

Lead in Modern Chemical Construction

What you should know about the various types of lead construction, if you use lead in your processing or have plans for doing so.

KEMPTON H. BELL

The latest techniques and improvements which have passed the test of actual industrial application in the chemical process industries 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 acidproof brick with an impervious lead interlayer.

SHEET LEAD CONSTRUCTION

Lead in the form of sheet supported in a steel or wooden framework, or a steel or wooden shell lined with sheet lead are the two principal methods of sheet lead construction. The latest developments in both methods, generally termed cage construction and lead lined construction, are described in detail below. Actually there are probably as many modifications as there are applications for both types of construction, for they are the oldest methods of using lead as a material of construction. But despite their antiquity, they 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 may 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, chromizing and copper plating, acid storage, manufacture of a wide variety of chemicals—are among the common applications of sheet lead linings.

CAGE CONSTRUCTION

The first chambers for the manufacture of sulphuric acid were of cage construction, simply large sheet lead

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beams supported by timber. 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 Kalk-Friedrich system for suspending the lead while at the same time permitting freedom of movement is illustrated (p. 243).

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 acid dilution. Heat 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 lead 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.

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 usage and have been for many years. Storage vessels for corrosive acids, chromizing and copper plating tanks, an-

odizing tanks, tanks for electrolytic refining of lead, zinc and copper, chemical reaction vessels, packing 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 other words, by lining any old but structurally sound vessel with lead, it becomes unnecessary to construct an entirely new one, thus eliminating the extra costs of labor and materials.

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 16 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. A press of the gun's trigger applies welding current for a preset amount of time. The stud has a small recess at its end which contains the flux necessary for welding. A ceramic ferrule over the end of the stud confines the arc to a limited space, giving a shielded arc effect. Portable motor-generator sets or battery-powered units provide current for the arc.

The stud may be welded directly through preset 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 cut). After bolting the strap, a lead strip is placed

ent the steel and welded securely on each side to protect the steel from corrosion. Straps are usually placed on 18-in. centers, occasionally 12 in., but never more than 24 in.

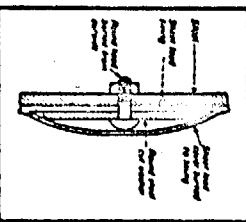
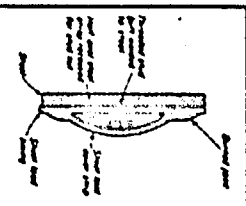
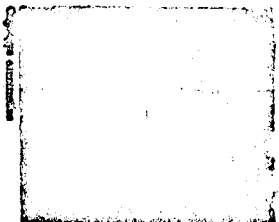
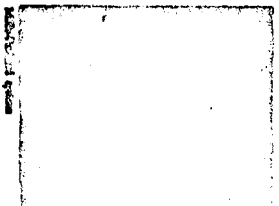
Once it is determined to use a lead-lined container, the lead must be of the correct thickness and be bonded to the lining. This tends to distribute the lead over a large area and thus avoid the concentration of lead in one place. The lead must be the correct lining and must be bonded to the steel.

Exact lead for lining of types, design and size of container or vessel must usually come in rods ranging from 8 to 12 ft wide and up to 40 ft long, depending upon the thickness of the lead. Lead is sold in coils, usually 20 ft. Thickness varies from 1/32 in. to 1 in., or more, in the practice procedure for the lead industry is 1 lb to 120 lb (lead 1/64 in. thick weighs about 1 lb. per sq. ft. and is designated 120). In chemical containers, lead is sold in coils that are 12 in. wide and 12 ft long.

Lead or lead lining can be used in a variety of ways.

A non-destructive method of testing lead lining and welds requiring no electrical equipment and involving only the experience of the chemist is the use of the lead lining test. The test is performed by exposing the surface of the lead lining to a radioactive source, such as a lead-210 source, and measuring the radiation emitted. The radiation is measured by a Geiger counter and the results are compared to a standard. This method is used for testing lead lining in a variety of containers, including those used for the storage of radioactive materials.

Lead-Lined Containers



Lead lining is used in a variety of ways. It can be used to line the interior of a container, or it can be used to line the exterior. Lead lining is used to protect the container from corrosion, and it is also used to protect the container from radiation. Lead lining is used in a variety of containers, including those used for the storage of radioactive materials.

