SilcoTek. Driving Innovation

Coating services that expand material limits.

Review of Silicon Coatings Capabilities and Applications

Dursan. SilcoNert. Silcolloy. SilcoKlean. SilcoGuard.

Dursan®

Our newest coating! A durable, inert, corrosion resistant coating that is harder than steel and highly resistant to acid and base attack. Ideal for valves and components that require a tough scratch resistant coating. Dursan is a hydrophobic surface that strongly repels water.

SilcoNert®

The ultimate in inert coating technology. Eliminate surface interaction in process, analytical, oil and gas sampling. Allow for fast accurate sampling the first time, every time. Improves test efficiency while reducing overall sampling/analytical cost.

Silcolloy®

A corrosion resistant coating that increases the lifetime of system components. Improve the corrosion performance of stainless steel, eliminate the use of costly high performance alloys while reducing component corrosion.

SilcoKlean®

A non-stick coating designed to reduce the onset of carbon coking and fouling on stainless steel. Extend maintenance cycles in refining and petrochemical operations, improve engine and fuel delivery performance by reducing carbon build-up on fuel injectors and combustion surfaces.

SilcoGuard®

A low outgassing, rapid pump down, high purity coating designed to improve ultra high vacuum system performance. Reduce vacuum pump-down cycle time, improve product yield by eliminating surface impurities.

Industries Served

Coating Technical Literature

Application Solutions

Oil & Gas Sampling, Refinery

Oil & Gas Sulfur Sampling

Mercury Sampling

Semiconductor Corrosion

Refinery Sulfur & Mercury

Corrosion Resistance

Moisture, Hydrophobicity

Application Solutions: Coating Care and Material Properties

Material compatibility

SilcoNert® Material Properties

Dursan® Material Properties

Dursan Material Comparison

Application Guide

Recommended Care

Sample Cylinder Care

FAQ for Inert, Corrosion Resistant, High Performance Coatings

Questions? Call Us!

CHROMalytic +61(0)3 9762 2034
TECHnology Pty Ltd
Australian Distributors
Importers & Manufacurers
www.chromtech.net.au
14/15
Website NEW : www.chromalytic.com.au E-mail : info@chromtech.net.au Tel: 03 9762 2034 . . . in AUSTRALIA

Review of Silicon Coatings Capabilities and Applications

SilcoTek Corporation

www.SilcoTek.com

Overview

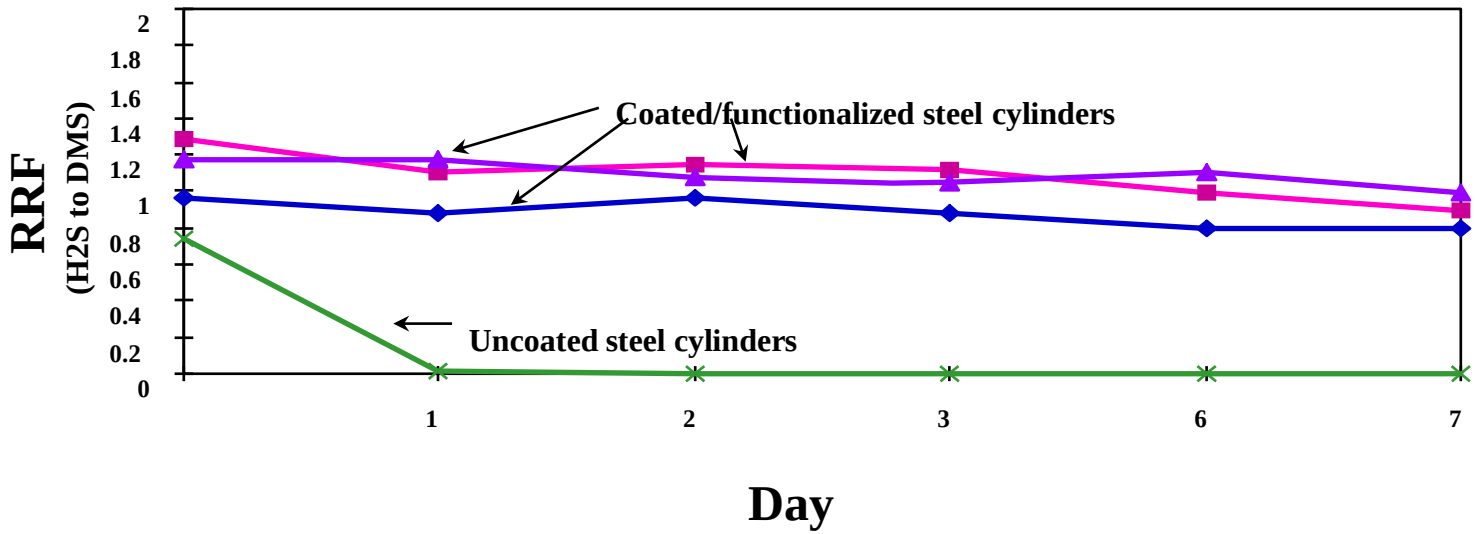
- Background:
  - About silicon coatings, CVD process and capabilities
- Comparative Testing, Benefits, Applications
  - Inertness and Sulfur
  - Corrosion resistance
  - Anti-coking
  - Purity/Ultra high vacuum
- Questions

Why use coatings?

- Reduce loss of active compounds
  - Avoid false negatives
  - Sulfur compounds quickly lost without coatings
  - Improved sample transfer
  - Sample stable from field to lab
  - Avoid loss of sample due to adsorption
    - Sulfur
    - Mercury
  - Immediate response during process changes
  - Creates savings when used in feedback monitors
  - Reduces moisture contamination effects

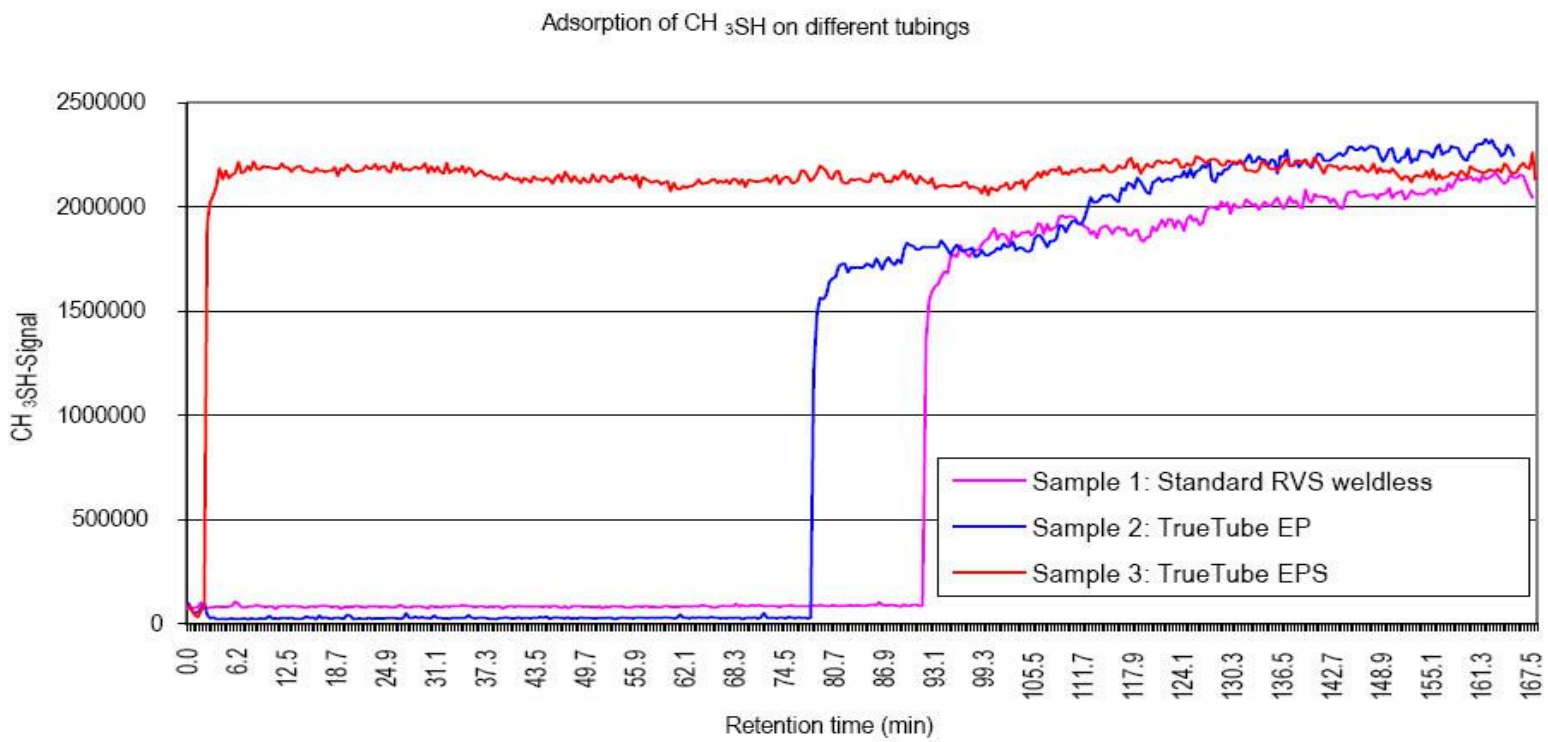
No Loss during storage!

