



SilcoTek[®] Corrosion Resistant CVD Coatings

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The Challenge of Corrosion

- Aggressive process and sample media
- Harsh external environments
- Expensive maintenance and replacement
- Little room for failure

SilcoTek's Solutions

Dursan[®]



Amorphous silicon oxide coating with full pH range resistance and increased mechanical durability.

Silcolloy[®]



Amorphous silicon coating ideal for improving service life in acidic and oxidative environments.

Salt Spray (ASTM G85)

- 8,064 hours of acidified salt spray per ASTM G85-A2
 - Dursan coating is unaffected and provides excellent protection on stainless steel in a salt spray environment. Silcolloy shows minor rust.



Uncoated 316L



Silcolloy-coated 316L

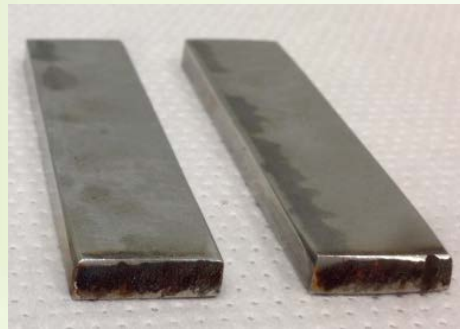


Dursan-coated 316L

Salt Spray (ASTM G85)

(continued from previous slide)

- Dursan-coated 316L SS is completely unaffected by 168 days of acidified salt spray
 - Even corrosion resistant duplex alloy 2205 showed moderate corrosion under these conditions



Uncoated Duplex Alloy 2205



Dursan-coated 316L

Salt Spray (ASTM G85)

- 4 weeks of pH-neutral salt spray (NaCl), then 4,032 hours of acidified salt spray per ASTM G85-A2
 - Total exposure time: 8,736 hours



Uncoated 316L



Silcolloy-coated 316L



Dursan-coated 316L

Salt Spray (ASTM G85)

(continued from previous slide)

- Dursan coating provides complete protection even after 8,736 hours of cyclic salt spray exposure
- Silcolloy shows minimal corrosion at coupon edges



Uncoated 316L



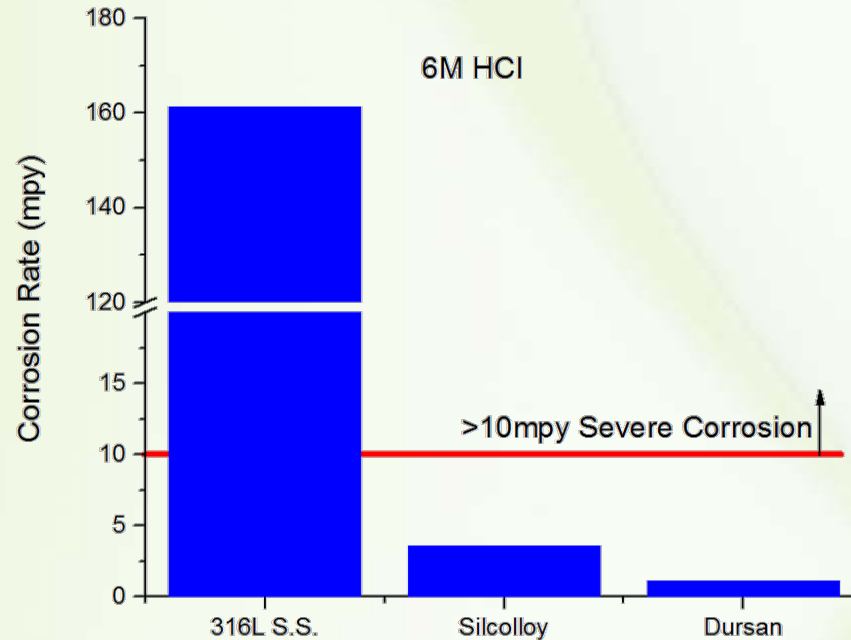
Silcolloy-coated 316L



Dursan-coated 316L

Hydrochloric Acid (HCl)

- ASTM G31 Guidelines
- 6M HCl Acid Exposure
- 24 hrs at Room Temperature

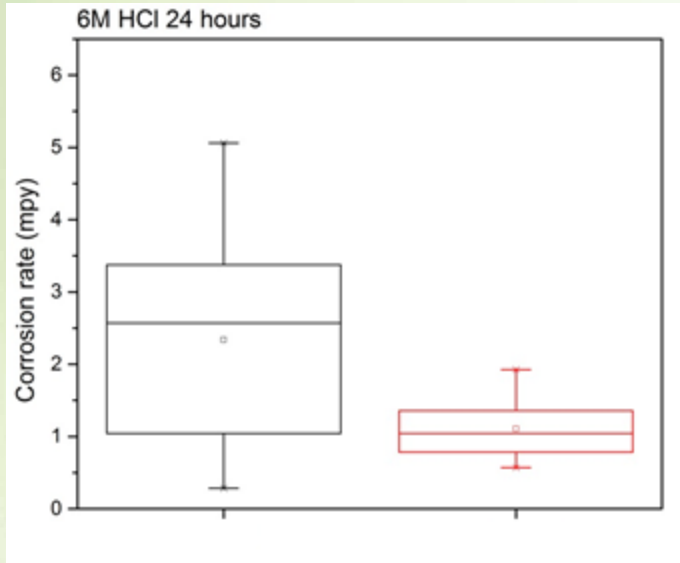


Both Dursan and Silcolloy coatings provide an excellent barrier to corrosion from HCl.

The coatings add considerable lifetime to parts in refinery and chemical manufacturing service, amongst others.

