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METALLIC LEAD PRODUCTS DIVISION

see Chemical Bul. No 44

July 20, 1951

LEAD CHEMICAL CONSTRUCTION
BULLETIN NO. 3

SUBJECT: NEW DEVELOPMENTS EXPAND
USE OF LEAD CONSTRUCTION

Attached is a reprint from "Materials and Methods" magazine (April, 1951) entitled "New Developments Expand Use of Lead Construction." The article describes in detail and brings up to date the latest developments in the use of lead as a material of chemical construction.

As long as our supply lasts, we will be pleased to send you additional copies of this reprint. As similar material becomes available we will send it on to you so that it may be added to the series.

Very truly yours,

Robert L. Ziegfeld

Robert L. Ziegfeld
Secretary

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New Developments Expand Use of Lead Construction

by KEMPTON H. ROLL
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Distributed by
Lead Industries Association
420 Lexington Ave.,
New York 17, N. Y.

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Reprinted from MATERIALS & METHODS, *May 1951 issue*
Reinhold Publishing Corporation
330 West 42nd St., New York 18, N. Y.

LIA10031

New Developments Expand Use of Lead Construction

Improvements in lead fabrication and installation methods continue to keep pace with developments in the chemical and process industries.

by KEMPTON H. ROLL, Lead Industries Association

● LEAD HAS BEEN an important material for handling corrosive chemicals ever since the beginning of the chemical and process industries. Although other materials have been developed to compete with lead in this field the use of lead for corrosive handling has continued to expand. This is partly due to the inherent desirable characteristics of lead as a corrosion resistant material. But it is also due to the experience gained from long and varied use of lead in this field. This experience has taught where and how lead may be used to best advantage and has led to improvements in construction and installation methods which have kept pace with developments in the chemical and process industries.

Lead pipe for conducting corrosives, lead heating or cooling coils, sheet lead for tank linings, bonded lead linings, and various cast lead objects all figure among the customary uses of this metal. Acid and chemical manufacture, pickling, plating, anodizing, waste recovery, air pollution control, and a host of other operations are making use of lead's resistance to attack by corrosives—particularly sulfuric acid.

A review of modern lead construction methods will disclose the latest techniques and improvements, all of which have passed the test of actual industrial application. These include improvements in methods of supporting sheet lead, new methods of testing lead linings and welds, lead bonded to steel, usually referred to as bonded or "homogeneous" lead, lead covered copper or steel heating coils, and the use of acid proof brick with a lead interlining. Little has been published to show what these improvements are, where they can be used, and how it's done. So here, brought together for the first time, are the details.

Sheet Lead Construction

Lead rolled into sheet and supported in a steel or wooden framework (cage construction) or a steel or wooden shell lined with sheet lead (lead lined construction) are the two principal methods of sheet lead construction. Actually, there are probably as many modifications as there are applications for both types of construction. They are the oldest methods of using lead as a material of construction, but still represent the major part of all the lead used by industry for handling corrosives.

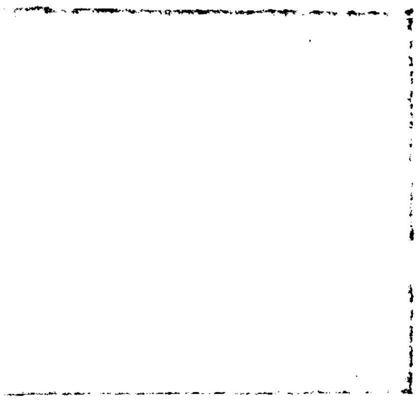
Sheet lead construction is ideal for the storage of corrosive chemicals, and is generally regarded as the method which requires the least capital outlay. Should repairs be necessary, they are easily effected in the field, and once the vessel's useful service life has expired, the lead can be reclaimed as scrap and sold at the highest relative rate of any of the common metals. Sheet lead can easily be assembled and welded in the field with the aid of only a lead burning torch. Tanks of great variety, both as to design and usage—pickling, chromium and copper plating, anodizing, acid storage, manufacture of a wide variety of chemicals, etc.—are among the common applications of sheet lead linings.

Cage Construction—The first chambers for the manufacture of sulfuric acid were of cage construction, simply large sheet lead boxes supported by timbers. Acid chambers today are being built with lead walls supported in a special steel framework that permits the metal to move freely with changing temperature. A detail of the Mills-Packard system for suspending the lead while at the same time permitting freedom of movement is illustrated.

