LEAD INDUSTRIES ASSOCIATION

420 LEXINGTON AVENUE
NEW YORK 17, N. Y.

METALLIC LEAD PRODUCTS DIVISION

See Chemical Bull. No. 52

June 1, 1953

LEAD CHEMICAL CONSTRUCTION
BULLETIN NO. 7

SUBJECT: LEAD AND LEAD
ALLOYS

Attached is a reprint from "Chemical Engineering," February, 1953, entitled "Lead and Lead Alloys." It covers the corrosion resistance of these materials of construction to more than 188 commercial corrosives with details about the forms available, fabrication methods and applications in the chemical process industries.

This is the latest and most comprehensive list of corrosives with data on the performance of lead.

As long as our supply lasts we will be pleased to send you additional copies for distribution to those whom you feel may benefit. 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

The Corrosion Forum Edited by Morgan M. Hoover

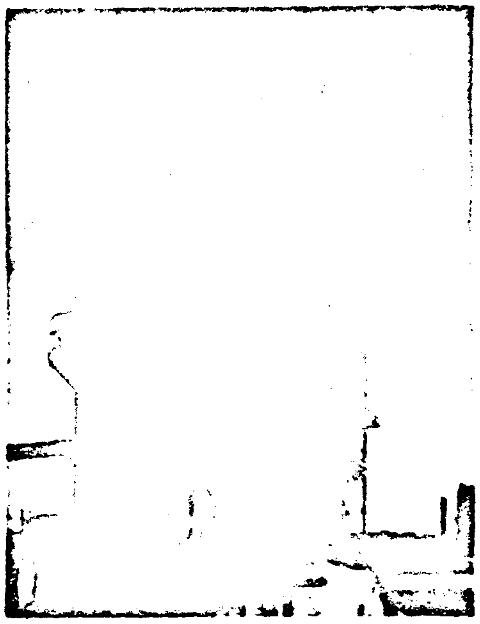

Fig. 1—SHEET LEAD supported in steel framework

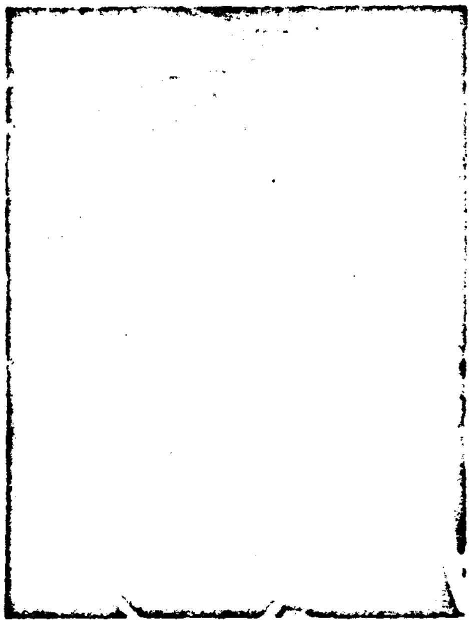

Fig. 2—LEAD PIPE in the form of coils

Lead and Lead Alloys

The corrosion resistance of these materials of construction to a number of corrosives, with forms available, fabrication, and applications in the CPI.

KEMPTON H. ROLL
Lead Industries Association, New York, N. Y.

More than one-third of the lead consumed each year in the United States is used for the prevention of corrosion.

Lead and many of its alloys are widely used in the construction of equipment for the production, transmission, storage and use of a variety of corrosive chemicals. Despite the development of other materials to compete with lead in these applications, its use for corrosives 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 resulted in improvements in construction and installation methods which have kept pace with developments in the chemical process industries.

Grades generally specified for chemical construction are chemical lead, acid lead or copper lead. They contain small percentages of silver and copper which have been found to add to the corrosion resistance of lead and to improve its creep and fatigue resistance.

Specifications*

		Chemical Lead	Acid Lead	Copper Lead
Ag	max.	[illegible]	[illegible]	[illegible]
	min.	[illegible]		
Cu	max.	[illegible]	[illegible]	[illegible]
	min.	[illegible]	[illegible]	[illegible]
As, Sb, Sn	max.	[illegible]	[illegible]	[illegible]
Zn	max.	[illegible]	[illegible]	[illegible]
Fe	max.	[illegible]	[illegible]	[illegible]
Bi	max.	[illegible]	[illegible]	[illegible]
Lead	min.	99.90	99.90	99.90

* A.S.T.M. Standard Designation (B 29-55) for pig lead.