Hydrochloric Acid (HCl)

HCl Corrosion

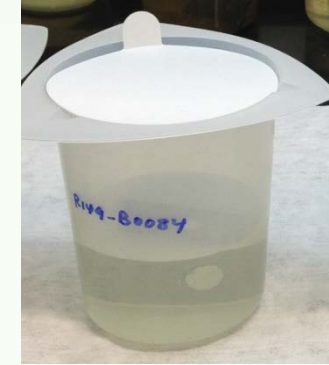


Other coating

Dursan®



Other Coating

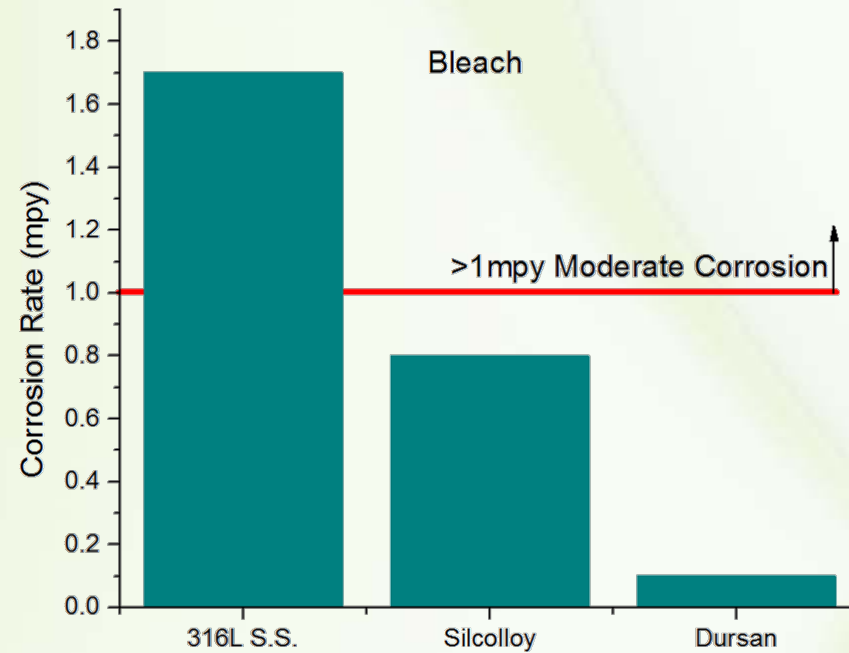


Dursan®

The solution containing Dursan-coated 316L SS shows no discoloration (corrosion) after the 24hr immersion test.

Bleach (NaClO)

- ASTM G31 Guidelines
- 15% NaClO Exposure
- 72 hrs at Room Temperature

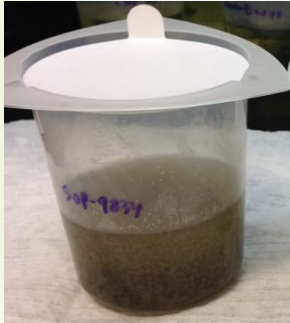
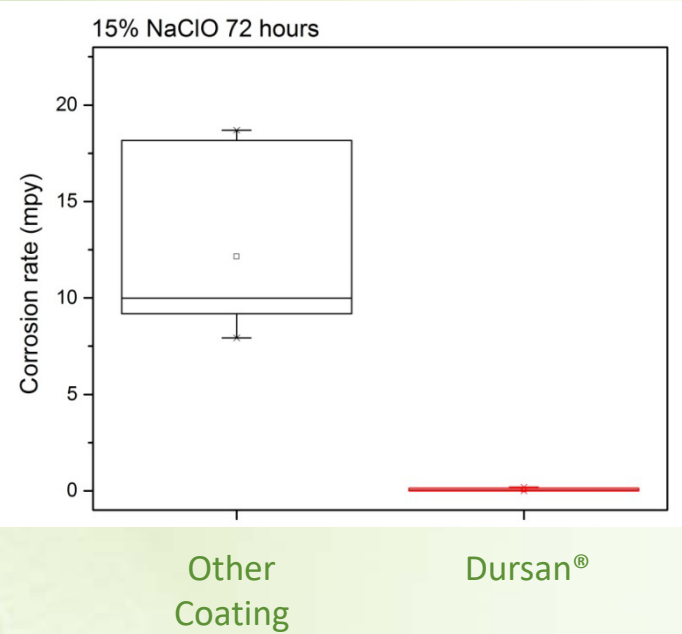


Bleach is very aggressive to stainless steel and other surface treatment, but Dursan provides stable protection.

This is especially useful in biomedical and pharma applications where bleach is commonly used.

Bleach (NaClO)

Bleach Corrosion



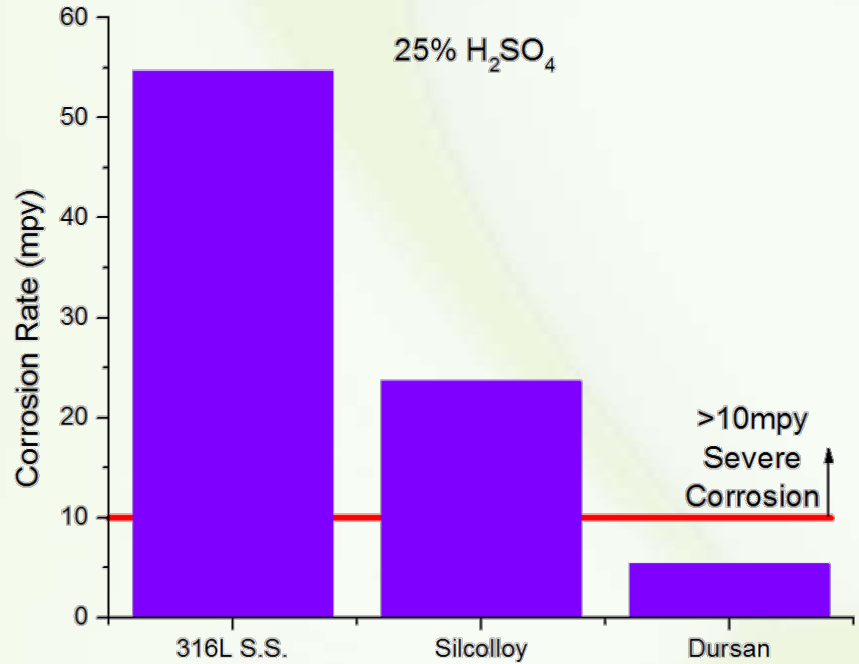
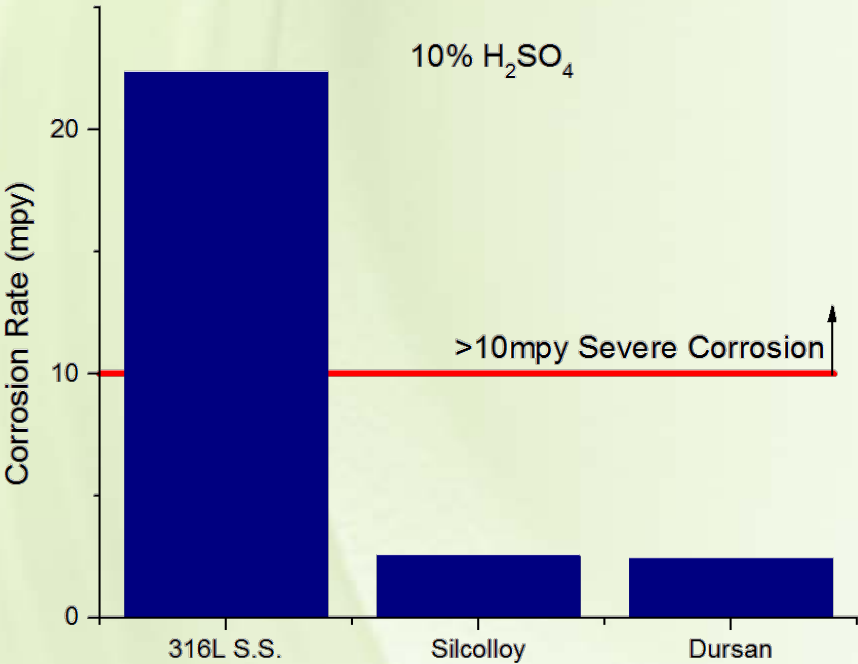
Other Coating