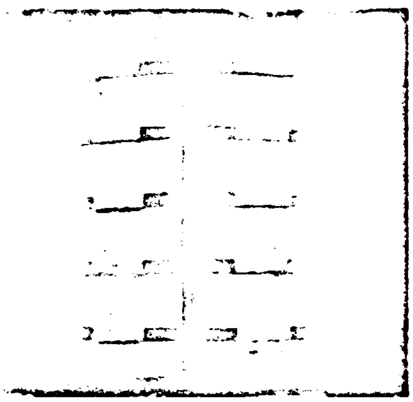
The cage or basket type of support is by no means new, but its merits are still not appreciated by many potential users. In place of using a steel or wooden shell lined with sheet lead, a basket or cage-like structure made of steel flats and angles welded together to form an open framework is used for supporting the lead. Depending upon the height of the vessel, the straps are often placed closer together at the bottom than at the top to give extra support where hydrostatic pressure is greatest.

This type of open construction in which the lead is fully exposed to the atmosphere provides an extremely effective and inexpensive method for cooling liquids which are received hot or where heat is generated by reaction, such as in battery acid dilution. Heat within the vessel is dissipated rapidly to the atmosphere by air convection and radiation.

Cage construction offers several other advantages over solid steel tanks as long as high pressure or vacuum is not encountered. The spacing between the straps permits a leak to be seen immediately. Furthermore, it can be repaired from the outside in a matter of minutes. If the size of the vessel calls for extra support, internal strapping, which of necessity must pierce the lead lining in order to be fastened, can be eliminated by using the cage-type construction. Instead, strips of lead can be burned from the outside over the horizontal steel straps and thus support the lead externally, so



Mills-Packard system of freely suspending lead side walls on modern sulfuric acid chamber.



Cage-type tank construction with strips of lead burned from outside over horizontal steel strips.

shown in the illustration.

Other advantages of cage construction are lower material costs and often easier assembly in the field, the handling of bulky and heavy steel sheets being eliminated.

Lead lined Construction—Sheet lead lined wooden or mild steel tanks are in common use and have been for many years. Storage vessels for corrosives, nickel, chromium and copper plating tanks, anodizing tanks, tanks for electrolytic refining of lead, zinc and copper, chemical reaction vessels and pickling tanks are all common examples of equipment lined with sheet lead. Lining thicknesses usually range between 8 and 16 lb, sometimes two or more different thicknesses being used in the same vessel, such as in areas subject to erosion or where greater strength is required. Either existing vessels or specially constructed ones of concrete, wood or steel can be readily lined with lead to make them suitable for handling corrosives.

In small storage vessels the lining is hung from the top without any strapping. More often it is provided with additional support by any of the means described below. Generally in the form of strapping, extra support is resorted to when fluctuating temperatures, fatigue or stress corrosion must be considered. In deep tanks, because of the high density of lead (0.410 lb per cu in.), loose linings must be strapped to overcome the effect of gravity. In practice, the optimum height of a loose lead-lined vessel without benefit of any support from strapping rarely exceeds 10 ft, depending upon the weight of lead. Good vertical strapping practice is to place the straps about 18 in. apart and no more than 24 in.

Fastening the straps used to support loose sheet lead linings has been simplified by a recent innovation making use of automatic stud welding. A threaded stud can now be butt-welded directly to the inside of the shell with a special gun into which the stud is loaded. The stud can be welded directly through pre-cut holes in the lead or between two lead sheets where they butt together. Half-oval steel strapping is slipped over the threaded stud and on top of the lead. The top of the strap is recessed to receive the fastening nut (see drawing). After bolting the strap, a lead strip is placed over the steel and welded securely on each side to protect the steel from corrosion. Studs are usually placed on 18-in. centers, occasionally 12-in., but never more than 24-in.

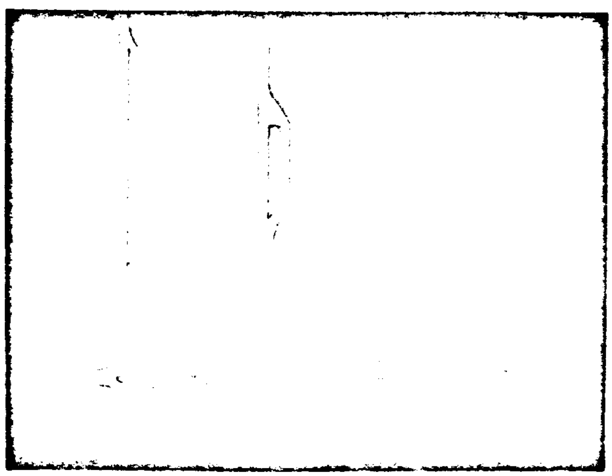
Occasionally it is advantageous to use a large steel cut washer and a roundhead bolt to fasten sheet lead to a steel or wooden shell. The bolt and washer are covered with a lead cap which is burned to the lining. This tends to distribute the load over a large area and thus aids in minimizing fatigue. The bolts used in this manner are evenly spaced over the entire lining at about 18-in. centers. This method of support is shown in the drawing.

