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NEW YORK 17, N. Y.

METALLIC LEAD PRODUCTS DIVISION

see Chemical Bulletin No. 65

November 26, 1956

LEAD CHEMICAL CONSTRUCTION
BULLETIN NO. 17

SUBJECT: TENTH ANNUAL MATERIALS
OF CONSTRUCTION REVIEW
(1956)

Attached is a reprint of the section on Lead and Its Alloys, prepared by the Lead Industries Association and published in the September, 1956 issue of "Industrial and Engineering Chemistry," official publication of the American Chemical Society. The section is part of the Tenth Annual Materials of Construction Review.

Additional copies are available as long as our supply lasts.

Very truly yours,

Robert L. Ziegfeld

Robert L. Ziegfeld
Secretary

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Reprinted from INDUSTRIAL AND ENGINEERING CHEMISTRY, Vol. 48, Page 1731, September 1956

I/EC CHEMICAL ENGINEERING REVIEWS

MATERIALS OF CONSTRUCTION

Lead and Its Alloys

THE lead supply continued plentiful and at a reasonable price. Of basic interest to both lead producers and consumers was the final adoption of revisions by the American Society for Testing Materials of the ASTM Standard Specification for Pig Lead (B29-55). The revisions were brought about by the fact that some of the grades that had been listed have not been commercially available for some time. Table I shows the new pig lead designations and specifications, according to B29-55 (2).

Engineering Advances

Putnam and Roare (46) describe plating and control procedures and the solution developed to plate lead-base alloy containing 11% tin and 7% antimony.

Glander (17) tested the extrusion properties of lead-antimony alloys for cable sheaths and found that the extrusion pressure is reduced by 7% through addition of 0.06% copper.

Keil (28) described soft solders for special purposes covering binary and ternary alloys of cadmium, lead, tin, and zinc. Fluxes and special effect of copper and silver additions are included.

Sprengler (51) covered the properties and applications of low melting metals and alloys. Indium and cadmium alloys are included in the group of low melting alloys based on bismuth, lead, and tin.

Kloss (30) elaborated on the fundamentals of welding nonferrous heavy metals and their alloys, including suitable welding processes for lead and lead alloys.

Cannon (8) modified the standard metallographic specimen preparation procedure for application to lead and other soft metals based on the use of alpha- and gamma-alumina abrasives.

Smelting and Refining. Davey (12) proposes a new process for continuous desilverizing of lead which is claimed to have advantages over the Williams process.

Fenzi (14) describes a new method for extracting silver from lead-zinc-silver alloys obtained by the Parkes process. Zinc is separated by melting the alloys with sodium hydroxide at low temperature. The silver-bearing lead obtained is then cast into anodes and electrolytically refined using a sulfamic electrolyte.

De Sousa Santos (50) described the softening of lead bullion with arsenic content between 0.9 and 1.9%, antimony 0.2 to 0.4%, and low tin. Oxygen injection was the principle of the method employed.

Bucchieri (6) described a quantitative spectrographic control of the drossing process during lead refining.

Hewett (22) described the ore treatment, smelting and refining of lead, and covered some manufacturing techniques such as cable sheathing, rolling, and lead pipe fabrication and welding.

Mackertoom (35) showed how the capacity of a lead smelter was increased twofold by lowering the hearth on the blast furnace and converting to single-pass sintering.

Gorts and Debbrecht (18) described a method for determining lead in lead sulfide ores and concentrates.

Campbell, Block, and Fugate (7) showed by means of a laboratory-scale process how lead-tin alloys can be recovered from wet solder dross skimmings. Feasibility of recovering zinc chloride as well as 92% of the metal values in the dross are given.

Thews (55) described modern refining methods for lead scrap and babbitt-metal scrap using alkalies as flux and refining with sodium. The recovery of tin and antimony from alkali slag is included.

Jenarn (27) described German lead smelter operations citing roasting, blast furnace smelting, lead refining, and by-product treatment. Data on annual smelting capacity are also included.