Dursan®

Sulfuric Acid (H₂SO₄)

- ASTM G31 Guidelines
- Sulfuric Acid Exposure
- 24 hrs at Room Temperature

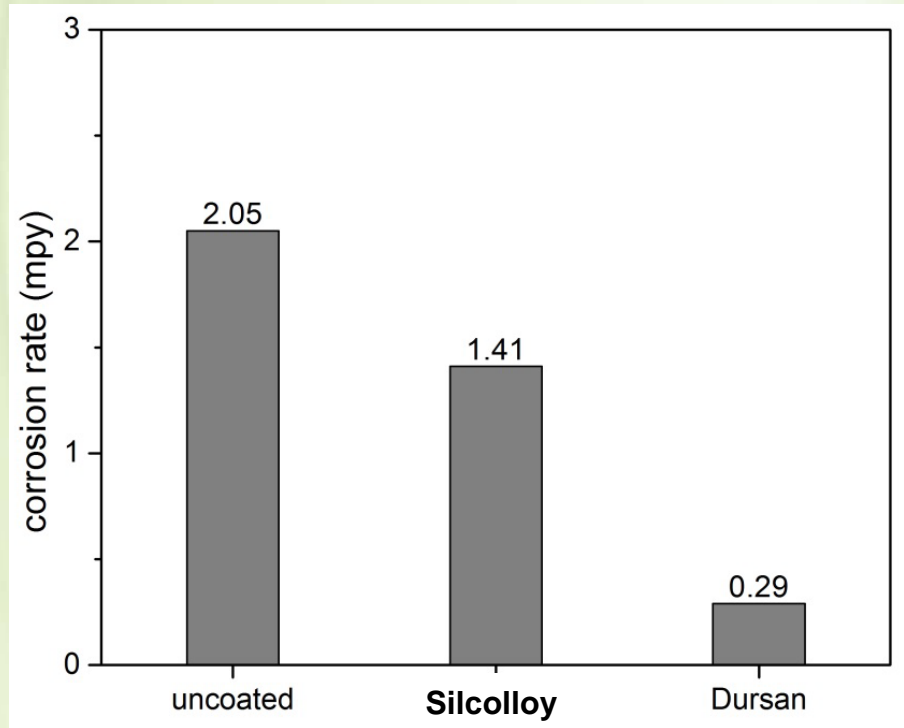


SilcoTek coatings can even withstand aggressive concentrations of sulfuric acid.

Even in the harshest conditions of a refinery or other chemical process, SilcoTek-coated stainless steel will improve the performance of your products.

Hydrobromic Acid (HBr)

- ASTM G31 Guidelines
- 48% HBr Exposure
- 11 days (264 hours) at Room Temperature

