LIA09787

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[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

To Members of the [illegible] Lead
Products Division:

With Chemical Bulletin No. 2, dated September 3, 1946, we sent you a reprint of the section on lead in contact with phosphoric acid, appearing in the Corrosion Forum in "Chemical Engineering" recently.

We are now able to send you a reprint of the complete group of articles on the subject "Phosphoric Acid vs. Materials of Chemical Plant Construction," which includes the lead section already sent you.

We believe that the information given on materials competitive with lead will also be helpful.

Very truly yours,

Robert L. Ziegfeld

Robert L. Ziegfeld,
Assistant Secretary.

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Reprinted from *Chemical & Metallurgical Engineering*, [illegible], [illegible], September, 1945

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[illegible]

[illegible]

LIA09790

HASTELLOY ALLOYS

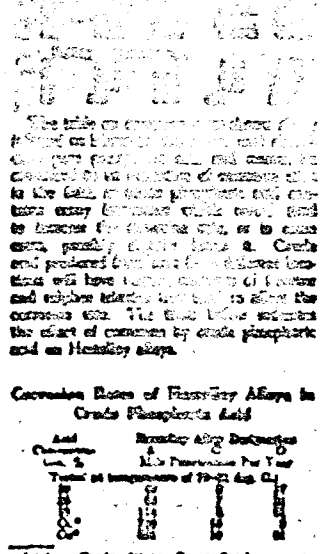
C. G. CHANDLER
Haynes Stellite Co.
Kokomo, Ind.

THE Hastelloy alloys, a series of high-strength nickel-base corrosion-resistant alloys designated as grades A, B, C, and D, have excellent corrosion-resistant properties for phosphoric acid. The general rate of attack on these alloys at normal room temperature is higher in the weaker acids, with the corrosion rate falling off rapidly as the strength of the acid increases. In 85 percent phosphoric acid at room temperature there is practically no measurable rate of penetration. In chemically pure phosphoric acid at room temperature, the highest rate of attack on any grade is only 0.001 ipy.

With increase in temperature, the cor-

AB-Hastelloy pump and fittings handling 45-to-55% H_3PO_4 solutions





Corrosion Rates of Hastelloy Alloys in Crude Phosphoric Acid

* C = Crude acid. S = Crude acid, sparged. Tested in tests run by J. R. Cuthrell and Corrosion Section, Bureau of Chemistry and Soils, Washington, D. C.

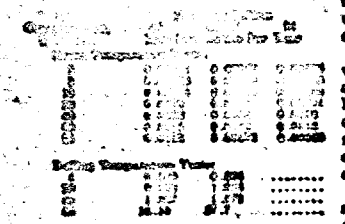
At the time these tests were run, Hastelloy B was unsatisfactory and included because of its lack of oxidizing resistance. It is quite probable, however, that in crude acid, satisfactory examples may be given B would be comparable in these circumstances to grade A. All of these [illegible] rate as [illegible] produced [illegible] [illegible] such as [illegible] solutions, [illegible] [illegible] [illegible]

LIA09791

[illegible]

[illegible] Rate of [illegible] Glass [illegible]

[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
Boiling Temperature Tests			
[illegible]	[illegible]	[illegible]	.....
[illegible]	[illegible]	[illegible]	.....
[illegible]	[illegible]	[illegible]	.....
[illegible]	[illegible]	[illegible]	.....



Assuming an average thickness of the [illegible] glass to be 36 mils, then the probable consolidated life of the glass [illegible] mils upon its chemical durability, [illegible] the highest values obtained, is as follows:

Acid Concentration, Percent by Wt.	Temperature	Glass No.	Est. Life, Years
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]

For glass No. [illegible] see same values as for glass No. [illegible] at boiling temperature.

It should be emphasized that the foregoing life expectations must not be construed as representing the probable life service of glass lined steel equipment under actual operating conditions, because necessarily they do not evaluate uncontrollable variables such as areas of sub-average thickness, [illegible], imperfections in the steel [illegible] of mechanical injury.

