's understanding of decibels and their meaning. PNR is the product noise rating (its scale ranges from 0 to 120). The Red Arrow in the Figure 3.4-2 example identifies the product noise rating, 90 in this case. The blue bar on the scale indicates how this product compares to a range of similar products. Along the left of the image are icons of speakers indicating soft, low-level sounds ranging to loud high-level sounds. On the right in the box is a numerical expression of the range of other similar products. In this case, the range is 88 to 109, indicating that this product, at 90 dB, is near the bottom of the range of similar products.

[17] See the paper by W. Probst elsewhere in this report.

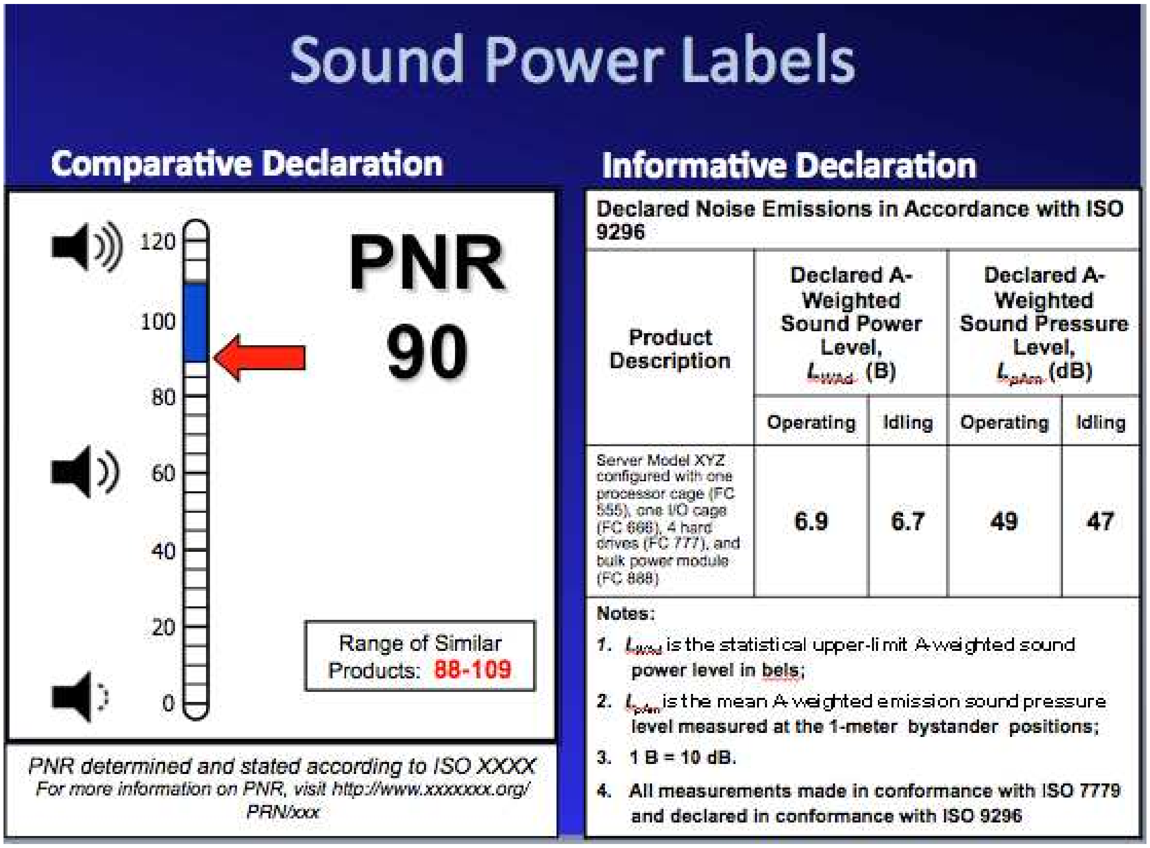

Figure 3.4-2 Noise emission labels.

On the right of Figure 3.4-2 is an *informative declaration label*, which gives the numerical performance of the product according to a specific international standard (ISO 9296). The numbers on the left half are sound power in bels[18] (1 bel = 10 decibels) for the product when it is operating and when it is idling. The numbers on the right half are the sound pressure level when the product is operating and when it is idling. For assessing the risk of noise-induced hearing loss, an industrial hygienist will need to know the level at the ear where a worker might be positioned. Additional information could be included with the informative declaration. That is, the sound power spectrum could be included in secondary information. The spectrum is critical to determining risks. Sound with content in the 2000 to 6000 Hz range can present an increased risk compared to that at lower frequencies.