Sheet lead for lining all types, shapes and sizes of chemical equipment usually comes in rolls ranging from 8- to 12-ft wide and up to 60-ft long, depending upon the thickness of the sheet. Twenty feet is generally considered a standard roll. Thickness varies from 1/80 in. to 2 in., or measured in the parlance peculiar to the lead industry—½-lb to 120-lb (lead 1/64-in. thick weighs about 1 lb per sq ft and is designated 1-lb). In chemical construction lead weighing less than 8-lb is rarely encountered.

Testing of Lead Linings and Welds

A nondestructive method of testing

Drawing showing various methods of modern lead construction



Burning bar method of lead bonding. Area ahead of man has been bonded.

lead linings and welds requiring no electrical equipment and involving only the expense of the chemicals used was recently placed on the market. The new process is used for inspecting the surface of metals and detecting any openings, such as cracks, laps, cold-shuts and porosity. Discontinuities are indicated by bright red lines, dots or blotches on a white background.

The process involves the use of three liquids—penetrant, developer and cleaner—which can be sprayed, brushed or dipped on the surface to be inspected. First the surface is cleaned, then covered with the penetrant, which is left on for 5 or 6 min. A gallon of penetrant will cover an area of approximately 5000 sq ft. After removing the penetrant with the cleaner, the developer is applied. The red penetrant will remain in any crevices until it is drawn to the surface by the action of the white developer. A red line or blotch indicates a crack or cold-shut, a series of red dots in a line indicates a tight crack, cold shut or partially welded lap. Tiny hairline cracks which appear when lead has been overstressed, particularly under corrosive conditions, can be detected by this method.

Bonded lead linings described below can be tested by either the above method or by this one: brush on a solution of 50% hydrochloric or muriatic acid and allow to stand for 24 hr. The presence of pinholes will be indicated by rusty discoloration. After marking such spots the entire surface is washed with water and repairs made where required.

Another leak detection method that has also been used on lead is based upon a fluorescent penetrant instead of a colored dye penetrant. Surface discontinuities are indicated by this method in much the same manner as by the dye penetrant method described above. A fluorescent penetrant is applied by brushing or spraying and then removed by a water wash, after 5 to 15 min. Developing powder brings out the penetrant, and observation under a "black light" reveals any discontinuities.

Brick and Lead Linings

The handling of corrosive slurries and other combinations which both corrode and erode most materials of construction have led to the development and practical acceptance of brick and lead lining, i.e., a steel shell lined with lead, with or without a layer of asbestos sheeting followed by a layer or two of acid-proof brick set in suitable acid-proof cement.

Brick and lead lined vessels are recommended, particularly where any of the following conditions prevail:

1. Abrasion or erosion is a factor.
2. The vessel operates under high pressure or vacuum.
3. Severe corrosive conditions are encountered. (For example, where acids and alkalies must be handled in the same vessel.)

Brick linings alone are always somewhat permeable, due to the inherent porosity of the brick and the inability of the bricklayer to secure a continuous film of cement between and in back of the brick. No cemented conglomerate can be as impervious to liquids as can a metal.

A lead lining acts as an impervious barrier between the shell and the brick so that any corrosive seepage through the brick lining is retained by the lead, thus preventing damage to the steel shell. The lead and brick linings are then complementary to each other and serve as a particularly effective type of construction.

In building a brick and lead lined steel tank, the tank should be built to support the weight of the entire structure. Bottoms should be dished where pressure is involved and the welds performed at or above the bottom edge (see drawing).

A lead lining is applied next after removing all burrs or other projections on the inside of the tank which might cause injury to the lead. Chemical grade 8- or 10-lb lead is usually adequate and has found most application. Eight- or 10-lb lead is 1/8 or 5/32 in. thick. It should be lapped over the top edge of the vessel to prevent seepage between the lining and the steel, the side sheet extending down about 4 in. over the top of the bottom sheet. They should be welded together around the entire exposed edge. In very large vessels or at high operating temperatures, it is advisable to strap the lead to the shell.

