

Handling Concentrated Acids

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Outline

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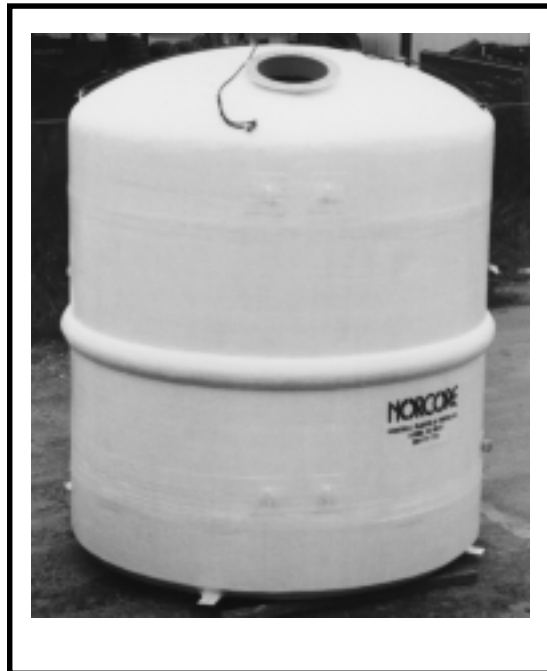
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The Use of Thermoplastic Lined Dual Laminate Construction

Introduction

Concentrated acids are aggressive and difficult to handle. There are many horror stories about the problems created by selecting the wrong material for hot or concentrated acids.

This paper discusses the use of dual laminate fabrication for handling concentrated acids. Dual laminates have proven to be quite effective for high temperature and concentrated applications.

Six different oxidizing, reducing, and organic acids are reviewed. Graphs are presented to show the common types of liner materials used. The graphs show temperatures and concentrations where various dual laminates are commonly used.

The choice of the thermoplastic liner material is based on an analysis of the chemistry, temperature, and mechanical loading expected during use. Many different types of thermoplastic are available for dual laminate applications.

Common Thermoplastics Used

The Table in Chapter 2 summarizes the common thermoplastics used in dual laminate fabrication. PVC and CPVC are "amorphous" plastics and fiberglass is "chemically" bonded to them. Fiberglass is "mechanically" bonded to the other thermoplastics (polyolefins and fluoropolymers) by means of a woven or knit fabric which is pressed into the molten plastic during extrusion. The fiberglass bonds to the fabric.

Each thermoplastic has different characteristics and is used for different purposes. Characteristics in each of the following capability areas should be reviewed: chemical resistance, temperature capability, mechanical strength, fire resistance, permeation resistance, purity and leachability, coefficient of thermal expansion, impact resistance or brittleness, method of joining (cementing or welding) and weight (specific gravity).

The Table in Chapter 2 summarizes some of the engineering differences between the plastics. For example, PVC is generally recommended for a maximum service temperature of 140 °F where PFA Teflon can, under fully supported conditions, handle 500°F. CPVC has a flexural modulus of elasticity of 420,000 PSI where FEP Teflon is only 90,000 psi. High Density Polyethylene has a coefficient of thermal expansion of 110×10^{-6} inches per inch per degree of

Fahrenheit temperature change compared to only 35 for PVC. It is important to know the characteristics of each thermoplastic when making selection and design decisions.

Cost and Other Selection Factors

For cost evaluation techniques please refer to Chapter 4. For a quick cost comparison of different tank materials refer to Chapter 3.

Acid Containment With Dual Laminates

Summary of Acid Types and Characteristics

An acid contains excess hydrogen ions and will react with most metals to liberate hydrogen and with bases form salts. There are three basic types of acids: oxidizing, reducing and organic.

Oxidizing acids pose an additional problem as they combine with oxygen and take up electrons. They tend to react with water, are toxic, embrittle many materials and cause them to stress crack. Examples of oxidizing acids include Sulfuric, Nitric and Chromic.

Reducing acids combine with or remove oxygen from oxides and tend to liberate or give up electrons. They have high vapor pressures, and easily permeate other materials due to their small molecular size. Examples of reducing acids include Hydrochloric, Hydrofluoric and Hydrobromic.

