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LEAD INDUSTRIES ASSOCIATION, INC.

292 MADISON AVENUE

NEW YORK, N. Y. 10017

TELEPHONE – AREA CODE 212

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August 6, 1964

SUBJECT: Reprint on
Lead for Noise Control

To the Members of the Lead Industries Association, Inc.:

The enclosed reprint of an article on noise control from American City was prepared by the LIA staff after discussions with the editors of that magazine. It appeared in the June, 1964 issue and several dozen requests for additional information have been traced to it.

Copies of this reprint have also been mailed to our list of architects, builders, and contractors (about 12,000 in all) and will be made available through the "Lead Library" in the next issue of LEAD.

Additional copies are available for your use. The first 25 are free and, in bulk, larger quantities may be had at our cost of $3.00 per 100.

Sincerely,

Bruce Foster

Manager, Technical Services

BF:bd
Enc.

Look Ahead with Lead

N 2335

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How to Stop Noise

By BRUCE FADER
Mgr., Technical Services
Lead Industries
Association, Inc.

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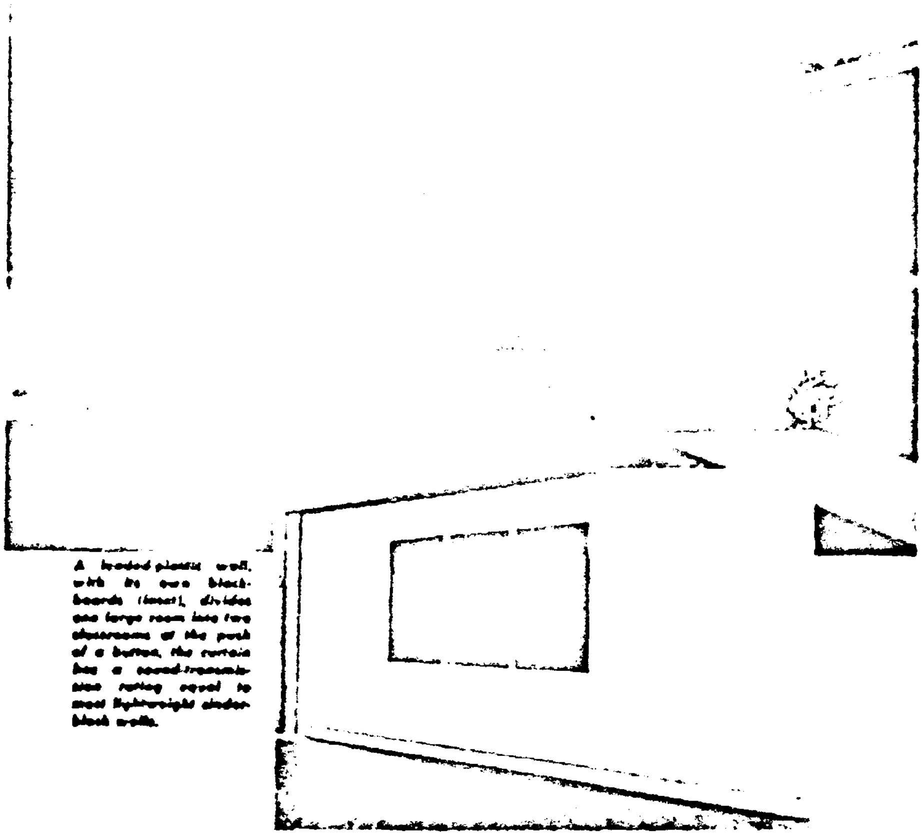

A leaded plastic wall, with its own blackboards (inset), divides one large room into two classrooms at the push of a button. The curtain has a sound-transmission rating equal to most lightweight cinder-block walls.

How to Stop Noise

By BRUCE FADER
Mgr., Technical Services
Lead Industries
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Stop for a moment and listen. What do you hear? If you are reading at home, probably nothing more than the dishwasher or television. But if you are in your office, you probably hear street noise, two telephone conversations in nearby offices, typewriters clacking away, and possibly even transformers or heavy machinery on some other floor. You may have been unconscious of the noise until you stopped to listen but these background noises have been vying for your attention, introducing errors in your work, and sandpapering your nerves.

In a recent article, Time magazine quoted the Air Force's Dr. von Gierke on noise, "It impairs both manual dexterity and accuracy." Mechanics working near howling jets, for example, were inclined to rush through their job, getting it done rather than getting it right. The same article cites a study by the Aetna Life Insurance Co. When Aetna improved the acoustic situation in its own offices—

- typists' errors went down by 29%
- machine operators made 52% fewer mistakes
- employee turnover dropped 47%
- absenteeism decreased 37.5%.

