For Corrosion Resistance in Your Critical Components

Swagelok®

Only the Best for Your Critical Components

SAT12® services is all about options – giving you more of them

The SAT12 process is a patented method of heat treating austenitic stainless steels that increases the surface hardness, while providing improved wear resistance and fatigue properties, with ductility substantially retained. In most cases, treated specimens maintain their corrosion resistance – and, in some cases, corrosion resistance is improved.

What does this mean for you? You can enhance the performance of the materials you are currently using. Or, instead of specifying an expensive corrosion-resistant alloy, you may find it more cost effective to choose a less costly alloy and treat your components with the SAT12 process.

We know the SAT12 process brings corrosion-resistant benefits because we have conducted validation testing that meets ASTM standards. This testing is in keeping with the materials research that has served as the foundation of our high-quality Swagelok® products for more than 60 years. Third-party testing of the benefits of SAT12 process have also been conducted by major research universities and national laboratories.

Corrosion test results are generally dependent on the quality and composition of the materials used, and these can vary widely, even within ASTM categories. Results also depend on the unique specifics of the application involved, such as temperature and pH.

At Swagelok, we stand behind our SAT12 process. Since 2000, we have been using the SAT12 process to treat the rear ferrule in our signature product, the Swagelok® tube fitting. Using the SAT12 process, we made the world's best tube fitting even better.

With Swagelok Technology Services Company (STSC), you get a company that does its homework. We are a wholly owned subsidiary of Swagelok that brings the benefits of the SAT12 process to market.

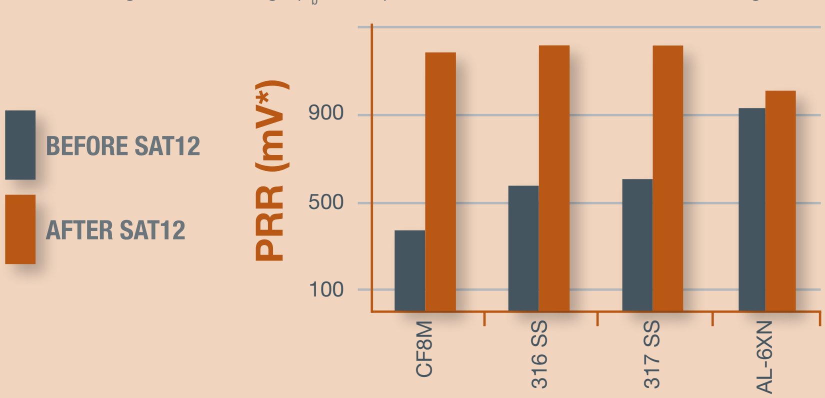
This document shows the results of that homework, outlining the ASTM tests and other key findings for the major categories of corrosion that your critical components face in the field every day.

Pitting Corrosion

Localized corrosion where cavities or holes are produced in the material.

PITTING RESISTANCE RANGE (PRR)

Pitting resistance range (E_b - Ecorr) before and after SAT12, delta descending



Pitting resistance increases significantly on lower PREN alloys after they have been treated with the SAT12 process.

E_b breakdown potential
Ecorr corrosion potential
PREN pitting resistance equivalent number

CONCLUSION

SAT12 process improved the breakdown potentials (E_b) of austenitic alloys CF8M, 316, and 317 by an average 696 mV. Superaustenitic alloy AL-6XN, which has intrinsically high E_b, exhibited minor changes in the E_b and remained above 90mV after SAT12 process. The alloys that exhibited the biggest increase in breakdown potentials also exhibited the greatest increase in pitting resistance range, an average of 665 mV. The remaining high alloys exhibited minor increases, less than 150 mV. The highly alloyed superaustenitic alloy AL-6XN exhibited the smallest pit propagation range. It was less than 40 mV.

** Measured versus saturated calomel electrode*

Uniform Corrosion

A corrosive attack proceeding evenly over the entire surface of a large portion of the total area, resulting in a thinning of the material.

IMMERSION DATA

Media Type/ Concentration (%BV)	316 SS CR(mpy)	316 SS SAT12 Process CR(mpy)
Hydrochloric, 50°C / 1%	0.28	0.22
Hydrochloric, 30°C / 5%	21.7	3.81
Hydrochloric, 23°C / 15%	26.0	9.0
Sulfuric, 70°C / 10%	14.9	3.9
Sulfuric, 50°C / 40%	1923	12.8
Sulfuric, 50°C / 100%	6.8	0.12

ASTM G157 recommends CR < 5-mpy for Chemical Process Industry

% BV – percent by volume **CR** – corrosion rate **mpy** – mils per year

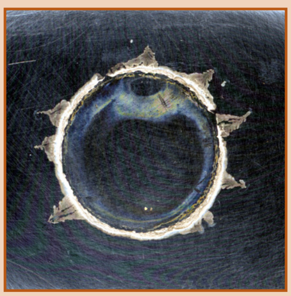
Data from immersion tests show that materials treated with the SAT12 process exhibit improved corrosion resistance and longer life. Lower CR (mpy) figures – corrosion rate measured in mils per year – indicate longer material life.

