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Attached is a reprint entitled "Lead Reference Sheet" (parts 1 and 2) from the January and February 1955 issues of "Chemical Engineering Progress."

Part 1 covers grades and alloys of lead and their characteristics with special emphasis on their use as materials of chemical construction. Part 2 covers the corrosion characteristics of lead and lead alloys.

Additional copies are available free of charge as long as our supply lasts.

Yours very truly,

Robert L. Ziegfeld
Secretary

Reprinted from CHEMICAL ENGINEERING PROGRESS, January, 1955

lead reference sheet (part I)

Kempton H. Roll Technical Director, Lead Industries Association, New York

Grades of Lead:

Chemical lead, acid lead, and copper lead are the A.S.T.M. grades of lead most commonly used for corrosion resistant chemical construction. These three grades are distinct from antimonial lead (hard lead) and tellurium lead, used in chemical construction.

Antimonial Lead:

To ordinary lead to which has been added up to 12% antimony. Though this hardens and improves the mechanical properties, antimony lowers the melting point and does not enhance corrosion characteristics. At temperatures below 212° F., 6% antimonial lead has more abrasion resistance than chemical lead. At room temperature it has better the hardness and tensile properties, but at about 250° F. the mechanical strength of antimonial lead is no better than chemical lead and above this temperature chemical lead actually possesses equal or better mechanical characteristics.

Tellurium Lead:

Is chemical lead to which has been added approximately 0.04% tellurium to improve resistance to fatigue due to vibration. Tellurium retards grain growth and allows lead to work harden or strengthen itself under stress.

Applications:

Lead has long been widely used in the construction and protection of equipment for the production, transmission, storage, and use of corrosive chemicals. It is especially useful with all concentrations of sulfuric acid, sulfurous acid, chromic acid, phosphoric acid, and salts of these acids.

Forms:

In chemical construction lead is used chiefly in the form of rolled sheet, pipe or other extrusions, castings, or as a lead cladding on steel or copper. Either existing or specially constructed vessels of concrete, wood, or steel can be readily lined with sheet lead to make them suitable for handling corrosives. A thick layer of lead can be bonded to steel or copper as a cladding to combine the corrosion resistance of lead with the working strength of the base metal.

Valves and Castings:

As lead has a low melting point in combination with high density and corrosion resistance, it has had extensive use, particularly antimonial lead (4 to 6% Sb), as castings. Cast hard lead valves are standard items for handling liquid corrosives and include gate, check, diaphragm, standard Y, and split T body styles. In addition to cast hard lead valves, lead lined cast iron and lead lined cast steel valves are available commercially for use at higher pressures and temperatures. Lead castings are used in the chemical industry in the form of reaction vessels, evaporators, etc., usually made from 6% hard lead.

Mechanical and Physical Properties:

(All data apply to chemical lead.)

Tensile strength	2200 to 3000 lb./sq.in.
Elongation	40 to 50%
Brinell hardness	4.5 to 6.0
Density, rolled, g./cc.	11.35 to 11.39
Melting point	618° F.
Mean specific heat (B.t.u./lb./° F.) 68° F. to 618° F.	0.032
Thermal expansion (X 10⁻⁶ in./in./° F.) 32° F. to 212° F.	16.3
Thermal conductivity (cal./sq.cm./cm./°C./sec.) 68° F.	0.082
Creep (× 10⁻⁶, lb./lb. at 200 lb./sq.in.) 68° F.	0.4
Electrical conductivity (micro ohms/cu.) 68° F.	20.640

Heat Treatments:

Lead is a self-annealing metal, and therefore never needs heat treatment.

Weldability:

Easily joined in the shop or field by fusion welding, known as lead "burning". Methods uses no materials other than lead and thus insures that no metal less resistant than lead will be exposed to the corrosive. Eliminates the possibility of galvanic action between dissimilar metals. Should repairs be necessary, they are easily effected in the field.

Thickness:

Thickness of sheet-lead linings depends largely on the degree of corrosive attack or corrosion anticipated. Rarely is sheet lead lighter than 3 lb. per sq. ft. thick used in chemical equipment, thicknesses usually ranging between 10- and 20-lb. (3/32 in. and 1/16 in.) Frequently different thicknesses are used for different parts of equipment.

Type of Construction:

Lead sheet supported either in (1) a framework of steel or wood or (2) as a lining in a steel, concrete, or wooden vessel, are the two principal types of sheet lead construction. They are generally termed (1) cage construction, and (2) lead lined construction. In the latter, strap or spot bonding or lead-covered steel strapping are usually used to support the lead.

Operation at high temperature or the handling of corrosive chemicals which both corrode and erode most materials of construction has led to the development and practical acceptance of brick and lead linings, 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.

A lead clad or bonded lead lining, in effect, combines the corrosion resistance of lead with the working strength of steel. Lining consists of a layer of lead bonded to steel plate to form a homogeneous or integral metallic structure which permits operation at higher temperatures and in vacuum.

Lead pipe coating coils are commonly used. For heating crude copper pipe is covered usually with a lead cladding although lead pipe alone may be used up to 50 lb. steam pressure. Bonding a layer of lead to copper combines the corrosion resistance of the former with the heat transfer and higher strength of the latter. Steel pipes available with internal lead linings. Corrosive gases condensed usually in ducts fashioned from sheet lead supported in a strap iron framework.