CORROSION RESISTANT ALLOYS

Antimonial Lead—Antimonial or hard lead is lead generally containing from 1 to 12 percent antimony, usually about 6 to 8 percent. Antimony hardens and improves lead's physical characteristics up to about the boiling point of water. However, it lowers the melting point and, while it may not detract from lead's corrosion resistance, seldom does it improve it.

Tellurium Lead—Tellurium lead is chemical lead to which has been added about 0.04 percent tellurium. In extruded lead products, the presence of tellurium retards grain growth and increases fatigue resistance. Corrosion

Reprinted from Chemical Engineering, February 1958

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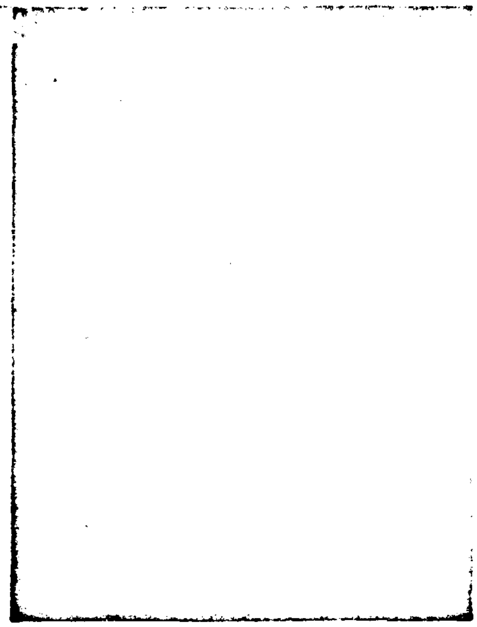


Fig. 3—CAST LEAD evaporator (8 percent antimonial lead)

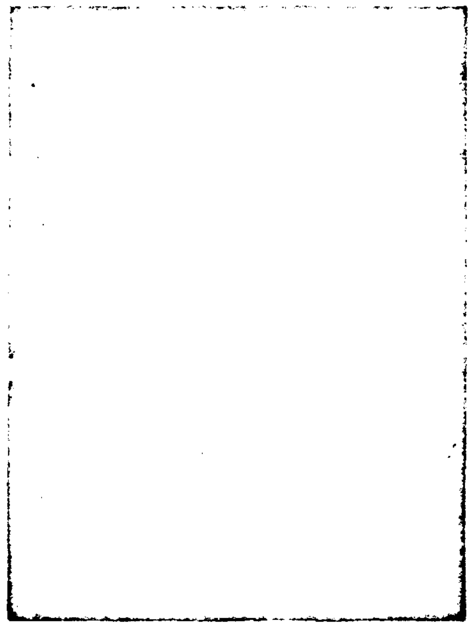


Fig. 4—LEAD CLADDING bonded directly to steel

resistance is comparable to chemical lead and in some instances is superior.

Other Alloys—There are several other lead base alloys that have been developed for handling special corrosives or for meeting special conditions of exposure. These include tellurium antimonial lead, 7 percent tin lead, calcium lead and others containing silver or other elements in fractional percentages. A number of these are proprietary and should be used in accordance with the recommendations of their manufacturers.

FORMS

Rolled Lead Products—Among the most generally useful lead and lead alloys products are those produced by cold rolling. Sizes may range in thickness from foil, 0.00035 in. thick, to sheet 2 in. thick or more, and may be rolled to any desired thickness. Sheet lead weighs approximately 1 lb. per sq. ft. for each 1/64 in. of thickness.

Sheet Lead Weight and Thickness

Approx. Lb. Per Sq. Ft.	Thickness, In.	Approx. Lb. Per Sq. Ft.	Thickness, In.
[illegible]	[illegible]	[illegible]	[illegible]

Sheets may be produced in widths up to 10 ft. and lengths up to 60 ft. depending upon thickness, but 10 ft. wide and 20 ft. long is usually considered standard. Lead sheets are available as strips or ribbons of various widths such as 12, 18 or 24 in.