- Reduces adsorption effects
- Improves analytical reliability
- Faster cycle times and
- increased accuracy
  - 17ppbv H_2S Containment in 500ml Cylinders

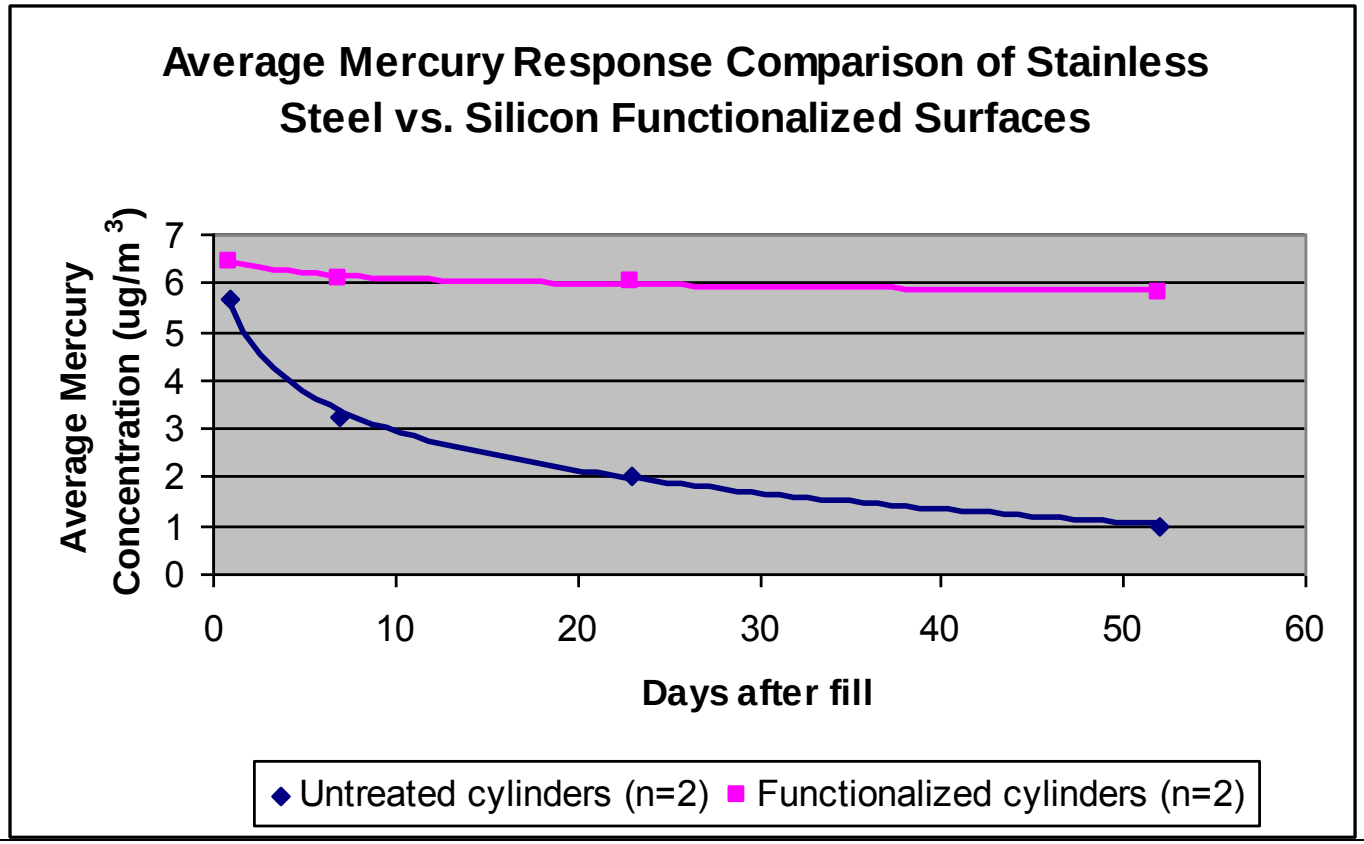


No transfer Loss!

Reduce sample adsorption by 98%
Improve Process Response
Improve Yield

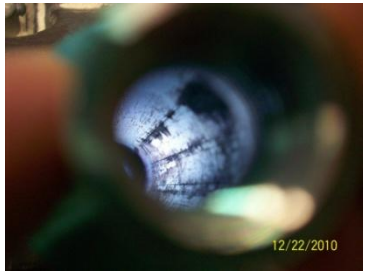


Mercury stable during storage!



SilcoNert 2000 Advantages

- Most inert coating available



- High Temperature
- Durable/flexible/high tolerance
- Enable testing in rugged environment
- Allows user to modify surface without redesign/remanufacture

SilcoNert 2000 & Dursan Applications

Sulfur contaminants, CO2	NOx and SOx from coal plants
Sulfur emissions, refinery flares	Mercury emissions, coal and gas
Ethylene/propylene feedstock testing	Water quality testing, headspace + purge and trap
Exhaust, stack emissions, ammonia	Toxic organics, whole air monitoring
Defense security, chemical warfare agents, explosives	Low moisture sampling and control
GC testing of active compounds	Oil and gas, downhole, transport and refinery sampling

Why use coatings?