Temperature Limitations:

Chemical lead melts at 618° F. At 250° F it possesses about half its normal strength. Spreading out the base temperature cycle in periodic operations substantially improves performance. Bonding lead directly to steel as in lead clad vessels or to copper as in lead-covered copper coils permits operation at higher temperature ranges. By providing an insulating layer of acid-proof brick over the lead, still higher temperatures may be successfully tolerated, 300° F. being not uncommon.

Chemical Compositions:

A.S.T.M. Pig Lead Specifications * for Chemical, Acid and Copper Lead

	Chemical Lead	Copper Lead	Acid Lead
Ag, Maximum	0.020	0.008	0.008
Minimum	0.002		
Cu, Maximum	0.002	0.080	0.040
Minimum	0.040	0.040	0.040
As, Sb + Sn, Maximum	0.002	0.002	0.015
Sn, Maximum	0.001	0.001	0.002
Fe, Maximum	0.002	0.002	0.002
Bi, Maximum	0.025	0.025	0.10
Lead, by Diff., Minimum	99.90	99.90	99.80

* A.S.T.M. Standard Designation B 29-49.

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lead reference sheet (part 2)

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Corrosion Characteristics of Lead

Lead relies for its resistance to corrosion upon a thin protective coating which forms on its surface. When the coating is one of the highly insoluble lead salts such as sulphate, carbonate or phosphate, resistance to corrosion is high and the environment generally promotes self-healing of the coating upon mechanical injury. On the other hand, if soluble films form such as the nitrate, acetate, or chloride, little protection is afforded and the lead may corrode further. Likewise, if insoluble protective coatings are removed mechanically, as by abrasion, or erosion, or dissolved chemically as in the case of some mixed corrosives, corrosion resistance is similarly reduced.

The manner of installation, proper design, and awareness of the exact service conditions are all important in lead chemical construction in order to minimize the mechanical limitations of lead and to take advantage in the best way of its superior corrosion characteristics.

CORROSION RESISTANCE*

ACIDS

Acetic, dilute	B
Acetic, glacial	F
Arsenic	A
Boric	F
Carbonic	F
Chromic	F
Fatty	A
Formic, concentrated	F
Hydrochloric, up to 20%	A
Hydrochloric, above 20%	F
Hydrocyanic	A
Hydrofluoric	F
Mixed acids	A
Nitric, dilute	B
Nitric, conc.	A
Oxalic, cold	F
Phosphoric	F
Salicylic	F
Sulfuric, below 90%	F
Sulfuric, above 90%	F
Sulfurous	F
Tannic, Conc.	F
Tartaric	F

ALKALIES

Ammonium hydroxide	F
Calcium hydroxide	F
Potassium hydroxide, up to 20%	A
Sodium hydroxide, up to 20%	A

ACID SALTS

Alum or Aluminum sulfate	F
Ammonium chloride, up to 10%	F
Ammonium fluoride	F
Ammonium phosphate	A
Bisulfates	F
Calcium acid phosphate	F
Chromates	F
Ferric chloride	B
Ferrous chloride	A
Nitrates	F
Phosphates	F
Sulfates	F

ALKALINE SALTS

Barium sulfide	F
Calcium bisulfite	F
Calcium carbonate	F
Phosphorus oxychloride	F
Potassium cyanosulfite	F
Sodium bisulfite	F
Sodium carbonate, dilute soln	F
Sodium chloride, dilute	F
Sodium hypochlorite	B
Sodium hyposulfite	F
Sodium sulfide	A
Sodium sulfite, up to 20%	F
Zinc hydrosulfite	F

NEUTRAL SALTS

Calcium chloride	A
Magnesium chloride	F
Magnesium sulfate	F
Sodium chloride	F

GASES

Acetylene	F
Ammonia, dry	F
Ammonia, wet	A
Bromine, cold	F
Carbon dioxide	F
Chlorine, dry	F
Chlorine, wet	A
Hydrogen chloride, dry	A
Oxygen, dry	F
Oxygen, wet	F
Sulfur dioxide	F
Sulfur trioxide	F

ORGANIC MATERIALS

Acetone	F
Acetophenone	F
Alcohol	F
Benzol, pure	F
Benzyl chloride	F
Benzyl phenol	F
Carbon tetrachloride	A
Chlorobenzenesulfonic, dry	A
Ether	F
Hexachlorbutadiene	F
Hexachlorethane	F
Naphthalene	A
Nitrobenzol	B
Nitrophenols	A
Pentachlorethane	A
Phenol	F
Pyridine	F
Urea	F

OXIDES

Antimony chloride	F
Hydrogen peroxide	F
Nitrous sulfide	F
Potassium permanganate	B

PAPER MILL APPLICATIONS

Alum	F
Chlorine bleach	A
Chlorine bleach	B
Sulfur dioxide	F
Sulfite liquor	F

PHOTOGRAPHIC INDUSTRY

General use	A

FERTILIZER INDUSTRY

General use	F
Superphosphate	F

STEEL INDUSTRY

Hydrochloric acid pickling	F
H_2SO_4–HNO$_3$ acid pickling	F
Sulfuric acid pickling	F

TEXTILE INDUSTRY

Rayon solutions	F

PLATING INDUSTRY

Anodizing	F
Chromium	F
Copper	F
Hard chrome	F
Nickel	F
Waste disposal	F

* Data applies to A.S.T.M. Chemical Grade Lead.

F—Excellent resistance. Corrosion so slight as to be harmless.

A—Good resistance. Satisfactory service expected.

B—Fair resistance. Satisfactory service under specific conditions.

C—Poor resistance. Satisfactory for temporary service only.

D—No resistance. Rate of attack too great for any use.

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