[illegible] for all concentrations of [illegible] free from [illegible] the chemical [illegible] of [illegible] glasses listed is satisfactory [illegible] temperature is at or near room temperature.

For [illegible] involving elevated temperatures, [illegible] No. 42 and No. 42PF, and [illegible] satisfactory for all concentrations of phosphoric acid up to but not exceeding 40 percent by weight.

For concentrations of phosphoric acid in [illegible]

[illegible]

There is considerable difference of opinion with respect to the most suitable wood for acid work. Some species have given excellent results in a wide variety of applications of the inorganic acids. Aside from the consideration of analyzing about the pH value of any inorganic acid offers an index of the action on wood of any acid.

Phosphoric acids are relatively weak, and at normal temperatures have an important disintegrating effect on some woods.

Wood is satisfactory for 10 percent acids. Over 10 percent strength, a lining has been deemed necessary. A strong acid acts destructively and a lining of some material is used. Wood tanks have in some instances been in service for 17 years and longer. Concerning the 17 yr. installation, these particular tanks are of various capacity, 18 ft. dia., and up to 12 and 14 ft. high. Three inch fir was the wood used, and the lining was lead and/or chemical brick. They have not been under pressure, but have closed tops. They handle 50 to 75 percent acid at 75 deg. C.

Rectangular wood tanks are commonly used in phosphoric acid service. In the transfer of solutions, wood troughs or launders have an advantage over metals in that wood does not plug and close by scaling. Fume ducts and stacks in phosphoric acid service may be of wood if it is paraffin treated. In a large chemical plant in the South wood thickeners of the Dorr type have been in use for years and are giving satisfactory service.

Many manufacturers whose product is from low grade rock using sulphuric acid are tanks and filter pieces made of wood. Filter pieces are pitch pine; frames are pine or oak, and in one instance the launders or gutters are made of plain tree wood. Redwood has also been used successfully in phosphoric acid service.

Wood tanks are used in the manufacture of fertilizer phosphates, phosphate water softeners, baking powder, beverages, and other food products.

LIA09792

Phosphoric Acid Manufacture—Part II

[illegible]

[illegible]

[illegible]

LIA09793



D. F. STEWART
U. S. Stoneware Co.
Akron, Ohio

One of the virtues of modified vinyl resins is their resistance to phosphoric acid at boiling temperatures. Laboratory tests have indicated that the present resin is unaffected by 75 per cent phosphoric acid at room temperature to 600 deg. F., whereas the unmodified resin (167 deg. F.) under the same conditions, 50 percent acid by weight is 0.17 to 0.18. The above mentioned figures hold true for practically all concentrations of phosphoric acid from dilute to strong concentrations. Not only will vinyl-base resins resist phosphoric acid, but it provides an important added barrier to phosphoric acid, allowing most of it to be stopped through the material and thus preventing any contamination or corrosion of the protected equipment. For protection of equipment involving processing or use of phosphoric acid, vinyls may be used either in the form of a film as sheet lining material bonded to the metal surface, or as a liquid to be applied in the same manner as paint. It is recommended that vinyl paint be used primarily for exterior protection of tanks and structural steel, with the heavier lining material being used for tank interiors.

Conditions of Operation—In recommending the vinyls for phosphoric acid, the only limiting condition is one of temperature. While the maximum temperature recommended for linings is 175 deg. F., the temperature limit, in the case of linings, can be extended as much as 50 deg. F. by overbacking with a mastic or flexible course of acid brick. The overbacking provides a temperature gradient between the solution and the lining temperature. Therefore, even above 250 deg. F. will cause the vinyl to soften and will hasten chemical attack.

In solutions of phosphoric acid involving the development of hydrogen, or in mixtures

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[1] For detailed discussion of bonds on the [illegible] see Corrosion Resistant Linings for Chemical Equipment, by D. F. Stewart, Chemical Engineering, Vol. 54, No. 11, November, 1947, p. 112.

[illegible] of phosphoric acid and [illegible] the acid has been bonded. Typical applications

[illegible] phosphoric acid is used to clean or to metal preparation, the equipment may be completely protected by two coats of vinyl lining.