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Attaching

In attaching a lead and lead lining to a container, the lead must be bonded to the container. This is done by using a bonding agent, which is applied to the lead and the container. The bonding agent is then cured, and the lead is bonded to the container.

A lead lining is applied next after removing all lead or other previous lining from the container. The lead lining is applied in a variety of ways, including the use of a bonding agent, the use of a lead lining machine, or the use of a lead lining manual.

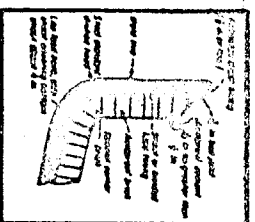
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film scraped with special tools until a uniform thickness is obtained. Peeling may or may not precede the scraping.

A new method has been successfully adapted for testing bonded lead piping to detect the presence of unbonded areas. The completely bonded vessel is sealed and heated internally by means of an appropriate hot air blower system so as to raise the temperature of the shell to about 400 deg. F.

If any non-bonded areas are present, a thin film of air trapped in this case expands and raises a conspicuous bubble in lead. It is a simple matter, after cooling, to inspect the vessel for the presence of bubbles and re-bond these areas by hand.

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 may include wall thicknesses of any size and cross sections of practically any shape. The largest commercial lead extrusion currently made is 12 in. inside diameter.

Joints in lead pipe may be of the Van Stone type made by butting together flanged sections and securing them with two bolted cast iron or steel slip-on flanges. They may also be butted 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 cooling 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 may 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.

One of the latest lead coil developments is a heat exchanger consisting of two lead pipes, one within the other. The larger pipe has an inside diameter of 2 in. with $\frac{1}{8}$ in. wall and is extruded from 6 percent antimonial lead. The inside pipe made of soft lead is 1 in. diam. with a $\frac{1}{8}$ in. wall at the thin portions. 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 to exact 11 ft. in circumference and 27 coils high. 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 trip hangers or by laying it in steel channels or by using lead lined pipe. Steel or iron pipes lined with lead are used to advantage where pressures exceed 50 lb. steam (298 deg. F.) or the expense of supporting the pipe by other means is disproportionate. Lead lined pipe is commercially available from 1 in. to 12 in. in diameter, the lead lining thickness ranging from $\frac{1}{8}$ in. to $\frac{1}{2}$ in.

BONDED LEAD 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 is first cleaned and flared. Then molten lead is cast on in sections by rotating 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 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 deg. F. vacuum, high pressure, vibration or physical shock and, of course, the handling of corrosive chemicals. Pipe sizes range from $\frac{1}{2}$ in. I.D. to 12 in. I.D. with lead lining thickness either $\frac{1}{8}$ in., $\frac{1}{4}$ in. or $\frac{1}{2}$ 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 is length of about 10 ft. is cleaned and flared 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 pressure 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.

Formula for calculating the theoretical over-all coefficient of heat transfer for bonded lead covered copper:

$$U = \frac{1}{\frac{1}{K} + \frac{1}{K_c} + \frac{1}{K_s}}$$

Where:

U = theoretical over-all coefficient heat transfer coefficient, Btu./sq. ft./°F., K = conductivity of lead wall per in. (use 240), K_c = conductivity of copper wall per in. (use 2680), X = thickness of lead wall in inches, Y = thickness of copper wall in inches, h = steam film (use 1,000), h_l = liquid film (use 300).

Formula for calculating the area of heat transfer surfaces for bonded lead covered copper:

$$A = \frac{H}{U \Delta T}$$

Where: A = area of heat transfer surface in sq. ft., H = total heat load, Btu. per hr., U = overall rate of heat transfer, Btu./sq. ft./deg. F., ΔT = mean temperature difference between the hot and cold fluids, in deg. F.

For heating coils:

$$\Delta T = \text{steam temp. (°F.)} - \left(\frac{\text{starting + finished temp. of out.}}{2} \right)$$

For cooling coils:

$$\Delta T = \left(\frac{\text{starting + finished temp. of in.}}{2} \right) - \text{cooling water temp.}$$

Lead bonded steel coil support lugs are commercially available to eliminate the sagging of cool lead legs after prolonged operation at elevated temperatures. —Lead