Noise need not be deafening to be a serious hindrance. Offices need telephones and typewriters and industry depends on dynamite and diesels. We make more noise than any previous generation in history and every new mechanical aid and technical advance adds to the noise load. However, we can control it.

Most people know about materials that absorb noise. "Acoustic" ceiling tiles, carpeting, heavy drapes and overstuffed furniture soak up noise and reduce it by cutting down echoes. Oddly, though, very few people realize that there are other methods of noise control—and some of them are much more effective than absorption in dealing with the most common noise problems.

One of the best noise control measures consists of blocking the paths from the noise source to your ear. To build a good noise block, or wall, make it limp and heavy rather than stiff and light. For example, a sheet of lead foil only 0.008 inches thick produces the same effect as a sheet of 3/16-inch plywood, despite the fact that the lead is lighter than the plywood (about ½ pound per

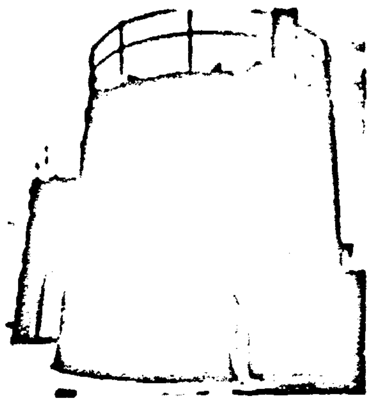

Fig. 3. Water-cooled sulfur and chambers constructed of sheet lead supported by a free-standing steel structure

vessel shell, but this is confined to relatively small vessels. A variety of tank designs using hanging lead linings have given satisfactory service. A variety of support methods for deeper vessels have been developed, of which the use depends upon the tank design, size, and the proposed usage. Lead sheets can be supported on a steel or wooden shell by large cut steel washers and round head bolts as shown in Fig. 4. The cut washer distributes the load over a larger area than the bolt alone; subsequently bolt and washer are covered with a lead cap burned to the lining.

Strapping. In deep tanks, or under conditions involving fluctuating temperatures or higher stresses and vibration, a series of vertical, and sometimes horizontal, steel straps are used for support. Strapping consists essentially of supporting the lead sheet against the steel shell with flat steel bars fastened at frequent intervals inside the lead lining and through it to the outer steel shell. These straps are covered with strips of lead welded to the lead lining on either side, thus presenting a continuous, resistant lead surface to the corrosive chemicals contained.

Lead Bonded Sheath

In addition to the lead linings previously discussed, lead can be bonded directly to iron and steel for use with corrosive chemicals, particularly in high temperature processes. The thickness of the homogeneously bonded layer, depending on the use, ranges from $\frac{1}{8}$ in. to $\frac{3}{8}$ in. As relative motion between the two metals is constrained by the plastic flow of the lead, such linings are recommended where: (1) The reaction vessel operates under vacuum, (2) Rapid or wide temperature variations occur that would cause fatigue and stress corrosion in loose linings, (3) Good heat transfer characteristics are required, (4) High temperature operation is essential (bonded linings will not creep at temperatures up to 450°F), (5) Lightweight construction, as in tall vessels, is required, and (6) Vibration and repeated shocks are encountered.

Two methods of bonding lead linings on

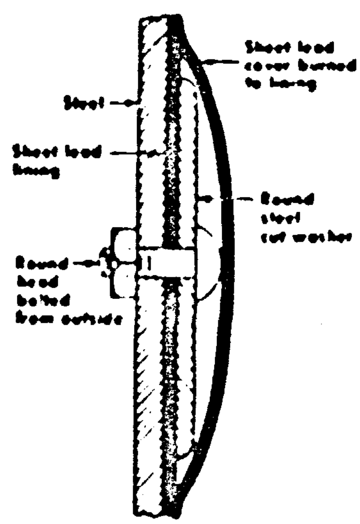

Fig. 4. Button-type fastening of sheet lead lining to steel structure.

steel are in common use, that is burning bar and casting. The critical step in both methods is preparation of the base metal surface before leading. The usual method is to clean the steel initially by shot blasting to expose an oxide-free surface. Pickling, usually with 10 per cent sulfuric acid, is then sometimes used. Fluxing with zinc-ammonium chloride and stannous chloride or certain proprietary fluxes is carried out just before leading.

