

## Equipment Related FAQs

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### Handling Equipment

**Q.**

What kind of pump do you use to transfer acid from the tank to the process?

**A.**

A centrifugal, sealless magnetic-drive pump is the preferred pump for sulfuric acid transfer. The wetted parts should be 316 stainless steel, Alloy 20 or Teflon<sup>®</sup>-lined.

**Q.**

What kind of metering pump is used for small quantities of acid (<5 gpm)?

**A.**

Positive displacement pumps, with wetted parts of Alloy 20, 316 stainless steel or Teflon<sup>®</sup> are typically used for this application.

**Q.**

What do you recommend for piping?

**A.**

The materials of construction for piping are dependent on fluid flow velocities and quality concerns. In general, seamless carbon steel piping is used for flow velocities between 1-3 feet per second (fps). 316 SS is acceptable for flow velocities of 0-8 fps. Alloy 20 works for flow velocities of 0-20 fps, and Teflon<sup>®</sup>-lined pipe works for all ranges of fluid velocity. If iron contamination is a concern for the process, stay away from carbon steel. These recommendations assume ambient temperatures. All metal piping should be welded per "ANSI B31.3 - Normal Service" specifications. Screwed fittings are discouraged. PVC and CPVC piping is recommended

for vent/vapor lines only. They are not recommended for liquid service.

**Q.**

What do you recommend for storage tanks?

**A.**

The most common material used for sulfuric acid (>70%) storage tanks is carbon steel. It is relatively inexpensive and offers good corrosion resistance. If iron contamination is a problem in your process, 304 or 316 stainless steel is acceptable. For more aggressive environments, Alloy 20 may be an economical choice. For small tanks (<4500 gallons) with sulfuric acid concentrations below 95%, high-density, cross-linked polyethylene (HDXPE) may be suitable.

**Q.**

Are vertical or horizontal tanks better?

**A.**

Both horizontal and vertical tanks can give good service as a sulfuric acid storage tank if properly designed and maintained.

**Q.**

Are PVC and/or CPVC acceptable for sulfuric acid?

**A.**

PVC and CPVC are acceptable only for vent line or overflow line piping. PVC and CPVC chemically will withstand exposure to sulfuric acid. They are not recommended for liquid service, though, as the plastic pipe does not have adequate "mechanical strength" to hold the sulfuric acid (remember, the acid weighs almost twice as much as water) and is subject to mechanical failure.

**Q.**

Is Teflon<sup>®</sup> OK for sulfuric acid?

**A.**

All grades of Teflon<sup>®</sup> are acceptable for all strengths of sulfuric acid up to 400° F.

**Q.**

What do you recommend for valves?

**A.**

Plug valves or full-port ball valves are generally recommended for sulfuric acid service. Valves should be constructed of cast Alloy 20 for acid strength above 70%.

**Q.**

What kind of hoses are OK for sulfuric acid?

**A.**

A Teflon<sup>®</sup> PTFE-lined hose is acceptable for 93-98% sulfuric acid service. The hose should be designed with a 200-psi minimum working pressure and be full vacuum rated. The end fittings must be crimped or swaged - banding is not recommended. The hose manufacturer must list the hose as "satisfactory" for 93-98% sulfuric acid service. The hose end fittings should be 316 stainless steel with flanges or quick-connect fittings. The gasket must be virgin Viton<sup>®</sup> B. The user should have a "hose management program" in place to ensure the integrity of the hose. The hose must be dedicated to sulfuric acid service.

## **Instrumentation**

**Q.**

What level gauges work for acid storage tanks?

**A.**

Several different types of level gauges will give satisfactory service for sulfuric acid storage tank levels. These include differential pressure (d/P) cells, sonar probes, radar probes, capacitance probes and floats. The "wetted" parts should be 316 stainless steel, Alloy 20 or Teflon<sup>®</sup>-lined.

**Q.**

What kind of flow meters work?

**A.**

Several types of flow meters will work with sulfuric acid, including: magnetic flow meters, coriolis (mass flow) meters (Micro Motion), armored rotameters and ultrasonic flow meters. All of these can give adequate service for sulfuric acid.

**Q.**

Are there any in-line acid strength meters that work?

