



Application Note to the Field

Common Application: Sulfuric Acid

Application Note Number: 0012-1

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The most common application that Liquiflo sees is for concentrated Sulfuric Acid (H₂SO₄), 93-98%. This chemical is used for a wide variety of things across many different industries. Notable are water treatment and papermaking.

Many of the selections that people make for this fluid are perfectly acceptable and are what has been done by convention for quite some time. There are, however, a couple of materials that Liquiflo has been offering for a few years that are just as compatible chemically and also have the benefit of being mechanically superior. As well, the metals used will be discussed.

In concentrations above 91% and at ambient temperature (68°F/20°C), 316 SS has an "A" rating. Many people prefer to use Alloy-C. This is fine, but if the concentration will not fall below this level, a lot of money can be saved by using stainless steel. If the concentration is less than 93% and the supply tank is open to atmosphere it may be wise to use Alloy-C nonetheless. This is because sulfuric is highly hygroscopic (absorbs water) and so if there is a very humid period the concentration could fall on its own. For anything less than 91%, Alloy-C should always be used (50-70% is the most corrosive concentration range).

The pump internals that are commonly seen are an Alloy-C drive gear, Teflon idler gear, and Teflon wear plates and bearings, possibly with ceramic-coated shafts. Many pumps ordered are sealed, and an "S" single internal seal (Teflon vs. silicon carbide) is chosen. Since concentrated sulfuric provides for good film lubrication, this is usually acceptable for low to moderate differential pressure, although as pressure rises, life can start to get lower. Additionally, if the pump base material is 316 SS, there is the problem of the gland plate and drive shaft. As mentioned above, sulfuric is hygroscopic. As it crosses the seal faces, it will tend to collect in a drop. This drop will absorb what moisture it can from the air and the concentration will fall. This will start to corrode the drive shaft where it exits the pump, and once the drop gets heavy enough to run, it will also attack the gland plate, eventually cutting a channel through it. In the case where a single seal is to be used, an Alloy-C pump, or at least one with an Alloy-C gland plate and drive shaft should be used. As well, a "U" (carbon vs. silicon carbide) seal typically gets better life, as the carbon rotating face wears better than the Teflon of the "S." In this day and age of environmental friendliness and trend towards lower maintenance, a mag-drive pump is the norm, however.

The "E" acid-grade carbon now being offered by Liquiflo is acceptable for all concentrations of sulfuric acid less than 100%. This material is harder than Teflon and will not deform as the Teflon does under load, does not contain glass (as PTFE does, for reinforcement) which can be abrasive to the metal shafts, is relatively self-lubricating and has a much lower coefficient of thermal expansion. As a result, the carbon generally lasts longer and is more resistant to damage (or to damaging other parts) than is Teflon, especially if there is some sort of upset or short period of dry running. This material is therefore generally superior for this application for the wear plates, but especially for the bearings.

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If the concentration is 70% or higher and/or the pressure is relatively low, coated shafts can be foregone. If coated shafts are required, tungsten carbide is the preferred coating, as this material has a coefficient of thermal expansion much more closely matched to the parent shaft material than ceramic, and so if there is a temperature excursion for any reason (dry running, etc.) the coating is much less likely to fail. Coatings can fail when the shaft expands more than the ceramic does as temperature rises. It can crack, and this edge may eventually be caught resulting in the coating being partially or completely torn off. Since the coating is approximately 10 thousandths of an inch thick, the clearances of the pump are destroyed. Additionally, pieces of ceramic are now free in the pump, which can cause other damage.

In a 316 SS pump, a 316 SS drive gear can be used. An Alloy-C gear does not provide any additional performance or corrosion resistance, and is more expensive. Of course, an Alloy-C drive gear should be used in an Alloy-C pump.

The idler gear for all concentrations except 93% can be Ryton. This material stress cracks at this particular concentration, but is mechanically superior to Teflon for all others below 100%. It is also reinforced with glass, but is harder, stronger, and chemically inert to sulfuric within the above constraints. For pumps, size H7/37 and larger, Teflon is acceptable for idler gear use up to about 65 PSI (4.5 bar) differential. For the smaller pumps, 50-60 PSI (~ 3.5-4 bar) differential (depending on other parameters) is about the limit. (These pressure limits should be derated by 0.25%/°F at temperatures above 80°F. In addition, Teflon gears should be properly trimmed when operating above 80-100 °F – depending on the pump size – to account for the high thermal expansion of PTFE.) Teflon gears for the smaller pumps have lower pressure ratings because their smaller teeth can make them more susceptible to deformation and failure. In the case of the H1/31/41, where Teflon is not available as a gear material due to its small size, Ryton must be used, or in the case of 93%, two metal gears. While this is not a perfect solution, it is the only choice that will work for this narrow range. Alternately, go to a H3/33/43 and operate the pump more slowly or bypass excess flow (to the supply tank, not the pump suction).

For concentrations higher than 100%, 316 SS can be used, but unfortunately the other materials are rather limited. The conventional wisdom of Teflon for the idler gear, wear plates and bearings should be observed.

As always, use a relief valve. Deadheading a gear pump will break it and higher than design pressures will cause more rapid wear and/or failure.

Some Physical Properties of Sulfuric Acid @ STP

Concentration in Water		10%	50%	98%
Specific Gravity	–	1.07	1.40	1.84
Viscosity	cP	1.23	~ 5	26
Melting Point	°F	+23	-31	+30
Boiling Point	°F	215	254	621
Vapor Pressure	mmHg	< 17.5	< 12	< 1

STP = 68°F (20°C) & 1 atm (1.01 bar)

Note: Sulfuric acid is nonflammable at all concentrations.