- Corrosion resistance
  - Prolong component life
    - Salt water environments (platforms)
    - Chemical process industry
    - Refining
  - Save money by avoiding use of chrome/moly or high-nickel alloys for:
    - Chloride exposure
    - Produced water
    - Instrumentation
  - Some coatings offer both corrosion and inertness

2 Corrosion Resistant Coatings

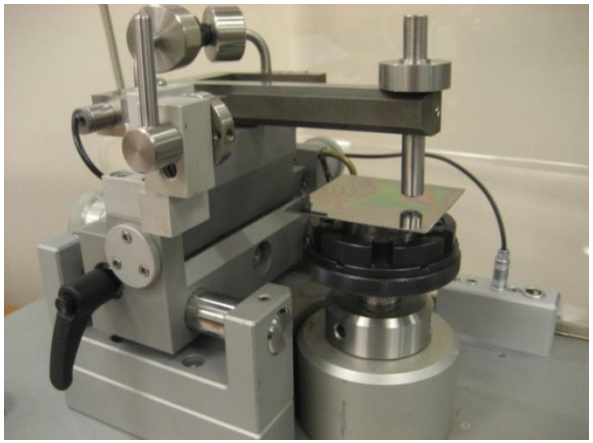
- Silcolloy 1000
  - Silicon, up to ½ um thick
  - Semiconductor, purity

- Dursan
  - Silicon, carbon, oxygen, 1/2um + thick
  - High durability, greater corrosion resistance

Wear Resistance Comparison

Pin on Disc; 2.0N	316 SS	Silicon	Carboxysilane
Wear rate ($x10^{-5} mm^3/N\ m$)	13.810	15.344	6.129
Improvement Factor over Stainless Steel	---	0.9 X	2 X

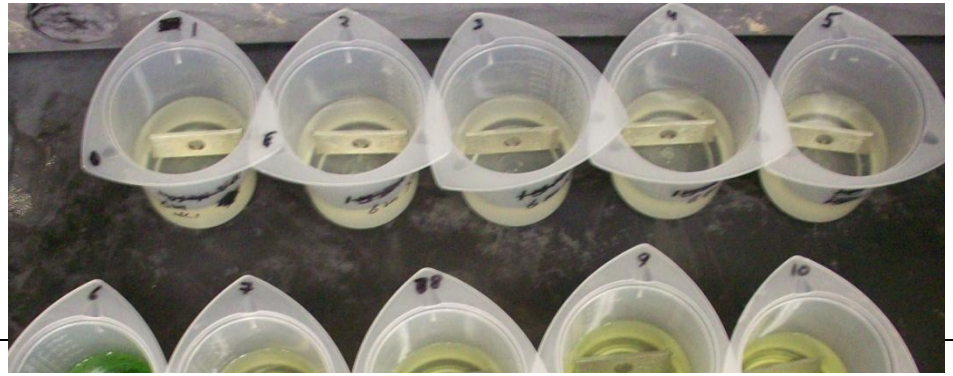
- CSM Instruments
- Tribometer 18-343 used to measure surface wear resistance



Acid Corrosion Resistance

- ***ASTM G31 Guidelines: <u>6M HCl</u>; 24hr; 23ºC***

	316L SS	Silcolloy	Dursan
MPY	181.98	4.32	0.44
Improvement Factor over 316L stainless	---	42	411



Comparative Corrosion Resistance

- *10% H_2SO_4; 24hr; 22ºC*

ASTM G31	316L SS	Silcolloy	Dursan
MPY	22.35	2.52	2.42
Improvement Factor over 316L stainless	---	8.9	9.9

Base Corrosion Resistance

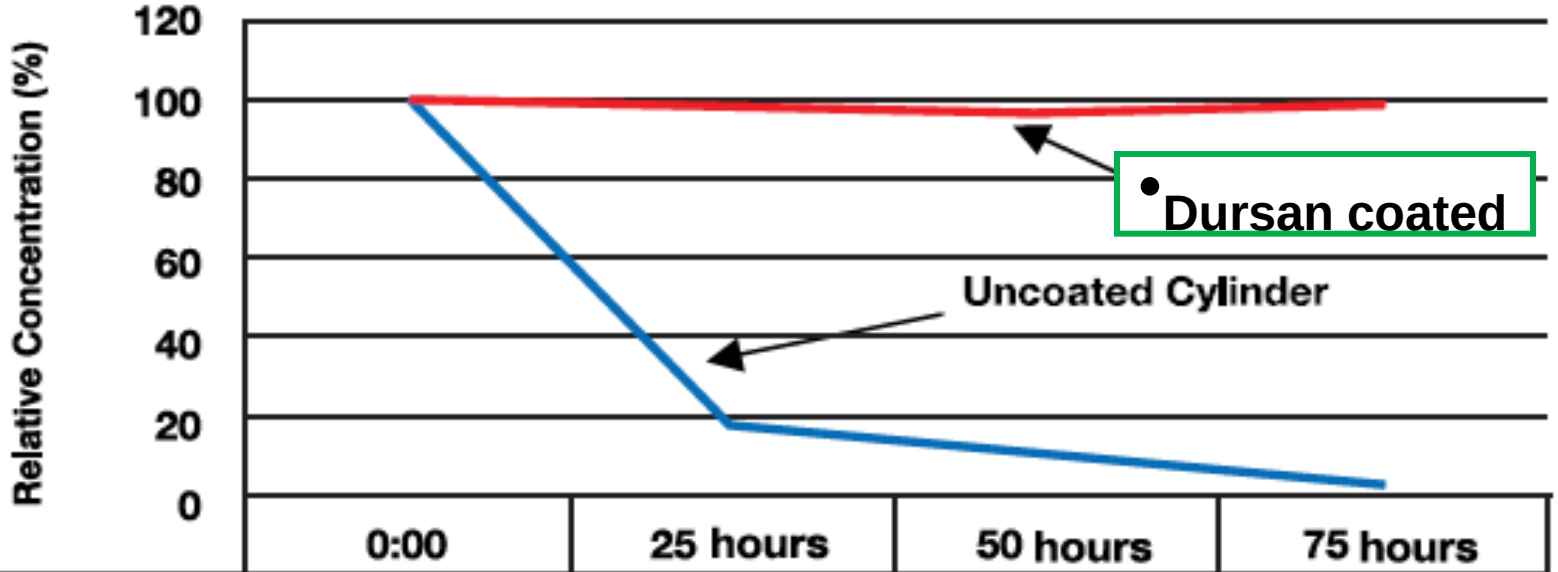
- ***ASTM G31 Guidelines: <u>1M KOH</u>; 24hr; 22ºC***

	316L SS	Silcolloy	Dursan
MPY	0	3.40	0.01
Improvement Factor Over a-Silicon	--	--	261

Chemical Inertness

H_2S Stability: Dursan vs. Stainless Steel

50ppmv, 300cc cylinder



	0:00	25 hours	50 hours	75 hours
Stainless Steel	100	19	10	4
Dursan	100	98	96.6	98.3

Hydrophobic Properties

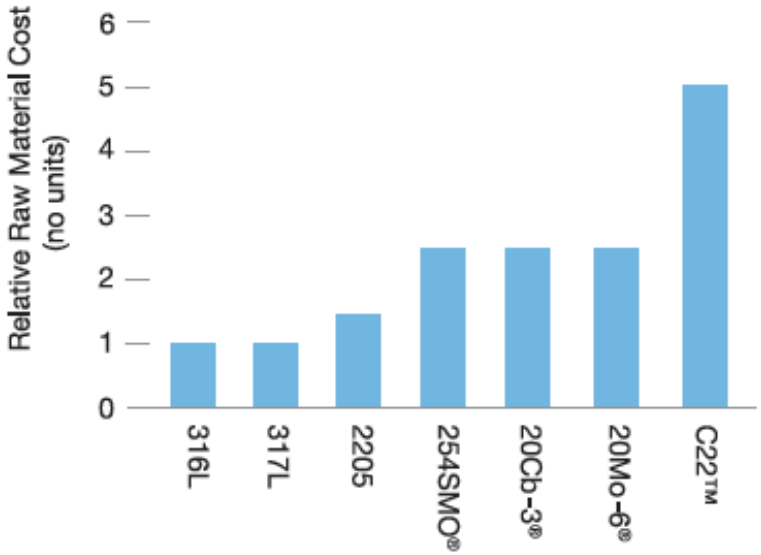
- Krüss K100 Tensiometer
- Testing on
- 304 SS
- ¼” OD tubing

