Silcosteel®-CR Treatment

Silcosteel®-CR surface treatment protects equipment exposed to hydrochloric acid, nitric acid, or marine environments, upgrading the corrosion resistance of 300-grade stainless steels by an order of magnitude. Silcosteel®-CR treatment provides a significant cost savings, relative to high performance alloys, and offers major advantages over traditional overlay coatings. Traditional coatings rely primarily on primers or surface tension to remain in contact; delamination and blistering are common problems. In contrast, the Silcosteel®-CR layer is incorporated into the stainless steel lattice. The dense, chemically inert surface is both durable and flexible—treated components can be worked into place without chipping, cracking, or otherwise damaging the coating. Silcosteel®-CR treated tubing and many fittings are available from stock on pages 392-396. Contact us for custom coating service.

Features	Benefits
Improves corrosion resistance of 300 grade stainless steels by an order of magnitude.	Significantly decreased maintenance cycles and costs for components in corrosive environments.
Durable and flexible layer, incorporated into the surface.	Items can be worked after treatment—no flaking, chipping, or cracking.
Use to temperature of 600°C.	Use under conditions in which conventional coatings fail, reducing the need for high-cost super alloys.

industries served

Marine
Oil and gas exploration
Process plants

it's a fact

A Silcosteel®-CR layer upgrades the corrosion resistance of 300-grade stainless steels by greater than an order of magnitude.

An effective, durable solution to corrosion—achieve specialty alloy performance using austenitic stainless steels!

In acidic environments it is critical to engineer solutions to account for the depreciation of equipment caused by corrosion. Current commercial solutions that address corrosion are specialized alloys (e.g., Inconel®, Monel®, Hastelloy®) or coatings. A Silcosteel®-CR layer upgrades the corrosion resistance of 300-grade stainless steels by greater than an order of magnitude and are more cost-effective than specialty alloys.

Like all other Restek surface treatments, a Silcosteel®-CR layer is both durable and flexible. The coating builds from many starting points on the steel surface. Repeated overlaying as the coating grows on the surface creates a dense, chemically inert layer. The layering process also creates flexibility—treated components can be worked into place without cracking, chipping, or otherwise damaging the coating.

Pitting and Crevice Corrosion Testing of Silcosteel®-CR Treated 316L Stainless Steel and Bare Steel, by ASTM G 48, Method B

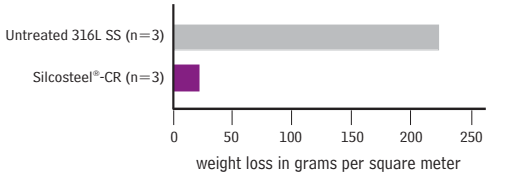
Each sample was weighed to the nearest 0.0001 gram, then a rubber gasket was wrapped around the center to simulate a crevice. Each sample was immersed in 6% by weight ferric chloride solution for 72 hours, per the ASTM test method. After 72 hours, the sample was recovered and reweighed to the nearest 0.0001 gram, to determine weight loss.

Table I shows Silcosteel®-CR treated 316L stainless steel exhibited an order of magnitude less corrosion, compared to bare stainless steel. Silcosteel®-CR treated stainless steel exhibited no crevice corrosion, while untreated stainless steel exhibited severe crevice corrosion (Figure 1).

Figure 1 Silcosteel®-CR treated 316L stainless steel shows no crevice corrosion and only slight pitting corrosion, while bare 316L stainless steel exhibits severe crevice corrosion.

Table I Silcosteel®-CR treated samples show very little weight loss after exposure to 6% w/w ferric chloride solution.

Sample	Weight Loss (g/m²)
Silcosteel®-CR sample 1	19
Silcosteel®-CR sample 2	25
Silcosteel®-CR sample 3	25
Bare Steel sample 1	231
Bare Steel sample 2	209
Bare Steel sample 3	228



Cyclic Polarization Electrochemical Corrosion Testing of Silcosteel®-CR Treated 316L Stainless Steel and Bare 316L and Bare 304 Stainless Steel, by ASTM G 61

Samples were tested in accordance with ASTM G 61 in acidic and neutral aqueous solutions, at 23°C, at three chloride ion (Cl^-) levels. Tables II and III summarize the test results: Silcosteel®-CR treated 316L stainless steel outperformed bare 316L stainless steel by a factor of approximately 30-50 in neutral chloride solutions, and by approximately 10-15 in acidic chloride solutions. At a chloride concentration of 3000ppm, Silcosteel®-CR treated 316L stainless steel outperformed 304 stainless steel by a factor of approximately 45 in neutral solutions and by approximately 17 in acidic solutions.