Fig. 1 is an electrostatic precipitator for suppressing sulphuric acid mists. It is constructed entirely of sheet lead in a steel framework.

Extruded Lead Products—Lead and most of its alloys may readily be fabricated by the extrusion process. Joints may be made by welding, soldering or mechanically—the choice depending upon the use to which the pipe is put. Sizes may range from fine tubing [illegible] in. inside diameter and even less, to 12 in. or larger pipe, with almost any desired wall thickness. Either pure lead or alloys may be used. Fig. 2 illustrates how lead pipe is used as coils for cooling hot acid liquors. Note the cage or basket type vessel construction.

Cast Lead Products—Lead and certain of its alloys are excellent for castings providing high strength is not a requisite and they are not for use at temperatures higher than the melting point of the alloy. Casting qualities are excellent, the melting temperatures low, and corrosion resistance

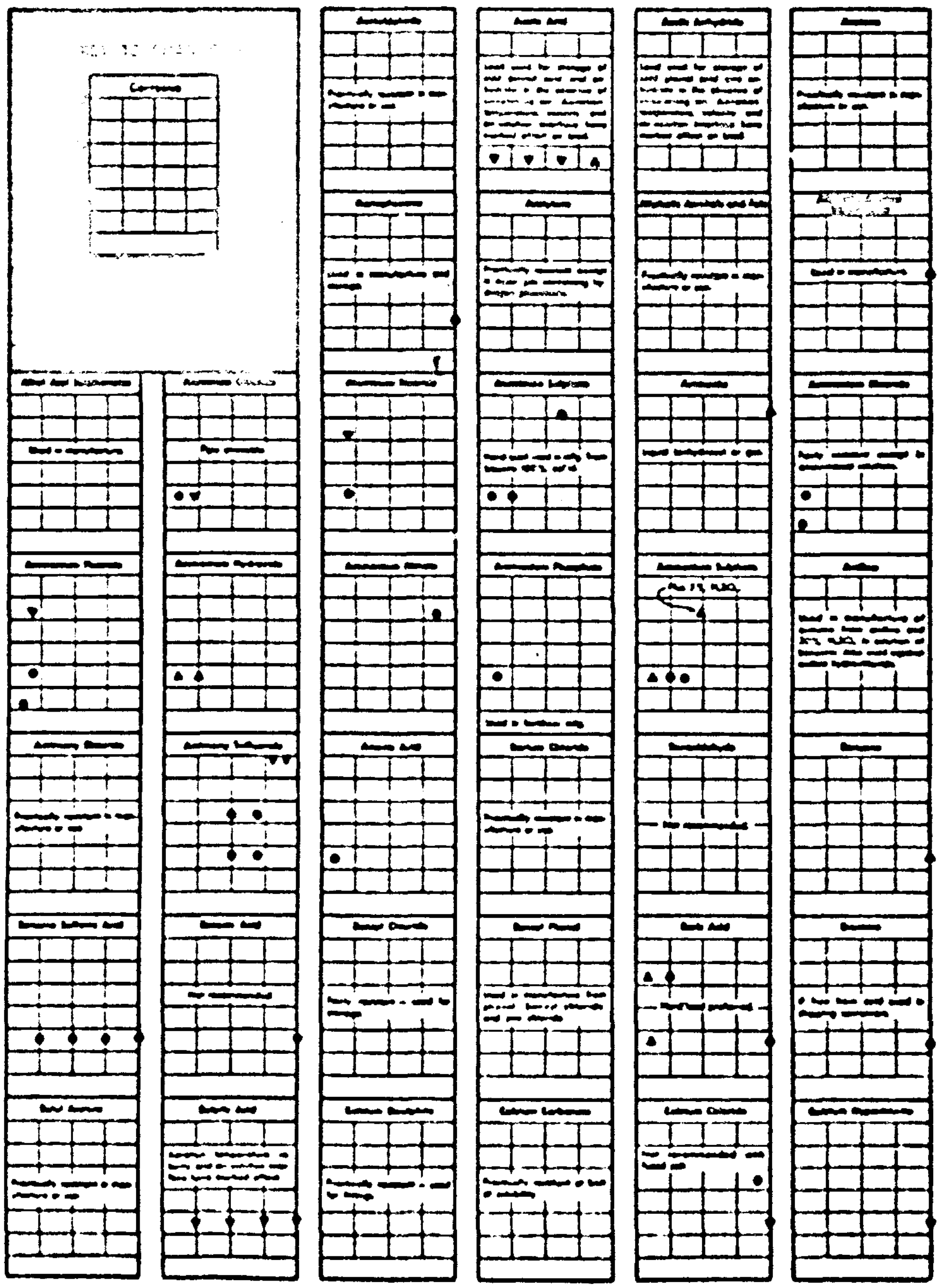
Lead Products Commonly Used in Chemical Construction