Haney and Hopkins (20) showed that increasing the specific surface of the sinter results in an increase in the rate and degree of sinter reduction in a lead blast furnace shaft.

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KEMPTON H. ROLL, secretary of the Metal Powder Association (formerly technical director, Lead Industries Association), has been our review author for Lead and Lead Alloys since 1953. Roll, a metallurgical engineer, attended Carnegie Institute of Technology, received the degree of B.S. from Yale University and M.S. from the Polytechnic Institute of Brooklyn. He is past regional chairman of the National Association of Corrosion Engineers and 1956 general conference chairman. Roll holds memberships in IME, ACS, ASTM, AIChE, AIME, SAE, and is vice chairman of the New York Section of the American Society for Metals.

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Bell, Turner, and Peters (*4*) calculated the zinc oxide activities in typical lead blast furnace slag to assess the probable effect of fuel composition, oxygen enrichment and preheating on efficiency, and capacity of slag-fuming.

Research Progress

Gates and Mathers (*15*) showed that organic lead sulfonates are suitable for lead electroplating because they are stable, easily prepared, sufficiently soluble in water, and their aqueous solutions satisfactorily conductive.

Heidenreich (*21*) investigated by electron metallography the transition structure of lead-silver alloys (0.007 to 0.25% silver). The possibility of mass transport of solute to grain boundaries by means of dislocations is advanced to explain accelerated silver precipitation in grain boundaries.

Tiller and Rutter (*55*) determined the theoretical and experimental factors affecting the modes of solidification of lead-tin, lead-silver, and lead-gold alloys. They studied the changes in appearance of the solid-liquid interface during growth conditions and the effects of extremely small amounts of soluble impurities.

Vinarev and Druelle (*59*) studied the phenomenon of migration of zinc-lead eutectic in cast zinc.

Tenenbaum (*52*) gave the analysis and properties of nonferrous die-casting alloys including lead and tin-base alloys with recommendations for their selection, handling, and melting.

Lundberg (*34*) described the effect of nuclei and crystal growth in a variety of alloys including the addition of sulfur to antimonial lead.

Dewey (*13*) examined the boundary layers of lead-tin alloys and confirmed previous observations which indicated an eutectic casting surface.

Thomsen, Yang, and Bierbower (*54*) reported on an experimental investigation of the mechanics of plastic deformation of metals basing their conclusions on the extrusion of a billet of commercially pure lead at room temperature using an inverted extrusion process. They described the technique for obtaining infinitesimal strain or strain rate and stress distributions in axially symmetrical metal parts.

Turnbull and Treaftis (*56, 57*) interpreted the precipitation of tin from lead and developed a theory of "cellular precipitation." They found that the precipitation takes place in two distinct stages: the first stage is a fast reaction that drains about 60% of the thermodynamic excess of tin from the solution; the remaining 40% is drained at a rate of about two-order magnitude slower than the fast reaction.

Pink (*45*) gave the activity coefficients of lead, cadmium, zinc, tin, and bismuth in liquid ternary solutions.

Winter and Drickamer (*61*) measured the thermal diffusion of binary liquid metal mixtures containing 50 mole % of each component including gallium, cadmium, zinc, tin, lead, bismuth, and mercury. The results are totally consistent with previously presented theory. The separations depend on the activation energy density of components. Results are also given for three ternary mixtures.

Pelzel (*44*) determined the solubility of copper, nickel, and cobalt in molten lead. The solubility curves are determined from which the entropy of melting is calculated.

Hoffman, Turnbull, and Hart (*24*) measured the effects of solute additions on silver and the rate of self diffusion of lead in silver-lead alloys to determine whether there is rapid lead-silver interchange.

Gebhardt, Becker, and Trageser (*18*) described the viscosity of magnesium-lead alloys, primarily the effect of temperature and concentration. Viscosity decreased with decreasing temperature in all cases.

