B&W UNIVERSAL

INDUSTRIAL NOISE SERIES

PART VI: FUNDAMENTALS OF NOISE CONTROL

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June 10, 2013

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NOISE PATH MODELING

Noise control or mitigation involves several steps and the amount of noise reduction is driven by having to meet some regulatory limit. The following figure illustrates the classical approach to noise control and by developing this simple model the options for effectively and economically reducing noise may be examined.

Source of Noise ⟶ **Path of Noise** ⟶ **Received Noise**

Figure 1 - Classic Noise Control Modeling Method

Applying noise control involves affecting one of these three elements and most often it is the "*Path of Noise*" that is controlled by use of acoustical enclosures, barrier walls, duct silencers, and other similar noise control treatments that are installed near the source to effectively reduce the sound level. This method is the most widely used as the degree of noise control can be varied depending upon the noise requirements. Reducing the noise at the *Source of Noise* can be expensive because most equipment manufacturers assemble their products using commodity parts that are economically produced for the industrial market and reducing noise at the source may require a complete redesign and retooling process which takes time and money.

This model can be further demonstrated by the following traditional equation used for calculating the sound level at a receptor (received noise).

$$L_p = L_W + 10 Log\left(\frac{Q}{4\pi r^2}\right) - \sum A_i \qquad \text{dB re: } 20\mu\text{Pa} \qquad (1)$$

Where L_p is the received sound level, L_W is the source of noise and the remaining terms describe the path of the sound energy. Refer to Part IV for a description of Equation (1). Again, this equation is applied for each frequency band and the overall sound level determined from all the bands. Remember, the acoustical characteristics in each frequency band is unique thus all the frequency bands must be considered when determining noise control needs; refer to Part I.

Frequently, more silencing is needed than what can be described as the bare minimum in order to account for noise from other equipment or sources that all combine to create a total sound level; thus, a ***balance of plant*** or *total noise* analysis must be performed to adequately account for all possible sources of noise, including those ***out-of-scope***. The reduction of significant sources of noise frequently results in what were once obscure sources of noise now becoming important when having to meet a low noise requirement. Grouping smaller sources together can be beneficial such that a common noise barrier or enclosure can solve a lot of small problems.

NOISE REDUCTION AND CRITERIA

Noise control and the principles of acoustical engineering apply universally to virtually every type of facility; the approach is the same: identify the need, evaluate mitigation options and specify the mitigation selected. The amount of noise reduction is driven by meeting a regulatory limit, either established by a governmental body or by the developer/owner of the property.

For instance, say the sound level at a receptor 100 meters away from the noise source cannot be in excess of 55 decibels (dB). Applying the standard model for outdoor sound propagation and for simplicity, assume only the ground plane is present and $\sum A_i$ is zero, the allowable sound power level (note the algebra) is determined by

$$L_p = L_W + 10Log\left(\frac{Q}{4\pi r^2}\right) - \sum A_i \quad \text{dB re: } 20\mu\text{Pa} \qquad (2a)$$

$$L_W = 55 - 10Log\left(\frac{2}{4\pi 100^2}\right) \quad \text{dB re: one pico-Watt} \qquad (2b)$$

$$L_W = 103 \quad \text{dB re: one pico-watt} \qquad (2c)$$

If the source of noise is an exhaust that has a sound power level of 140 dB, then the amount of noise reduction needed is 37 dB and adding 3 dB for safety margin results in 40 dB reduction being needed. This is a simple illustration of the process. If there was an octave band criterion, then this calculation would be performed for each frequency band of interest and the necessary noise reduction for each frequency band determined.

Now, in examining the above equations we can identify at least two variables that affect uncertainty in calculating the sound level, the accuracy of the sound power level and we are assuming perfect hemispherical divergence. Thus, the reason why a little design margin is desired, especially in critical applications. Sophisticated computer models can help refine the calculation process but are still dependent upon the accuracy of the sound power level of the noise source, the distribution of sound energy across each bandwidth, discrete frequency tones versus broadband noise and the corresponding performance of noise control devices that typically consist of silencers, noise barriers, enclosures, etc.

SOUND FROM OPENINGS

Sound radiation from openings includes any type of openings allowing equipment noise to directly enter the environment by what is commonly called, the *gas path*; the sound level is reduced by installing silencers in the gas path (ducting). See the above example.

SOUND FROM STRUCTURES

Sound radiation from structures is important for two main reasons; meeting a near field or far field sound limit. The near field is typically three feet or one meter from the surface and can be problematic in calculating because the sound field is not well developed and traditional spreading loss does not work.

Instead of a 6 dB reduction for a doubling of distance, it is more like a two or three decibels reductions per doubling of distance until free field conditions are obtained.

The sound emitted from the structure is based on the sound power level (L_{Wi}) that is inside the wall or duct that generates a sound pressure level. In the case of aerodynamic sources (behaving as a plane wave), the sound pressure level inside a duct, pipe or similar defining containment area (S) in square meters is,

$$L_{pi} = L_{W\,i} - 10Log\left(S\right) \quad \text{dB re: } 20\mu\text{Pa} \qquad (3)$$

The sound pressure inside ducts is required in order to determine the necessary transmission loss (TL) of the duct wall in order to meet any near field sound level requirements or to reduce the breakout noise so as not to become a contributor to the far field sound level.

The sound level outside the wall or duct is based on its noise reduction (*NR*) which is the difference in sound pressure levels across the wall and is a function of the wall's transmission loss (TL). The **near-field sound level** outside the wall (L_{po}) is calculated based on the *NR* of the wall, not the TL,

$$L_{po} = L_{pi} - NR \quad \text{dB re: } 20\mu\text{Pa} \qquad (4)$$

The *NR* is the noise reduction of the wall and accounts for the acoustical boundary conditions on the receiver side as explained in Part V.

The sound power that is radiated by the structure (L_{Wo}) into the environment is based on the near field sound level (L_{po}) and the surface area (A) in square meters as calculated by,

$$L_{Wo} = L_{po} + 10Log\left(A\right) \quad \text{dB re: one pico-Watt} \qquad (5)$$

The sound level at some point as caused by the structure is calculated by importing L_{Wo} into Equation (1). Directivity parameters may become a factor depending on where the far field receiver is located relative to the walls or if there is a barrier of some type.

Substituting the various expressions above into Equation (5) results in,

$$L_{Wo} = L_{W\,i} - NR + 10Log\left(\frac{A}{S}\right) \quad \text{dB re: one pico-Watt} \qquad (6)$$

What is shown is the relationship between the duct surface area (*A*) and inside cross sectional area (*S*). A reduction in L_{Wo} is realized when $S > A$, but this is very rare.

TRANSMISSION LOSS

The transmission loss (TL) of walls (including duct walls) cannot be simply calculated. There is no closed formed equation that adequately models all the variables involved in the wall design, tolerances, and construction variances that affect the transmission loss. The spacing of stiffeners, weld spacing and variability, torsion of panels, the wall thickness and packing density of insulation and the field erection are all too complicated to simply calculate or model. There are fundamental calculations of wall TL for homogeneous (infinite) plates based on mass law that result in higher TL values than what is ordinarily obtained and you cannot simply add TL values together in complex wall assemblies.

NOISE MITIGATION

The preceding sections presented fundamental methods for modeling and determining the necessary noise reduction to meet a criterion. The particular noise reduction is of course tailored to the particular source of noise and how that noise enters the environment or the space in question. The vast span of applications makes any detailed treatment formidable to convey, but there are many excellent noise control texts available.

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