How to Transfer Corrosive Chemicals Safely Using Centrifugal Pumps

FINISH THOMPSON INC.

Contents

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This guide has been designed to provide important information on corrosive chemicals and the considerations for their safe transfer using centrifugal pumps.

Centrifugal pumps provide smooth flow and are ideal for a number of applications including transfer from bulk storage, tank truck/rail car unloading, filtration, and recirculation.

This guide will focus on flooded suction designs where the liquid level is above the pump suction and applications where the pump will be located above the liquid source in which case a self-priming design may be the best option.

What are Corrosive Chemicals?

Corrosive chemicals are fluids that will attack and destroy the materials with which they come in contact. Metals, stone, glass, elastomers and even some types of plastics can be susceptible to corrosion from various liquid acids, bases and solvents. Some corrosive materials can even cause physical hazards when exposed to incompatible materials. For example, many inorganic acids, when exposed to an incompatible metal, can release hydrogen gas which can pose a fire and explosion hazard.

Corrosive liquids also pose a major risk to health, as OSHA (United States Occupational Safety and Health Administration) recognizes in defining a corrosive substance as "a chemical that produces destruction of skin tissue, namely, visible necrosis through the epidermis and into the dermis, in at least 1 of 3 tested animals after exposure up to 4-hour duration. Corrosive reactions are typified by ulcers, bleeding, bloody scabs and, by the end of observation at 14 days, by discoloration due to blanching of the skin, complete areas of alopecia and scars. Histopathology should be considered to discern questionable lesions."[1]

The workplace risks posed to people, property, and the environment requires familiarity with corrosive liquids and their hazardous chemical and physical properties in order to select the proper materials and technologies to handle them in a safe and compliant manner.

ANSI/Hydraulic Institute standard 5.3.3.4.7 states that *"material selection is the responsibility of the purchaser of unusual corrosion requirements but…the manufacturer shall proscribe materials of construction sufficiently so that the purchaser has the information required to ascertain proper selection."*[2]

While it's ultimately the pump purchaser's responsibility to select pump materials compatible with the fluid to be pumped, an adept pump manufacturer can provide invaluable guidance during the selection process. The first step in the process is understanding corrosive chemicals.

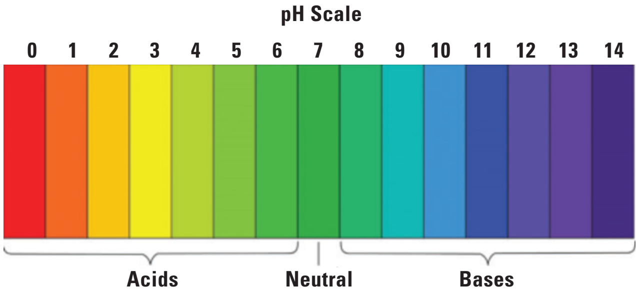
Corrosive chemicals can be broadly defined as the following:

- Strong acids
- Weak acids
- Strong bases
- Weak bases
- Dehydrating agents
- Oxidizing agents

Some chemicals can belong to more than one category. For example, sulfuric acid is a strong acid, a dehydrating agent, and an oxidizer. Corrosive materials can also belong to other hazard categories such as toxicity (poisonous) or flammability.

Definition of strong or weak acid or base (strength)

Acids and bases are commonly recognized by their pH. We refer to anything with a pH lower than 7 to be acidic and anything with a pH above 7 to be basic. We can consider strong acids to be atoms which readily donate protons (H+), and strong bases to be atoms which readily accept protons [donate electrons, (OH-)].



Therefore, an acid solution would contain a higher concentration of H+ ions and a basic solution would contain a lower concentration. How readily an acid or base dissociates into its H+ and OH- ions correlates to the strength of the solution. Below is a chart for common acids and bases with their respective pH, assuming a molarity of 0.1.