Bar lead
Bonded lead lined pipe
Bonded linings (cladding)
Cast lead valves, fittings and flanges
Castings
Die castings
[illegible] lead pipe
Extruded lead lined pipe
[illegible] anodes
Lead covered pipe
Lead lined valves, fittings and flanges
Lead rivets
Lead wire
Lead wool
Pipe
Sheet
Various extrusions
Various prefabrications
[illegible] and trays
Extruded electrodes
Lead covered copper electrodes
[illegible]
[illegible] and [illegible] coils
Heat exchangers
Laboratory fittings
[illegible]
[illegible] and trays

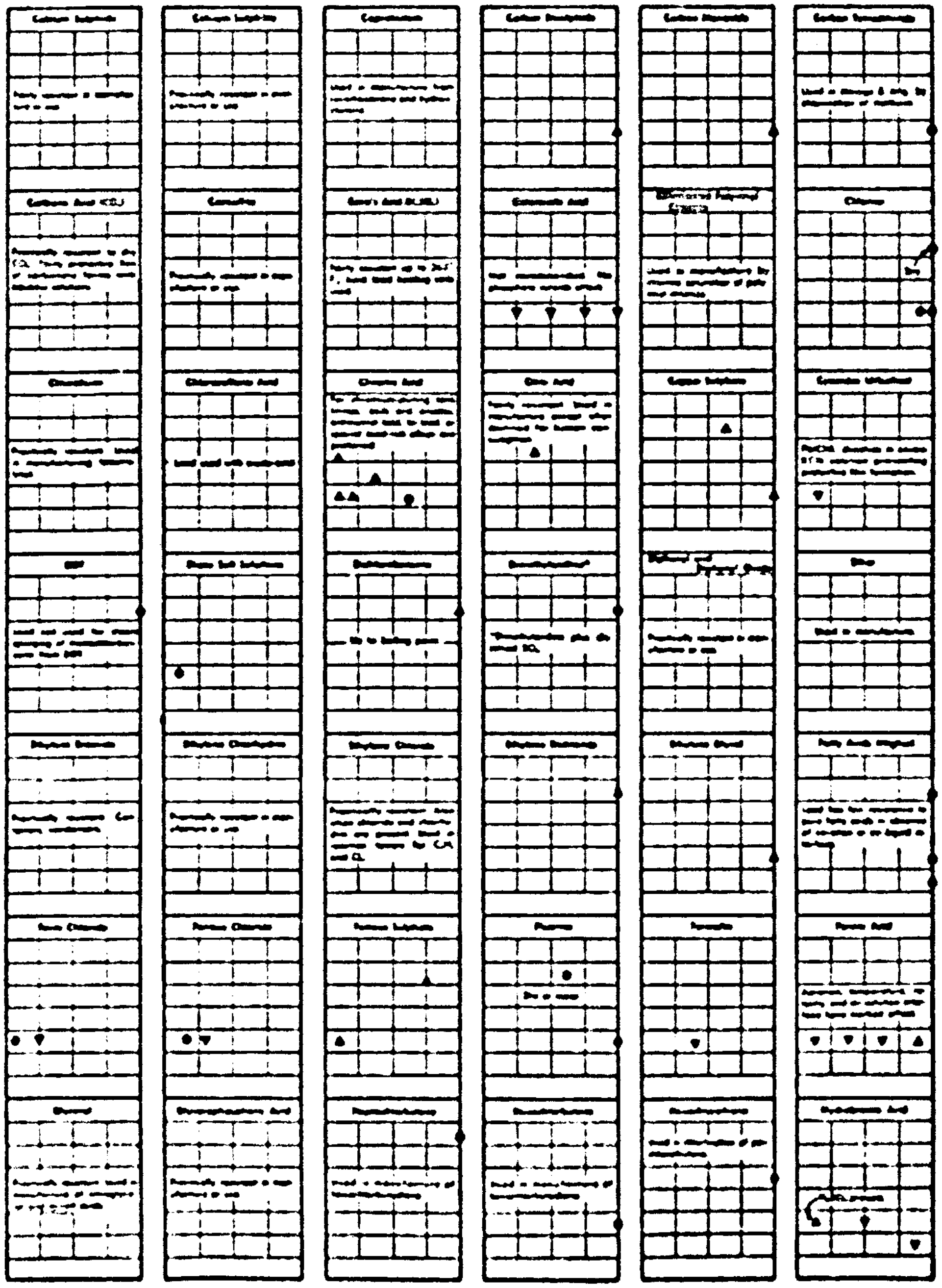
Typical Lead Protected Equipment Used in the CPI