CONCLUSION

SAT12 outperformed untreated 316 SS by factors of 4 to 400 in sulfuric acids across the complete acid concentration range, at temperatures below 50°C. Similarly, SAT12 made 316 SS more corrosion resistant by factors of 2 to 5 in dilute (<20 %) hydrochloric acid. These results are based on short-term (48-hour) experiments. The corrosion rate does not necessarily remain constant.

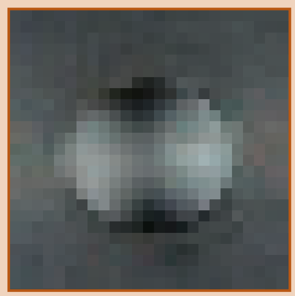
Crevice Corrosion

Localized corrosion that occurs in shielded areas, such as under gaskets, washers, fastener heads, coatings, insulation, etc.



Untreated Alloy 625 after 60 hours

Untreated 316L after an hour



Treated 316L after 160 hours

In a saltwater solution, 316L stainless steel specimens treated with the SAT12 process showed no damage after one week, whereas untreated specimens showed damage within hours.

CONCLUSION

Treated 316L showed crevice-corrosion behavior comparable to that of aerospace titanium-based alloys or Hastelloy® C22, a nickel-based alloy.

Corrosion Resistance and More

Corrosion resistance is only one of the benefits offered by STSC SAT12 process. The SAT12 process also:

- Increases surface hardness while retaining significant ductility
- Improves wear resistance
- Improves fatigue resistance
- Causes no distortion or change of components' shape

The STSC SAT12 process corrosion capabilities are not limited to those described in this brochure. Others are possible.

To obtain more information about our corrosion test results, to arrange your own tests, or to learn more about how the SAT12 process can help you, contact us at SAT12service@swagelok.com or visit www.swagelok.com/services/sat12.htm.

Swagelok Corrosion Testing Capabilities

Pitting Corrosion	**ASTM B117**	Practice for Operating Salt Spray (Fog) Apparatus *Standard practice to produce relative corrosion resistance information for metal and coated metals in a controlled corrosive environment used in general salt spray tests.*
	ASTM G48	Pitting and Crevice Corrosion Resistance of Stainless Steels and Related Alloys by Use of Ferric Chloride Solution *Standard test methods for pitting and crevice corrosion resistance of stainless steels and related alloys by use of ferric chloride solution.*
	ASTM G61	Test Method for Conducting Cyclic Potentiodynamic Polarization Measurements for Localized Corrosion Susceptibility of Iron-Nickel, Cobalt-Based Alloys *Standard test method for localized corrosion resistance developed to allow experimenters to test their equipment and procedures on systems that are well characterized.*
	ASTM G150	Test Method for Electrochemical Critical Pitting Temperature Testing of Stainless Steels *Standard test method utilizing temperature and electrochemical techniques to accelerate localized attack allowing for a quantitative ranking of materials or surface finishes in terms of resistance to pitting.*
Uniform Corrosion	**ASTM G59**	Test Method for Conducting Potentiodynamic Polarization Resistance Measurements *Standard test method for determination of the uniform corrosion rate of a material in a particular environment.* *Standard test method to determine the general corrosion resistance of iron-based and nickel-based alloys is determined in 14 test solutions at various temperatures and concentrations.*
	ASTM G157	Guide for Evaluation Corrosion Properties of Wrought Iron- and Nickel-Based Corrosion Resistant Alloys for Chemical Process Industries *Standard test method to determine the general corrosion resistance of iron-based and nickel-based alloys is determined in 14 test solutions at various temperatures and concentrations.*
Crevice Corrosion	**ASTM G78**	Guide for Crevice Corrosion Testing of Iron-Based and Nickel-Based Stainless Alloys in Seawater and Other Chloride-Containing Aqueous Environments *Standard test method using various crevice geometries exposed primarily to seawater to evaluate the crevice corrosion susceptibility through mass loss, measurement of corrosion area, and depth of penetration.*

Swagelok's corrosion capabilities are not limited to the examples shown above – others are possible. The above tests have been carried out as needed. Custom electrochemical corrosion testing is possible, as well as other ASTM and NACE test procedures. If you are interested in learning more about Swagelok products or services, contact a Swagelok Michigan | Toledo or visit the company's website at www.swagelok.com

Swagelok
Value beyond the expected℠