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LEAD INDUSTRIES ASSOCIATION

420 LEXINGTON AVENUE

NEW YORK 17, N. Y.

METALLIC LEAD PRODUCTS DIVISION

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December 8, 1954

Lead Chemical Construction
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Attached is a reprint of the section on lead and lead alloys prepared by the Lead Industries Association and published in the October issue of "Industrial and Engineering Chemistry," official publication of the American Chemical Society.

The enclosed section is part of the Eighth Annual Materials of Construction Review. Additional copies are available as long as our supply lasts.

Yours very truly,

Robert L. Ziegfeld

Robert L. Ziegfeld
Secretary.

N3091

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LEAD AND LEAD ALLOYS

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Lead and Lead Alloys

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The lead supply situation continues much as it was last year. Physical and mechanical properties of lead and lead alloys, particularly creep characteristics, have been determined. The effects of purity and additions of antimony, tin, copper, arsenic, bismuth, zinc, magnesium, calcium, tellurium, thallium, and silver on the creep characteristics of lead were investigated. New engineering applications of bonded or clad lead linings on steel and copper were described. The performance of lead equipment in the handling of liquid alum and other corrosives was covered along with some applications for lead in modern architecture where resistance to atmospheric corrosion is paramount. Lead metalizing as a means of prolonging the service life of steel equipment exposed to sulfuric acid was described. The use of lead for radiation protection was compared with other possible shielding materials. The technique of using a cartridge powered stud driver for anchoring sheet lead and steel strapping to steel or concrete vessels has been put to practical use in the field resulting in substantially reduced sheet lead lining erection cost. Corrosion performance and other characteristics of lead-tin alloy coated strip steel were described along with several patents facilitating the manufacture of bonded lead-lined equipment, bonded lead covered pipe, and the lead coating of ferrous objects.

MARKET conditions are such that the users of lead are assured a continuing supply free of government restrictions and at a price competitive with other materials of chemical construction. In fact, the current potential supply of lead is actually in excess of what is being consumed.

Noteworthy technical advancements have been made in the installation of lead, particularly in strapped sheet linings and in utilizing lead claddings whereby the corrosion resistance of lead can be combined with the working strength of steel or conductivity plus strength of copper. A number of excellent papers on the behavior of lead and lead alloys in engineering applications have been published.

RESEARCH PROGRESS

Lead Alloys. Hopkins and Thwaites (11) of the British Non-ferrous Metals Research Association laboratories showed that if 99.994% pure lead is used to make a 1% antimonial alloy, no age hardening effect can be produced. In the course of an investigation of the creep and fatigue properties of lead and lead alloys, a binary alloy with 0.85% antimony was extruded from a specially refined billet. Impurities detected in the lead amounted to only 0.0006%. No estimates of oxygen content were made.

After extruding the alloy as rod and aging it at 20° C. no hardening was observed even after 12,000 hours at 175° C. and water quenching. In fact, it did not age harden even after 20,000 hours at 30° C. or 770 hours at 100° C.

According to Hopkins and Thwaites neither tin nor copper added in amounts of 0.01% to the pure alloy produced any detectable age hardening. On the other hand, as little as 0.001% arsenic caused age hardening to proceed as effectively as it does in commercial alloys. The addition of 0.001% arsenic, moreover, had just as great an influence on the rate of age hardening as had larger amounts to 0.02%. The only other element that induced age hardening was silver, but it was possible to produce some hardening by prestraining the specimens.

Simon and Jones (4) of the Naval Research Laboratory in dealing with microsegregation in antimonial lead alloys were particularly concerned with the effects of microstructure on the corrosion of lead antimony alloys and of nearly pure lead when used as the plates of lead-acid batteries. With as little as 0.01% antimony, there was pronounced segregation in slowly cooled alloys. Only chill cast alloys showed a normal eutectic structure and of the chill cast samples only those containing 12% antimony showed 100% eutectic in the microstructure. Slowly cooled alloys, on the other hand, never showed a normal eutectic structure, whatever the composition.