Agitators
[illegible]
Electrostatic precipitators
[illegible]
([illegible] or plate and frame)
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible] scrubbers

Corrosion Resistance of Lead and Lead Alloys



Corrosion Resistance of Lead and Lead Alloys, *cont . . .*



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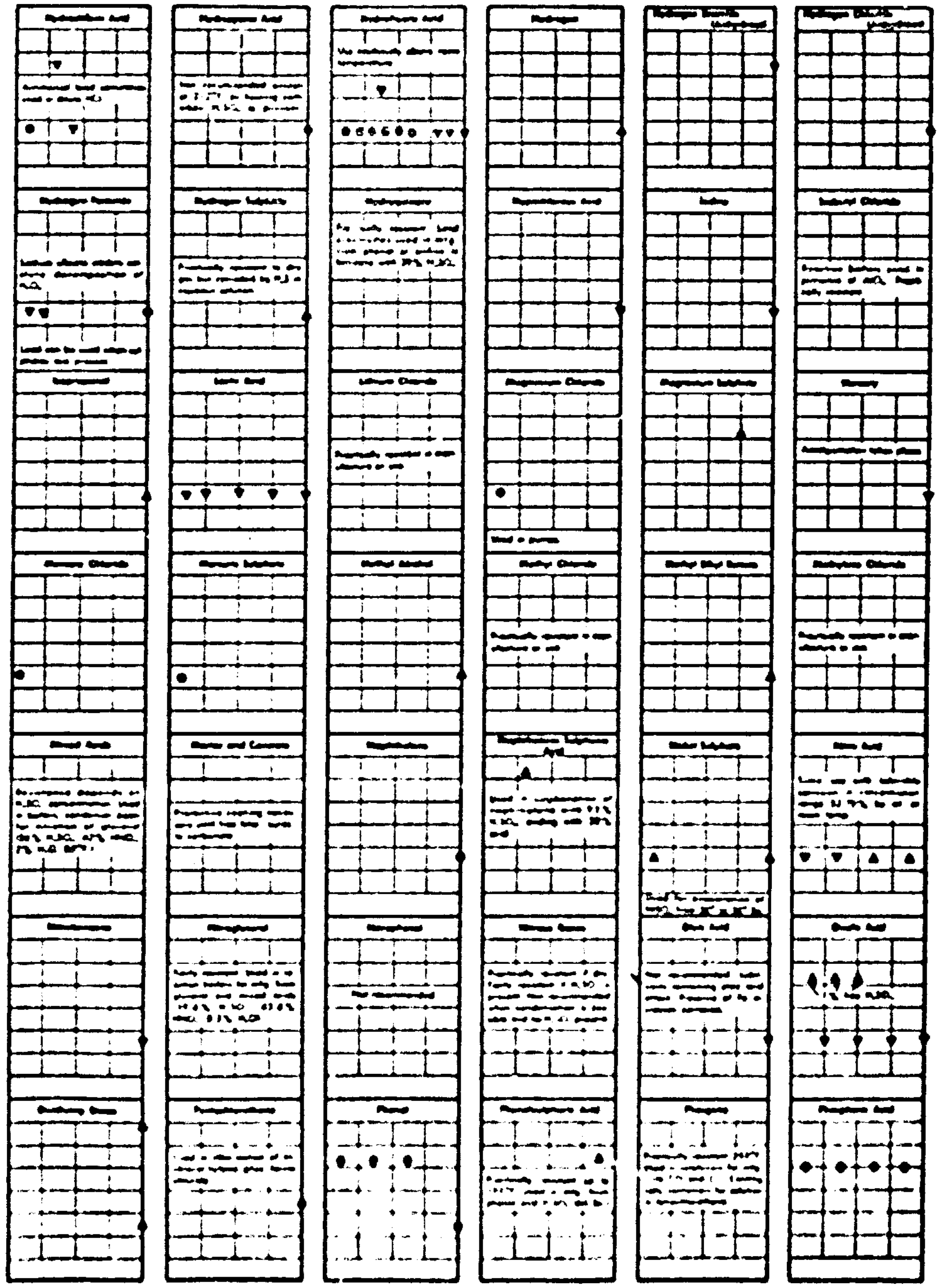