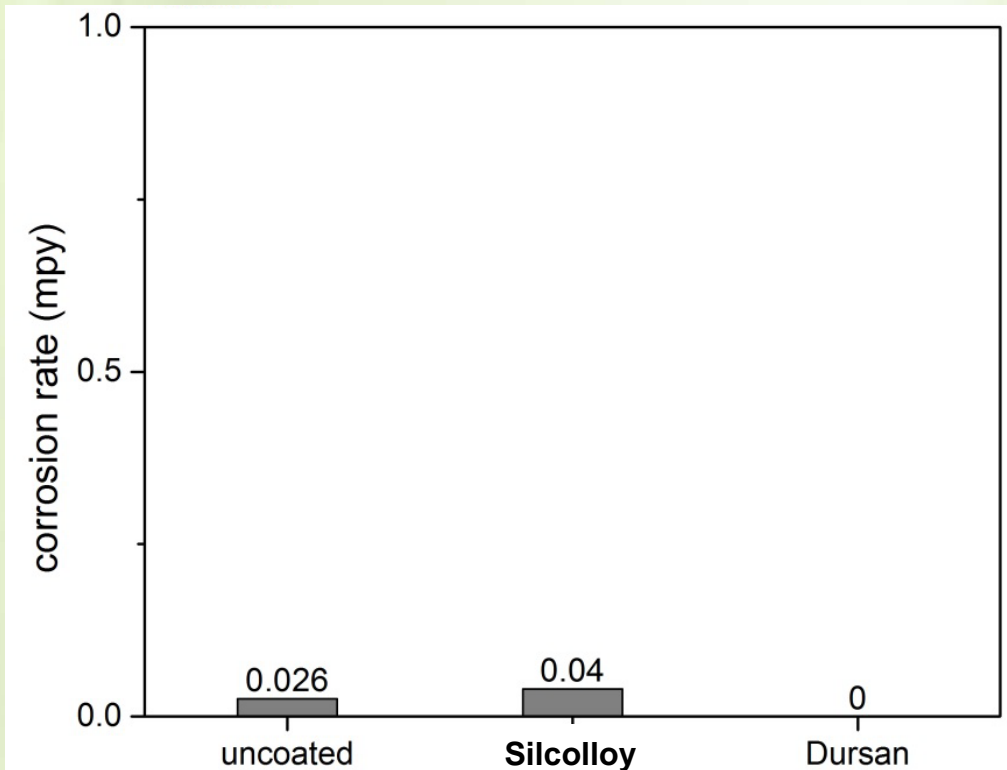


HBr is a critical chemical of concern in semiconductor processes.

In addition to protecting stainless steel from HBr, Silcolloy and Dursan both can increase tool uptime in challenging chloride and acidic chemistries.

Nitric Acid (HNO₃)

- ASTM G31 Guidelines
- 68% HNO₃ Exposure
- 11 days (264 hours) at Room Temperature

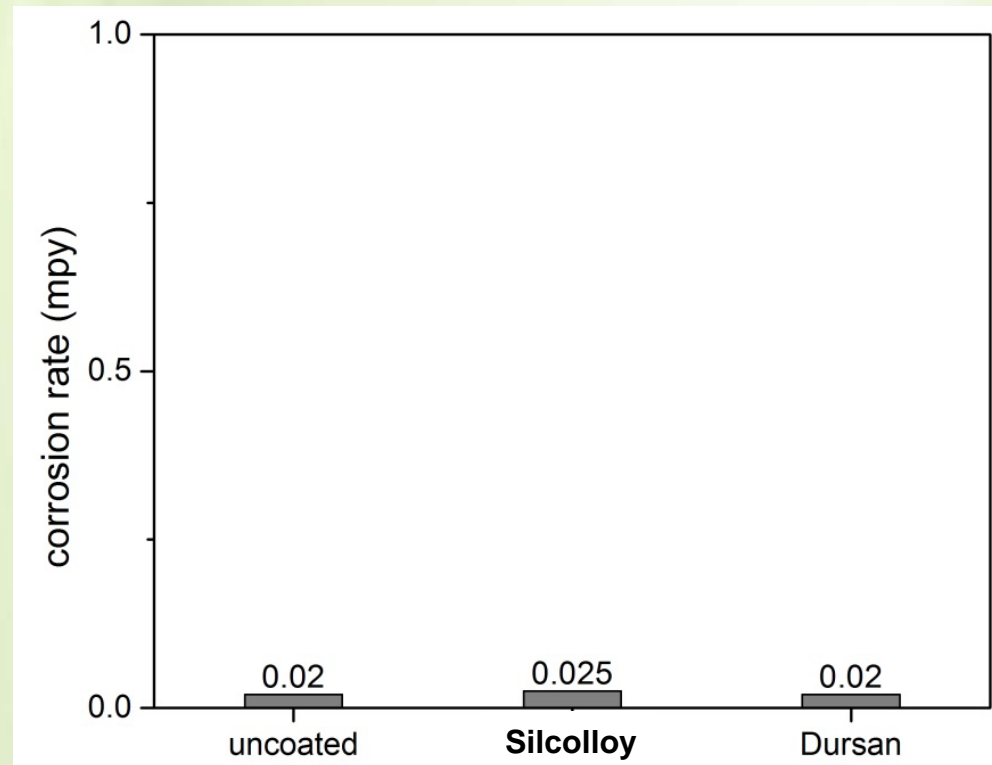


Though nitric acid isn't overly aggressive to uncoated stainless steel at room temperature, our testing confirms that SilcoTek coatings are compatible with nitric acid even after several days of exposure.

No samples were affected in this test, and all corrosion rates are within measurement error.

Phosphoric Acid (H_3PO_4)

- ASTM G31 Guidelines
- 85% H_3PO_4 Exposure
- 13 days (311 hours) at Room Temperature

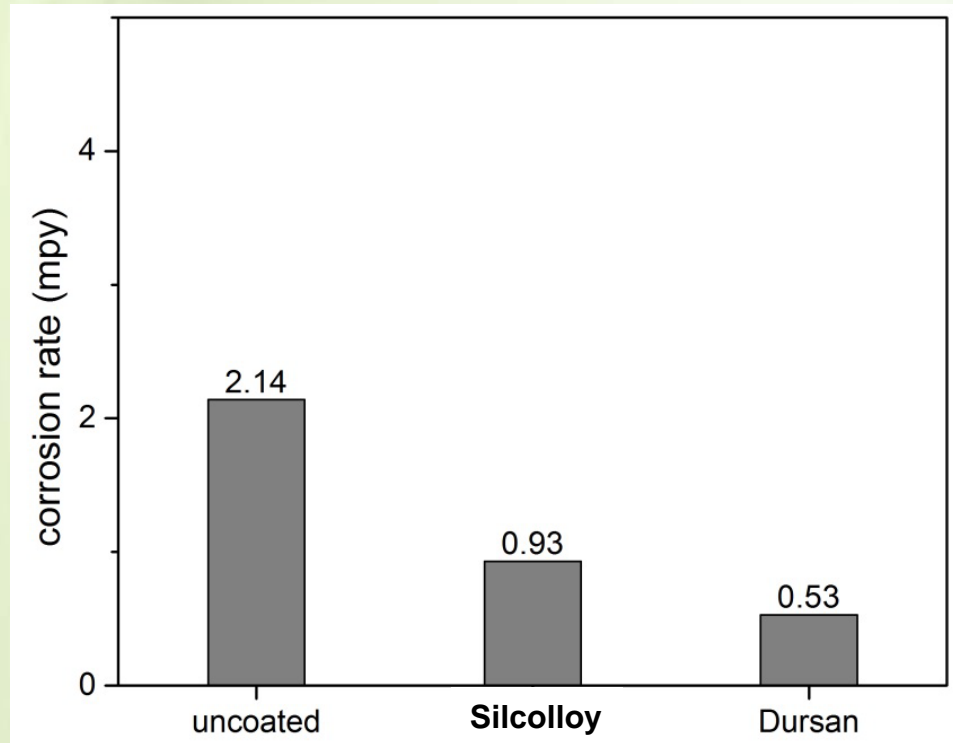


Though phosphoric acid isn't overly aggressive to uncoated stainless steel at room temperature, our testing confirms that SilcoTek coatings are compatible even after several days of exposure.