The oldest method of bonding lead to steel, the *burning bar method*, is particularly useful for small areas and irregular shapes. In this hand operation, lead is applied to the prepared surface by melting from a "burning bar" using a manual burning torch. A skilled operator can check the bond before continuing to cover the surface with a layer of lead about 1/16 in. thick.

Casting. The second method of bonding lead to steel is efficient and relatively inexpensive. After the steel has been cleaned and fluxed, molten lead is carefully poured on the surface. After cooling, the steel-lead plate is often rolled in a conventional rolling mill to reduce grain size and to increase density. The plate is subsequently formed into the desired shape.

Sprayed Coatings. Lead coatings also may be applied by spraying. Lead wire is fed into a spray gun which melts the metal and blows it onto the surface to be coated. Since there is no chemical bond between the lead and base metal, the latter is first sandblasted or otherwise roughened and cleaned to provide good mechanical anchorage for the coating. Pinholes may be minimized by peening the surface after coating.

Lead Acid-Brick Construction

An important method of chemical construction which has been devised to resist the most severe conditions encountered such as the handling of corrosive slurries and high operating temperatures has led to the development of lead acid-brick construction—a lead-lined steel shell with an acid-brick

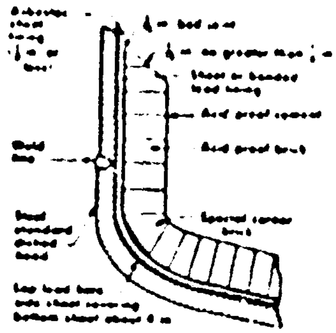

Fig. 5. Acid-tank lining with impervious lead membrane for chemical tanks

inner lining (Fig. 5). This type of construction has proved effective in a large number of installations where lead alone or other materials of chemical construction have been inadequate. When properly designed and installed, they will perform admirably under the most severe conditions.

Brick linings have excellent corrosion resistance but cannot be used alone because they are essentially permeable materials. In fact, the best grades of acid-proof brick are intentionally made 3 to 4 per cent porous for thermal shock resistance. The lead lining, therefore, acts as a membrane between the shell and the brick lining so that any liquid that penetrates the brick work will be contained by the lead.

The special conditions which warrant the selection of lead acid-brick construction are discussed below.

High Temperatures. Referring to temperatures beyond the mechanical limitations of lead, the brick lining provides an insulating layer resulting in a temperature gradient. Consequently, although the temperature within the vessel at the lining may be anywhere from 300 to 1300 F, the temperature of the lead membrane is well within its mechanical limits. The upper temperature limitation of this type of construction is merely a function of the thickance and thermal insulation properties of the brick lining. For example, there are quite a few applications for sulfuric acid-sulfur dioxide scrubbing operations with entering temperatures ranging as high as 1600 C.

High Pressure or Vacuum. Certain acid recovery units are brick- and lead-lined and operate under vacuums as low as 0.25 in. of mercury at about 250°F. Under these conditions, the brick lining affords a uniform support under static or cyclic conditions of vacuum and pressure which would normally cause a great deal of undesirable movement of the lead lining.

Abrasion and Erosion. Many vessels use methods of agitation such as steam jet lances, which would cause serious erosion of an unprotected lead lining. A brick lining protects the lead membrane from the strong scouring effect of the agitators or from any other abrasive condition that may be present such as the presence of abrasive slurries. In addition, pickling tanks holding sulfuric acid mixtures are frequently lead-brick lined to eliminate the possibility of damage due to careless handling of the objects being pickled.

Thermal Insulation. In addition to allowing ambient vessel temperature well above the temperature limits of the lead membrane, a brick lining is desirable in the operation of vessels with rapid time-temperature fluctuations in the lead lining, thereby reducing markedly the tendency for thermal fatigue in the lead.

Severe Corrosion Conditions. In certain cases, the presence of the brick layer deters "drilling" and "scabbing" type attack which occurs when lead is exposed to the direct action of combinations of sulfuric acid and certain organic chemicals. Such attack, for example, occurred in a vessel which contained 25 per cent sulfuric acid plus oxalate at 120°F. A comparison of corroded pieces with pieces which were protected by a 4½-in. course of hard-burned high silica acid-resisting brick and backed with acid-proof cement, demonstrated the effectiveness of the lead acid-brick construction in this application.