Definition of dehydrating agents vs. oxidizing agents

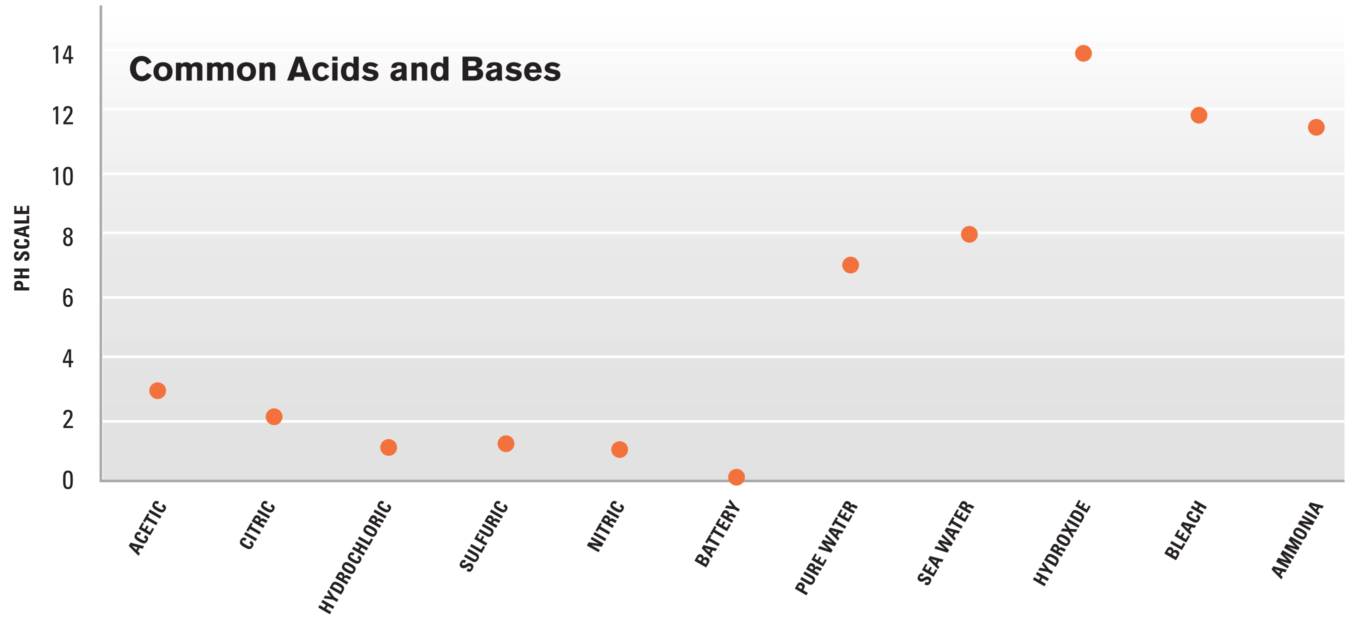
Some strong acids are not only corrosive, they are dehydrating. This means they undergo reactions that remove water from molecules. Sulfuric acid, a known strong acid, readily deprotonates water when added to organic solutions, causing the formation of salts (anhydrides) in solution.

An oxidizing agent is a substance that has the ability to oxidize other substances—in other words to cause them to lose electrons. Although some of the most common oxidizing agents are very basic (e.g., bleach, sodium and potassium hydroxide) it is important to note that acids can also be oxidizers. Strong oxidizing agents are compounds that contain atoms with high electronegativity which means the greater an atom's attaction for electrons. Going back to concentrated sulfuric acid, it is not only a good dehydrating agent, it is also successfully used as an oxidizer due to the strong electronegativity of the sulfate ions present.

Both dehydrating and oxidizing agents can be hazardous and contribute to unsafe working conditions if not handled properly. This is why it is crucial to understand the chemicals being dealt with and how they react not only in solution but when exposed to air, water, or heat.

Concentration

Concentration of a chemical is unrelated to its strength. It is the amount of the chemical dissolved in water. The level of corrosivity depends upon the concentration, pH, and temperature. In some cases a lower concentration results in higher levels of corrosivity.



Common Corrosive Chemicals

Acetic Acid (CH_3COOH)

Classified as a weak acid, concentrated acetic acid is corrosive and can attack the skin. It is used in various applications ranging from dyes and perfumes to synthetic fibers, as well as food additives. It is most commonly found in vinegar which is made up of between 5 to 20% acetic acid.

Chromic Acid ($H_2Cr_2O_7$) (aq)

The term "Chromic Acid" actually refers to a collection of compounds produced by the acidification of solutions containing chromate ions or by dissolving chromium trioxide in sulfuric acid. Most commonly used as an intermediate in chrome plating, chromic acid is classified as a strong acid.

Ferric Chloride ($FeCl_3$)

Ferric chloride dissolved in water yields a highly corrosive solution. Approximately 80% of its use is as a coagulant and flocculant for many industrial and sanitary wastewater treatment applications. It is also used as a catalyst in organic synthesis. It is a fairly strong acid and dehydrating agent. Typical concentrations range from 30 to 60%.

Hydrochloric Acid (HCl)

Also known as muriatic acid, it is a strong acid. Common concentrations range from 32 to 36%. Hydrochloric acid is hydrogen chloride gas dissolved in water. It has a high vapor pressure which causes it to fume in higher concentrations. Common uses are pH control, steel pickling, and production of various organic and inorganic compounds.