No samples were affected in this test, and all corrosion rates are within measurement error.

Phosphoric Acid (H_3PO_4)

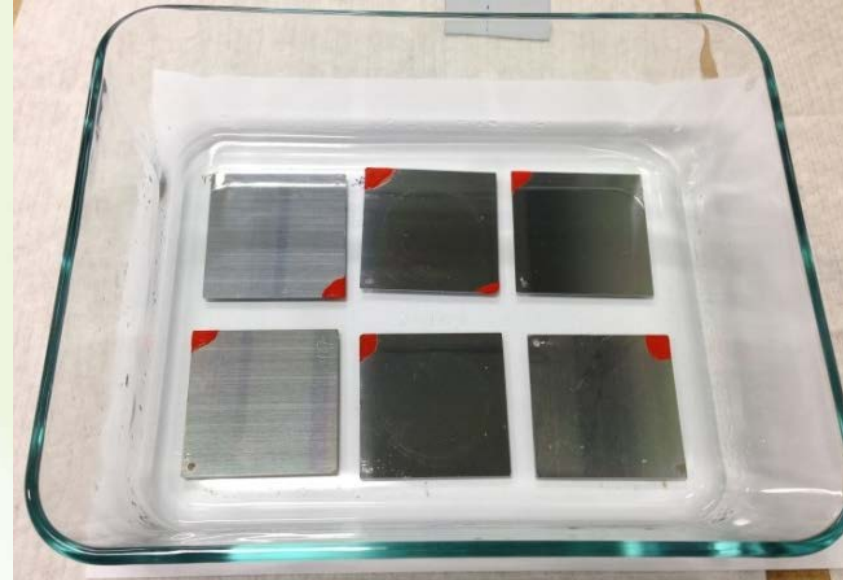
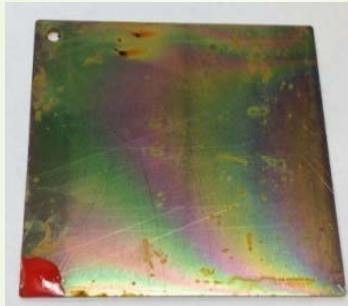
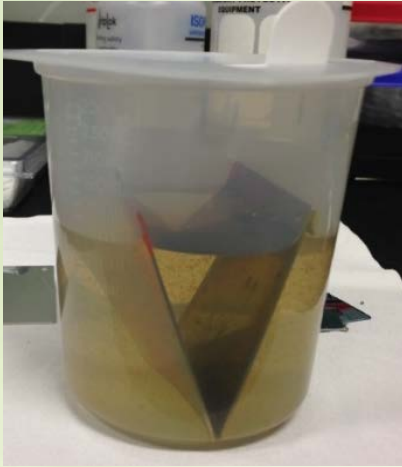
- ASTM G31 Guidelines
- 85% H_3PO_4 Exposure
- 7 hours at elevated temp. (80° C)



Increasing temperature often increases the aggressiveness of corrosive effects.

SilcoTek's Silcolloy and Dursan coatings outperform uncoated 316L SS by more than 2x in the presence of 85% phosphoric acid at 80° C (176° F)

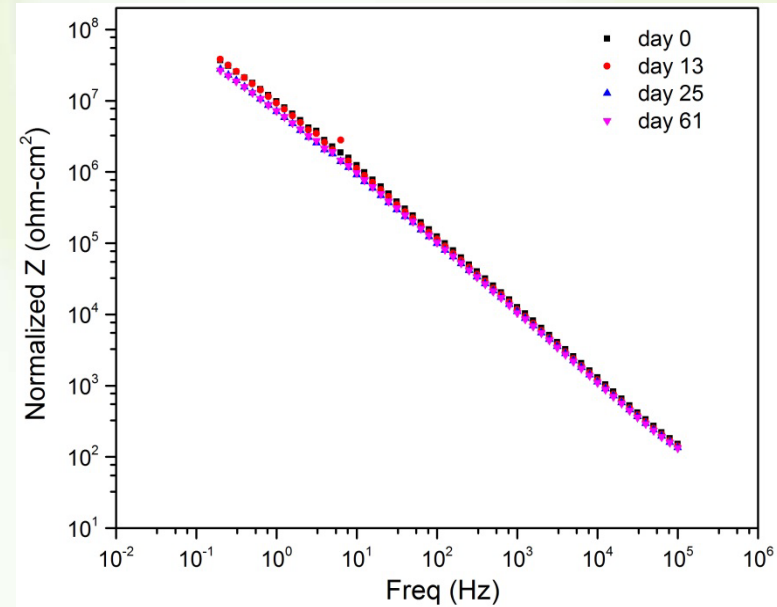
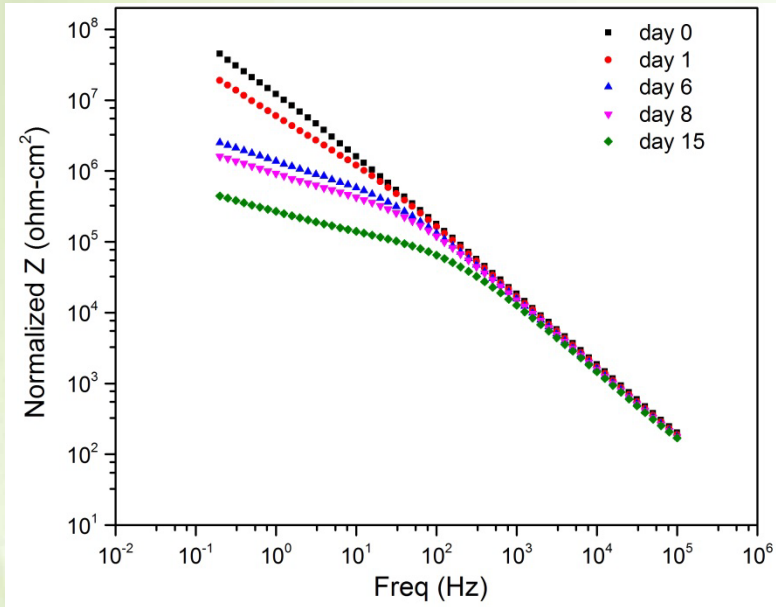
Salt Water Immersion