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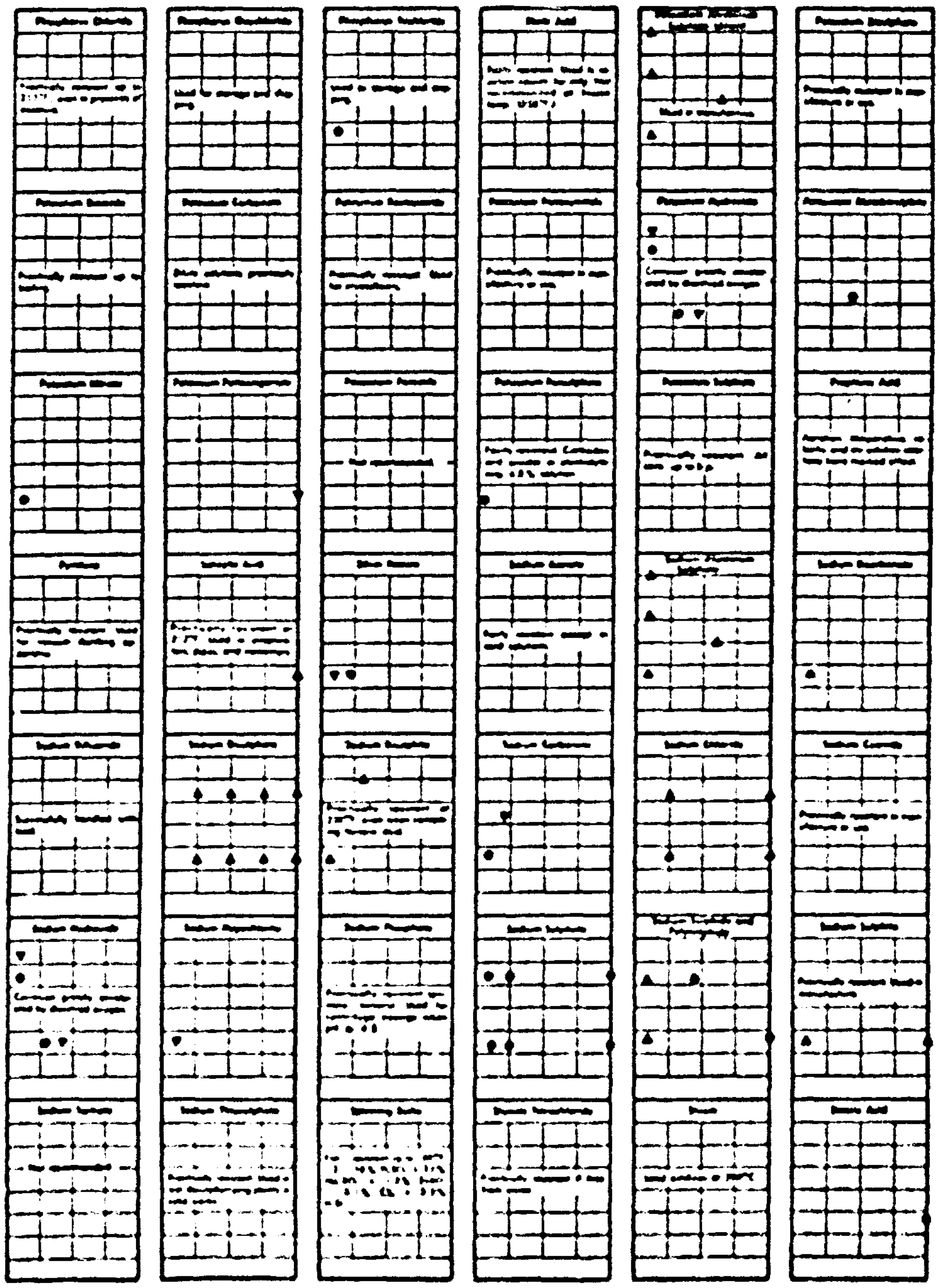
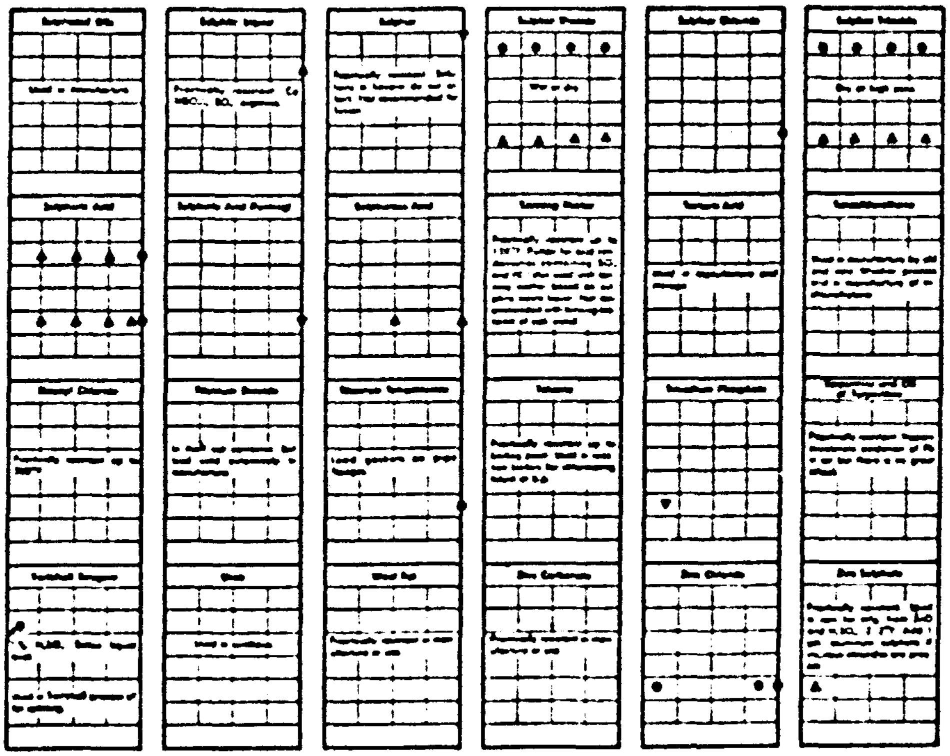