Grace and Derge (*19*) measured the diffusivity of bismuth in liquid bismuth-lead by the capillary reservoir method as a function of temperature and composition. Fair agreement is reported between theory and experiment for

Table I. Chemical Requirements for Pig Lead[a]

	%			
	Corroding lead[b]	*Chemical lead*[c]	*Acid-copper lead*[d]	*Common desilverized lead*[e]
Silver				
Max.	0.0015	0.020	0.002	0.002
Min.	...	0.002	...	...
Copper				
Max.	0.0015	0.080	0.080	0.0025
Min.	...	0.040	0.040	...
Silver and copper together, max.	0.0025	...	...	...
Arsenic, antimony, and tin together, max.	0.002	0.002	0.002	0.005
Zinc, max.	0.001	0.001	0.001	0.002
Iron, max.	0.002	0.002	0.002	0.002
Bismuth, max.	0.050	0.005	0.025	0.150
Lead (by difference), min.	99.94	99.90	99.90	99.85

[a] From ASTM Standard Specification B29-55.
[b] Corroding lead is used to describe lead which has been refined to a high degree of purity.
[c] Chemical lead is used to describe the undesilverized lead produced from Southeastern Missouri ores.
[d] Acid copper lead is made by adding copper to fully refined lead.
[e] Common desilverized lead is used to describe fully refined desilverized lead.

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diffusion coefficients, activation energies, and viscosity in low lead alloys.

Weertman and Salkovitz (60) measured the internal friction and Young's modulus for a series of single crystals of lead containing 0.01 to 0.1% of either bismuth, tin, or cadmium. They found that friction was independent of the strain amplitude up to the critical strain amplitude, at which point friction increased and the modulus decreased with further increase in strength.

Kunz and Holden (31) irradiated single crystals of lead at room temperature and described the effects on mechanical properties. The flow stress of lead crystals remained unchanged while that of iron and zinc increased after exposure.

Hogan (25) analyzed the existing lead creep data from the standpoint of absolute rate theory. He studied the influence of alloying elements and other factors upon mechanical properties of lead and concluded that the absolute rate theory provides an excellent hypothesis for engineering applications of the creep of lead.

Kanderer (5) discussed the physical and mechanical properties of bearing metals including lead-base alloys and lead bronzes.

Heat capacities of liquid lead-tin alloys made on a new high temperature reaction calorimeter were given by Kleppa (29).

Corrosion Studies

Markovic (36) discussed the decomposition mechanism of hydrogen peroxide on lead, covering the influence of surface condition on the rate of corrosion. Based on chemical and x-ray analyses, the author attributes the mechanism of hydrogen peroxide decomposition to the formation of higher lead oxide (PbO_2).

Markovic and Dugi (39) tested to determine the passive and active behavior of lead in salts. They give the effects of various chemicals including carbon dioxide, carbonates, chlorides, and sulfates.

Mannchen and Baumann (35) describe the absorption of hydrogen by lead and lead alloys containing magnesium and calcium. They found that lead does not dissolve hydrogen, on the other hand, lead-magnesium alloys increase the absorption of hydrogen in proportion to the magnesium content.

Carr and Company (9) described the nature of a lead surface passivated in sulfuric acid. They showed that the rate of establishment of the electrochemical potential of lead passivating in the sulfuric acid is markedly dependent on the concentration of hydrogen peroxide, either formed by irradiation or added directly to the system.

Markovic (37) reported on an investigation of the corrosion of lead in distilled water, covering the influence of the rate of the diffusion of oxygen and the formation and nature of lead hydrides, such as Pb_2H_2, PbH_2, and PbH_4.

Hoffman and Manley (23) compared sodium, lithium, and lead as heat transfer media from the corrosion standpoint and described liquid metal corrosion mechanisms.

National Association of Corrosion Engineers Task Group T-4B1 on the Corrosion of Lead and Other Metallic Cable Sheaths issued a third interim report which cited examples of concentration cell corrosion on lead-cable sheaths (41). Attack on a lead-cable sheath by differential aeration cell action is illustrated. Another example of unusual corrosion which may be considered as a type of concentration cell action is also illustrated.

A selected bibliography of articles covering the period 1937-1954 on corrosion products of lead and lead alloys was published by the National Association of Corrosion Engineers Technical Unit Committee T-3B (47).