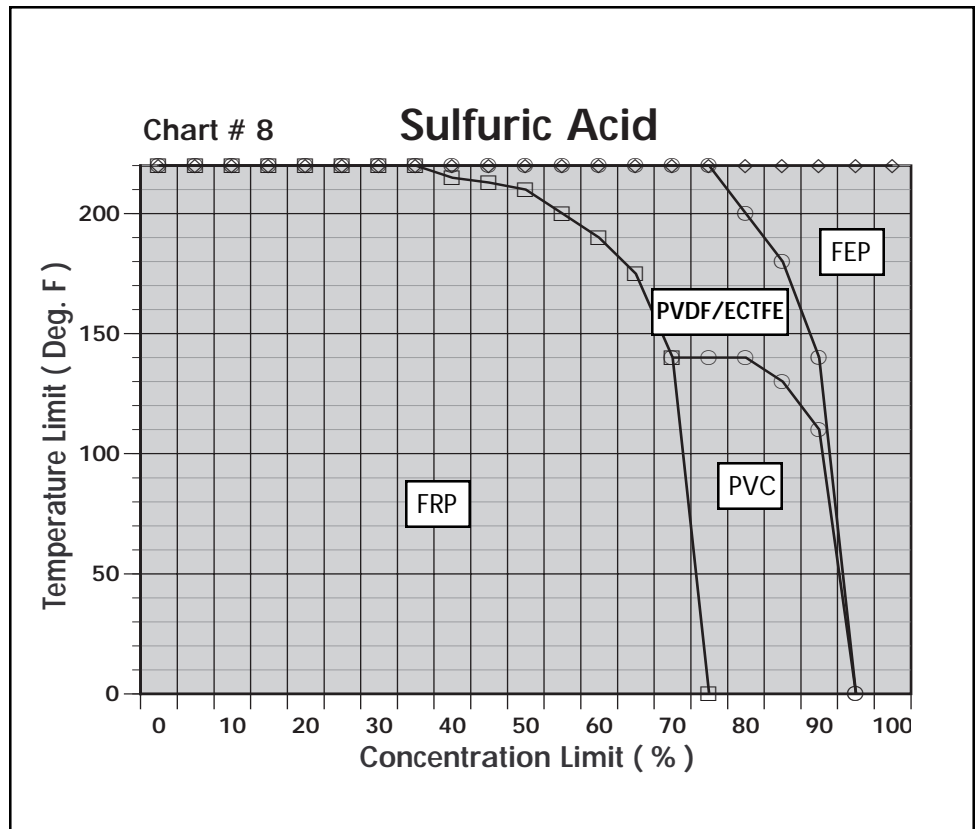
Organic acids are of the carboxyl group which contain hydroxide (OH) hydrogen and oxygen. They often are flammable or combustive and can permeate other materials. Examples of organic acids include Acetic and Formic.

Sulfuric Acid.