Research progress in antimonial lead alloys was summarized in two issues of *Metal Industry* by Recorder II (21, 22). The investigations of Hopkins and Thwaites and Simon and Jones were reviewed and correlated with that of previous investigators.

Lohberg (19) surveyed the relationship between the melting point of various nonferrous alloys and the temperature at which creep begins. The various means by which creep resistance can be increased are reviewed. Studying the effect of alloying additions on lead alloys showed that antimony and bismuth in the order of 0.1% each affect the creep resistance of lead unfavorably or not at all. The more favorably reacting metals include zinc, magnesium, and calcium which are dissolved by lead only in quantities of less than 0.1%. The improvement in creep with copper is remarkable, requiring less than 0.005%. The paper is of the review type and does not represent an original investigation.

Gofkins (8) investigated the influence of thallium additions on the creep of lead. Variations in creep characteristics with thallium concentrations of 0.5%, 0.5 to 8%, over 8%, and 40.5% are plotted.

Loten (15) conducted tests both at constant internal pressure and at constant hoop stress on lead and lead alloys in the form of pipe. The results provided some indication of the effects of alloy additions, grain size, and prior deformation on fracture, ductility, and creep of lead cable sheath alloys. Some alloy additions, notably antimony (0.25%) and tellurium (0.01%), appear to promote considerable embrittlement at slow creep rates.

Atkinson and associates (1) described the creep and fatigue characteristics of a new arsenical tin-copper-lead alloy used for cable sheathing.

	%
Arsenic	[illegible]
Tin	[illegible]
Copper	[illegible]
Silver	[illegible]
Bismuth and Antimony	[illegible]
Lead	Balance

At a given stress the creep rate for this alloy is lower than for a common copper-lead alloy. The creep rate at hoop stresses below 370 pounds per square inch is not greatly affected by variations in heat treatment which produce a tensile strength in the range between 2200 and 3700 pounds per square inch. Addiproper leverage for drilling. Stud driving, on the other hand, takes approximately 2 minutes per hole for loading the gun and shooting the rivet after the setup, making a total of only 4 minutes per hole or a time saving of more than 70%. Furthermore, marking time can be cut considerably because in driving studs, it would not be necessary to adhere to a specific spacing. Studs can be driven virtually at random.

Special "button nuts" 2 inches in diameter have been perfected which eliminate the strapping as each nut can be tightened down against the lead with a spanner wrench. Of course, the steel buttons must be in turn covered with lead to prevent corrosion.

Metallizing or the spraying of metals, much as paint is sprayed, has gained considerable recognition as a means of improving the corrosion resistance of the less expensive but more readily corroded metals. An application where sprayed lead was used to particular advantage was described (17). It was concerned with steel battery boxes used for supporting lead-acid storage batteries where, because of the sulfuric acid electrolyte, unprotected steel became severely corroded in a short time. By metallizing with approximately 0.03 to 0.05 inch of lead, sufficient corrosion resistance was provided to enable steel to be used successfully. The article points out, however, that because of its porous nature, metallized or sprayed lead does not successfully serve as a substitute for sheet lead or bonded lead.

The shielded arc welding technique has been extended in one instance to the welding of lead flashings. A fabricator (23) of lead vent pipe flashing units found that shielded arc welding reduced production costs to one quarter the cost of methods previously used. Flashings were welded on a production line basis at an average speed of 30 inches per minute employing an electrode operated at 50 amperes. It produced smooth, uniform welds in lead while eliminating post-welding cleaning steps. However, as far as can be determined, no attempts have been made to apply this type of lead welding to commercial applications in the chemical process industries. Tests that have been conducted indicate definite shortcomings that may be overcome in the future.

Roehl (19) emphasized the superior corrosion resistance of lead-tin alloy coated strip steel. Referring to the 85% lead and 15% tin alloy deposited on strip steel from a recently developed fluoborate solution, he pointed out that strip steel thus coated offers several important fabricating advantages. The coating acts as a lubricant thus reducing wear on dies and forming rolls, its presence substantially reduces post-fabrication plating costs, and it offers excellent solderability. The paper is well illustrated with photographs of the coating operation.