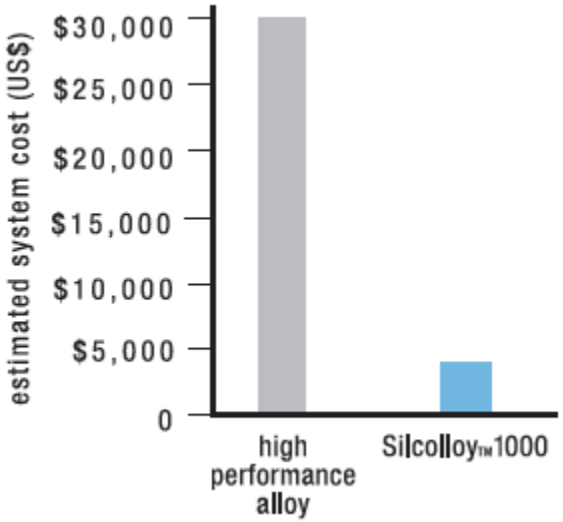
	304 SS	Silcolloy 1000	SilcoNert 2000	Dursan	PTFE Plate
Advancing	36.0	53.6	87.3	105.5	125.4
Receding	5.3	19.6	51.5	85.3	84

304 SS **SN 1000** **SN 2000** **Dursan**

Materials Cost Comparison

80% estimated life cycle cost savings: a-Si vs. HP Alloy





Dursan Advantages

- Significantly improves material performance beyond exotic alloys
- Improve SS acidic and basic corrosion resistance
- 2X improvement in wear resistance
- Inert, non reactive, non-adsorptive
- Withstands temperature up to 450° C
- Hydrophobicity and oleophobicity similar to Teflon surface

Coating Advantages

- Longer Life:
  - Extend lifetimes of equipment exposed to corrosive environments
- Low Cost Material Option
- Protection:
  - Protection of high value equipment
- Inert:
  - Provide enhanced corrosion resistance to analytical equipment
  - Maintain inert sample pathway
  - More inert than Inconel, Hastelloy, or glass. Ideal for 10ppm levels or higher
- High Temperature:
  - High temperature stability up to 1000°C

Silcolloy & Dursan Applications

- ❑Process streams
- ❑Process sampling/Refinery
- ❑Continuous Emissions Monitoring Equipment
- ❑Automotive Exhaust
- ❑Semiconductor corrosion (Silcolloy)
- ❑Fasteners in Offshore/Marine, Drill bits
- ❑Off-shore drilling platform equipment
- ❑Produced water management

Why use coatings?

- Reduce coking and carbon fouling
- Extend maintenance cycle
- Improve equipment efficiency
- Reduce emissions
- Prevent system failures due to fouling

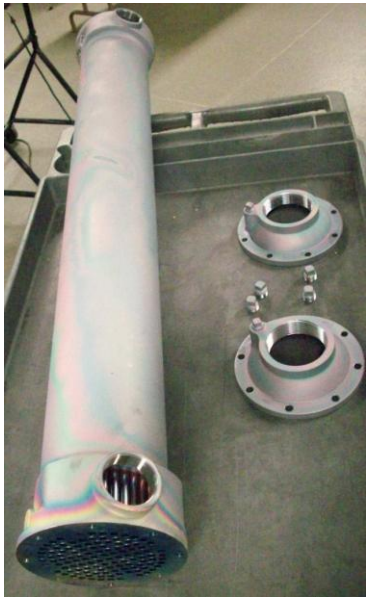
Why use coatings?

- High Purity
  - Reduce system contamination
  - Reduce moisture effects
  - Eliminate ion contamination
  - Reduce vacuum pump down time

Conclusion

- Coatings are available for a wide range of applications

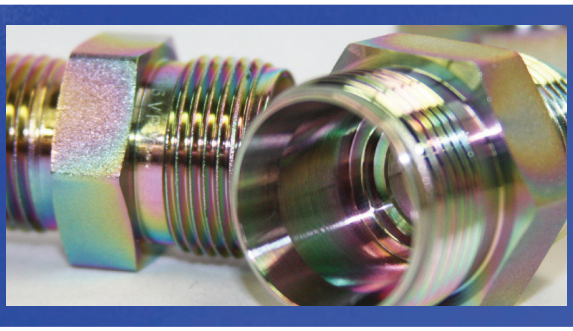
- Optimize based on desired property
  - Inertness
  - Corrosion Resistance
  - Anti-Coking
  - Purity



- Ultimate benefit is superior performance
  - Analytical results
  - Extend life
  - Reduce labor and capital cost
  - Improve efficiency
  - Optimize material selection and cost performance

Dursan®

U.S. Patent Pending



New! Tough, durable, inert and corrosion resistant coating.

Ideal for refinery, oil & gas and chemical process industries.

Dursan®

Ultimate Performance!

Improve corrosion resistance of stainless steel 10x or more
- Increase component life
- Reduce maintenance cost
- Improve reliability

Highly inert surface
- Reliable, consistent sampling even in harsh environments
- Ideal for sulfur, H_2S, mercaptan, ammonia and mercury sampling

Twice the wear resistance of stainless steel!
- Reduce valve wear
- Extend component life in abrasive environments

Able to stand up to harsh field and process environments
- Stack sampling
- Oil and gas exploration
- Chemical process
- Refining

SilcoTek®

225 PennTech Dr. | Bellefonte, PA 16823
814-353-1778 | Fax 814-353-1697
www.SilcoTek.com

Dursan® CVD coating technology.

Dursan® is a proprietary patent pending coating designed to improve the inertness, hardness, and corrosion resistance of stainless steel, alloys, glass, and ceramics. Dursan will deform with tubing or part surfaces, allowing a leak-free seal or radius bend while maintaining high dimensional tolerances.

Dursan offers superior wear resistance and durability under extreme conditions.

Dursan's scratch resistant, high temperature, pH stable and hard surface is the logical choice for harsh environments. Dursan remains inert under the most extreme conditions:

- Temperature limit: -210c to +450c
- Acid/base exposure: pH 0 to 14
- Maximum pressure: Limited by the base material
- Wear resistance: Excellent

Comparative wear studies show Dursan is significantly more wear resistant than uncoated 316 stainless steel. (Table 1)

Table 1: Studies prove Dursan significantly improves the durability and wear resistance of stainless steel

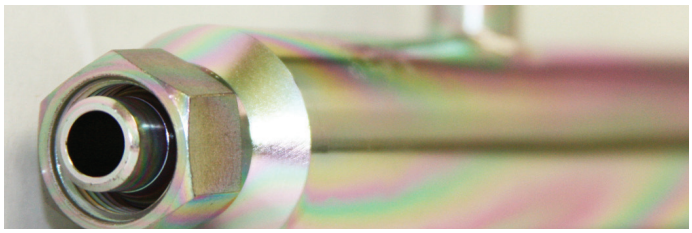
Pin on Disc; 2.0N	316 SS	Dursan
Wear rate ($x10^{-5}$mm3/Nm)	13.810	6.129
Improvement Factor	---	2 times

Dursan's tough, intermolecular coating stands up to abrasive environments while maintaining a flexible, and installation friendly surface.

Dursan's 450°C maximum temperature limit and acid/base pH stability offers durability in applications normally reserved for the most expensive super alloys. Dursan applications include:

- Stack gas testing
- CEMS
- Refinery
- Downhole sampling
- Produced water
- High purity/semiconductor

Lit Cat# DUR-001



Improve H_2S, mercaptan, sulfur, mercury, ammonia, and active compound sampling performance while reducing operating cost with Dursan.

Dursan's superior inertness and extreme corrosion resistance make it the ideal coating for harsh environments found in:

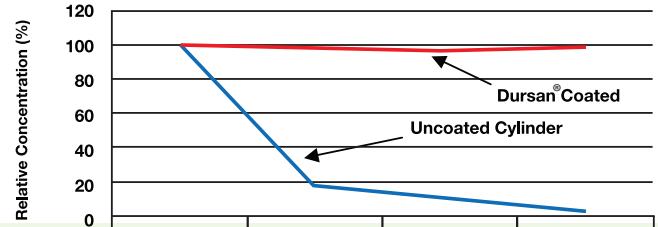
- Chemical process industries
- Refining
- Oil & Gas exploration and transport
- Stack monitoring, CEMS
- Offshore/Marine

Dursan's inert surface prevents interaction of active compounds like H_2S, mercaptan, SO_x, mercury compounds, ammonia and others.