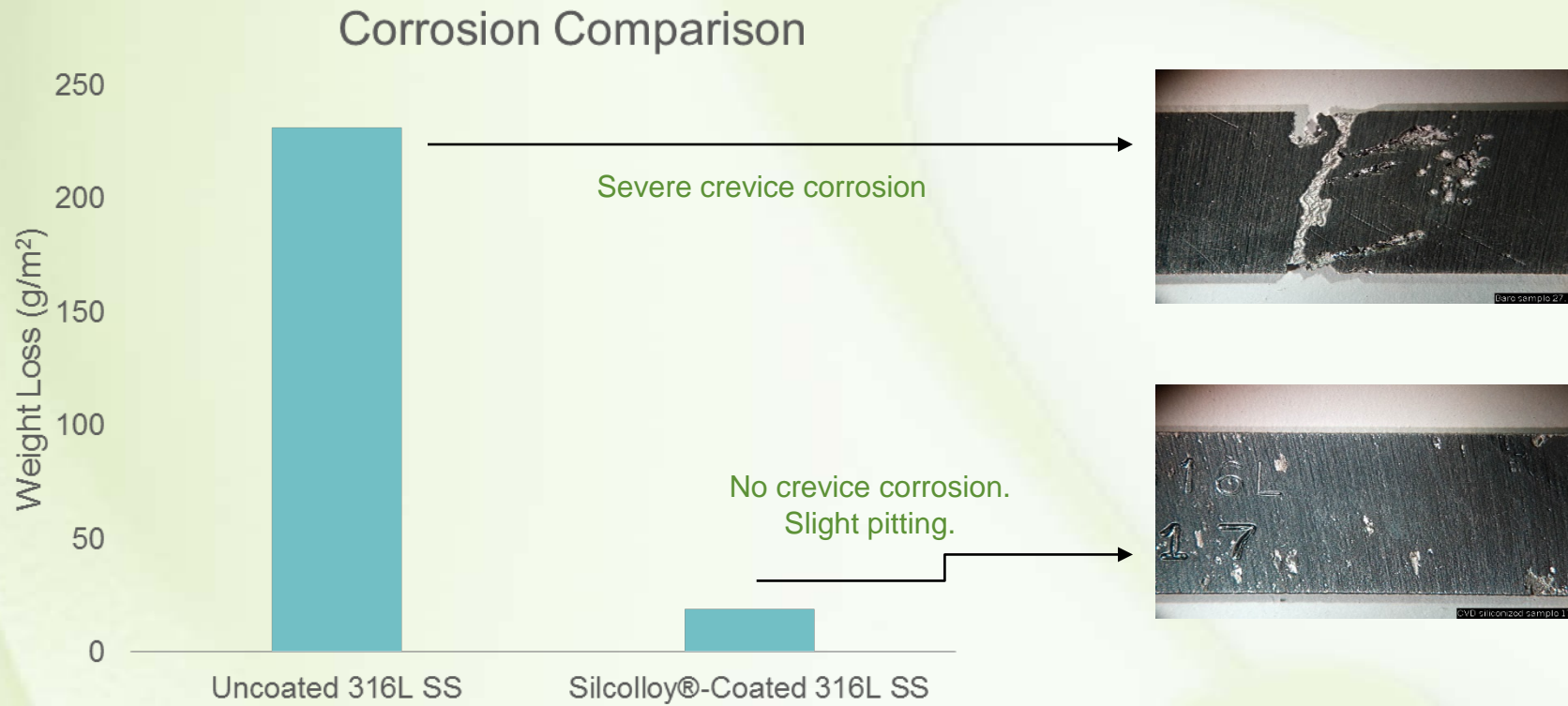
Dursan[®] Coating (right) shows no degradation in salt water after 60 days of exposure

Salt Water

Dursan® Coating (right) shows excellent dielectric stability in salt water after 60 days, providing an effective corrosion barrier on the substrate.



ASTM G48 B: Pitting and Crevice Corrosion



Corrosion Resistance on Carbon Steel

Carbon Steel

- SilcoTek's coating processes are optimized for stainless steel, titanium, and other performance alloys
- Carbon steel can still be coated successfully
- Coatings perform well on carbon steel for barrier/general chemical resistance applications. They do not provide corrosion resistance comparable to SilcoTek coatings on stainless steel substrates

Material

- Three types of carbon steel corrosion coupons were tested, with increasing amount of carbon content
 - C1018 is the most commonly available of the cold-rolled steels
 - A36 is the most commonly available of the hot-rolled steels
 - C1045 is generally supplied in the hot-rolled condition

