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SOME EXPERIENCES WITH LEAD IN SOUND BARRIERS*

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My experience in this field has been comparatively short and to date a lot of it has been rather frustrating but if I didn't believe there were bright spots on the horizon, I wouldn't be here. I hasten to add, however, that under no circumstances do I wish to pose as an expert in the field. Accordingly, you may regard this talk as a bit of whistling in the dark to keep my courage up, but my objective is really to plant a pine cone in the industry's cushion of complacency in its chair of product development.

Our industry has invested a fair amount of money in probing the acoustical field and the inescapable conclusion I draw from this work is that lead must be designed or engineered for the job or it will not sell. If this is done with a careful control of costs, I am confident that a substantial market for lead can be developed.

This discussion is concerned with barriers to shut out or reduce the transmission of airborne sound. Collateral problems not covered here involve the reduction of impact or structural borne noise and the absorption of sound within a room by reducing the reflection of sound waves through the use of porous acoustical materials.

The capacity of a barrier to block sound is expressed in decibels and is known as its transmission loss or TL. The figure as commonly stated represents the arithmetical average of the sound reduction in decibels at each of nine specific frequencies from 125 to 4000 cycles per second. The transmission loss of a barrier remains constant regardless of the magnitude or volume of the sound.

The sound we hear is a composite of many sounds of different wave lengths or frequencies. The sound spectrum is also important to consider, for the ear is more sensitive to high frequency sound in the speech range than to low frequency sound, and fortunately high frequency sound is easier to shut out than low frequency sound. Accordingly, when judging the performance of a barrier, it is preferable to examine the plotted curve of the TL for the various frequencies tested.

To determine the desired or required capacity or TL of a barrier, one must consider the magnitude of the offending noise, the background noise normally found in the receiving room and the degree of quiet desired by the occupant. It is obvious that barrier requirements can vary over a broad range of conditions.

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Look Ahead with Lead

Let us accept for the time being that a barrier such as a wall or partition in a typical office without air conditioning and where reasonable quiet is desired, should usually have a minimum average transmission loss of forty decibels and that in actual practice the great majority of walls in modern homes and buildings fail to meet this requirement, often by a considerable margin.

From the beginning it was apparent that lead has all the desired properties for an acoustical barrier, namely high density, limpness, good damping capacity, good workability, ready availability and reasonable cost at least in terms of its conventional uses. It was soon evident, however, that concrete, gypsum block and board, dry sand, steel sheet and other materials also possess relatively high density, are lower in cost per pound, are available around the corner instead of miles away, and are familiar to most craftsmen. Further, these common materials in the building industry move in large quantities and at low profit margins and, if properly installed, can provide satisfactory acoustical barriers. The specialty items in this field, however, are another matter. They command more attractive margins by virtue of better appearance, greater convenience or comfort, new or unusual physical properties, lower labor costs, portability, or any one of a number of other advantages which the buying public is willing to pay for. Specialty applications in my judgement are where lead must be made to fit. The mere addition of lead to conventional walls in most cases does not improve the barrier properties sufficiently to justify the cost. A prefabricated panel, however, designed for the incorporation of lead, can, I believe, qualify as a specialty material with attractive properties.

The advantages listed for conventional materials, though formidable, are not insurmountable. First, lead can provide more mass in a given space than any conventional material and mass is an essential quality of a good acoustical barrier. Second, lead when properly applied has a better natural damping capacity per unit of weight than most other materials. Third, the stiffness of any material increases by the cube of its thickness with a result that its barrier properties are partially offset by its stiffness through the mechanism which the experts call the coincidence effect where the material will readily transmit sound. In contrast, lead as a material can be increased in thickness from 0.010 inch to 1.0 inche without incurring coincidence effect in the range of sound with which we are concerned. Fourth and finally, in combination with other materials — and this is fast becoming an age of composite materials — lead can frequently provide a better barrier at a lower total weight per square foot than other materials.

It is now pertinent to inquire as to whether there is an actual basic need for improved sound barriers and, if so, whether this market is likely to be an enduring one.

