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Sheet Lead Insulation in Recording Studios

Consideration of lead sheets for noise insulation includes a hard look at extra cost as well as the efficiency of the material.

IN DISCUSSIONS concerning the sound proofing of a partition between two adjacent rock recording studios intended to be employed for simultaneous recording sessions, the use of sheet lead is almost always mentioned. It seems to carry a magic connotation, as if the material had sound insulating qualities far above the more common building products, assuring excellence in sound insulation. It is the purpose of the following to examine the advantages and disadvantages of sheet lead for the sound attenuation of barriers.

ACOUSTIC MASS LAW

To break the "spell" of lead immediately, it may be said that at 500 hertz it is no better than any other product of equal surface density, that is, mass per square foot. This may be quantitively conveyed by stating the *acoustic mass law:*

$$^{TL}500 = 23 + 14.5 \log M$$
$$= 13 + 14.5 \log M^1$$

where $^{TL}500$ = sound transmission loss of a homogenous barrier

M = surface density of barrier, lbs./sq. ft.

M^1 = surface density of barrier, kg.m^2

The above equation pertains to random sound incidence, and was derived empirically. It agrees well with theory, except for the fact that it does not quite provide an increase of 6 dB for double the surface density, but one of only 4.5 dB. Except for the low- and high-frequency resonances associated with such panels, the sound transmission loss between these resonances increases 6 decibels per octave above 500 hertz and decreases a similar amount per octave below 500 hertz.

One advantage of lead lies in the fact that its coincidence frequency is higher than that of any other building material with the same surface density. This latter condition of equal mass per unit area must always be considered in such comparison evaluations, because, as shown above, near 500 hertz. materials of equal surface density offer the same amount of sound attenuation. Wave coincidence occurs when the wavelength of the bending wave in the panel equals that of the incident sound in air; this causes the amplitude of the transmitted signal on the far side of the barrier to be almost equal to that on the source side. The frequency at which wave coincidence occurs in a simple partition is given by

$$f_c = \frac{2x10^6}{d}\sqrt{\frac{D}{E}}$$

where D = density of panel material, kg/m^3

E = modulus of elasticity, kg/m^2

d = thickness of panel, cm

PANEL THICKNESS

The table below gives the panel thickness in both centimeters and inches of various building materials which have the equal surface density of 48.82 kg/m^2 (10 lbs./sq. ft.).

Material	cm^d	inch	D/E	f_c (Hz)
Lead	0.431	0.17	6.65x10^{-6}	12,000
Plywood	3.180	1.25	0.5x10^{-6}	422
Concrete	2.12	0.833	1.04x10^{-6}	1000

The surface density of 10 lbs./sq. ft. in the above table was chosen because it conforms well with the surface density of *one* wall of a double-stud partition separated several inches from the other, as is often the construction of a partition between two recording studios.

FIGURE 1 shows the sound transmission loss characteristics of the three materials listed in the above table when they have the same surface density. It is seen that the 0.431 cm (0.17 in.) thick sheet lead is really a far better sound insulator above 5,000 hertz than required. The TL at this frequency for *one* stud wall is 57.5 dB, whereas at 125 hertz it is only 27 dB, the same as it is at the other materials. But it is exactly at the low frequencies where most recording studios' partitions are insulation-deficient, since the sound pressure levels of low musical notes is generally much greater than in those of the treble range.

The high coincidence frequency on the part of lead exists for all thicknesses of sheets as long as they are compared with other building materials having equal surface density. It is only by going to thicker sheets of lead (thicker than the 0.17 in. considered in the table) that this frequency can be lowered. Thus, by employing a 0.34 in. thick lead panel, weighing 20 lbs./sq. ft. the frequency can be halved to 6,000 hertz. Obviously by employing a sheet of lead thinner than 0.17 in., the frequency will be raised, as is evident from the equation for the coincidence frequency.

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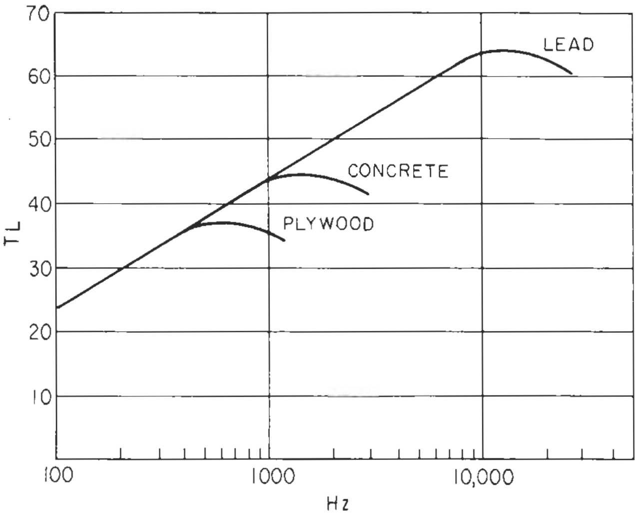

Figure 1. Sound transmission loss characteristics of plywood, concrete, and lead.

One advantage of lead is that it can readily take curvilinear shapes, because it is so soft, unlike plasterboard and plywood.

One decided disadvantage of lead is its cost when compared to other materials of equal surface density. Thus, presently, (1976), the price of sheet lead is 40¢/lb. Since ½ in. plasterboard, weighing 2 lbs./sq. ft. costs 8¢/sq. ft., it is seen that lead sheets comparable in sound insulation to plasterboard cost ten times as much.

PARTITION THINNESS

To overcome the structural weakness of sheet lead, and to take advantage of its high surface density to achieve a thin partition when the resulting increased floor space provides a return on the money, the material is advantageously employed in laminate form, whereby it is sandwiched between two sheets of plasterboard, plywood, Transite, etc.

We see, therefore, that the chief advantage of sheet lead in recording studios lies in the relative thinness of the partition required to achieve a desired sound transmission loss over most of the common audio frequency range, compared to other building materials of equal surface density. Its chief disadvantage lies in the high material cost per pound, compared to that of other building products of equal weight. This disadvantage can only be compensated for by the extra floor space resulting from the thinner partition—actually by the greater monetary return gained from the extra floor space. In the case of a 30 ft. long partition between two recording studios, where the sheet lead partition results in a 4 in. thinner partition (2 in. thinner measured from the center line of the partition) the extra floor space in each studio comes to 30x2/12 = 5 square feet, representing possibly the floor space for one additional instrument in each studio.

Assume now that the above partition is 20 ft. high and is to have a surface density of 20 lbs./sq.ft. With sheet lead priced at 40¢/lb., the lead partition material will cost 30x20x20x.4 = $4,800, compared to the cost of an equally heavy plasterboard partition of $960. Will the extra 10 square feet of floor area gained by the thinner lead partition return $4,800 − $960 = $3,840 within a few years?

The decision whether or not to use lead must incorporate the cost return on the gained space as well as lead's noise insulation capacity in relation to cheaper, but bulkier materials. ■