



Technical Note

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Subject: Corrosion resistance of 316L stainless steel as a marine SO_x scrubber material

1. Introduction¹

Type 316/316L stainless steel is a molybdenum bearing grade of stainless steel. The presence of molybdenum gives 316/316L stainless steel better overall corrosion resistance than types 301 or 304 stainless steel. Type 316 gives useful service at room temperature in sulfuric acid of concentrations lower than 15% wt. and greater than 85% wt. It also resists chloride attack and is often used in marine environments.

Typical chemical composition of 316/316L stainless steel is as shown in Table 1.

Table 1. Typical chemical composition of 316/316L stainless steel (weight %)

		316	316L
Nickel	Ni	10.0 - 14.0	10.0 - 14.0
Chromium	Cr	16.0 - 18.0	16.0 - 18.0
Manganese	Mn	2.0 max	2.0 max
Iron	Fe	Balance	Balance
Carbon	C	0.08 max	0.03 max
Phosphorus	P	0.045 max	0.045 max
Sulfur	S	0.030 max	0.030 max
Silicon	Si	1.0 max	1.0 max
Molybdenum	Mo	2.0 to 3.0	2.0 to 3.0

¹ http://www.sulphuric-acid.com/techmanual/materials/materials_metals_316.htm



2. Corrosion rates

This section provides two curves showing corrosion rates of stainless steel in sulfuric acid solution. Units for corrosion rate is “mpy (mils penetration per year)”, which means one thousandth of an inch per year; 0.0254mm per year of corrosion speed.

The point, **A**, in Figure 1, shows the temperature level during the scrubber operation. During the scrubber operation, weight concentration of sulfuric acid is in the range of 10⁻⁴% by weight percentage and this gives the acidity level of ~pH³. It means that the stainless steel of 316/316L is in the “Passive Regions” with <0.1mpy.

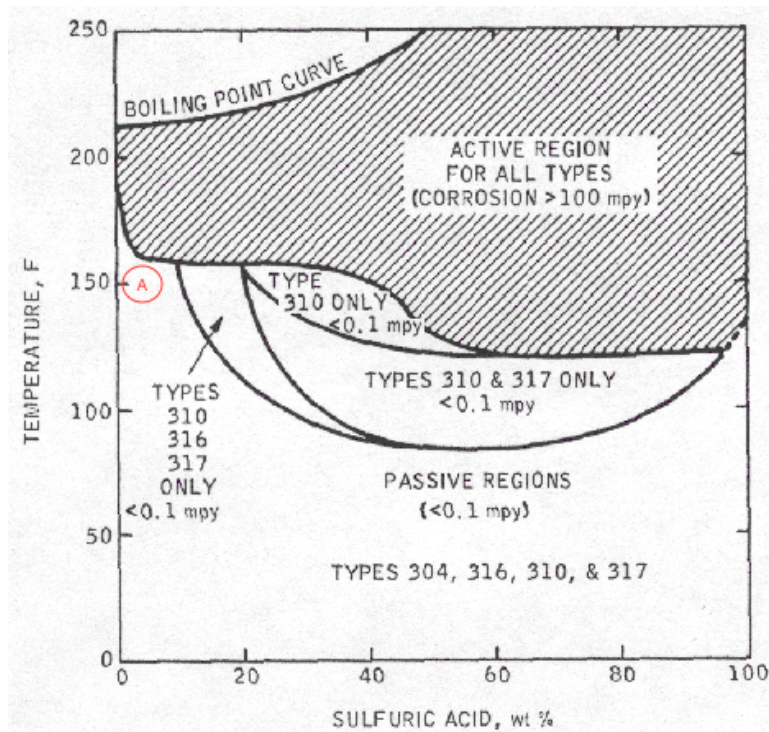


Figure 1. Corrosion resistance of stainless steel against sulfuric acid³
(mpy: mils penetration per year, equal to one thousandth of an inch per year;
1mpy = 0.0254mm per year of corrosion speed)

² Technical note: STI TN Sulfuric Acid concentration and ph 18Aug2017, <http://simulationtech.co.kr/wp/wp-content/uploads/2017/08/STI-TN-Sulfuric-Acid-concentration-and-ph-18Aug2017.pdf>

³ http://www.sulphuric-acid.com/techmanual/materials/materials_metals_316.htm



Figure 2 shows the corrosion speed of stainless steel taken from a literature. The corrosion rates of SUS316L at 79°C is highlighted as red squares. When the weight concentration of the sulfuric acid approaches to zero, the *mpy* drops dramatically. Lowest point in Figure 2 is 0.03mpy, corresponding to 0.000762mm/year of corrosion speed.

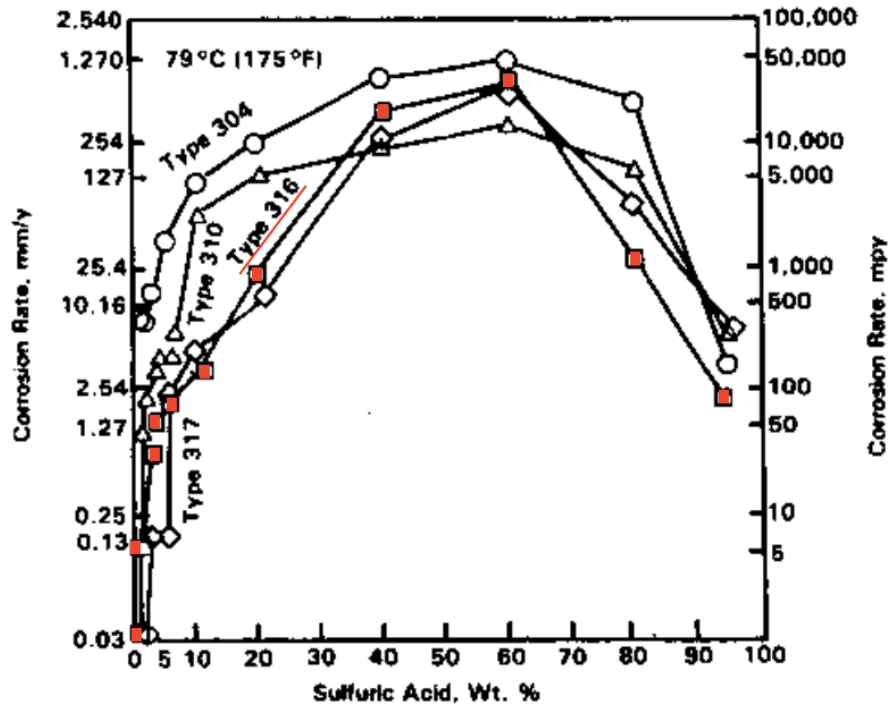


Figure 2. Corrosion of stainless steels in as-mixed sulfuric acid⁴

3. Summary

Operating conditions of SO_x scrubber units while running are,

- temperature: <100°C
- weight concentration of sulfuric acid: ~10⁻⁵%.

316L stainless steel has enough corrosion resistance in the presence of low sulfuric acid at temperature levels while scrubber units are in operation. It is thanks to the molybdenum contents being over 2% in weight contents. See Figure 1 and Figure 2.

Duplex stainless steel, super duplex stainless steel, and other higher graded stainless steel are material with high weight concentration of sulfuric acid and/or high temperatures of well over 100°C.



⁴ Figure 6, Page 8, “The corrosion resistance of Nickel-Containing alloys in Sulfuric acid and Related compounds”, 1983, The international Nickel Company Inc., Inco-Sterling Forest, PO Box 200, Suffern, NY, 10901