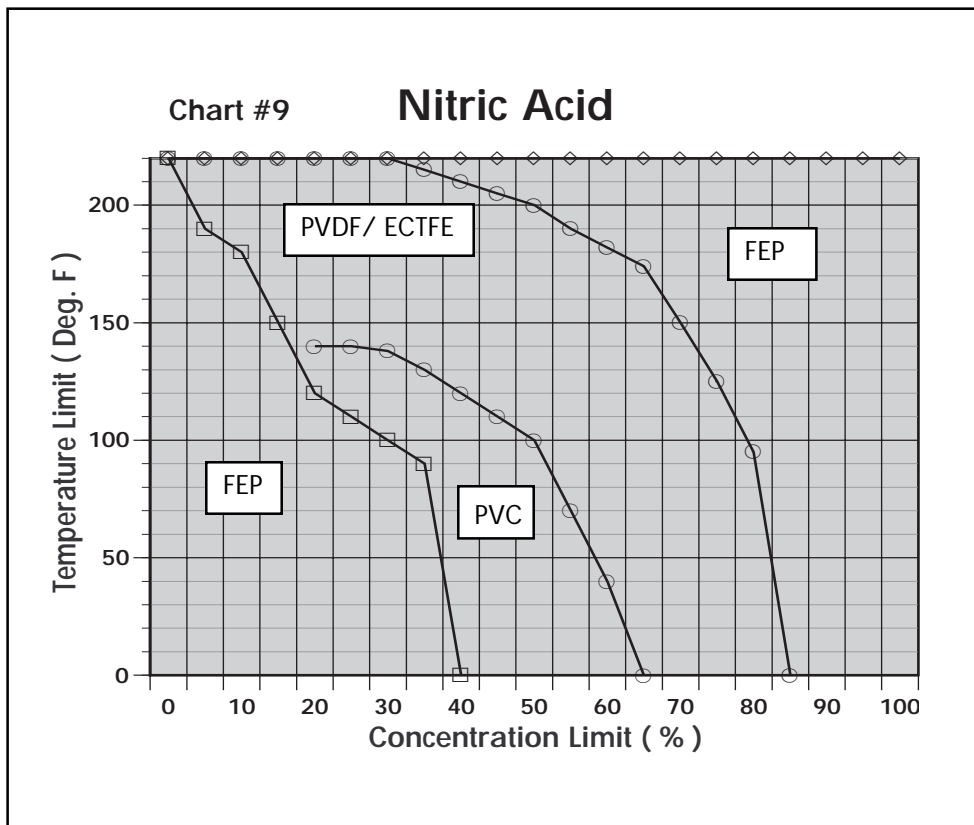
Sulfuric Acid (H_2SO_4) is an aggressive oxidizer. It has an affinity for water and is commonly used for pH balance in water treatment and for stripping, cleaning, and etching metals.

Stainless steel can be used to contain Sulfuric Acid at very low (less than 6%) and very high (over 90%) concentrations, but not in the middle range. Sulfuric Acid contained in metal may form an iron sulfate scum on the surface. While this provides some protection from corrosion if undisturbed, it can pose an unacceptable contamination threat for high purity applications.

Chart 8 demonstrates the most economical thermoplastic dual laminate material preferences for the given range of temperature and concentrations of Sulfuric Acid. Not indicated on the chart is the effect of using a Chlorendic Anhydride resin. Its use may allow fiberglass service at slightly higher temperatures and concentrations. Generally, fiberglass may be used for 75% and lower concentration when the temperature of the Sulfuric does not exceed 120°F; or for 50% concentration below 220°F. PVC and PVDF are commonly used for Sulfuric Acid. Polypropylene is not recommended for Sulfuric.



Nitric Acid



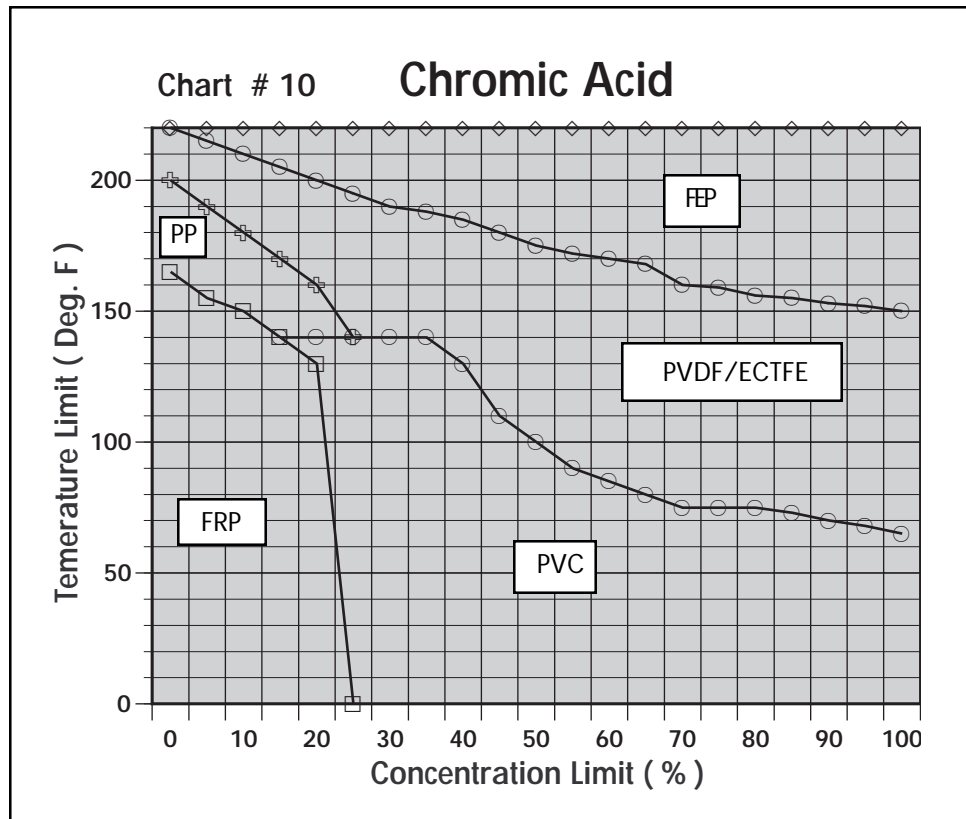
Nitric Acid (HNO₃) is also an oxidizer. This powerful acid tends to fume at over 70% concentration and is commonly used for metal stripping and etching. Nitric acid is commonly used along with hydrofluoric in metal etching applications. Stainless steel can effectively handle Nitric unless other acids are also present. Fiberglass is able to handle up to a 40% concentration at 80°F or 10% at 120°F. A chlorendic anhydride, or high temperature vinyl ester resin, may handle up to 40 to 50% of concentration.