Figure 1: Dursan's highly inert surface prevents sulfur and sulfur compound loss in sample cylinders, tubing, fittings, and other sample transfer components.

H_2S Stability: Dursan® vs. Stainless Steel

50ppmv, 300cc cylinder



	0:00	25 hours	50 hours	75 hours
Stainless Steel	100	19	10	4
Dursan	100	98	96.6	98.3

H_2S stored for only a day in a stainless steel sample cylinder is completely adsorbed, while the Dursan coating maintains sample integrity for 3 days or more. Dursan's inert surface assures superior sample reliability; saving thousands by eliminating sample errors like:

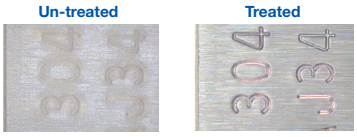
- False positive/negative response
- Sample adsorption
- Lost response due to moisture interaction
- Sample loss due to active sites
- Sample loss due to corrosion related contamination

Dursan is the coating choice for improved corrosion resistance and durability. Improve corrosion resistance by up to 200X!

Dursan extends the life of stainless steel in harsh, corrosive environments. Laboratory testing proves Dursan is the ultimate high durability, corrosion resistant surface.

Comparative ASTM G31 hydrochloric acid immersion testing of Dursan coated and uncoated stainless steel coupons demonstrate Dursan's exceptional corrosion resistance (Table 2).

Table 2: Dursan improves corrosion resistance 200x compared to 304SS



24hr; 6M HCl; 22ºC	304 SS	Dursan
Mils Per Year	389.36	1.86
Improvement Factor	---	209.8

After 24 hours of immersion in 18% hydrochloric acid the Dursan coated 304SS coupon exhibited minimal corrosive attack, while the uncoated 304SS coupon is severely corroded.

Dursan minimizes process contamination by preventing corrosive interaction with stainless steel; eliminating potentially harmful contamination of process streams.

Summary

Dursan is ideal for environments demanding inert, corrosion resistant, high durability coatings. Test data show Dursan's inert surface allows low ppm sampling of active compounds such as H_2S, mercaptans, SO_2, mercury and many others. Dursan improves the corrosion resistance of stainless steel while reducing the overall system maintenance cost and sampling reliability. To learn more about how Dursan can improve the performance of your sampling or process system, visit our website, www.SilcoTek.com, contact us at (814) 353-1778 or email us at Silcod@Silcotek.com.

SilcoTek®
225 PennTech Dr. | Bellefonte, PA 16823
814-353-1778 | Fax 814-353-1697
www.SilcoTek.com

SilcoTek treatments are available worldwide!

SilcoTek offers treatments on a custom basis direct from our facility. Just follow 2 easy steps to maximize the performance of your product!

Step 1 - Get a quote!
We make it easy with quote options to fit your needs visit our website at www.SilcoTek.com and complete our on-line quote request form or fax your quote request to Quotes at 814.353.1697 or e-mail it to Silcod@SilcoTek.com. We'll get a quote out to you within 24 hours!

Step 2 - Send in your parts!
Mailing instructions, shipping labels and a service number will be forwarded to you along with your quotation. Box up your parts and send them to us. Your order will be processed in 10 working days or less.

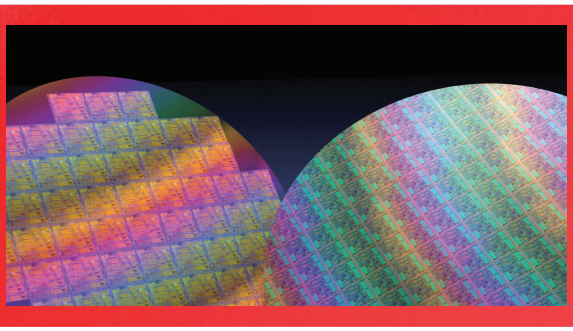
Our 2 touch system means zero disappoinents. We'll notify you when we receive your parts and when your order is ready to ship.

green TECHNOLOGY

SilcoTek treatments are available worldwide through representatives in analytical instrumentation, tubing specialists, fitting manufacturers, and other technology industries. For a complete listing of where you can purchase SilcoTek treated products, go to our website www.SilcoTek.com

Lit Cat# DUR-001

SilcoGuard® U.S. Patent 7,070,833



UHV, high-purity gas system and vacuum

SilcoGuard® 1000 formerly Silcosteel®-UHV

SilcoGuard® 1000 greatly enhances semiconductor & vacuum process performance

Dramatically Reduce Outgassing in UHV Systems

SilcoGuard® 1000

- Save process time - reduce vacuum pump-down times by 2.5X.
- Improve process yields - reduce moisture and ion contamination.
- Add value - reduces or eliminates costly equipment burn-in or stabilization
- Simple! - improve performance of existing components with SilcoTek custom coating service.

Applying SilcoGuard® 1000 on the internal surfaces of vacuum systems can dramatically reduce outgassing rates and provide a productivity advantage to process chambers that require more rapid and efficient evacuations.

A SilcoGuard 1000 layer significantly reduces outgassing by steel components in ultra high vacuum (UHV) systems. Applied to and incorporated into the steel surface, the SilcoGuard 1000 layer acts as a barrier, isolating any materials trapped on or in the steel and preventing them from entering the UHV environment, without liberating any contamination of its own.

Figure 1 compares pump-down rates for a SilcoGuard 1000 treated vs. an untreated chamber. SilcoGuard 1000 will reduce pump down times by 2.5x or more, compared to untreated chambers.
Data courtesy of Elvac Laboratories[1].

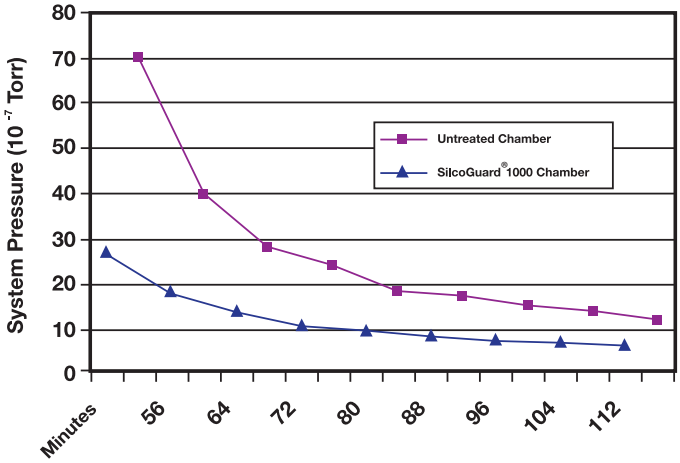


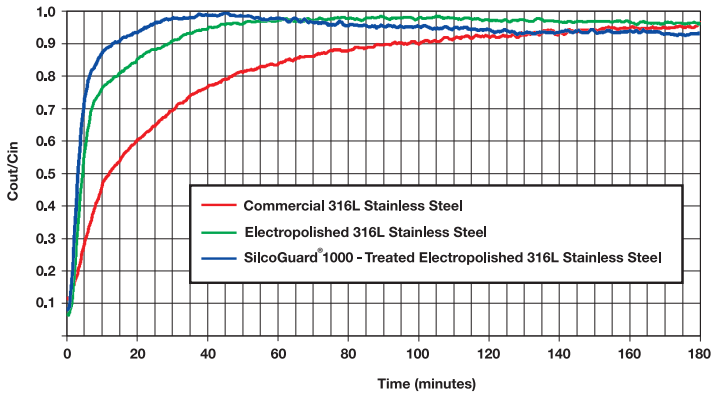
Figure 1 demonstrates the dramatic improvement attained by using SilcoGuard 1000-treated components in a UHV assembly, relative to heat-cleaned components. After 10 hours under vacuum at 61°C, the SilcoGuard 1000 coated part demonstrated a 14-fold lower outgassing rate than the heat-cleaned part, SilcoGuard 1000-treated parts make it possible to achieve and maintain a UHV environment with less pumping capacity and with little to no pre-cleaning or bake-out.

