B&W UNIVERSAL

INDUSTRIAL NOISE SERIES

PART V: ROOM ACOUSTICS AND NOISE CONTROL

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INTRODUCTION

Room acoustics describes the acoustics of an interior space and the transmission of noise from one space into another space and may include the noise that breaks out into the environment through the walls, windows, vents and roof. In most industrial applications, the concern is the breakout noise into the environment affecting the nearby community. In some cases, it is the interior sound level that is important in order to limit the occupant's noise exposure or to ensure the sound level is low enough to allow ease of communications, especially in critical applications such as in control rooms. These industrial spaces are generally large enough to allow propagation of acoustic energy within the space. Small fitting enclosures over equipment are a special case and room acoustics is not an accurate method for analyzing those cases. The following sections are intended to present the basic concepts of room acoustics.

ROOM ACOUSTICS

The sound level (L_p) in any part of a room is calculated using the following general form.

$$L_p = L_W + 10Log\left(\frac{Q}{4\pi r^2} + \frac{4}{R}\right)$$

dB re: 20mPa (1a-meters)

L_W is the sound power level (PWL, dB) of the source of noise, the term, *R* describes the acoustical properties of the room or space, and under free field conditions (sound can freely propagate) the *4/R* term goes to zero. The small *r* is the distance from the source of noise to where the sound level is to be calculated. *Q* accounts for the reflective planes that bound the source of noise and for general modeling has the following values,

Q	Boundary Conditions
1	Noise source freely radiating in all directions
2	Noise source with a single reflective plane (floor)
4	Noise source on the floor or near a ceiling and near a vertical wall
8	Noise source in the corner of a room; three surfaces: two walls and either the floor or ceiling as the third surface

If using feet, the form of the equation (1a) becomes,

$$L_p = L_W + 10Log\left(\frac{Q}{4\pi r^2} + \frac{4}{R}\right) + 10.3$$

dB re: 20mPa (1b-feet)

Frequently, the 10.3 is rounded off to 10 as it is just not possible to achieve this level of accuracy.

MATERIAL SOUND ABSORPTION

The room constant term *R*, is a bit complicated to calculate but is determined by the combined sound absorption properties of all the interior surfaces of the room. In an industrial application this would also include the surface area of all the equipment. The room constant has the form of,

$$R = \frac{\bar{\alpha} \cdot S}{1 - \bar{\alpha}} \quad \text{m}^2 \text{ or ft}^2 \qquad (2)$$

Where *S* is the total interior surface area and $\bar{\alpha}$ is the room averaged absorption coefficient. This calculation process is done for each octave or one-third octave band frequency and the resulting sound level determined as shown in Equation (1).

The sound absorption (α) of a surface is frequency dependent, it has very low values at low frequencies and very high values at high frequencies. When evaluating the effectiveness of materials the following equation may be employed but the result also depends on the surface area coverage.

$$NR = 10 Log\left(\frac{\alpha_2}{\alpha_1}\right) \quad \text{dB} \qquad (3)$$

Where NR is the change in noise reduction is going from material (α_1) to material (α_2). The coefficients range from near zero (low frequency) absorption to a maximum value of 1.0 or slightly higher (high frequency) absorption. Absorption coefficients greater than one are the result of the measurement standard allowing multiple reflections in the test chamber.

NOISE CONTROL

The noise that breaks out of a building is principally determined by its interior sound level, and the amount of the sound transmitted through the walls and roof. The sound level impinging upon the interior room surfaces is what is transmitted into the walls and roof. The sound that escapes into the environment is called breakout noise. The sound energy can travel through walls, ceilings, roof deck, roof vents, windows, doors, and louvers, to name a few features, that all have very different acoustical properties. In order to meet environmental noise limits, these features must provide some level of noise reduction. The noise reduction of standard, commercial-industrial products may be adequate but in some cases special acoustical products must be used.

The noise reduction (NR) of a wall or feature is a measure of the difference in sound pressure levels across the wall and is a function of its transmission loss (TL). The sound level outside the wall (L_{po}) is calculated based on the inside sound level (L_{pi}) and the NR of the wall as shown in the following equation.

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

The noise reduction of the wall accounts for the conditions that affect the sound level, L_{po}. The *NR* of the wall is determined by,

$$NR = TL - 10Log\left(\frac{1}{4} + \frac{S_w}{R_2}\right) \text{ dB} \quad (5)$$

Where *TL* is the transmission loss of the wall, S_w is the wall area between the two rooms and R_2 is the room constant in the receiving room, where L_{po} is calculated per Equation (4).

Under free field conditions R_2 becomes very large causing the term, S_w/R_2 to become zero. So then the NR for exterior walls and roofs becomes,

$$NR = TL + 6 \text{ dB} \quad (6)$$

The TL of a wall or feature is measured in special test rooms at acoustical laboratories and measured in accordance with national or international standards. Unfortunately, the TL of walls is seldom measured below the 125 Hz band because low frequencies have very large wavelengths creating the need for very large test facilities and special measurement techniques. Low frequency TLs are frequently estimated from field measurements. Many common commercial and residential building walls and products have their TL cataloged for ease of performing these calculations. However, because industrial applications are generally so specialized for noise control, cataloged or published TL data is rare and special testing must be performed. Because the testing is very expensive the data is held proprietary and not made available or published.

TL STANDARDS

ASTM E 90-(year), *Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements*.

ISO 140-1: (year), *Acoustics -- Measurement of Sound Insulation in Buildings and of Building Elements*. This is a guide for selecting the appropriate ISO 140- series for performing various measurements including field measurements.

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