Under severe operating conditions bonded lead linings are employed, in which case lead of greater thickness is generally used. Because the initial cost is essentially that of the bonding operation, using thicker lead adds little, proportionately, to the total expense involved but it does make for increased service life.

After installation, the lead lining should be tested for leaks in the manner described elsewhere in this article. After the lead has been installed and tested, a layer of asbestos sheeting or some similar material 1/16 to 1/8 in. thick is added to act as a cushion between the brick and the lead, protecting the lead against abrasion during expansion and contraction.

Finally, the vessel is lined with one or two courses of brick, the brick selection depending upon several factors: the degree of acid insolubility required, minimum allowable porosity, and the degree of thermal shock involved. The thickness of the brick is determined by the dimensions of the vessel, the amount of mechanical abuse anticipated, and the thermal insulation required. Brick size is commonly 9 by 4½ by 2½ in., though other sizes and special shapes are available.

Brick in two courses is laid so that the wall and the floor courses can be keyed in and joined with a minimum of cement, usually a 3/16-in. layer, and no greater than 5/16-in. The bed joint (between the brick and asbestos or lead) is about ½-in. thick. Classes of cements are considered on the basis of desired corrosion resistance, temperature, erosion and porosity, plus the economics of cement and installation costs. Acid-proof cements available on the market include silicate cements, sulfur cements, phenolics, furfural alcohol resin base cements and modified phenolic resin base cements. Litharge-glycerin cement (80 to 100 cc of glycerin per lb of litharge) is occasionally used, particularly in the paper making industry, where its excellent resistance to sulfurous acid liquors is utilized. It has good water resistance, withstands attack by nonoxidizing acids, and can be used safely up to 350 F.

Bonded Lead Linings

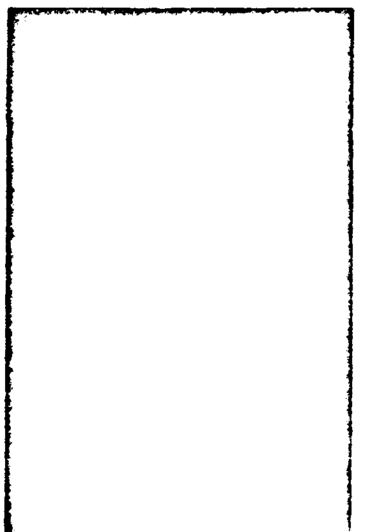
Combine the corrosion resistance of lead with the strength of steel and, in effect, you have what has been achieved with a bonded lead lining. Bonded lead is simply a layer of lead bonded to a steel plate so as to form a homogeneous or integral structure. The thickness of the layer, depending upon the ultimate use, ranges from 1/8 to ¼ in., ¼ to ½ in. being common. By literally anchoring the lead to steel at all points of contact, relative movement between the two metals is minimized.

Bonded lead lined vessels are recommended for use where any of the following conditions prevail:

1. Fluctuating temperatures are encountered.
2. High temperatures.
3. The vessel operates under vacuum.
4. Vibration or physical shock are encountered.
5. Heat transfer is important, such as in jacketed vessels. (No insulating layer of air exists between the shell and the lining.)

The advantages of bonding lead to steel have been known for many years, but the development of efficient and less expensive methods for accomplishing this have, until recently, been lacking. Two methods that have been put into commercial practice for manufacturing bonded lead linings on steel are described below.

With both methods the first step is preparation of the steel prior to bonding. The usual procedure is to clean it first by shot blasting so that an oxide-free surface will be exposed. This can be followed by pickling, usually in a 10% solution of sulfuric acid, and rinsing with water. If the bonding is done immediately after shot blasting, no pickling is required. Flux is then applied to the working area where the bonding is to commence and immediately prior to the bonding operation. Zinc-ammonium



Lead burner burning lead cover over strap for supporting sheet lead lining. Note type of tools used.

chloride and stannous chloride are two fluxes commonly used, in addition to several proprietary fluxes for which certain advantages are claimed.

Burning Bar Method—This method begins with preparation of the steel in the manner described above either as a unit or in sections. Then lead is melted from a "burning bar" onto the prepared steel surface by using a hand operated lead burning torch. This procedure is used to advantage in bonding small areas and irregular shapes. After building up the lead layer to slightly more than the thickness desired, the lead is peened, scraped, or its surface otherwise made uniform.