For Nitric, Chart 9 shows where fiberglass and thermoplastic dual laminates can be used. PVC and PVDF are commonly used in Nitric environments.

Chromic Acid

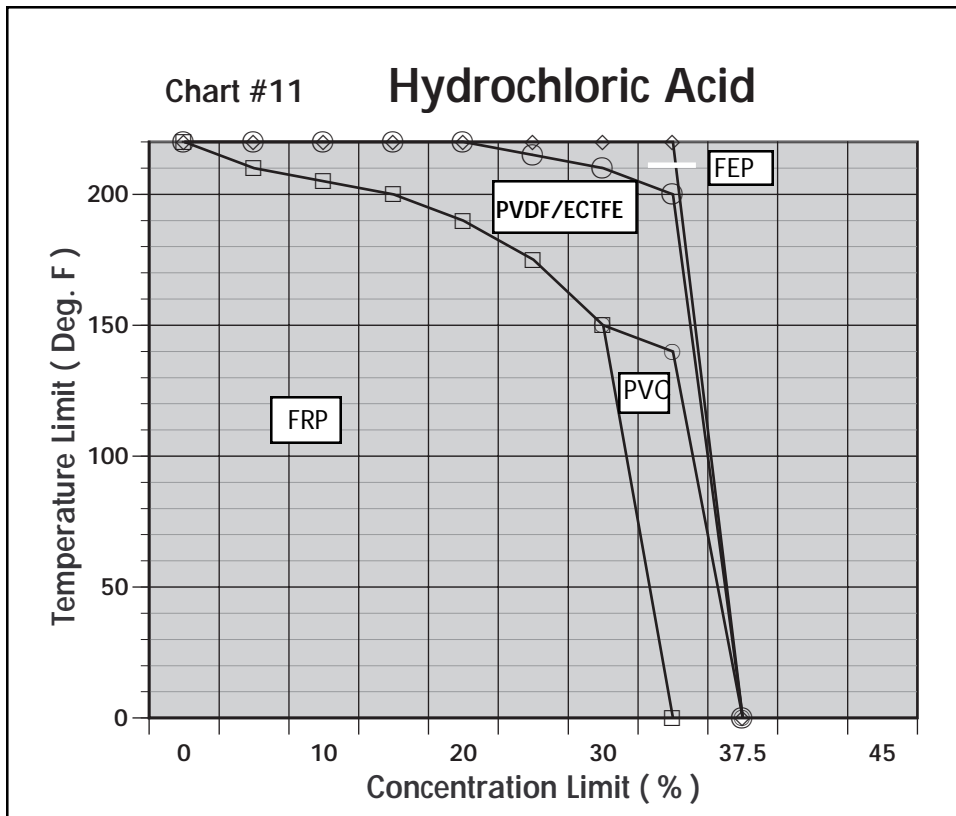
Chromic ($\text{CrO}_3 + \text{H}_2\text{O}$) is an oxidizing acid. This very aggressive acid is listed as a potential carcinogen and is commonly used to deposit or plate chrome on metal surfaces.