Corrosion Resistance of Lead and Lead Alloys, cont . . .



Lead, continued

good under most conditions. A 17-ton evaporator made entirely of cast 8 percent antimonial lead is shown in Fig. 3.

Where strength is a critical factor, many articles can be cast of stronger lead alloys or provided with extra reinforcement through proper design. Sometimes reinforcing elements made of stronger metals are cast into the lead to give greater strength.

Lead Clad Products—To better cope with the demands of today's chemical plant operations, lead's corrosion resistance is combined with the strength of steel or the high heat transfer of copper through clad or bonded lead. Vessels designed for operation at high temperatures, fluctuating temperature or vacuum are usually constructed of steel with a lining of lead clad or bonded directly to the steel, as shown in Fig. 4. Heating coils of copper with an external lead cladding are in common use as are steel pipes and valves with an internal lead cladding.

METHOD OF JOINING

Joints in lead used for corrosion resistant equipment are made by fusion welding, a method of joining that is commonly known by the somewhat misleading term of lead "burning"—misleading because the lead is not burned but only melted. This method insures that no metal less resistant than lead will be exposed to corrosive attack.

If metal has to be added through the use of a filler or welding rod in making joints, the rod should have the same composition as the lead being joined so that all exposed metal may resist attack uniformly. Oxygen and hydrogen are the most generally preferred gases for lead welding. Others, such as oxygen and acetylene, and oxygen and city gas, are also used.

For welding, lead is prepared much the same as for soldering, being scrupulously clean, but no flux is employed. Lap joints are preferred except on very heavy lead. Lead welding rod used as a filler in the joints should be from [illegible] to [illegible] in. in diameter, depending upon the thickness of lead.

CORROSION CHARACTERISTICS

Lead relies for its high resistance to corrosion upon a thin protective coating that forms on its surface.

When the coating is one of the highly insoluble lead salts such as the sulphate, carbonate or phosphate, resistance to corrosion is high and the environment generally promotes self-healing upon mechanical injury.

On the other hand, if a soluble film forms 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.

Dilute nitric acid is an example of a corrosive which reacts with lead to form a soluble salt. It is also capable of reacting with lead sulphate to reduce its function as a protective coating depending upon the concentration. Obviously where lead linings are protected by a brick lining, the protective film will not be disturbed.

In the case of corrosives which, in themselves, do not readily form a protective film and will not dissolve lead sulphate, it is often possible to make the lining corrosion proof by swabbing the lead with dilute sulphuric acid or filling the vessel with dilute sulphuric acid for a short period of time to establish a protective sulphate film.

At 70 deg. F. in 25 to 35 percent sulphuric acid, chemical lead will form a complete sulphate film in from 9 to 10 hr. Under the same conditions 9 percent antimonial lead forms a sulphate film in from 1 to 1½ hr.

Lead generally has good resistance to neutral solutions where lead carbonate and possibly oxide are corrosion products, and fair resistance to alkaline solutions in which these are soluble. Experience has shown that lead is commercially resistant to chromic, sulphuric, sulphurous and phosphoric acids; that it is subject to corrosion at somewhat higher rates by hydrochloric and hydrofluoric acids, and that it is susceptible to being strongly corroded by acetic, formic and nitric. Nitrate solutions are moderately corrosive, carbonates are not.

PERFORMANCE WITH CORROSIVES

Among the many variables determining the suitability of lead or any other material may be temperature, concentration, grade of lead or type of alloy, rate of flow, presence of oxygen, degree of abrasion-erosion and presence of impurities. A careful evaluation of these factors is a prime requisite before selecting or rejecting any material.

When comparisons are being made between corrosive resistant materials, the corrosion rate data should be carefully interpreted because use of either the rate of penetration or rate of weight loss as a corrosion measure can be misleading. For example, at a given rate of penetration the greater thickness of a lead lining obviously means a longer service life than could be expected from a thinner material of construction. Similarly, when corrosion is based on weight loss the high density of lead should be kept in mind. What might appear as excessive corrosion expressed in lead weight loss would be a nominal rate in terms of volume loss or penetration.

Actually with most corrosives a specific corrosion rate for lead is often a hypothetical figure since the protective film which forms on contact usually results in a high initial rate of corrosion but once the film has developed, the corrosion rate slows down to a practically negligible figure.

The data given on the charts herewith is indicative of the performance of lead in contact with various corrosive chemicals. Since operating conditions vary widely, it is usually wise to use actual exposure tests made under operating conditions to forecast performance in a specific application. However, corrosion rates based on actual plant tests conducted under operating conditions do not necessarily represent the highest concentrations or temperatures under which lead would serve satisfactorily. It is reasonable to expect the corrosion rate to decrease at lower temperatures and, in most cases, lower concentrations.

Processes With Which Lead or Lead Protected Equipment May Be Used

Acid recovery
 (regeneration process)
Acid recovery
 (vacuum process)
Air pollution control
Ammonia saturation
[illegible]
Chamber process acid manufacture
Chromium plating
Copper plating
Dye intermediate reactors
Electrogalvanizing
Electrowinning of zinc, manganese and copper
[illegible]
Halogenation
Hydrolysis
Nickel plating
Pickling
[illegible]
Stream pollution control
[illegible]
Sulphonation
Sulphuric acid dilution
Waste recovery

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Lead Industries Association
420 Lexington Avenue
New York 17, N. Y.