Hydrofluoric Acid (HF)

Hydrogen fluoride dissolved in water yields hydrofluoric acid, which is highly corrosive due to the electronegativity of the fluorine atom present. It is considered a weak acid despite being one of the most dangerous inorganic acids known. Even brief physical contact with HF can cause severe skin and tissue burns. Common concentrations range from a few percent to more than 50%. Applications include titanium pickling and semiconductor wafer manufacturing.

Hydrofluorosilicic Acid [$(H_3O)_2SiF_6$]

Most fluorosilicic acid is used in industrial or municipal applications/processes. A common application is the fluoridation of municipal drinking water supplies. Common industrial solution strength concentrations are 23 to 25% and 40% in water. Hydrofluorosilicic acid is very corrosive and interacts with various metals to produce hydrogen gas.

Hydrogen Peroxide (H_2O_2)

Primarily used as an oxidizing/bleaching source, hydrogen peroxide is also largely used as a rocket propellant. Although its chemical formula closely resembles water, hydrogen peroxide has a higher viscosity and is about 40% denser than water. Even though nonflammable, it is a powerful oxidizing agent that can cause spontaneous combustion when it comes in contact with organic material. Typical concentrations range from 20 to 50%.

Nitric Acid (HNO_3)

A strong acid, it reacts violently with bases and is corrosive to metals. It also reacts very violently with organic chemicals (acetone, acetic acid, acetic anhydride), causing fire and explosion hazards. Production of nitric acid is the sixth-largest chemical industry in the United States. It is utilized across many industries, but primarily in the manufacture of fertilizers and explosives. Other applications include plating, titanium pickling (combined with hydrofluoric acid), semiconductor wafer manufacturing, and clean-in-place solutions used in food, beverage, and pharmaceutical industries. Common concentrations range from 15 to 70%.

Phosphoric Acid (H_3PO_4)

Although it can be considered a weak acid, the most common concentration (70 to 85%) is acidic enough to be considered corrosive. The main use of phosphoric acid is in fertilizers and some foods such as soft drinks and jams.

Plating Solutions

There are various types of plating solutions with different benefits. Nickel and chrome solutions are commonly utilized in plating. The nickel sulfamate solution used in nickel plating can improve resistance to wear, heat, and corrosion. The largest application is for plating hard disc drives for computers. Other uses include the metallizing of automotive parts, pumps, electronics, and other engineered products. Nickel sulfamate is also used as a precursor (undercoat) to chrome plating with chromium trioxide solutions. Chrome plating yields a decorative finish, but also provides corrosion resistance which adds to its extensive use in the automotive industry.

Potassium Hydroxide (KOH)

Frequently referred to as caustic potash, potassium hydroxide is classified as a strong base. It is also very chemically active and reacts violently with acids, producing significant heat in the process. The leading use of KOH is in the production of potassium-containing compounds (50%), while approximately 10% is used in the manufacture of soaps and detergents. Typical concentrations range from a few percent up to 50%.

Sodium Bisulfite ($NaHSO_4$)

This strong acid is used in many industries including treatment of plating industry wastewater contaminated with heavy metals such as chromium, the paper industry, and to remove chlorine from treated municipal wastewater before discharge. In addition, it is commonly used as a preservative in meat processing, is used in almost all commercial wines to prevent oxidation and preserve flavor, and as a dietary supplement in drugs. It reacts violently with strong bases and strong oxidizing agents, but is stable under normal conditions. Exposure to water causes decomposition. Typical concentrations range from 30 to 60%.

Sodium Hydroxide (NaOH)

Also known as lye or caustic soda, it is the most commonly used base in the world. It is a strong base, has a high specific gravity, and is also extremely exothermic. One of the common concentrations of sodium hydroxide is 50%, at which it is somewhat viscous and freezes at 58° F (14.4° C). Sodium hydroxide is used to manufacture soaps, plastics, and paper. It is also used in processing cotton fabric, metal cleaning, electroplating, and peeling fruits and vegetables.

Sodium Hypochlorite (NaOCl)

Sodium hypochlorite (bleach) is commonly found in 5.5% concentrations (i.e., household bleach) because it is more stable than higher concentrations. It is very corrosive to a wide variety of materials. Industrial strength sodium hypochlorite is typically 12 to 15% concentration and is often produced at these higher concentrations to reduce shipping costs but is then cut by the user to approximately 5.5% due to the more stable nature of the lower concentration. Common uses include disinfection of potable and waste water and disinfection at food processing plants.

Sulfuric Acid (H_2SO_4)

The most commonly used acid in the world. It is a strong acid, has a very high specific gravity in concentrated forms (is heavy compared to water), is extremely exothermic when mixed with water (liberates large quantities of heat), and is extremely corrosive to many materials. Common concentrations include 98% and 93%. Common uses are manufacture of fertilizers and chemicals, petroleum refining, and as an electrolyte in lead-acid batteries.