Type of steel	C1018	A36	C1045
Carbon content	0.18%	0.26%	0.45%



uncoated



SL1000-coated

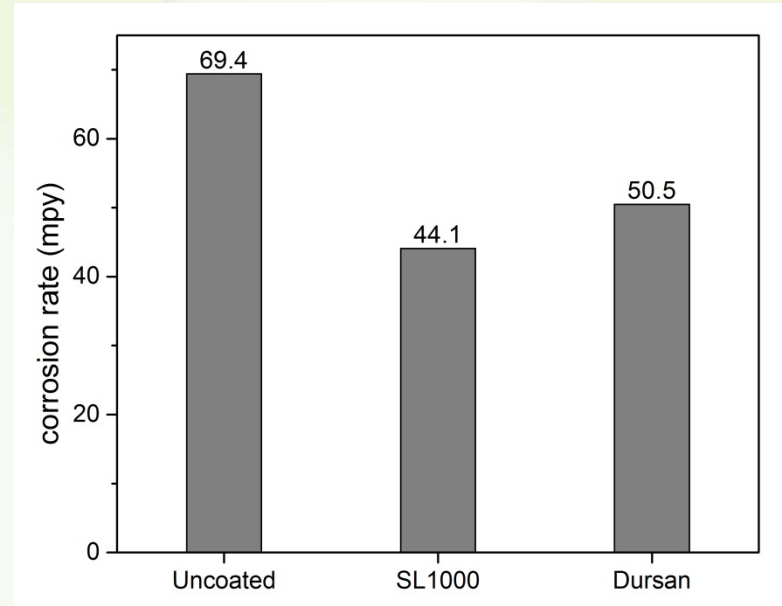


Dursan-coated

Carbon Steel –Salt Spray

Salt spray: ASTM G85-A2

- Carbon steel type: C1018



Salt spray: ASTM G85-A2

- Carbon steel type: A36

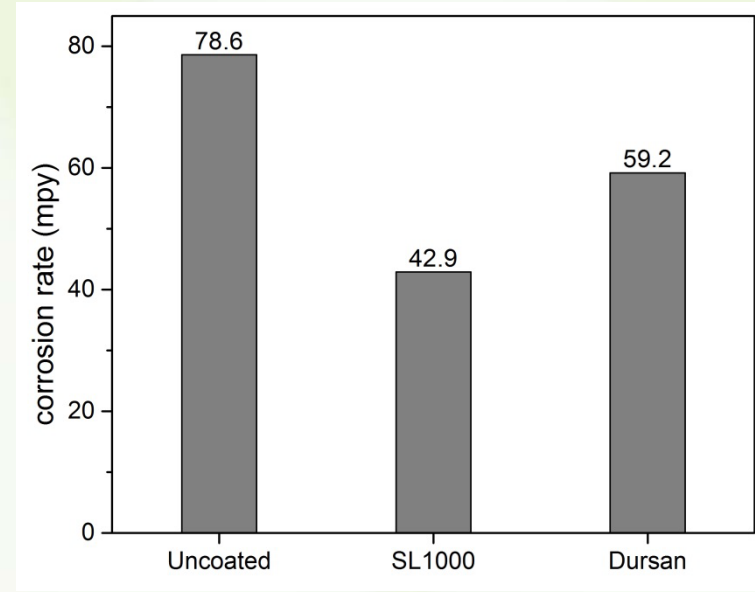
uncoated



SL1000-coated

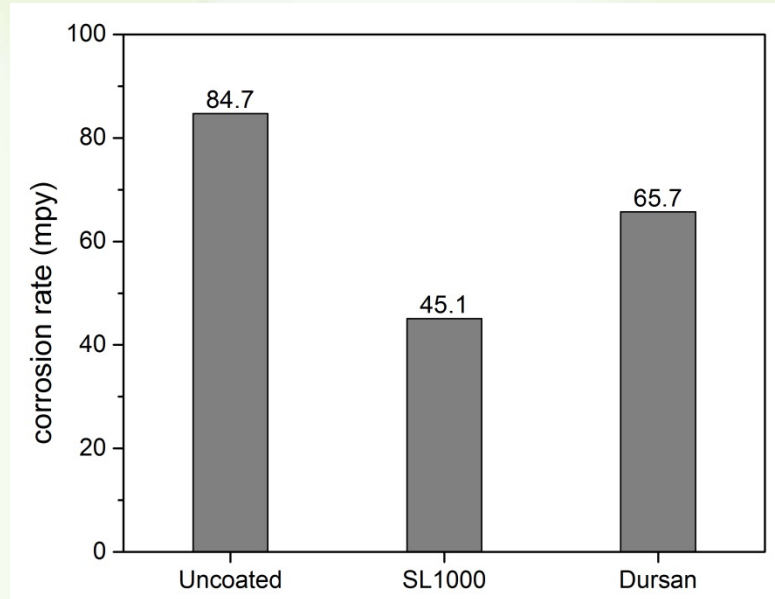
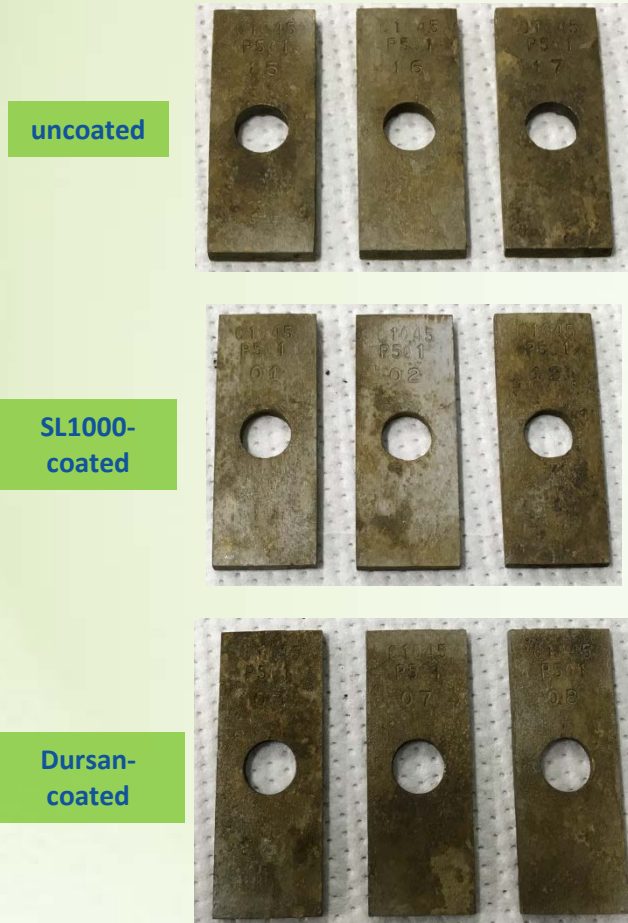