SilcoTek.
225 PennTech Dr. | Bellefonte, PA 16823
814-353-1778 | Fax 814-353-1697
www.SilcoTek.com

Accelerate moisture dry-down with SilcoGuard 1000

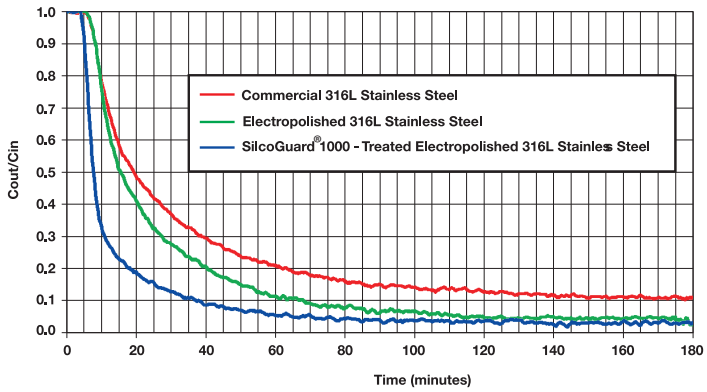
Gas transfer systems serving the semiconductor industry require low moisture content. Data for wet-up and dry-down experiments, measuring the relative response time for moisture content change in treated electropolished stainless steel tubing and standard 316L stainless steel tubing demonstrates a great advantage in using SilcoGuard 1000 treated versus untreated tubing.

Figure 2 SilcoGuard 1000 treated electropolished tubing stabilizes at 1ppm moisture much faster than conventional surfaces.[2] Data courtesy of O'Brien Corporation. [2]



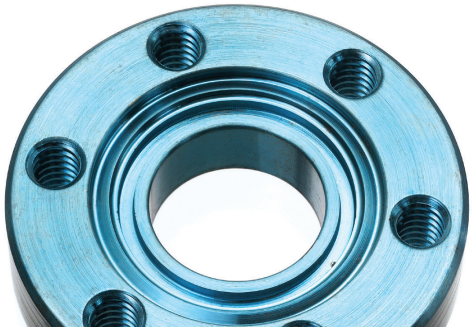
Wet-up curves for SilcoGuard 1000 treated electropolished, untreated electropolished, and standard tubing are compared in Figure 2. Treated electropolished tubing reached the 98% saturation limit in 30 minutes, compared to 60 minutes for electropolished tubing. Standard tubing could only achieve a 96% uptake, after 180 minutes.

Figure 3 SilcoTek treated electropolished tubing dries much faster than conventional surfaces.[2]



Moisture dry-down curves show SilcoGuard 1000 treated electropolished tubing achieved dry-down in 35 minutes, electropolished tubing required 65 minutes, and standard tubing required 175 minutes. Figure 3 compares the dry-down performance for tubing saturated with 10ppm of moisture.

Figure 4 The durable SilcoGuard 1000 layer will withstand the sealing requirements of UHV, maintaining knife-edge integrity.



The SilcoGuard 1000 layer is rugged and durable enough to stand up to the sealing requirements needed to attain a UHV environment. Figure 4 shows the knife-edge of a SilcoGuard 1000-treated Conflat® sealing surface. The knife-edge penetrates and seals in the copper O-ring seated within the Conflat® surface. Even after multiple cycles of this sealing process, the SilcoGuard 1000 layer remains intact.

In Summary

SilcoGuard 1000 is a high purity silicon chemical vapor deposition (CVD) surface treatment that can be applied to existing UHV systems. SilcoGuard 1000 significantly reduces outgassing in stainless steel UHV systems. The hydrophobic nature of SilcoGuard 1000 allows for fast, efficient pumping of moisture and other common surface contaminants from UHV systems. Less contamination results in improved process yields, improved process efficiency and improved process equipment productivity. For more information on how SilcoTek can improve the performance, productivity, and profit of your process; go to our web site, www.SilcoTek.com or call us at 814-353-1778.

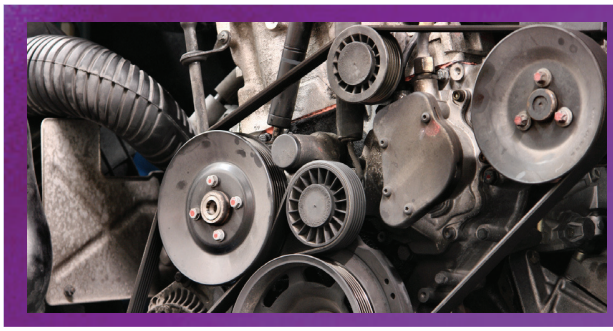
References
1. D. Smith; M. Higgins; B. Kendall; Low Outgassing of Silicon-Based Coatings on Stainless Steel Surfaces for Vacuum Applications; Presented at annual SVC meeting, Restek Corporation/Elvac Laboratories (2005).
2. Relative Response Time of True Tube when Measuring Moisture Content in a Sample Stream Test Report, Haritec Scientific & Engineering Support, Calgary, Alberta, Canada, May 2004. Courtesy of O'Brien Corporation, available on request from SilcoTek.

SilcoTek®
225 PennTech Dr. | Bellefonte, PA 16823
814-353-1778 | Fax 814-353-1697
www.SilcoTek.com

Lit Cat# SG-001

SilcoKlean®

US Patent 6,444,326



Non-stick, Anti-coking, Anti-fouling, Anti-sludge

SilcoKlean®1000 formerly Silcosteel®-AC

SilcoTek® surface treatments inhibit catalytic coking and carbon fouling.

SilcoKlean® 1000 treatment adds value to your process:

- Inhibits catalytic coking
- Longer component lifetimes
- Decreased maintenance costs
- Higher thermal efficiency
- Will withstand temperatures over 600°C
- Apply to existing equipment

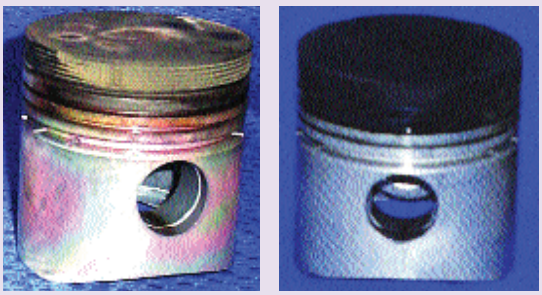


Figure 3 A SilcoKlean1000-treated piston (left) shows dramatically less coke buildup than an untreated diesel piston (right). Data courtesy of The Pennsylvania State University.