Application Considerations

The pump supplier needs certain pieces of information in order to make the proper centrifugal pump recommendation for your application. These include:

Fluid Characteristics

The fluid name, concentration, specific gravity, and any flammability characteristics can be found in the Safety Data Sheet (SDS, formerly MSDS) for the fluid. This data is needed to determine the chemical resistance of the materials offered by pump manufacturers.

■ Fluid name

Required to use chemical resistance guides; may be more than one chemical listed if fluid is a mixture. Can also list trade name which can vary by manufacturer.

■ Concentration

Required to use chemical resistance guides; some materials may be suitable with lower (or higher) concentrations but not others.

■ Fluid temperature

Required to use chemical resistance guides; chemical resistance can vary by temperature (typically at higher than ambient temperatures).

■ Specific gravity

Used to specify the correct motor power (heavier fluids require more power to pump the same volume compared to lighter fluids) and if a self-priming application, to adjust the pump's maximum lift capability. Specific gravity is also used to calculate the maximum working pressure requirement to confirm it does not exceed the pump's rating.

■ Viscosity at pumping temperature

Used to adjust the head, flow, and motor power on centrifugal pumps.

■ Solids

If solids are present, what is the concentration, particle size, and hardness? Solids can affect pump material specification. Some materials, such as silicon carbide, are very hard and handle solids better.

■ Flammability

Is the material flammable or combustible? This can affect the pump components and materials of construction, such as the electric motor type and ability of the pump to be grounded/bonded. National Fire Protection Association publication NFPA30, Flammable Liquids Code, is a good reference in the United States for the handling, storage, and use of flammable liquids with a flash point below 200° F (93° C).

Hydraulic and Application Requirements

Along with the fluid characteristics, this is the information that will allow the pump to be properly sized to meet your requirements using the pump manufacturer's head-capacity curve.

■ Total head

Head is defined as the energy required to discharge water from a pump to an equivalent height expressed in feet or meters. The total head is the discharge head minus the suction head or plus the suction lift. Total head is based on the piping system and is the value used (along with flow rate) to choose a pump from manufacturers' pump head-capacity curves.

■ Flow rate

Flow rate is the volume of liquid that needs to be pumped per unit of time (i.e., gallons per minute or cubic meters per hour). Flow rate is also required to calculate friction loss in the user's piping system.

NPSHa (Net Positive Suction Head available)

NPSHa is the suction head made available to the pump and provided by the piping system. To avoid damage to pump components caused by cavitation, the NPSHa must exceed the NPSHr (described in the Centrifugal Pump Head-Capacity Curve section of this document).

Description of application

Helps ensure that the pump will meet the application requirements. It is also helpful for confirming if a self-priming style pump is recommended.

Customer experience with suitable materials of construction

This can be extremely helpful in centrifugal pump specification, especially when the fluid being pumped is a mixture of chemicals. Sometimes particular pump construction materials like a certain plastic or elastomer might be suitable for certain individual chemicals, but when the chemicals are mixed they can negatively affect the construction materials. A good example is aqua regia, a mixture of hydrochloric and nitric acids. Individually these two acids do not dissolve gold but when mixed together in the right proportions, gold is dissolved.

Ambient temperature range

The maximum and minimum temperatures can be important if the pump is going to be installed outdoors or indoors where the temperature is not controlled. The motor is usually the deciding factor for high ambient temperature applications. Most common motors have a 104° F (40° C) maximum temperature.

For low ambient temperatures, pump materials of construction are the deciding factor. For example, polypropylene has a minimum working temperature of 32° F (0° C) and if the pump will be working below that, it will require a different material of construction.

Atmosphere environment

This has to do with the motor enclosure type. For example, if the atmosphere is corrosive vapor filled, a chemical-duty motor may be required. If the atmosphere is a hazardous location with the potential for flammable vapors, an explosion-proof motor may be required.

Altitude

Higher altitudes have reduced atmospheric pressure. This affects:

- Maximum potential lift for self-priming pumps. Lift is reduced by 1.13 feet (0.34 m) for every 1,000 feet (304 meters) of altitude
- NPSHa (Net Positive Suction Head available). Higher altitudes have reduced pressure on the surface of the liquid.
- Motor cooling ability. The air is less dense at higher altitudes and heat is not dissipated easily, so cooling is reduced. Standard motors are typically designed to operate below 3,300 feet (1,000 meters). Most motors must be de-rated at higher altitudes.

Centrifugal Pump Specifics

Centrifugal pumps are the most common pump type used to transfer corrosive fluids. They provide smooth fluid flow, are more energy efficient than other pump types, are available in standard flooded suction or self-priming designs, and offer a large variety of sizes to handle applications from a few gallons per minute, to hundreds, and even thousands of gallons per minute (1 m^3/hr to 500+ m^3/hr).

