Reverberant Room Sound Pressure Level from Sound Power Point Source

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Statistical Energy Analysis approach.

Assume a point source radiating uniformly into a diffuse, reverberant field.

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| $\langle E \rangle$ | Acoustical energy |
| $V$ | Volume |
| $\langle p^2 \rangle$ | Spatial average of the mean square pressure |
| $\rho$ | Gas density |
| $c$ | Gas speed of sound |
| $\Pi_{in}$ | Input power |
| $\eta$ | Loss factor |
| $\omega$ | Angular frequency |
| $f$ | Frequency |
| $T_R$ | Reverberation Time (60 dB decrease) |

The energy equation is taken from Reference 1, equation (5.35).

$$\langle E \rangle = \frac{V}{\rho c^2} \langle p^2 \rangle \tag{1}$$

$$\langle p^2 \rangle = \frac{\rho c^2}{V} \langle E \rangle \tag{2}$$

The power is calculated from energy per Reference 1, equation (5.36) with the interior surface absorption coefficient set to zero for conservatism.

$$\Pi_{in} = \eta \omega \langle E \rangle \tag{3}$$

$$\langle E \rangle = \frac{1}{\eta \omega} \Pi_{in} \tag{4}$$

By substitution,

$$\langle p^2 \rangle = \frac{\rho c^2}{\eta \omega\ V}\ \Pi_{in} \tag{5}$$

$$\langle p^2 \rangle = \frac{\rho c^2}{2\pi f\ \eta\ V}\ \Pi_{in} \tag{6}$$

The loss factor is related to reverberation time via Reference 2.

$$\eta = \frac{2.2}{f\ T_R} \tag{7}$$

By substitution,

$$\langle p^2 \rangle = \frac{\rho c^2\ f\ T_R}{(2.2) 2\ \pi\ f\ V}\ \Pi_{in} \tag{8}$$

$$\langle p^2 \rangle = \frac{\rho c^2\ T_R}{4.4\ \pi\ V}\ \Pi_{in} \tag{9}$$

Orbital Reef Requirement: The system will provide a reverberation time in the habitable volume of less than 0.6 second within the 500 Hz, 1 kHz, and 2 kHz octave bands.

So assume $T_R$ = 0.6 sec for all bands.


References

1. R. Lyon, Machinery Noise and Diagnostics, Butterworth-Heinemann, Boston, MA, 1987. (Section 5.8)
2. J. Wijker, Random Vibrations in Spacecraft Structure Design, Springer, New York, 2009. Equations (4.117) through (4.122) and page 272.