Dursan-coated



Salt spray: ASTM G85-A2

- Carbon steel type: C1045



Carbon Steel – Salt Spray Testing

- Both coated and uncoated carbon steel coupons were severely rusted after 264 hours of exposure
- Still, SilcoTek coatings helped to reduce the corrosion rate
- Consult SilcoTek tech. service to select both the best coating and substrate for your application

Carbon Steel - Hydrochloric Acid

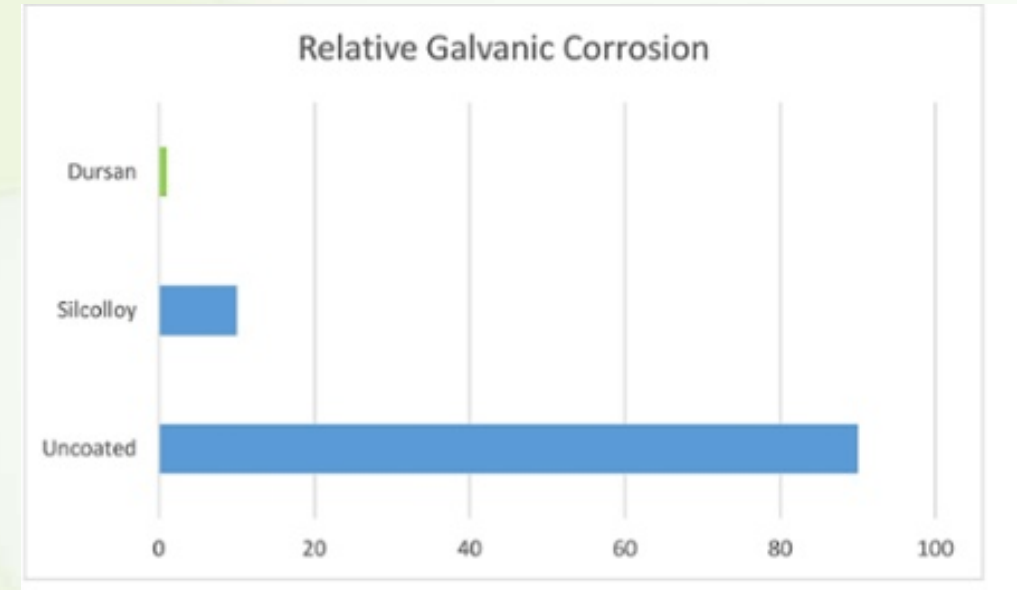
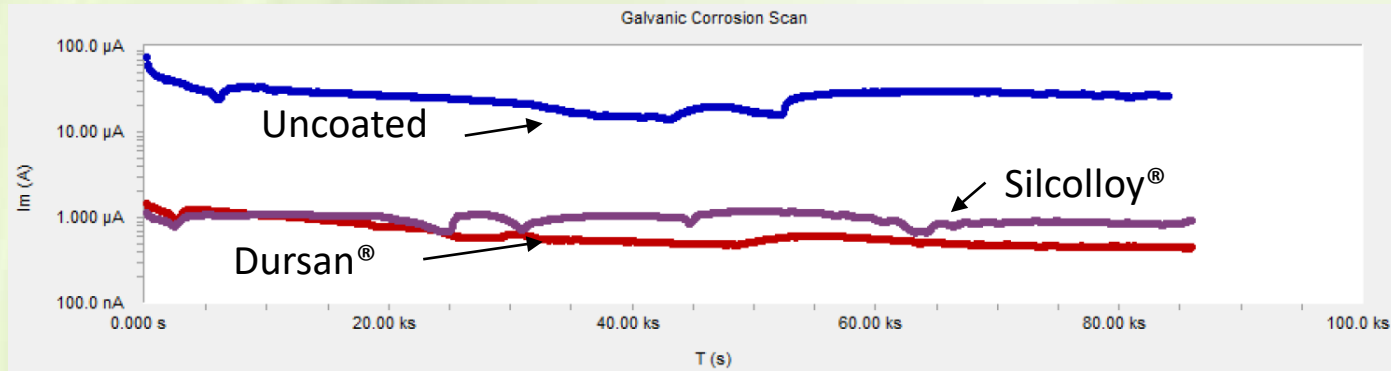
Carbon Steel – HCl Corrosion Resistance

- SilcoTek coatings on stainless steel provide excellent protection to HCl exposure (see previous slides)
- However, the coating did not provide much benefit on carbon steel in the same tests
- **Optimizing coating and substrate selection to deliver best performance for the right cost is key**

Galvanic Corrosion

304 SS coupled to 6061 Al

Galvanic Corrosion




- Both Dursan and Silcolloy noticeably minimize the effect of galvanic corrosion when coated 304SS is coupled to 6061 aluminum.
- Dursan offers drastically improved protection from galvanic corrosion over uncoated 304 SS (up to 2 orders of magnitude).

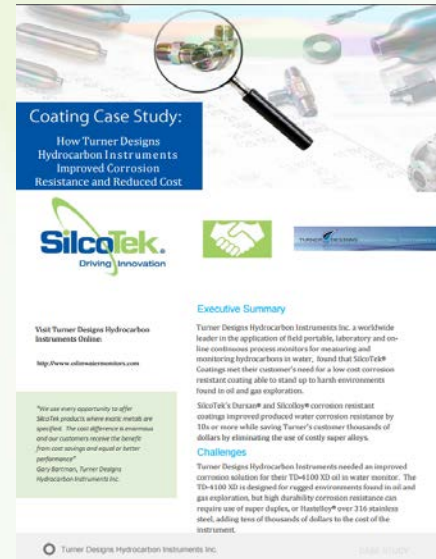
SilcoTek Coatings as a Solution

- Cost-effective alternative to exotic metals
- Upgrade current components or easily install new, coated parts
- Advantages of CVD process: easily coats complex geometries; doesn't affect tolerances; environmentally benign

Case Study: Turner Designs Hydrocarbon Instruments

See how [Turner Designs Hydrocarbon Instruments](#) cut costs and increased performance of their oil in water monitors by using stainless steel coated by SilcoTek's corrosion resistant surface technology instead of exotic metals.

Download the case study 



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