Application Note to the Field	**Common Fluid: Pumping Sulfuric Acid with Liquiflo Gear Pumps**
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Sulfuric acid (H_2SO_4) is the world's most produced chemical. It is used for a wide variety of things across many different industries. Notable are water treatment, ore processing, oil refining, and the production of paper, steel and batteries. It makes sense that the most common application that Liquiflo sees is for concentrated sulfuric acid, 93-98%.

This application note will discuss materials of construction for sulfuric acid applications and suggest standard gear pump constructions based on the concentration range. (Refer to the chart on the following page.)

In concentrations of 93-100% and at ambient temperature (68°F/20°C), 316 SS has an "A" rating. Many people prefer to use Alloy-C. This if 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 96% and the supply tank is open to the 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 93%, 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, and in the case of a sealed pump, an "S" single internal seal (Teflon vs. silicon carbide). Since concentrated sulfuric provides for good film lubrication, this is usually acceptable for low to moderate differential pressure ($\leq$ 50 PSI), 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. Thus, in the case where a single seal is to be used, an Alloy-C pump should be used. As well, a "U" seal (carbon vs. silicon carbide) is suggested, which typically gets better life, as the carbon rotating face wears better than the Teflon of the "S." A better alternative is to use a mag-drive pump, which has no mechanical seal to replace, no leakage of fluid to the environment and can be made of 316 SS for concentrations of 93% or higher.

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 Teflon does under load, does not contain glass (as Teflon bearings, wear plates and gears do, for reinforcement) which can be abrasive to the metal shafts, is relatively self-lubricating and has a much lower thermal coefficient of expansion. As a result, 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.

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.

Several material choices are available for the idler gear: PEEK is not compatible with sulfuric acid for other than dilute solutions (< 10%). Ryton can be used for all concentrations but has a "B" rating within 10-100% and is known to stress crack at 93%. Teflon is compatible at all concentrations but has significant physical limitations. The differential pressure must be limited to 50-65 PSI (3.4-4.5 bar), depending on the pump size, to prevent rapid wear, deformation or breakage of the gear teeth. Kynar, which is now available in the H-Series pumps, is compatible with sulfuric acid at all concentrations up to 100%. The Kynar offered by Liquiflo is FDA grade PVDF, which is a pure, unfilled material and has twice the strength of Teflon. It is therefore the preferred idler gear material for sulfuric acid. In the case where the pressure limit of Kynar is exceeded (100-130 PSI or 6.9-9.0 bar) and the acid is concentrated (93-100%), double metal gears can be used provided that the speed is limited to 600 RPM. This is allowed due to the moderate viscosity of concentrated H_2SO_4 (see physical properties chart below).

Tungsten carbide coated shafts are highly recommended for extending pump life for all conditions of service, but especially at lower concentrations and higher pressures.

For concentrations higher than 100% (i.e., oleum), 316 SS can be used, but unfortunately the other materials are rather limited. In this case, Teflon should be used for the idler gear, wear plates and bearings.

Suggested Materials of Construction for Specific Sulfuric Acid Concentrations

Gear Pump Component	H_2SO_4 Concentration		
	< 93%	**93-100%**	**> 100%**
Housing & Shafts	Alloy-C	316 SS [1]	316 SS
Drive Gear	Alloy-C	316 SS [1]	316 SS
Idler Gear	Kynar [2]	Kynar [2]	Teflon [2]
Wear Plates	Carbon-60	Carbon-60	Teflon
Bearings	Carbon-60	Carbon-60	Teflon [2]
Shaft Coating	Tungsten Carbide	Tungsten Carbide	Tungsten Carbide
O-rings	Virgin Teflon	Virgin Teflon	Virgin Teflon
Mechanical Seal [3]	Carbon vs. SiC	Carbon vs. SiC	Teflon [2] vs. SiC

[1] Alloy-C suggested for Sealed pumps or temperatures greater than 95°F.
[2] Observe pressure limit for plastic material. [3] Not applicable for Mag-drive pumps.

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.