In general, whether or not an organic material will attack lead in combination with sulfuric acid apparently is related to the materials' polarity or lack of it. Non-polar substances such as gasoline, benzene, and toluene are not corrosive to lead. Evidently the assistance provided by the acid-brick lining is to restrict the penetration of the polar substances to the lead lining. The nonpolar materials, interestingly, penetrate acid-brick very rapidly; nevertheless, they are harmless.

Lead Pipe and Coil

Lead is extruded readily into various shapes, and large quantities of extruded lead pipe are used in the building, chemical, and related industries, principally as pipe for conducting corrosive solutions and as cooling or heating coils submerged in a corrosive medium.

One of the great advantages of lead piping, in addition to its corrosion resistance, is its adaptability and the facility with which it can be installed. When pipe bends are required, straight pipe may be filled and packed with sand and bent. During the operation, the outer wall becomes thinner; moreover if the radius of the bend is less than four times the inside diameter of the pipe, this outer wall or "heel" is reinforced by "burning on" an added layer of lead. Shorter radius bends may be made by means of mitred joints between short sections of pipe. Alternatively, a variety of pipe fittings may be purchased as stock items, cast in chemical lead or antimonial lead. These are supplied in four forms:

(1) With solid lead flanges welded in place.

(2) With cast iron or steel slip-on flanges.

(3) With over-length for flanging in the field.

(4) With plain ends for welding.

Horizontal runs of lead or lead alloy pipe are generally continuously supported in steel or wooden troughs or in specially constructed sheet metal shells. Vertical runs are supported at frequent intervals such as every 18 in. Long runs are provided with expansion bends if they operate at high or fluctuating temperatures.

This traditional method of supporting pipe has the disadvantages that any leakage may cause damage to the supports. Free expansion and contraction are hindered, and the location of any leak is not always evident or easily accessible for repair.

Thickness of lead pipe depends on several factors, including corrosive attack, abrasion, and pressure to be handled. For example, if wall thickness is calculated in the usual manner to accommodate a given pressure, additional wall thickness is allowed to compensate for loss through corrosion or abrasion. The velocity at which a corrosive solution flows across the surface of lead is an important factor in the rate of corrosion, but it is difficult to establish a definite relationship between the two. As an illustration, Table 2 shows the effect of increasing the velocity of a 20 per cent sulfuric acid solution at 25°C (75°F) across the surface of lead:

Table 2

Velocity of Solution Across Lead Surface	*Rate of Corrosion in/month × 10⁻⁶*
8.4	[illegible]
97	17
186	36
300	[illegible]

The erosion of lead pipe may be retarded by designing the system to reduce flow rate friction as much as possible, e.g., eliminate short bends, use larger pipe, or both. Lead pipe is especially useful when a high rate of flow is desired because it can be curved and assembled without extra fittings and because extruded lead offers a minimum of surface friction.

One of the more interesting lead coil developments is a heat exchanger consisting of two lead pipes one within the other. The larger pipe has a 2 in. inside diameter with $\frac{1}{4}$ in. wall and is extruded from 6 per cent antimonial lead. The inside pipe made of soft lead is 1 in. in diameter with a $\frac{1}{8}$-in. wall at the thin portion. The exterior of the inner pipe has been extruded in the shape of a six pointed star to provide extra support and also to retain concentricity.

Ribbed and finned lead pipe are used in many systems requiring greater surface area. Lead sheathed electric heating devices have been used successfully in place of steam-heated coils in some installations where using steam is difficult or hazardous or where electricity is inexpensive.

Bonded and Lead Covered Pipe. Under conditions of high temperature or excessively high pressure where greatest strength is essential, lead-lined steel or cast iron pipe or, possibly, lead-covered copper pipe may be used. Bonding techniques similar to those described earlier are utilized in the manufacture of these products.

In making bonded lead pipe a length of steel is first cleaned and fluxed. Then molten lead is cast on in sections by heating the pipe. A second method uses instead of molten lead a length of extruded lead pipe which is inserted inside a properly prepared pipe of steel. The ends of the lead pipe are sealed and steam pressure applied to expand it against the outer pipe. Pressure is raised until the temperature reaches the point where bonding occurs between the lead and steel, aided by pre-tinning the steel with a thin solder film. In this way, the lead is said to be "sweated" to the steel pipe.

