Acoustical Engineering Report

McGill AirSilence LLC
An enterprise of United McGill Corporation — Founded in 1951

Authored and Published by United McGill Corporation's Engineering Department

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Sound Power and Sound Power Level

Introduction

Previous engineering reports (AER Numbers 1 and 2) introduced the concepts of sound pressure level and frequency. Properly understood and applied, these two properties can often be used to provide solutions to many types of noise problems.

When a noise problem can be traced to an identifiable noise source, an accurate set of sound pressure level measurements may serve as a valuable guide in arriving at a proper solution to the problem. However, it should be kept in mind that these sound *pressure* level measurements have significance only at the locations where they are taken. These measurements have limited use in predicting the acoustical conditions that the same noise source may produce at other locations or in different situations.

The effect that a sound may have on the surrounding environment is dependent on many variables, some of which are:

1) the acoustical characteristics of the sound source
2) the path that the sound must travel to reach a receiver
3) the characteristics of the area surrounding the sound source
4) the characteristics of the area surrounding the receiver
5) the effects of other ambient sound levels

Examples of these variations abound in everyday life. A good example that most people are familiar with is their home stereo system. Low frequency loudspeakers have the tendency to radiate sound equally in all directions while high frequency loudspeakers have highly directional acoustic radiation characteristics. The sound source location may drastically alter the end results. Properly locating loudspeakers within a room is an important factor in guaranteeing a quality sound. Placements near walls, corners, and floors may enhance or defeat the expected quality of a sound system.

The *path* that sound travels from the source to the receiver is also important. Is the path direct or is what you hear mostly reflected sound? Does the path contain sound-reflective or sound-absorbent furniture, carpet, ceilings, and walls? How far away is the source from the receiver? All of these factors may change the "received" sound from the originally "radiated" sound.

Sound Power

Sound is a series of air pressure waves radiating outward from a noise source. Sound does not create itself—something must generate the pressure waves, be it a loudspeaker, rotating body, or some other device. The pressure waves are a result of *acoustical energy transfer* from the sound source to the surrounding ambient air. The actual amount of radiated acoustical energy, expressed in terms of *watts* of power, is referred to as the *sound power* of the sound source.

The goal in all acoustical designs is to provide specific sound pressure levels at specific locations. To achieve these design sound pressure levels, the designer must analyze the surroundings of all receivers, analyze the characteristics and effects of all sound paths to the receivers, and *must have an accurate analysis of the acoustical characteristics of the sound source.*

The standard method of characterizing a sound source in a singular and reproducible manner is by determining the *sound power* of that source. Using sound power data, one can analyze the effects of environments and paths and predict sound pressure levels at various locations. Should the predicted sound pressure levels at the receivers be different than required, sound-absorbent (and occasionally sound-generating) treatments can be introduced to achieve the design goals.

Sound Power Level

An extremely wide range of radiated sound power is encountered in every-day life. This range extends from as little as 0.00000000001 (10^{-11}) watts or lower up to 100,000,000 (10^{8}) watts. Due to the extremely wide range of power values (a ratio of 10,000,000,000,000,000,000 : 1, or 10^{19}:1), sound sources are not usually rated in terms of watts, since the numbers become so cumbersome.

In lieu of linear or exponential presentation, sound power data is typically presented as a *sound power level*.

Table 1 presents typical sound power levels of representative sound sources and corresponding sound powers in both linear and exponential forms.

Just as in the conversion of sound pressure to sound pressure levels, the conversion of sound power to sound power levels requires logarithmic mathematics. The resultant sound power levels are simple two- or three-digit numbers which are rounded to whole numbers and expressed in terms of *decibels (dB)*.

Sound power level is defined in **Equation 1**.

Table 1 Approximate Sound Powers and Sound Power Levels of Representative Sound Sources

Sound Power Level dB re: 10^{-12} Watts	Source	Sound Power: Exponential Watts	Sound Power: Linear Watts
10	Human Breath	10^{-11}	0.00000000001
20	Rustling Leaves	10^{-10}	0.0000000001
30	Voice in a Soft Whisper	10^{-9}	0.000000001
40	Small Electric Clock	10^{-8}	0.00000001
50	Office Air Diffuser	10^{-7}	0.0000001
60	Electronic Equip. Ventilation Fan	10^{-6}	0.000001
70	Voice at Conversational Level	10^{-5}	0.00001
80	Garbage Disposal Unit	10^{-4}	0.0001
90	Voice Shouting	10^{-3}	0.001
100	Automobile at Highway Speed	10^{-2}	0.01
110	Blaring Radio	10^{-1}	0.1
120	Small Aircraft Engine	10^{0}	1
130	Large Pipe Organ	10^{1}	10
140	Four-Propeller Aircraft at Takeoff	10^{2}	100
150	Turboprop Aircraft at Takeoff	10^{3}	1,000
160	Four-Engine Jet Aircraft at Takeoff	10^{4}	10,000

Equation 1

$$\text{Sound Power Level} = Lw = 10 \log_{10} \left[\frac{W}{W_{ref}} \right] \text{ dB re: } (W_{ref})$$

Where:

Lw = Sound power level in dB (Note: Many texts will abbreviate this as SWL or PWL)

W = Sound power of the source in watts

W_{ref} = A standard reference sound power of 10^{-12} watts

It should be noted that the *present* standard reference sound power is 10^{-12} watts. American standards organizations became members of the International Standards Organization (ISO) in 1963, and this reference sound power has been in effect as the standard in the United States since that date. Sound power level data that was generated before 1963 in the United States was typically referenced to a standard sound power level of 10^{-13} watts. It is not recommended that sound power level data that was generated using the 10^{-13} watts reference base be used in acoustical designs.

Since sound pressure levels and sound power levels are both expressed in decibels but refer to two totally different acoustical properties, it is recommended that these two properties *always* be followed by the proper reference sound pressure or sound power.

Sound power level data can be broken into octave band frequency components. Information about source sound power levels should always be requested/provided as an octave band sound power level analysis.

Example: A sound source is radiating 0.15 watts of sound power into the surrounding environment. What is the sound power level of this source?

Using Equation 1:

$$Lw = 10 \log_{10} \left[\frac{0.15 \text{ watts}}{10^{-12} \text{ watts}} \right] \text{dB}$$

$$= 10 \log_{10} (150{,}000{,}000{,}000) \text{ dB}$$

$$= 10\,(11.176) \text{ dB}$$

$$= 111.76 \text{ dB}$$

$$Lw = 112 \text{ dB } re\text{: } 10^{-12} \text{ watts}$$

Note that the decimal value of the sound power level in the example has been rounded off to the nearest integer. There is no significance in carrying the fractional value of the dB after the final calculation has been made.

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Form No.: MASIL-AER#3 Rev. 3 6/05