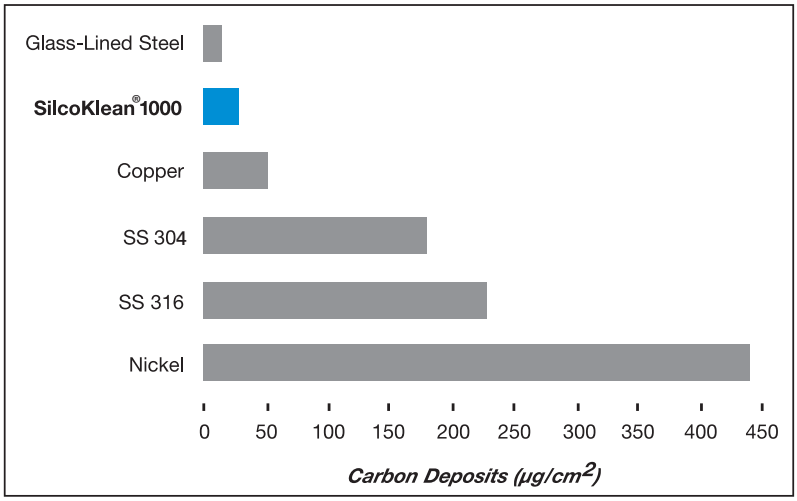
SilcoTek®

225 PennTech Dr. | Bellefonte, PA 16823
814-353-1778 | Fax 814-353-1697
www.SilcoTek.com

Reduce coke formation 8-fold with SilcoKlean®1000 surface treatment

SilcoKlean®1000 reduces the formation of coke by preventing exposed metal surfaces from catalyzing fuel into carbon filaments. Figure 1 compares the carbon buildup on various surfaces. SilcoKlean 1000 reduces carbon fouling or coking by 8-fold when compared to an uncoated 316 stainless steel surface.

Figure 1 SilcoKlean 1000 treatment reduces coking up to 8-fold.[2] Data courtesy of The Pennsylvania State University.



A SilcoKlean 1000 treated surface not only prevents the formation of filamentous coke, it simplifies removal of other types of coke that typically bind to a heated surface.

Studies have shown that carbon deposits can be removed from a SilcoKlean 1000 treated surface simply by sonicating the surface in common solvents, thus dramatically simplifying maintenance procedures and extending maintenance cycles.[3] (Figure 2)

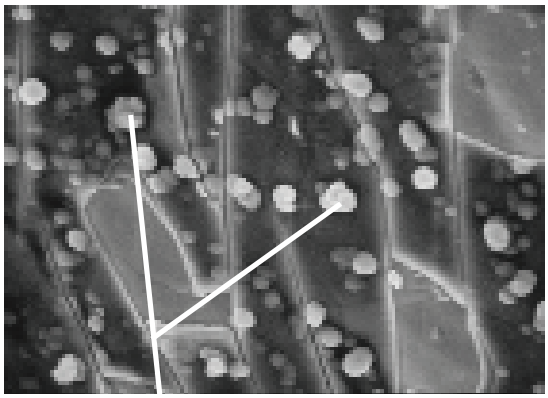
SilcoKlean 1000 treatment extends maintenance cycles for engines while maintaining high dimensional tolerances, high temperature capability, and leak-free conditions, making it an ideal treatment for:

- fuel injection nozzles
- fuel and oil lines
- jet engine nozzles
- pistons
- EGR systems
- valves
- turbine shafts
- heat exchangers

An important contributor to high maintenance costs is a buildup of carbon-based deposits on combustion related components or process systems known as carbon fouling, or coking. Coking has been responsible for engine failures, shortened maintenance cycles, and unplanned repairs. For example, diesel engine manufacturers have determined that coking on pistons is a contributor to shortened engine life and costly rebuilds (Figure 3).[1] Aircraft maintenance personnel are discovering significant coking in fuel lines, oil lines, and nozzles.

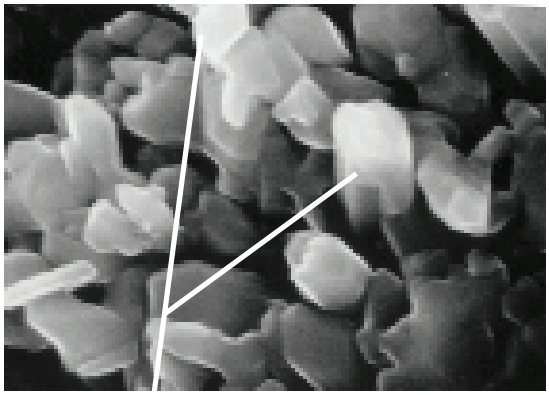
Figure 2 Carbon deposit from JP-8 fuel on various types of tubing (500°C, 500psi, 1cc/min. flow rate). Data courtesy of The Pennsylvania State University.

SilcoKlean 1000



Carbon nucleation lands on surface but can easily be removed from a SilcoKlean 1000 surface.

304 Stainless Steel



Untreated stainless steel promotes carbon filament growth that cannot be removed with sonication.

Studies have shown that coking occurs when fuels or oils are exposed to temperatures over 200°C, and increases significantly at temperatures over 400°C. Frequently, exposure to high temperature occurs after the engine or process is shut down, when there is no coolant flow to carry away excess heat.[2]

Apply SilcoKlean 1000 treatment to components susceptible to coking

SilcoKlean 1000 is a chemical vapor-deposited (CVD) layer, designed specifically to reduce coking of steel, stainless steel, and specialty alloys. The unique non-line-of-sight CVD process produces a flexible, amorphous silicon layer that diffuses into the metal lattice and conforms to the most intricate surface, while maintaining high dimensional tolerances.

SilcoKlean 1000 layer will flex with the metal surface, and form leak-free seals, even at the most demanding temperatures.

In Summary

Test data show that SilcoKlean 1000 treatment is highly effective in reducing catalytic coking, by as much as a factor of 8. Because SilcoKlean 1000 treatment can be applied to existing components, maintenance cycles can be extended without significant re-engineering. SilcoKlean 1000 treatment is a proprietary (U.S. patent 6,444,326), custom service, offered by SilcoTek.

To learn more about how SilcoKlean 1000 treatment can reduce coking in your process or engine fleet, visit SilcoTek on the web at www.SilcoTek.com or contact our technical service group at 814-353-1778.

References
1. Perez, J., A. Boehman, Penn State Multi-Discipline Tribology Group and Energy Institute Studies The Pennsylvania State University, University Park, PA (1998).
2. Jones, E.G., W. Balster, W. Rubey, Fouling of Stainless Steel and Silcosteel Surfaces During Aviation-Fuel Autoxidation Systems Research Laboratories, Inc, Dayton, OH; University of Dayton Research Institute, Dayton, OH (1995).
3. Altin, O., S. Eser, Analysis of Solid Deposits from Thermal Stressing of a JP-8 Fuel on Different Surfaces in a Flow Reactor Ind. Eng. Chem. Res, 40: 596-603 (2001).

SilcoTek®
225 PennTech Dr. | Bellefonte, PA 16823
814-353-1778 | Fax 814-353-1697
www.SilcoTek.com

Lit Cat# SK-001

Silcolloy®

US Patent 7,070,833

Corrosion resistant, Anti-oxidation, Increase material life

Silcolloy®1000 formerly Silcosteel®-CR

Silcolloy® improves corrosion resistance of stainless steel by up to 10x!

Economical protection against corrosion

Silcolloy 1000 is highly effective protection for equipment exposed to:

- **hydrochloric or nitric acid**
- **marine environments**

Silcolloy 1000 treatment extends the lifetime of steel and steel alloy systems. High temperature capability and leak-free sealing capability make it an ideal treatment for:

- **process tubing, fittings, valves, and reactors**
- **gas transfer and delivery systems**
- **nozzles**
- **stack gas monitors**
- **analytical testing equipment in harsh environments**

SilcoTek®

225 PennTech Dr. | Bellefonte, PA 16823
814-353-1778 | Fax 814-353-1697
www.SilcoTek.com

Silcolloy®1000 is a proprietary (U.S. Patent #7,070,833), multilayer silicon, chemical vapor-deposited (CVD) coating, specifically designed to improve the corrosion resistance of steel, stainless steel, alloys, glass, and ceramics. The unique non line-of-sight CVD process produces a flexible amorphous silicon layer that diffuses into the metal lattice. The layer will conform to the most intricate surface while maintaining high dimensional tolerances. Silcolloy1000 will deform with tubing surfaces, allowing leak-free seals or radius bends.