Building construction techniques and tenant requirements have undergone some drastic changes in recent years and the massive structures of a generation ago have given way to the glass and curtain wall closures, non-loadbearing interior walls, and hung ceilings. The extraordinary product development work and merchandising efforts of the aluminum, stainless steel, glass, plastic, air conditioning and insulation industries to name only the leaders, have brought about changes in home, office, store, apartment and motel construction and have provided a complete new look to our living and working areas. This lighter construction has also brought acoustical problems and the public clamor for the relief is now broadly acknowledged.

When the public press covers prominently the plight of a Brooklyn resident who at two in the morning called through the apartment wall to his neighbor down the hall to please put on his pajamas and go to bed so the rest of the building could get some sleep, it would appear that the market for good acoustical barriers is both of considerable importance and magnitude. If this doesn't convince you, then the fact that

the occupant of another apartment further down the hall contributed an audible "amen" to the first complaint, should do so.

There is little doubt that noise or objectionable sound is a problem of increasing importance in this day and age. Individuals are aware of it when they are disturbed, annoyed or are unable to work or sleep. Landlords are aware of it when tenant complaints necessitate expensive remedial acoustical work, tenants move out or space does not rent because of it. Industry is aware of it when people refuse to work in noisy areas or production slips or accidents occur because of it, or compensation courts grant generous awards for hearing impairment cases frequently dating back for several years. Thus there is in fact a basic human need for the control of noise.

We have approached the problem of incorporating lead in sound barriers in several ways: first, by testing the addition of lead to conventional materials and conventional types of construction under the ILZRO program; second, by investigating in the field noise problems referred to LIA as a result of their publicity; third, through cooperative installations made by LIA using information gained from the ILZRO work and experimental application techniques; fourth, by direct solicitation of large potential users for introductory installations; and finally, by setting up our own facilities to test and rank lead bearing panels of our own design and those of fabricators interested in this field.

Under the ILZRO program a number of panels were constructed and tested by Riverbank Acoustical Laboratory. These employed, in various ways, lead sheets in the available weights from 2½ to 8 lbs. per square foot. In this work it was demonstrated that the use of lead could improve the sound barrier properties of many types of walls and panels. It also became evident that the application of heavy sheets of lead to conventional walls would increase the cost materially. It was clear that the market was not likely to accept such costs and that a new approach was required.

During this period the BHAS people in Australia were perfecting a low cost continuous casting process to produce light gauge sheet lead under an ILZRO program and were testing same in a variety of applications. Evidence began to accumulate to indicate that two light gauge sheets might be preferable to one of equal total weight, that to be most effective lead should represent a major proportion of the total weight of the panel surface to which it was attached, which in turn pointed to the use of thinner panel skins, that the use of viscoelastic adhesive was preferable to a rigid adhesive in preserving limpness, that the use of fiber glass of mineral wool with the lead would be beneficial, that the double wall panels gave better results than solid panels and finally that there must be other untried designs for the incorporation of lead which might provide further improvement within competitive limits.

Also during this period the LIA were investigating various noise problems in the field from power transformers, plastic shredders, cable machines, ticket printers, aircraft and office machine shielding, polygraph and motor test rooms, and high presure gas reducing stations. Several successful cooperative remedial installations have been made, the results of which have been made, the results of which have been publicised. They typify the specialty applications referred to earlier.

A direct approach was made by Asarco to the Tishman Research Corporation for use of light gauge lead sheet as an overlay for acoustical tiles in hung ceilings and as an over the partition plenum barrier for partitions which terminate at the hung ceiling in buildings owned or operated by the parent Tishman Realty Corporation. A test was run on a one-pound lead sheet plenum barrier between two offices in the 666 5th Avenue building. The satisfactory performance shown in the accompanying graphs (Fig. 1 to 4) resulted in authorisation for the use of lead as an alternate

material for this application in that company's Gateway Center Building now under construction in Chicago. The E. F. Hauserman Company which holds the contract for partition work in that building has currently made an initial installation of 6000 square feet of one-pound sheet lead barrier in the new Chemical Bank Building at 277 Park Avenue in New York City. Several other introductory installations in other major new buildings are pending.