Stainless steel effectively contains chromic at low concentrations of 5% to 10%. Fiberglass can handle concentrations of up to 50% at 100°F, 30% at 140°F, and 100% at about 70°F. For Chromic, Chart 10 shows where fiberglass and thermoplastic dual laminates can be used.



Hydrochloric Acid

Hydrochloric (HCl) is a reducing acid. This corrosive fuming acid is commonly used for controlled metal etching in the printed circuit board industry and for regeneration of high purity water. The acid has a tendency to permeate plastic and can etch glass.

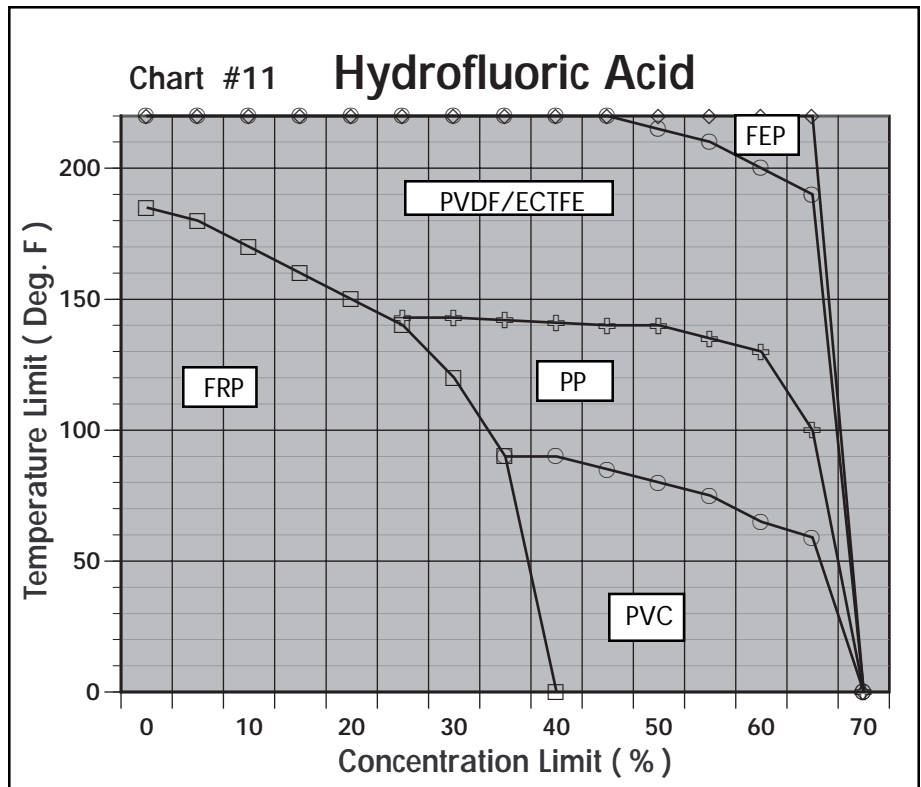


Most stainless steel is not acceptable but Hastelloy C is effective in containing HCl. Fiberglass is effective in most situations up to about a 36% concentration at 100°F or 20% at 200°F. Hydrochloric can permeate and react with "E" glass reinforcement causing blistering of fiberglass. For this reason a double C-veil or synthetic "Nexus" liner is important, particularly at higher concentrations of HCl. For HCl, Chart 11 shows where fiberglass and thermoplastic dual laminates can be used.