Pouring Method—Improvements in methods of pouring lead on steel have made this method of bonded lead manufacture an efficient and also less expensive one. The method consists first of preparing the steel surface, usually in the form of a large plate by the methods described above. Molten lead is then carefully poured on the heated steel surface. After solidification, the steel with the bonded lead lining is often rolled in a conventional rolling mill to compress the lead and curve it to shape. On heavy curved sections or irregular castings, the lead is cast in overlapping sections by partially rotating the vessel after each pouring. In either case, the lining is then scraped with special tools until a uniform thickness is obtained. Peening may or may not precede the scraping.

Lead Piping and Coils

Lead is readily extruded into a variety of shapes and sizes, and large quantities of extruded lead are used in the plating, chemical and related industries principally as pipe for conducting corrosive solutions and as cooling or heating coils submerged in corrosives. Sizes are limited only by the extrusion equipment available, and can include wall thicknesses of any size and cross-sections of practically any shape. The largest commercial lead extrusion currently made is 12 in. in inside dia.

Joints in lead pipe can be of the Van Stone type made by burning together flanged sections and securing them with two bolted cast iron or steel slip-on flanges. They can also be burned together and welded. In the case of vertical pipe, sections are joined with a "cup" joint. In this type joint, the lower section of pipe is flared out and the upper beveled to fit into the flared end where it can be welded.

Lead pipe coils have found widest acceptance for cooking purposes, chiefly because of lead's corrosion resistance and the ease with which it can be formed. Lead coils usually are helical in shape but can take other forms and are constructed of extruded lead pipe. Flat coils for the ends and bottoms of the tanks are also used. Pipe extruded with a fluted or ribbed cross-section for greater surface area is commercially available.

Cross-section of heat exchanger coil consisting of one lead pipe within another.

One of the latest lead coil developments is a heat exchanger consisting of two lead pipes, one within the other. The larger pipe has a 2 in. I.D. with ¼-in. wall and is extruded from 6% antimonial lead. The inside pipe made of soft lead is 1-in. in dia with a ⅛-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. The pipes were designed so that the area of the space between the two is approximately equal to the cross-sectional area of the inner pipe. After extrusion the coil was assembled by inserting the smaller pipe into the larger and coiling both into units 11 ft in circumference and 27 coils high (about 7 ft). The unit performs the dual function of cooling a solution circulating between the two pipes and heating another solution circulating through the inside pipe.

Because of lead's weight, it is frequently advisable to support it over long spans either with strap hangers, by laying it in steel channels or by using lead lined pipe. Steel or iron pipes lined with lead are used to advantage when pressures exceed 50 lb of steam (298 F) or the expense of supporting the pipe by other means is disproportionate. Lead lined pipe is commercially available from 1 to 12 in. in dia, the lead lining thickness ranging from ³⁄₁₆ to ⅜ in.

Bonded and Lead-Covered Pipe

Bonding techniques similar to those described above have been utilized in the manufacture of lead-lined steel pipe and lead-covered copper pipe. In all cases the purpose is the same: to utilize lead's corrosion resistance in combination with the strength of steel or copper. In making bonded lead pipe a length of steel pipe is first cleaned and fluxed. Then molten lead is cast-on in sections by rotating the pipe. A second method uses 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 takes place between the lead and steel, aided by pre-tinning the steel with a thin solder film.

Solder-bonded lead-lined steel pipe is recommended when design or operating conditions involve temperatures up to 250 F, vacuum, high pressure, vibration or physical shock and, of course, the handling of corrosive chemicals. Pipe sizes range from ½ to 12 in. I.D., with the lead lining thickness either ⅛, ³⁄₁₆ or ¼ in.

Lead-covered copper and steel pipe is made somewhat like bonded lead-lined pipe, except that the lead layer is on the outside instead of the inside. The pipe in lengths of about 10 ft is cleaned and fluxed and mounted centrally in a circular split mold. Molten lead is poured around the pipe until it is completely covered. The pipe is finished by drawing it through a drawbench to bring the lead down to the thickness desired. By other techniques, continuous lengths up to 100 ft can be made.

Lead-covered copper coils can be operated up to 150-lb steam pressure, while ordinary lead steam coils can operate successfully only up to 50-lb steam pressure. This is the reason why lead-covered copper has found such wide acceptance for use as heating coils. Copper absorbs and transfers heat with the greatest efficiency of the common metals and because lead is bonded directly to the copper with no air interface, heat transfer in lead-covered copper piping is maintained at its highest value. Because the physical strength to withstand high steam pressures is provided by the copper, it is practical to keep the thickness of lead covering at a minimum, thus, the combined thickness of copper and lead is materially less than the wall thickness of lead pipe for the same application.