In this application lead as a material is more expensive than gypsum board but is easier to cut, fit and install, thus providing a more effective barrier. In comparison with an aluminum foil-asbestos paper-fiberglass barrier, one-pound lead sheet is easier to fit and is half the cost per square foot. This market will not just drop in our lap. Architects and applicators must be taught how to apply it properly and this will require constant follow-up to get it established.

The partition industry is variously estimated to be a $100,000,000 business. At $10 per lineal foot, there would be 10,000,000 lineal feet annually. With, say, 10% of the partitions requiring plenum barriers, this would represent 1,000,000 feet of lead sheet 2-3 feet wide or 1000-1500 tons annually. The partition market would obviously be even more attractive if low cost, effective panels can be designed.

With this objective in mind, we have installed in our laboratory at South Plainfield, New Jersey a sound test facility to permit us to make noise reduction determinations on standard 4' x 8' panels or walls up to 9 feet wide by 8 feet high if desired. We are interested only in ranking various materials and panels by performance and cost. We are not in competition with commercial acoustical laboratories.

The facility consists of a source room 9' wide by 8'4" high by 12'6" long, inside dimensions, and a receiving room 9' by 8'4 by 15', isolated from each other by a ½" saw cut through the floor and similar gaps in the ceiling and side walls which have been stuffed and caulked, constructed of 8" solid concrete block except for the common dividing test wall which is made up of two sets of panels comprising 8 pound sheet lead on 2" x 3" wood frames backed with fiberglass and placed back to back with ½ inch of free air space to provide a test wall 8 inches thick with a transmission loss of 65 decibels. This was built, equipped, for less than $7500.

A 4' x 8' section of a commercially available steel partition system, embodying the normal posts, joints and fittings, was installed in our test wall by the vendor. Our test results in the as-installed condition fall slightly below the manufacturer's published TL data but, after carefully plugging all leaks, our test results compare closely with his and at several points exceed them. The next move is to endeavor to affect an improvement through the application of lead to his existing design or to modify it so as to permit an improvement to be obtained.

In the same vein we have endeavored to build up limp panel cores using one pound sheet lead as a basis for improved panel design. The results are certainly not conclusive but, by the same token, they are encouraging.

For example, in Figure 5 we have plotted the noise reduction values* in decibels for a single sheet of one pound lead and then for two limp sheets with varying space between them. The curve for one pound lead is a typical one and approximates the theoretical mass law curve. The addition of a second sheet with an air space of 1 5/8" shows marked improvement. Increasing the air space to 3 ½" gives further attractive improvement. Five inches of air space, however, adds little except at low frequencies and is hardly worth the space required.

Figure 6 shows two sheets of lead 1 5/8" apart and the effect of adding 2" of fiberglass to the air space. The improvement here is intriguing. A thin hardboard skin added to the source room side in simulation of panel construction adds several decibels. Another skin of hardboard on the receiving room side unfortunately could not be placed snugly against the lead core sheet so in this case the additional air dead space has contributed more improvement than the skin. Bear in mind that this panel was put together in situ and does not represent the equivalent of a prefabricated panel. It presents only an attractive objective of clothing an effective core assembly with a frame and skins in such a manner as to maintain its barrier properties, and to provide an attractive and durable panel at low cost which can be easily installed by anyone. I regret to advise that we do not yet have the answer to this phase of the problem.

Figure 7 shows a similar treatment using 2" of fiberglass in the 3½" air space and adding ¼" plywood instead of 1/8" hardboard. These curves seem to indicate that little is gained by increasing the panel thickness and perhaps the plywood stiffness is reducing the barrier capacity at low frequencies.

Perhaps it is unwise to exhibit such curves before obtaining a finished product with documented substantiating field performance data. I prefer, however, to take the gamble for if we can retain a major portion of this barrier capacity in a prefabricated panel, then we shall have something attractive to offer to a market of considerable magnitude.

We invite you to join us in this effort — that is, if you are strong of heart and young in spirit.

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*NR values determined in any given test facility are fully comparable with one another and approximate TL values, but they must be adjusted for the absorption characteristics of the receiving room to be classed as TL values.