Testing and Inspection

The inspection and testing of all types of equipment used in chemical construction has become more significant with the advent of more severe service conditions. More costly vessels, coupled with the dangers of breakdown and the expense of production shut-downs, have caused attention to be focused on testing and inspection procedures. While many techniques have been perfected for use on steel- and ferrous-alloy materials and described in detail in the literature, Roll (45) covered for the first time specific methods for testing and inspecting sheet-lead linings, bonded-lead linings, and brick-lead linings. Emphasizing the primary importance of a well-trained lead-burner as the first means of preventive inspection, Roll also described the fluorescent penetrant and dye penetrant techniques for detecting weld imperfections or minute perforations in

"The high level of industrial activity during 1955, which brought about an expansion of chemical processing facilities, created a substantial demand for lead as a material of construction for the chemical process industries. All indications point to a continued expansion of the chemical industry in 1956 and consequently it is expected that the heavy demand for lead will be maintained. Lead continues to be regarded as the most satisfactory and economical material for handling many chemicals."

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sheet lead linings. Other special techniques included the use of carbon tetrachloride or Freon-air mixtures and Halide torches. For bonded-lead linings the acid wash test in common use by most lead-burning contractors was described along with the location of bond discontinuities by mechanical means and by ultrasonic tests. Roll also described the applicability of radiographic testing on brick and lead-lined vessels reporting on the work done by Stuba and Bracken (49) in this field.

New Publications

The Lead Industries Association issued three more in its series of Lead Chemical Construction Bulletins. Bulletin No. 14 is a reprint of the "Lead and Its Alloys" section from the Industrial and Engineering Chemistry, Materials of Construction Review for 1955 (47). Bulletin No. 15 is a reprint of Roll's (48) paper on inspecting and testing lead linings presented before the Society for Nondestructive Testing, October 1955. Bulletin No. 16 is a reprint of a series of three articles appearing in the March, April, and May 1956, issues of *Chemical Engineering* which report in detail the practical experience of a large user of lead for chemical construction. The series is entitled "Best Designs for Lead Installations" (10).

The Association also issued Red Lead Technical Letter No. 10, "L.I.A. Formula 3-7, A Red Lead Alkyd Vehicle Primer for Industrial and Marine Environments" (33).

The U. S. Bureau of Mines issued a handbook on accident prevention in nonferrous metallurgical plants (58). Plant procedures and practices, hazards and safeguards, type, source, and cause of accidents are covered in addition to the possible means of preventing accidents in each of three sections dealing with smelters, refineries, and reduction plants.

Radiation Shielding. *Nucleonics* (42) issued a report on portable radiation shielding materials with particular emphasis on lead bricks and high density lead glass, listing types and sizes available and sources of supply. The Lead Industries Association reprinted for distribution a chapter on radiation protection from its book, "Lead in Modern Industry" (32). This covered both x-ray and nuclear-ray protection. The Oak Ridge National Laboratory issued a pamphlet describing "Radioisotope Containers Used by Oak Ridge National Laboratory" (43). It covers both disposable and returnable containers, most of which depend upon lead for protective shielding. The Atomic Energy Commission issued a book, "Reactor Shielding Design Manual," based on the techniques and data developed in the Naval Reactors Program (3). This manual is very comprehensive and includes methods of fabrication and installation for both lead shields and composite shields of lead and other materials. In discussing the comparative effectiveness of various materials for gamma radiation, the book states

Comparisons are usually expressed in terms of lead because it represents the best practical gamma shield material for most applications.

Huppert (26) reviewed the literature on light metal enameling with particular emphasis on the lead bearing, low melting porcelain enamels most generally used for aluminum. The American Iron and Steel Institute (1) reported on the use of similar porcelain enamels for decorating stainless steel. Chase (11) described in detail the commercial application of these enamels to aluminum at a California enameling plant.

Acknowledgment

The author wishes to acknowledge the staff assistance of the Lead Industries Association in the preparation of the manuscript.

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Printed in U.S.A.