Flooded suction or self-priming applications

Flooded suction: Suction head exists when the liquid supply to the pump is ABOVE the center line of the pump. Gravity allows the fluid to flow into the pump. A storage tank with an outlet near the bottom feeding the pump would be a typical example. This is commonly referred to as a "flooded suction" application.

Self-priming: Suction lift exists when the liquid supply to the pump is BELOW the pump. Generally, for this type of application a self-priming pump is the best option. A self-priming pump creates a vacuum in the suction piping allowing atmospheric pressure to push the fluid up the suction piping to the pump inlet. A sump located below the pump would be a typical example. Another common example is pulling liquid out of the top of a tank. To reduce the chance for leakage, it is becoming common for storage tanks or railcars to no longer feature an outlet below the liquid level.

Centrifugal pumps with mechanical seals

Standard centrifugal pumps used for corrosive fluids incorporate a mechanical seal to prevent leakage where the internal rotating impeller protrudes through the stationary pump housing. This is similar to how the water pump in an automobile uses a mechanical seal to prevent coolant leakage from the pump.

A mechanical seal uses very carefully machined flat rings – frequently manufactured from ceramic, carbon, or silicon carbide (other materials are available) – that run against each other.

One rotates with the shaft and the other is stationary in the pump. The fluid being pumped migrates between the seal faces and provides a lubricating film. If the pump is operated without liquid, the friction causes the seal faces to rapidly heat up causing wear and failure. Dry running is a common cause of pump failure.

In addition to damage caused by dry running, mechanical seals can be damaged by abrasives (even small amounts), materials that tend to crystalize (like sodium hydroxide, a common corrosive liquid), materials that tend to harden, or liquids with a high vapor pressure (such as solvents).

Eventually mechanical seals fail, allowing the liquid being pumped to leak from the pump. If the application is water, the resulting pool of liquid is inconvenient but may not be harmful. However if the pump is used for corrosive fluids, a leak can result in a situation that can be harmful to people, potentially cause extensive damage to the surrounding infrastructure, and possibly trigger a report to government agencies.

In addition, there are downtime and cost considerations when a pump has to be pulled from service and repaired.

Advantages of centrifugal pumps with mechanical seals

- Initial purchase price may be lower compared to other types of pumps
- Can pump corrosive fluids if the correct materials of construction and mechanical seal are selected
- Depending upon the type of seal, can handle some solids

Disadvantages of centrifugal pumps with mechanical seals

- Seals fail, resulting in downtime, repair cost, and potential leakage of corrosive fluids
- Pumps are more complex to specify for corrosive fluids due to many variations of seal types and materials of construction
- Cannot run dry without damage
- Higher life cycle cost
- Potential emissions of product being pumped

Mag drive centrifugal pumps

The best way to completely eliminate the issues created by mechanical seals is to eliminate the mechanical seal from the pump design by using a mag drive pump.

Unlike a mechanically sealed centrifugal pump where there is a direct connection between the motor shaft and the impeller, a mag drive pump has no physical connection between the motor shaft and the impeller.

Magnets mounted on the motor shaft transfer the motor power through a solid barrier (frequently corrosion-resistant plastic) to magnets inside the pump that rotate the impeller. This allows the mechanical seal to be eliminated.

Depending upon the manufacturer and bushing material, mag drive pumps can run dry for varying periods (depending on size) without damage.

Mean Time Between Failures (MTBF) is considerably better (longer life) because the main areas of concern are bearings and seals. Mag drive pumps differ from traditional sealed pumps because they have no bearings or seals.

The life cycle cost is generally lower compared to a mechanically sealed pump due to the lower maintenance cost (no seals to replace), ease of installation (no water/drain lines for seals that require a flush fluid), and increased productivity (less downtime).

Advantages of mag drive centrifugal pumps

- Eliminate release of corrosive fluids due to seal failure
- Increased productivity, eliminate downtime to replace failed seals
- Can run dry without damage depending upon the manufacturer and bushing type
- Easier to install, no need for water/drain lines for seal flushing
- Low life cycle cost

Disadvantages of mag drive centrifugal pumps

- Limited solids capability
- Potentially higher initial purchase price
- Reduced options for fluid temperatures exceeding 250° F/121° C
- Metal mag drives have lower efficiencies than sealed centrifugal pumps due to eddy currents created. Note that plastic mag drive pumps retain high levels of efficiency because they do not create eddy currents.

Centrifugal Pump Head-Capacity Curve

A centrifugal pump always operates at the intersection of its head-capacity curve and the system curve. Head-capacity curves are developed and provided by the pump manufacturer. System curves are performance curves of piping systems. They are graphical representations of the head required to move a given flow rate through a piping system and are provided by the pump user.