Inspecting and Testing Lead Linings

Lead-protected chemical-processing vessels are normally inspected for the presence of pinholes or porosity in welded seams on sheet-lead linings, hairline cracks, either in the weld or the sheet, resulting from fatigue or stress corrosion, and pinholes, inclusions, or bond discontinuities in the case of clad vessels. Defects falling into any of the above classifications, although they may not penetrate the lining completely, do form a potential trouble spot that may shorten the lining's expected life—a problem that can be minimized through the use of proper inspection and testing.

Testing Sheet-Lead Linings. After the completion of a new installation or extensive repairs on an old lining all the welded (burned) seams are carefully checked visually by the lead burner and all obvious defects corrected. If it is necessary to check the soundness of a lead weld such as on butt joints to determine the depth of fusion, a section of the seam can be trepanned with a trepanning drill to obtain a cross section. On a bonded lining, this technique has also been used to check the nature of the bond and the thickness of the lining. In either case, however, the test is destructive, whereas radiographic techniques provide a more effective, nondestructive test for weld soundness. For closer and more exacting examination of welds, a fluorescent or dye penetrant that is drawn into tiny cracks or pores by capillary action is often used. After the excess is cleaned off, the chemical remaining in the imperfections can be developed or brought to the surface, where it may readily be identified, either by a bright glow under ultraviolet light, in the case of the fluorescent penetrant, or by a distinctive color, in the case of the dye penetrant.

Interpretation of each indication is all important. Practically all procedures involving the fabrication of lead result in the possibility of confusion between a defect and a simple surface marking; therefore, it must be realized that a high degree of discernment must exist to differentiate between a true defect and a harmless surface irregularity.

Testing Bonded Linings

Acid-wash tests have been accepted as a standard inspection technique on bonded lead-lined vessels for the detection of pinhole penetration, surface imperfections, and porosity. It will not detect subsurface flaws. First, the entire lead surface must be cleaned free of any oil or grease films. Then, a dilute solution of hydrochloric acid (5 to 15 per cent acid) is freely applied to the entire surface by brushing or swabbing and is allowed to remain for 12 to 24 hr. Before the acid is cleaned off, the lead surface may be examined by an inspector for wet spots or discoloration, or, better still, the acid washed off with water, and the surface allowed to dry and then be examined. A wet spot indicates either surface porosity or a pinhole that has not penetrated the lead. Rusty discoloration indicates a pinhole that has penetrated through to the steel. Repairs are usually made on the wet spots by touching up with a lead burner's torch. Rust-spot areas are removed and the steel cleaned so that new lead can be bonded. After all rust-spot indications have been rebonded, the acid-wash test is repeated to give a final check.

A second method is the same test in principle, but it is more effective and is restricted to lead-clad pressure vessels. The vessel is heated by internal steam pressure to about 300°F until thermal equilibrium is reached. At this point, the steam is turned off and pressure rapidly released from the vessel. Air is subsequently admitted and the vessel is cooled and inspected for bubbles. If none are found, the test is repeated. After the second cycle, if none are found, the lining is accepted as 100 per cent bonded.

Ultrasonic tests involving the transmission and reflection of ultrasonic waves lend themselves well to the location of unbonded areas and subsurface inclusions and can also provide a simple nondestructive means for determining the lead thickness in bonded linings. Two basic methods of ultrasonic inspection have been used successfully on bonded lead linings: the resonance method, and the pulse or echo method.

In the resonance method, the crystal head on the instrument transmits an ultrasonic wave into the metal and the waves reflected from the opposite surface are detected au-

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cally in headphones or visually on a calibrated cathode-ray tube or a dial reading. When lead is well bonded to steel, the waves are not reflected from the steel-lead interface; consequently no signal is obtained. Small unbonded areas, one half of the crystal-head size or smaller, or semibonded areas, may result in partial reflection of the waves from the interface, indicated by weak signals. Strong signals reveal a complete lack of bond, larger in area than the crystal head, whose outline can be easily traced with the instrument.

In the pulse or echo method, vibrations are sent out through a similar crystal head. The pulse travels through the metal until it strikes a flaw and is reflected, whereas the rest of the waves travel on until they hit the opposite surface and are reflected. Although the vibrations are alternately off, the crystal detects the reflected pulses and the time difference is converted electronically to readable indications of depth on a cathode-ray tube.

Radiographic Testing. Although, because of its high density, lead is normally used as a material for shielding against radiation, it is possible with the higher radiation energies commercially available today to obtain practical radiographs of the lead in lead-lined steel vessels, to locate entrapped gases and subsurface foreign inclusions not detectable by acid-wash methods.

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R. B. Travis

Cross-references: *Brick-lined Process Equipment.*