**A.**

In-line acid strength analyzers can be designed for sulfuric acid service. Ones that have had success include sonic velocity analyzers, conductivity analyzers, refractive index analyzers and density meters. All of these analyzers can "flip-flop" at some acid strengths and give erroneous readings (conductivity at ~100%, sonic velocity at ~100%, refractive index at ~100% and density at ~97%).

**Q.**

Are sight glasses in the piping acceptable?

**A.**

Sight glasses can be successfully used in sulfuric acid piping systems. Care must be taken to ensure they are protected from mechanical damage and are constructed of suitable materials.

**Q.**

Do you need dry air or nitrogen for bubbler level gauges?

**A.**

Dry instrument air (dew point <-40° F) or nitrogen are preferred for bubblers. Moisture added to sulfuric acid only increases its corrosivity to most metals.

## **Materials of Construction**

**Q.**

What are the limits of carbon steel in acid service?

**A.**

In general, carbon steel is the most commonly used material of construction for storage tanks and piping with sulfuric acid above 77%. In piping care must be taken to design the piping system to minimize turbulence in the liquid flow. The piping should be sized to maintain fluid velocity between 1-3 feet per second (fps). Schedule 80 (minimum) welded piping is recommended. The temperature should be kept below 100° F wherever possible. For tanks, the design corrosion allowance should be 1/8".

**Q.**

When should I use stainless steel vs. carbon steel?

**A.**

Stainless steel should be used in place of carbon steel if iron contamination is a problem in your process. Also, stainless steel is acceptable for 100% sulfuric acid - carbon steel is not. Stainless steel is also preferred at low (<20%) acid concentrations. Stainless steel has a greater resistance to "hydrogen grooving".

**Q.**

Is copper/brass/bronze OK with acid?

**A.**

Copper/brass/bronze is not acceptable for sulfuric acid service, at any strength.

**Q.**

Is glass OK?

**A.**

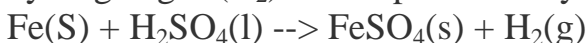
Glass has excellent corrosion resistance with sulfuric acid, at all concentrations.

**Q.**

What is the corrosion mechanism with acid and steel?

**A.**

When sulfuric acid first contacts carbon steel, iron sulfate ( $\text{FeSO}_4$ ) is produced. The iron sulfate coats the steel and forms a "passivation" film which then protects the carbon steel from further corrosion. Flammable hydrogen gas ( $\text{H}_2$ ) is also produced by the corrosion reaction:



**Q.**

What are the temperature limits of steel, stainless steel and Alloy 20 in acid service?

**A.**

For steel the temperature should be maintained below 100° F, for stainless steel below 120° F, and for Alloy 20 below 140° F.

**Q.**

Is Hastelloy<sup>®</sup> OK?

**A.**

Hastelloy<sup>®</sup> B and C are generally acceptable for most strengths of sulfuric acid. They are usually only used for specialty applications, as it is ~6X the cost of carbon steel.

**Q.**

Is PE and/or PP OK? At what temperature and %?

**A.**

Polyethylene (PE) and polypropylene (PP) have limited applications in sulfuric acid service. PE can be used for small (<5000 gallon) storage tanks for sulfuric acid at ambient temperatures and below 95%. High density, cross-linked PE (HDXPE) is the preferred resin for storage tanks.

Polyethylene can be used for sample bottles, drums and tote tanks at the same conditions. PP is slightly more resistant to sulfuric acid than PE in the 95-98% range, at ambient temperatures. Both plastics may be subject to stress cracking - the potential increases with temperature, storage time and strength.

**Q.**

What is "hydrogen grooving"?

**A.**

When sulfuric acid first contacts carbon steel, a passivation coating of iron sulfate is formed, along with hydrogen gas. The iron sulfate coating protects the steel from further corrosion. The hydrogen gas bubbles will float up in the liquid sulfuric acid. If, as the H<sub>2</sub> bubbles float up, they contact the metal, the bubbles will scrape off the iron sulfate coating, exposing bare metal. This will form more iron sulfate and more H<sub>2</sub> bubbles. The bubbles tend to follow the same track, exposing more bare metal. Eventually the metal will have grooves corroded/eroded into the surface from the "never-ending" cycle of iron sulfate formation/H<sub>2</sub> "scrubbing bubbles"/bare metal/iron sulfate formation. The striation in the metal is called "hydrogen grooving".

**Q.**

Why does piping develop leaks at elbows and/or welds?