Hydrofluoric Acid

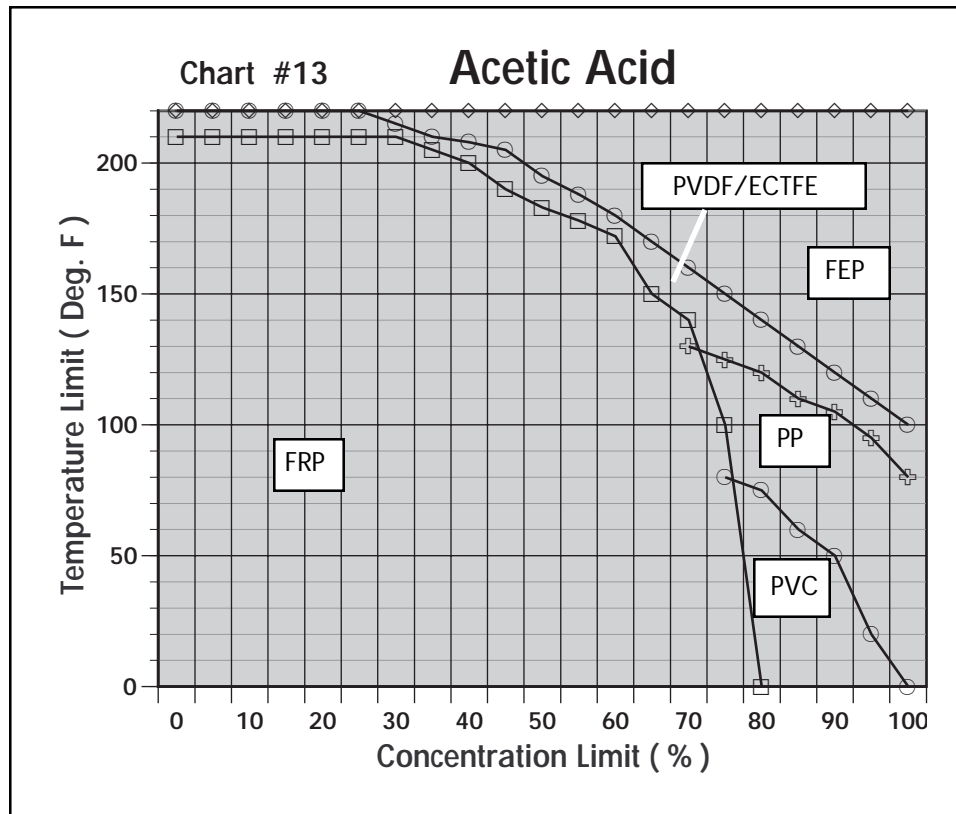
Hydrofluoric is a reducing acid with the chemical formula HF. This corrosive acid has an affinity for water and permeates plastics quite readily due to its small molecular size. HF is used to etch difficult metals such as zirconium. It also etches glass and with the addition of an oxidizing acid, such as nitric, HF etches silicon.

Stainless steel is not acceptable for Hydrofluoric but Hastelloy C can be effective. Fiberglass can be used up to about 20% concentration and 100°F, and 10% concentration at 150°F. When fiberglass is used, synthetic surfacing veil is important to keep the Hydrofluoric from attacking the glass reinforcement. For Hydrofluoric, Chart 11 shows where fiberglass and thermoplastic dual laminates can be used. With higher temperatures and concentrations, ECTFE may be preferable to PVDF. Permeation in ECTFE generally occurs at about half the rate that it does with PVDF. A thicker PVDF liner may need to be used for equivalent permeation resistance.



Acetic Acid

Acetic (CH_3COOH) is an organic acid. The acid has a tendency to permeate and cause swelling and is commonly used as a photo stop bath and in many chemical manufacturing applications.



Stainless steel (316) is effective except where the acid is very hot. Fiberglass can handle up to about 75% concentration at 100°F or 50% concentration at 180°F. For Acetic, Chart 13 shows where fiberglass and thermoplastic dual laminates are commonly used.

It is important to understand that all of the acid graphs presented in this paper show common areas where the thermoplastic materials are used. However, no decisions should be made without specific consultation and review of corrosion guides provided by each material vendor or with specific chemical engineering or case study review. Any minor

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constituents in the acids may cause major changes in the properties of the mixture and must be considered. If so, careful consideration must be given to how the acid will be removed from the tank and how the tank will be cleaned. Some acids give off a large amount of heat when mixed with water.

Summary and Conclusion

Acids are aggressive, hazardous and difficult to handle. Careful review of operating temperature and concentration is essential before making any material decision for tanks and piping.

Many different types of thermoplastic liner materials are available which can handle concentrated acids. Generally they are cost effective in the long range at the higher temperatures and higher concentrations.

Dual laminate rather than straight thermoplastic is needed to provide the mechanical strength needed. Dual laminate fabrication requires special design, skills, and tooling. With careful selection of a qualified vendor, long-term life should be expected.

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