Table II Corrosion rate in mpy (mil per year) determined by electrochemical testing.

	Silcosteel®-CR	Bare Steel	Improvement
Neutral Solution			
100ppm chloride	0.0006	0.03	49x
3000ppm chloride	0.0009	0.03	32x
5000ppm chloride	0.001	0.03	29x
Acidic Solution (1N H_2SO_4)			
100ppm chloride	0.05	0.45	8x
3000ppm chloride	0.05	0.83	17x
5000ppm chloride	0.07	0.84	11x

Table III Comparison of Silcosteel®-CR treated 316L stainless steel versus bare 304 stainless steel at 3000ppm chloride.

	Silcosteel®-CR	Bare Steel	Improvement
Neutral Solution			
Corrosion Rate, mpy	0.0009	0.04	45x
Breakdown Potential, E_b	1460	370	
Acidic Solution (1N H_2SO_4)			
Corrosion Rate, mpy	0.05	0.83	17x
Breakdown Potential, E_b	927	370	

Marty Higgins
Restek Performance Coatings Engineer
10+ years of service!

4000 Hour Salt Spray Testing (ASTM B 117) of Silcosteel®-CR Treated 316L Stainless Steel and Bare Steel

4000-hour salt spray testing shows Silcosteel®-CR treated stainless steel coupons exhibit no surface corrosion, while untreated coupons show surface corrosion and accelerated corrosion at the hole in the coupon (Figure 2). Neither coupon developed pitting over the test period.[1]

free sample
www.restekcoatings.com/sample

Improve reliability while reducing costs by up to 65%!

316L gas delivery systems exposed to corrosive environments typically are replaced within 5 years of installation. Substituting a high performance alloy for 316L stainless steel can increase the cost of the system by as much as 5-fold.[2]

By improving the corrosion resistance of 316L stainless steel by up to 10-fold, Silcosteel®-CR treatment reduces costly maintenance and field failures due to system corrosion. Figure 3 compares the cost of Silcosteel®-CR treatment versus Hastelloy® C22™ construction in a typical gas delivery system. Silcosteel®-CR treatment demonstrates significant life-cycle cost savings, compared to unprotected stainless steel or stainless steel alloys.

Figure 2 Silcosteel®-CR treated 316L stainless steel shows no sign of attack after 4000-hour salt spray exposure, per ASTM B117.

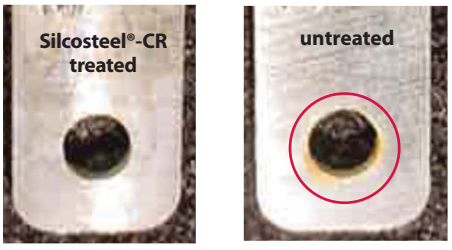
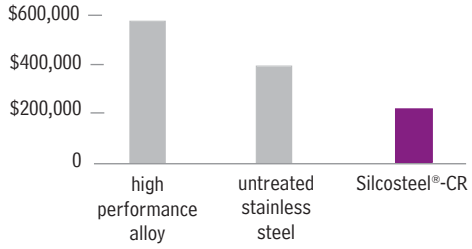


Figure 3 Silcosteel®-CR significantly lowers the life cycle cost of stainless steel or alloys (US dollars).



product guide

Silcosteel®-CR tubing (pages 394–396).

Silcosteel®-CR fittings (pages 392–393.)

Custom treatment is available for **your existing equipment**—see page 398.

References

[1] M. Zamanzadeh; G. Bayer; G. Rhodes; D. Smith; M. Higgins; *Laboratory Corrosion Testing of a Chemical Vapor Deposited Amorphous Silicon Coating*; Matco Associates, Inc. Pittsburgh, PA; Restek Corporation, Bellefonte, PA. 2005 Reference available on request.

[2] Vininski, Joseph; Lawrence, David; Torres, Robert; Diede, Ehrich; Daniels, Mia; "*Corrosion Resistance of Cost Effective Alternative Materials for Semiconductor Gas Distribution Systems*"; Matheson Tri-Gas, Longmont, CO; Diede Precision Welding, Longmont, CO; Sherwood, Harsco Corporation, Washington, PA. 2002