Several British publications described a continuous lead casting machine designed and recently installed by the Fraser and Chalmers Engineering Works of the General Electric Co., Ltd. (4, 8?). The machine is being used by a chemical producer and has a capacity of 10 tons of pigs per hour. The machine comprises 88 molds, each holding 2 pigs of 84 pounds each. The molds form a continuous train around the track of the machine somewhat like the chain on a sprocket drive.

NEW PATENTS

Patents were applied for by Knapp Mills, Inc., covering a new method for extruding a bonded lead covering on copper or steel pipe (15). The company reports that the new process is being used to make tubes and rods in small diameters.

After bonded lead tanks are assembled from knocked-down sections and field welded, the welded area must be clad with lead. Since the upright and girth seams are in a difficult position, the work of lead cladding these areas has been tedious and expensive. Patents (19) have been applied for by Knapp Mills, Inc., covering a "walking mold" which molds a lead cladding over a steel weld. The use of this device reportedly simplifies the cladding technique and decreases the cost of this phase of the work.

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A U. S. patent (25) was issued covering a new method of lead coating ferrous articles. The process involves first electroplating a thin coating of tin between 0.000003 and 0.000018 inch and then heating the tin plated article to 450° F. to melt and transform substantially all of the tin to a continuous layer of iron-tin alloy. Finally the article is dipped in a molten bath of substantially pure lead.

NEW PUBLICATIONS

The Federated Metals Div. of the American Smelting & Refining Co. released a brochure (5) consisting of a comprehensive compilation of data on lead and lead products. Beginning with a description of lead's use as a construction material, the brochure gives the grades of lead used, characteristics and specifications of sheet, pipe, and special fittings including flanges, solid lead valves, and lead-lined valves. Lead welding and construction techniques are also described and illustrated with photographs and line drawings of recommended construction methods for sheet lead and bonded lead-lined installations and for heating and cooling coils. In addition there are handy reference tables and data on lead's behavior with various corrosives along with the important chemical, physical, and mechanical properties of lead and lead alloys.

The National Lead Co. published a brochure showing in considerable technical detail the applications of lead in the chemical industry with special emphasis on its excellent corrosion characteristics (24). Production techniques for all the common lead products, including sheet-lined equipment, pipe, coils, valves, fittings, pumps, lead-lined pipe and lead die castings, are described and illustrated. Cast hard lead and lead-lined valves are specially featured with exploded detail drawings, photographs, and mechanical specifications. Other lead products such as acid recovery equipment and lead bricks used in radiation protection are included in the brochure.

The St. Joseph Lead Co. published a similar booklet on lead (31). Essentially a reference brochure on the properties and applications of lead and lead alloys, the St. Joseph publication also goes into some detail on the use of these materials in architecture, chemical construction, plumbing, radiation protection, cable sheathing, ammunition, solder, bearings, type metal, batteries, tetraethyllead, paint, and glass.

The Lead Industries Association, since the publication of last year's Review, released three more in its series of *Lead Chemical Construction Bulletins*. *Bulletin No. 8* is a flow sheet showing the manufacture of high purity sulfur dioxide from roaster gases (2). The process is based on the absorption and subsequent stripping of sulfur dioxide in dimethylaniline and makes considerable use of lead chemical construction. For example the absorption towers are constructed of 12-lb., 4.5% antimonial lead erected in cage-type construction, the solution collectors are entirely of 45-lb. lead, and the stripping tower is of lead bonded or clad steel. Unique countercurrent lead pipe heat exchanger coils are illustrated and described.

Bulletin No. 9 reprints the Lead and Lead Alloys Section of the Seventh Annual Materials of Construction Review (1953) which appeared in INDUSTRIAL & ENGINEERING CHEMISTRY (30).

Bulletin No. 10 describes the use of the stud driver in the erection of lead linings.

The Interstate Commerce Commission (12) formulated and published amendments to their regulations for the transportation of explosives and other dangerous articles that became effective December 31, 1953. Some changes of interest to the chemical industry cover the transportation of phosphorus oxychloride, phosphorus trichloride, and thiophosphoryl chloride so as to now include tank motor vehicles when the tanks are lead-lined.

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