Labeling can help consumers make purchasing decisions. Figure 3.4-3 shows sound power levels for a common household appliance, a dishwasher, plotted against the manufacturer's suggested retail price. It demonstrates that quiet can be a marketing tool to sell products. If you want a dishwasher that is 40 dB(A), you will pay upwards of $1,600. Louder machines will cost less. Consumers can understand a noise rating. They can understand that quieter equipment will not impair their ability to interact with others or to have a conversation.

[18] The unit *bel* has been introduced internationally as the unit of sound power level to distinguish it from sound pressure level for which the unit is the decibel. The bel has not been widely accepted, especially in the USA, and the decibel (with A-frequency weighting) is commonly used as the unit of both sound power level and sound pressure level. Thus, the quantity being specified (sound pressure or sound power) must be indicated in the text.

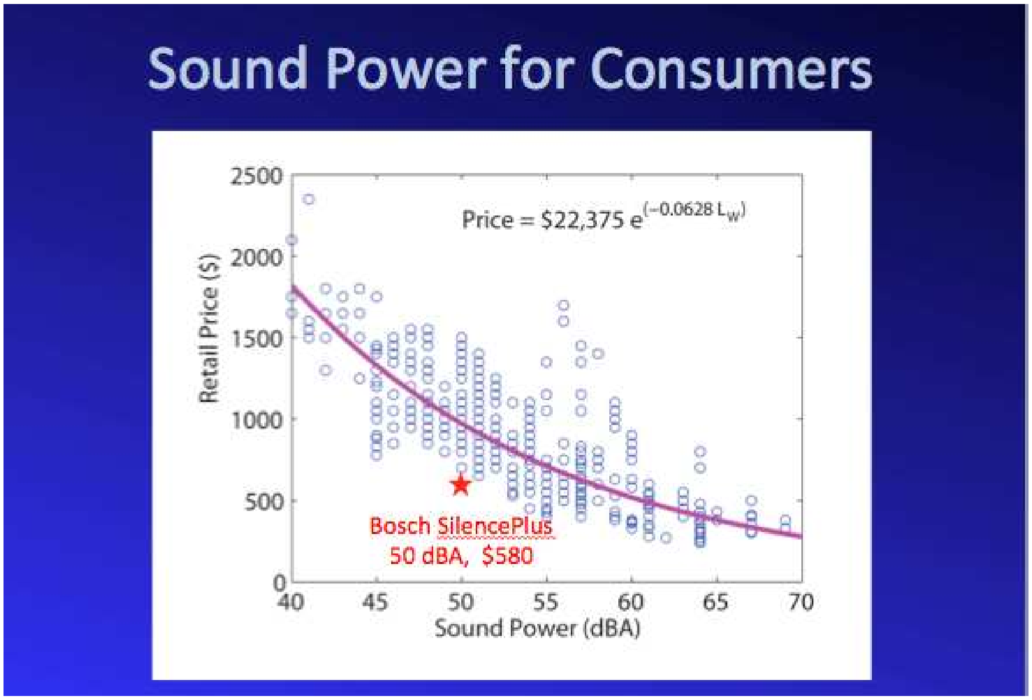

Figure 3.4-3 *As sound power goes down, price goes up.*

Murphy ended with a call to action. The public doesn't need a lot of education to interpret the numbers on the labels discussed in this paper. The labeling just needs to be put in place. In the United States, table saws don't necessarily come with noise ratings, but they could.

If we are going to reduce noise in the manufacturing environment, companies need to be aware that the product noise rating is a method through which noise emissions of competitive products can be compared. A manufacturer can publish noise emission declarations. With noise emission data measured according to national or international standards, consumers can verify that equipment is operating within its declared boundaries. Standards for the determination of sound power are available. What is needed is a widely accepted method for labeling the noise emissions of products.

Reducing Employee Noise Exposure in Manufacturing

Best Practices, Innovative Techniques, and the Workplace of the Future

a workshop sponsored by

The INCE Foundation, the Noise Control Foundation, and the National Institute for Occupational Safety and Health

organized by

The INCE Foundation and the National Institute for Occupational Safety and Health

hosted by

The National Academy of Engineering, Washington, DC

Cori Vanchieri, Rapporteur

edited by

George C. Maling, Jr., Eric W. Wood, Gregory Lotz, and William W. Lang

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This report has been approved by the Board of Directors of INCE/USA for publication as a public information document. The content, opinions, findings, conclusions, and recommendations expressed in the report do not purport to present the views of INCE/USA, its members, or its staff.

Generous support for this project was provided by the International Institute of Noise Control Engineering, the INCE Foundation, and the Noise Control Foundation

ISBN: 978-0-9899431-2-3

Library of Congress Control Number: 2014945796

Printed in the United States of America

This report is posted on the INCE/USA website, http://www.inceusa.org