A head-capacity curve usually represents pump performance on water at 70° F (21° C) and typically contains:

- Information on the model, pump size and speed
- Grid with flow on the X axis (horizontal) and head on the Y axis (vertical)
- Lines showing head and flow by impeller diameter (curve may show multiple impeller diameters for a specific model)
- Pump ISO-efficiency lines – represent how efficiency levels change along the pump curve.
- Power required – this is power required pumping water by impeller diameter
- Minimum NPSHr (Net Positive Suction Head required) – The minimum pressure required at the suction port of the pump to keep the pump from cavitating. NPSHr is a function of the pump and must be provided by the pump manufacturer.

A system curve consists of:

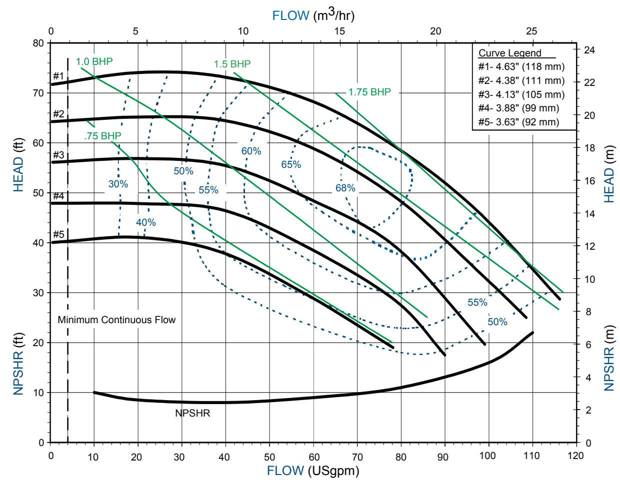
- Static head
- Pressure head (e.g., spray application)
- Friction loss in pipe and fittings

Selection of pump

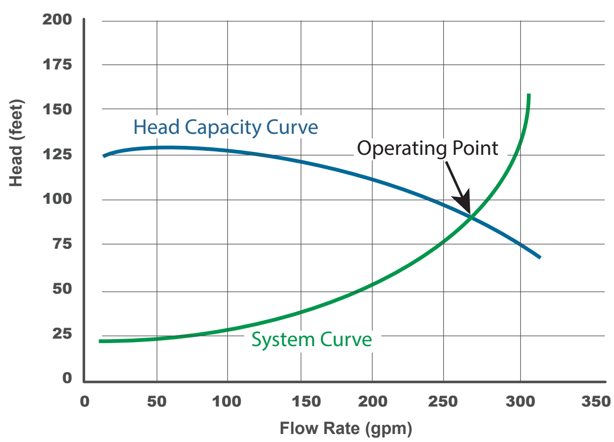
The proper pump can be selected by combining the system curve and the head-capacity curve (at right).

Head-Capacity Curve

Model DB11
3450 rpm, 60 Hz
Suction: 2" FNPT
Discharge: 1 1/2" MNPT



Intersection of Head-Capacity and System Curves



Selecting Proper Materials of Construction

When selecting a pump, specifying the proper materials of construction is critical to not only safely transfer corrosive chemicals, but also to provide a long pump life. There are numerous chemical resistance guides that can be found through Internet searches and many pump manufacturers have their own guides. Some pump manufacturers have computerized selection programs that ensure only compatible materials are selected.

Following are some common examples of construction materials used for pumps intended to convey corrosive chemicals.

METALS

Hastelloy C/Inconel/Alloy 625

Unlike stainless steel – which contains significant iron – these materials contain no more than 5% iron. They feature high nickel and chromium levels and up to 13% molybdenum. This high alloy content enables these materials to withstand a wide variety of corrosive fluids including sulfuric acid, hydrochloric acid, nitric acid at moderate temperatures, as well as many others. They are very expensive, typically at least three to four times the cost of 316 stainless steel.

Stainless steel

Stainless steel is an iron-based material (60%+ iron) that contains chromium which forms a thin layer of chromium oxide to protect the surface. Two common types used in pumps are 304 and 316. Stainless steel is significantly more expensive than steel, typically by a factor of two to three times.

- 304 also known as 18-8 since it contains 18% chromium and 8% nickel. It is commonly used in water pumps and is the primary metal used in stainless steel fasteners.
- 316 stainless steel contains a significant amount of molybdenum–typically 2 to 3 percent by weight versus only trace amounts found in 304. The higher molybdenum content results in grade 316 possessing increased corrosion resistance than other common stainless steel grades.