**A.**

For carbon steel piping, the recommended fluid velocity is 1-3 feet per second (fps). Below 1 fps the corrosion phenomena called "hydrogen grooving" takes place. Above 3 fps, generalized corrosion will occur. In sulfuric acid service, the carbon steel is protected from corrosion by a passivation coating of iron sulfate. If the fluid velocity exceeds 3 fps, the iron sulfate passivation coating does not form. In piping transition pieces (elbow, tees, valves, expansion, contraction, etc.) the fluid velocity tends to be greater (because of turbulence) than in the straight pieces of pipe, so the passivation coating does not form as well. Also, downstream of welds, if there is any slag left inside the pipe, turbulence tends to occur, and the iron sulfate coating doesn't form well. With less passivation coating, generalized corrosion is accelerated in those spot.

**Q.**

What are the flow limitations for acid piping?

**A.**

The "Rules of Thumb" for flow limitation when designing piping system at ambient temperatures are:

- Carbon Steel: 1-3 feet per second (fps)
- 304 and 304L stainless steel: 0-6 fps
- 316 and 316L stainless steel: 0-8 fps
- Alloy 20: 0-20 fps
- Teflon<sup>®</sup> and Kynar<sup>®</sup> lined: 0-50 fps

## **Inspection Procedures**

**Q.**

How do you inspect an acid storage tank?

**A.**

There are three types of inspections normally done on a sulfuric acid tank.

The first is an external "walk-around" inspection.

- Every year someone should "walk-around" the tank, looking for signs of sulfate leakage or other metal deterioration, making sure the insulation (if so equipped) is weather-tight, observing the overflow/vent line to make sure it is not plugged, looking at the tank foundation/supports.
- A more thorough external tank inspection would include an ultrasonic

thickness test. Areas around welds and nozzles should be carefully reviewed

- An internal tank inspection is the most thorough. It involves emptying and cleaning the tank. Someone (preferably an API-certified inspector) then enters the tank and visually inspect the internal welds and tank surfaces. Ultrasonic thickness testing should be done on the floor and any other questionable areas at this time. Be sure to follow all OSHA guidelines when entering the tank.

**Q.**

How often do you inspect an acid storage tank?

**A.**

General guidance for tank inspections is as follows:

- An annual external "walk-around" inspection.
- A biennial ultrasonic thickness test.
- Every 5-6 years empty and clean the tank, and internally inspect the tank.

These inspection frequencies can be increased or decreased, based on actual findings when the tanks are inspected. Be sure to document all inspections and keep copies in the tank files. Use API 653 for guidance on vertical tank inspections.

**Q.**

How do you inspect piping? How often?

**A.**

In general, piping is formally externally inspected visually every five years, and ultrasonic thickness tested biennially. Again, actual plant experience may dictate an increase or decrease in this schedule. Extra attention should be paid to elbows, tees, valves and any other places in the piping where flow disturbances (and erosion/corrosion) could occur. Use API 570, Class II piping standards for guidance.

**Q.**

How do you clean an acid tank?

**A.**

Sulfuric acid tanks are usually only cleaned when the tanks are due for the internal inspection (every 5-6 years) or when the iron sulfate builds-up in the tank enough to cause quality problems with the product.



## **Sulfuric Acid Process**

**Q.**

How do you make sulfuric acid?

**A.**

The primary process used to make sulfuric acid is called the "Contact Process". Molten sulfur is sprayed through an atomizer nozzle into the sulfur burner and combusted with dry air to make sulfur dioxide ( $\text{SO}_2$ ). The air is dried by running it countercurrent through a spray column filled with sulfuric acid. The acid absorbs all moisture in the air. The  $\text{SO}_2$  gas is passed through a multi-layer catalytic converter with more air to make sulfur trioxide ( $\text{SO}_3$ ). The catalyst used is vanadium pentoxide. The  $\text{SO}_3$  gas is absorbed in sulfuric acid to make a higher strength (tower) sulfuric acid. The tower acid is then blended with water to get the desired sales strength.

**Q.**

What do use for materials of construction in your plant?

**A.**

Carbon steel is the most commonly used material in a sulfuric acid plant.

**Q.**

What are the raw materials for sulfuric acid?

**A.**

The basic raw materials for sulfuric acid are sulfur, air and water. The sulfur can be from elemental sulfur, from  $\text{H}_2\text{S}$ , or roasted from metal sulfides.