In the metal finishing industry, wherever phosphoric acid is used in cleaning or in metal preparation, the equipment may be completely protected by two coats of vinyl lining.

In organic synthesis and processes involving organic chemicals and phosphoric acid, caution must be exercised as the use of vinyl linings, due to the hydrocarbons formed which may exert a solvating effect on the lining. Solvents such as ketones, esters, chlorinated hydrocarbons and aromatic hydrocarbons tend to swell or dissolve vinyl linings. Processes involving phosphoric acid and alcohols, ethers and aliphatic hydrocarbons may be handled safely. The above information applies equally to the salts of phosphoric acid in any concentration, upon the services being subject to the maximum temperature limitations.

In some cases, vinyl-base paint may be used to protect equipment from phosphoric acid, wherever temperatures are not encountered. It is not recommended that paints be used to build up a lining on the interior of a processing tank wherever agitation or temperature is encountered. In dilute acid and normal temperatures, a heavy coating of air to cover tanks and pipe for storage, storage or shipping. The paint may be applied to new pipes with [illegible] to properly constructed concrete storage tanks.

CHEMICAL STONEWARE

F. E. REDFERN
General Ceramics and Porcelain Corp.
Keasbey, N. J.

Chemical stoneware, in common with other compounds containing silica, re-

LIA09794

COPPER, COPPER-ALLOYS

C. L. BULOW
Bridgeport Brass Co.
Bridgeport, Conn.

Copper and copper base alloys are successfully used in the form of heat exchanger tubing, piping, fittings, etc., wherever the corrosion rates are comparatively low. From the standpoint of construction, many of these copper alloys can be welded using welding rod of the same composition which gives a weld having approximately the same corrosion resistance as the adjacent material.

Since all of the corrosion accelerating factors discussed may very from one plant to another, it is advisable to conduct preliminary service or field tests under actual operating conditions before using large quantities of copper alloys. In this way, consideration can then be given to the possible effect of all these corrosion accelerating factors. Selection of the most suitable material for use in a chemical industry is dependent upon several factors, such as (1) the availability of the materials in the proper form, (2) life expectancy, and (3) cost. Since some of the copper base alloys discussed here are not available in all the forms needed in a chemical plant, the availability of any particular alloy in the desired form and size should be checked before it is given serious consideration.

Effect of Alloy Composition—Some of the available data on the corrosion resistance of copper and a number of copper alloys will be found in accompanying tables. For ease of comparison, the data have been broken down into five groups covering the most common copper-base alloy systems, namely: Copper, copper zinc alloys, copper tin alloys, copper-nickel alloys, copper-aluminum, copper-aluminum-silicon, and copper-silicon alloys.

Examination of the laboratory, field and service data indicates that copper and copper-base alloys, on the whole, should give satisfactory service in handling pure phosphoric acid solutions in various concentrations.

Effect of Temperature—In the range from room temperature up to 100 deg. C. the corrosion rate of copper base alloys is comparatively small. However, the corrosion rate at 100 deg. C. is about five times that which takes place at room temperature.

Effect of Aeration—Aeration of phosphoric acid increases the rate of corrosion for copper and its alloys from 10-100 fold depending upon the degree of aeration. Since only a limited amount of aeration exists under usual service conditions, it appears that most of the copper base alloys should be satisfactory for piping and heat exchangers.

The data presented in connection with water line corrosion indicate that consideration must be given to this type of corrosion where tubes or pipes are partially immersed in phosphoric acid solutions. Consideration must also be given to the possible increase in corrosion at the water line in partially filled tanks of heat exchangers and so forth.