Titanium

Titanium is the fourth most abundant metallic element in the Earth's crust, but the processes for extracting titanium from its various ores are laborious and costly. Like stainless steel, it forms an oxide film for its corrosion resistance. Titanium performs best in oxidizing media such as hot nitric acid and sodium hypochlorite. It is lightweight and very expensive, typically 13+ times the cost of 316 stainless steel.

PLASTICS

CPVC

Chlorinated polyvinyl chloride is a thermoplastic that can be processed using injection molding technology. It has higher temperature capabilities compared to PVC (polyvinyl chloride) and has reasonable corrosion resistance. It is used in piping, valves, filters, and pumps (commonly vertical pumps used in plating applications) used for fluid transfer.

ETFE (Tefzel®)

ETFE (ethylene tetrafluoroethylene) is a fluoropolymer. It has better chemical resistance and a wider temperature range compared to PVDF. It has excellent mechanical strength, is very stiff and abrasion resistant. ETFE is used to line pipe, valves, and pump housings and can be injection molded into a variety of products including pumps.

Fiberglass

A glass-fiber-reinforced plastic that can utilize various plastic resins including vinyl ester, epoxy, or polyester resins depending upon the application and requirements. Fiberglass can be resistant to a wide variety of chemicals depending upon its composition and is frequently used for chemical storage tanks.

PFA

PFA (perfluoroalkoxy) is a fluoropolymer and is chemically inert with high temperature properties similar to PTFE and with very few chemicals affecting it. PFA can be melt processed making it easier to use than PTFE. Applications include lining pipes, valves, and fittings.

Polyethylene

It is the most common thermoplastic produced in the world and is used to make plastic milk containers. Various versions of cross linked polyethylene (XLPE) are used to manufacture chemical storage tanks and chemical transfer hoses and can be found in low-cost hand-operated drum pumps.

Polypropylene

The second most common thermoplastic in the world, polypropylene is resistant to a wide variety of corrosive materials. It is frequently injection molded and can have fillers added such as glass fibers to enhance dimensional stability and mechanical strength. It is frequently used in the manufacture of a wide variety of piping, fittings, and pumps used in the transfer of corrosive fluids.

PPS (Ryton®)

PPS (polyphenylene sulfide) is also branded as Ryton, a very stiff material with good dimensional stability, higher temperature capabilities, and fairly broad chemical resistance. PPS is resistant to most water-based solutions of acids and bases with the exception of strong oxidizing acids such as nitric acid, hydrofluoric acid, and hydrochloric acid.

PTFE (Teflon®)

PTFE (polytetrafluoroethylene) is a fluoropolymer which is chemically inert and stable at high temperatures with very few chemicals affecting it. It is difficult to process because it cannot be melt-processed and has a tendency to creep (cold flow).

PVDF (Kynar®)

PVDF (polyvinylidene fluoride) is a strong, abrasion-resistant fluoropolymer with outstanding chemical resistance. It has good low- and high-temperature capabilities and is resistant to UV rays (sunlight). PVDF is a very pure material – one of the few plastics that can be processed without the use of additives – which means that fluids that come in contact with it do not leach contaminants. It is commonly used in extremely corrosive and high-purity applications for piping, fittings, pumps, and instrumentation.

ELASTOMERS

Aflas®

Aflas® (a copolymer of tetrafluoroethylene and propylene) is highly resistant to a wide range of chemicals including many acids and bases and offers high temperature capability.

EPDM

EPDM (ethylene propylene diene methylene rubber), unlike FKM, is compatible with most caustics and has a good temperature range.

FEP Encapsulated

FEP (fluorinated ethylene propylene) is similar in composition to the fluoropolymers PTFE and PFA. FEP is softer than PTFE and more formable. FEP-encapsulated O-rings have an elastomer core that is completely covered with a seamless sheath of FEP fluoropolymer. The elastomeric core is normally either fluorocarbon (FKM) or silicone (VMQ).

FFKM (Simrez®, Kalrez®)

Perfluoroelastomers (FFKM) are the elastomeric form of polytetrafluoroethylene (PTFE). These elastomers are fully fluorinated providing the highest level of corrosion resistance. One downside is that they are very expensive.

FKM (Viton®)

FKM is a fluorocarbon elastomer with extensive chemical compatibility which spans considerable concentration and temperature ranges. This makes FKM a good choice for many applications.

Nitrile (Buna N)

A general purpose oil- and water-resistant rubber with a moderate working temperature range, nitrile is not compatible with many corrosive materials.

OTHER MATERIALS

Alpha sintered silicon carbide

Alpha sintered silicon carbide (SiC) offers superior hardness, high strength, high abrasion/wear resistance, and excellent corrosion resistance to even the most corrosive materials. Alpha sintered is superior to other grades of silicon carbide because it contains no silica. It is found in higher-end mechanical seals and mag drive pumps as thrust rings, shafts, and bushings.