Effect of Ventilation—Limited information is available on the effect of ventilation on the rate of corrosion of copper alloys in phosphoric acid solutions. In the absence of definite information, it would be wise to eliminate the possible accelerating effect of ventilation or aerating stirrers in phosphoric acid solutions as far as metal surfaces

Pure Phosphoric Acid

LIA09796

[illegible] Resistant to Hot Phosphoric Acid

[illegible] Chemical Plant Corrosion Problems

[illegible]

[illegible] T and 20

E. B. [illegible]
The Duriron Co.
Dayton, O. T.

Some resistance of corrosion in handling phosphoric acid can generally be considered in two phases, first, the production of the acid, and second, its use in industry. In both phases, stainless Type 316 has been used with considerable success but should be considered as a "borderline" application. There have been sufficient failures to warrant the use of alloys containing greater percentages of particularly nickel and molybdenum considered with copper. Duriron T (22 Ni, 19 Cr, 2 Mo, 1 Cu) and Duriron 20 (29 Ni, 20 Cr, 2 Mo, 4 Cu) have fulfilled this requirement. In some of the most severe services, it is anticipated that still higher alloy contents may give a sufficiently longer life to justify the additional cost.

In the manufacture of phosphoric acid from phosphoric rock, the fluorine content is of material importance. The phosphates rock in the United States varies in fluoride content from 0.3 to 2.0 percent. The fluorine content of the phosphoric acid, therefore, is such that in most cases high silicon iron is not recommended. Duriron T and 20, however, have given excellent service in such processes. The need for this additional corrosion resistance is emphasized by the corrosive action of the gaseous fluorides with the phosphoric acid.

[illegible] as a commercial acid to such services as metal cleaning, oil refineries, food and pharmaceutical industries [illegible] stainless steels given satisfactory service in some of the formulations of other chemicals and salts [illegible] Duriron T and 20 have given excellent service in these applications [illegible] are widely used. The additional protection offered from the higher alloy content when compared with the small additional cost, has resulted in many specifications where [illegible] Type 316 would have been adequate. [illegible] have been used with [illegible] equipment was found, where corrosion may be severe [illegible] has resulted in economy being realized. In practically all of these services, the [illegible] have proved to be very satisfactory.

Duriron T and Durichlor 20 are available from practically all manufacturers of such equipment as pumps, valves, [illegible] and other items necessary for chemical plant service. Duriron T is available in rolled bar form.

NICKEL, NICKEL-ALLOYS

W. E. Fritzsche
International Nickel Co.
New York, N. Y.

Use of nickel and the nickel alloys, Monel, Inconel, and Ni-Resist, with phosphoric acid is generally limited to the relatively pure acid derived from phosphorus vaporization processes (blast or electric furnace). Crude phosphoric acid produced by the treatment of [illegible] pure [illegible] [illegible] [illegible]

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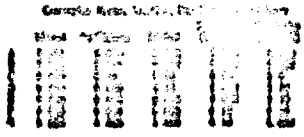
Table IV—Plant Corrosion Tests in Manufacture of Phosphoric Acid by Electric Furnace Process[a]



LEAD

H. H. CHURCH
Lead Industries Association
New York, N. Y.

Lead is widely used in the commercial production and handling of phosphoric acid because of its resistance to this corrosive. For its corrosion resistance lead usually depends upon the low solubility of the thin adherent film of lead compound formed on its surface. Good protection is offered by the lead phosphate film as a highly insoluble (0.1 p.p.m. in water). As lead sulfate is also highly insoluble, impure phosphoric acid containing sulfuric acid makes an equally good corrosion resistant lead.

Actual tests show that lead's resistance to [illegible] C. and [illegible] percent concentration to the [illegible] and [illegible] to be [illegible] and [illegible] lead is [illegible] strength acid.

References

HAVEG

D. L. HAWORTH, Jr.
Haveg Corporation
Newark, Del.

Haveg is a plastic construction material which is widely used for chemical equipment in corrosive service. [illegible] in which the plastic component is of the [illegible] and [illegible] has been [illegible] of [illegible] has been [illegible]

In handling of [illegible] material, two examples of phosphoric acid uses are [illegible]. Concentrated phosphoric acid at 1.71 sp. gr. (over 85 percent H_3PO_4) was used in one test, and acid of 50 percent strength

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[illegible]

[illegible]

[illegible]