Carbon graphite

Carbon graphite offers good chemical resistance to a wide variety of chemicals, even many that are extremely corrosive. When used in clean fluids, it provides a good service life. In addition, depending upon the specific manufacturer, when used in mag drive pumps as the bushing it can even provide dry running protection. In mechanical seals, carbon graphite/high purity ceramic seal faces are very common. In mag drive pumps, it is a common bushing material.

Ceramic

Alumina ceramic (aluminum oxide) is commonly used for mechanical seals and as thrust rings, shafts, and a bushing option (for enhanced abrasion resistance) in mag drive pumps. This is primarily due to its favorable price to performance ratio. Alumina ceramics are commonly subdivided according to their alumina content ranging from 80% to more than 99%. Higher purity (99.5%) alumina demonstrates enhanced wear and corrosion resistance.

Siliconized carbon

Also called reaction-bonded silicon carbide. It is not as hard or chemical-resistant as alpha sintered silicon carbide, but is typically less expensive and usually found in mechanical seals as a lower cost option.

Pump Selection Process

As discussed in this guide, there are many variables to the selection of the best centrifugal pump type with the correct materials of construction for chemical or corrosive applications. Here is a summary of the process:

1 Gather specific information on the fluid to be pumped

- Fluid name
- Concentration
- pH
- Fluid temperature
- Specific gravity
- Viscosity at pumping temperature
- Determine solids characteristics unless clean fluid (size, hardness, and concentration)

2 Gather specific information on the hydraulic/application requirements and environmental conditions

- Total head/suction head
- Flow rate
- NPSHa
- Description of application
- Ambient temperature range
- Atmospheric environment
- Altitude

3 Consult the experts

Once you have the necessary information, you can consult with pump manufacturers or local pump distributors who are experienced in the selection of centrifugal pumps for use with corrosive chemicals. If you have trouble gathering the required information, they can also be a valuable resource for evaluating your application and helping to determine pump requirements. The chemical manufacturer or distributor is also a valuable resource. There are even computerized pump selection programs to help as well.

Information Sources

There are several ways to learn more about the specific hazards associated with corrosive chemicals. Complete knowledge of the hazards of the material and suitable materials of construction for the transfer pump and associated piping, valves, etc. is critical. The consequences of improper selection of suitable materials can be devastating.

SDS – Safety Data Sheets

Formerly called MSDS (Material Safety Data Sheets). The information in an SDS is largely the same as the MSDS, except they are presented in a user-friendly, 16-section format.

The Hazard Communication Standard (HCS) [29 CFR 1910.1200(g)] requires that the chemical manufacturer or distributor provide Safety Data Sheets (SDSs) for each hazardous chemical to users to communicate information on hazards.

Sections 1 through 8 of the SDS contain general information about the chemical, identification, hazards, composition, safe handling practices, and emergency control measures.

Sections 9 through 11 and 16 contain other technical and scientific information, such as physical and chemical properties, stability and reactivity information, toxicological information, exposure control information, and other information.

Sections 12 through 15 (Ecological Information, Disposal Considerations, Transportation Information, and Regulatory Information) are required to be consistent with the UN Globally Harmonized System of Classification and Labeling of Chemicals (GHS), but OSHA will not enforce the content of those sections because they concern matters handled by other agencies.

Chemical Manufacturer Resources

- **Technical staff** – Speak to the company's support staff or technical sales person.
- **Guidebooks** – Some manufacturers provide guidebooks that provide additional technical information on the material. This can include more extensive details on the chemistry and properties; safe handling and storage information; system design and installation information; and materials that are compatible with the chemical.

Pump Manufacturer Technical Staff

Recommendations can be supplied that take into account the material being transferred as well as the application/ performance requirements. Make sure you deal with a reputable company that has years of experience in the application of centrifugal pumps for use with corrosive chemicals.

Footnotes

[1] https://www.osha.gov/dsg/hazcom/ghd053107.html

[2] ANSI/Hydraulic Institute standard 5.3.3.4.7, available from http://pumps.org/Standards_and_Guidebooks.aspx

[3] https://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=30

[4] https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_id=10099&p_table=STANDARDS

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Finish Thompson Inc. designs and manufactures pumps for the safe transfer of a wide variety of corrosive fluids. Products include sealless mag-drive centrifugal pumps with run-dry capability, mechanically sealed pumps, drum/barrel pumps, vertical mag-drive pumps, multi-stage pumps and the FTI Air line of air-operated double diaphragm (AODD) pumps.

Finish Thompson products are manufactured in Erie, Pennsylvania, U.S.A., and marketed worldwide through an international network of stocking distributors.

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