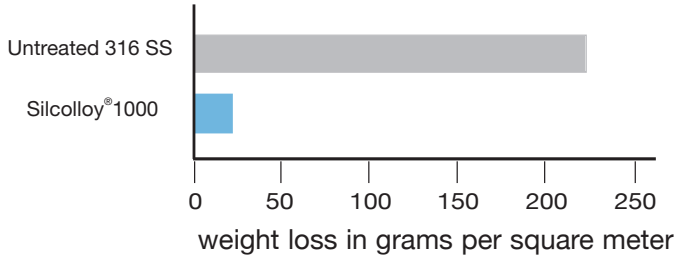
Methods available to control industrial corrosion are limited to corrosion-resistant alloys, barrier coatings, cathodic protection, and corrosion inhibitors. When properly applied, each method can be effective in slowing corrosion, but each has limitations as well. For example, some coatings are inexpensive, but require rigorous inspection and/or frequent reapplication. Corrosion-resistant alloys can provide exceptional protection, but can be prohibitively expensive. Some alloys require significant process redesign, increase operating cost, or generate hazardous waste. Silcolloy 1000 is the solution to high cost corrosion issues.

Independent Laboratory Testing

Silcolloy 1000 offers an order of magnitude or more improvement in corrosion resistance relative to existing processes.

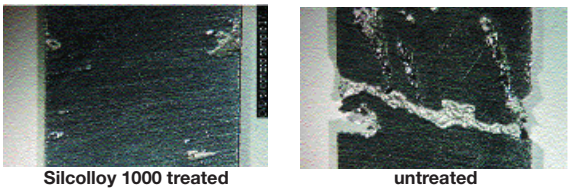
Corrosion testing of Silcolloy 1000 treated 316L stainless steel and untreated 316L steel according to ASTM G48, Method B2 (72-hour ferric chloride pitting and crevice corrosion testing), show corrosion of the treated stainless steel is reduced by an order of magnitude, as measured by weight loss (Figures 1 and 2).[1]

Figure 1 Silcolloy 1000 treated stainless steel outperforms uncoated metal by an order of magnitude (ASTM G48, Method B). Testing courtesy of Matco Associates.



Testing of Silcolloy 1000 treated coupons in neutral, acidic, and basic chloride solutions, according to ASTM G61,[1] shows Silcolloy 1000 treatment reduces corrosion rates by an impressive 50x, compared to untreated 316L stainless steel.

Figure 2 Silcolloy 1000 treated 316L stainless steel coupons show no crevice corrosion and only slight pitting corrosion; untreated coupons exhibit severe crevice corrosion. Testing courtesy of Matco Associates.



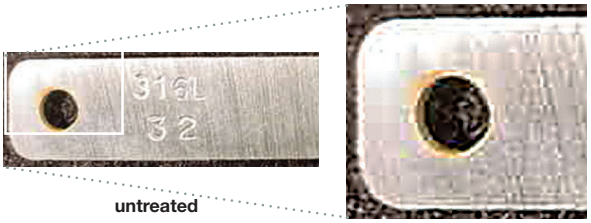
Silcolloy 1000 treated untreated

Improved Performance in Marine or Acidic Environments

Silcolloy 1000 treatment is effective in acidic or salt corrosive environments, in which the user demands extended service life for an existing process without using high-priced alloys. 4000-hour salt spray testing (salt spray accelerated weathering test ASTM B117) shows Silcolloy 1000 treated stainless steel coupons exhibit no surface corrosion, while untreated coupons show surface corrosion and accelerated corrosion at the coupon hole (Figure 4). Neither coupon developed pitting over the test period.[1]

Figure 4 Comparison of estimated lifetime costs in a typical process system, shows Silcolloy 1000 treatment can reduce the overall lifetime cost of the system by hundreds of thousands of dollars.

Silcolloy 1000 treated

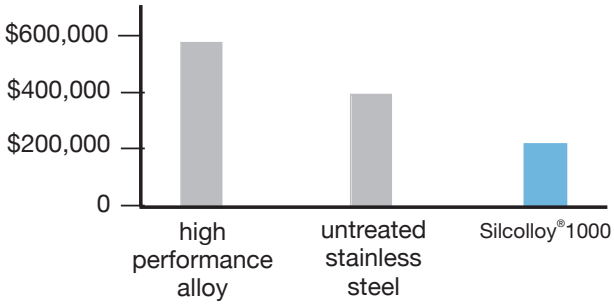


untreated

Save Thousands with Silcolloy!

Estimated lifetime cost savings of a typical process system show Silcolloy treated sample lines, fittings and valves will save the user hundreds of thousands of dollars. While the initial cost of an unprotected stainless steel system is lower than a comparable Silcolloy 1000 treated system, the overall lifetime cost, considering replacement cost due to corrosion is nearly double that of a Silcolloy 1000 treated system (see figure 5). High performance alloy systems offer superlative corrosion performance, but the initial material cost can be up to six times higher than a comparable stainless steel system.

Figure 5 Silcolloy 1000 demonstrates significant cost savings, compared to untreated stainless steel or alloys (US dollars).



Summary

Silcolloy 1000 treatment has extended the life of process systems in oil and gas production, oil refining, petrochemical processing, aerospace equipment, food and beverage processing, and laboratory testing facilities worldwide.

Test data show that Silcolloy 1000 treatment is effective in extending the corrosion resistance of stainless steel process systems while reducing overall system maintenance cost. Because Silcolloy 1000 treatment can be applied to a majority of existing process components; process equipment life is extended without significant re-engineering.

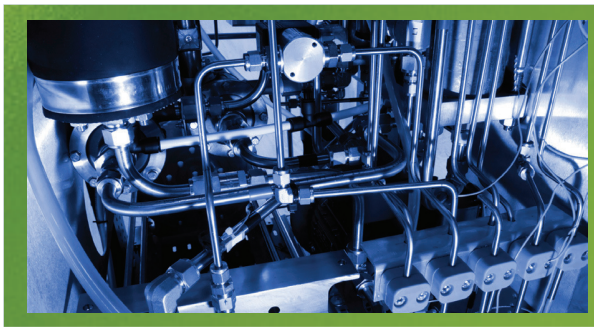
References
1. M. Zamanzadeh; G. Bayer; G. Rhodes; D. Smith; M. Higgins; Laboratory Corrosion Testing of a Chemical Vapor Deposited Amorphous Silicon Coating; Matco Associates, Inc. Pittsburgh, PA; SilcoTek Corporation, Bellefonte, PA. 2005

SilcoTek®
225 PennTech Dr. | Bellefonte, PA 16823
814-353-1778 | Fax 814-353-1697
www.SilcoTek.com

Lit Cat# SY-001

SilcoNert®

US Patent 6,444,326 & 6,511,760



Deactivated Sampling and Transfer System Components

SilcoNert®2000 formerly Siltek® & Sulfinert®

SilcoTek® surface treatments enable quantitative delivery of active compounds.

Maximize the performance of your products

SilcoNert.2000

The ultimate passivation for Stainless steel, glass, steel, and high nickel alloys of steel.

SilcoNert.2000

A required treatment for metal components when analyzing for parts-per-billion levels of organo-sulfur compounds.

SilcoNert®2000 surface treatment eliminates surface adsorption of active compounds on steel, glass, ceramic and carbon surfaces.

Sulfur Compound Storage in SilcoNert 2000 Treated vs. Untreated Sample Cylinders

Figure 1 depicts performance results from a comparison in which a gas containing 17ppbv of hydrogen sulfide was stored for 7 days in untreated and in SilcoNert 2000 treated stainless steel high pressure sample cylinders. The results show a SilcoNert 2000 treated sampling system will reliably store low levels of this active sulfur-containing compound in process streams for long periods of time. In contrast, hydrogen sulfide degraded rapidly in the untreated cylinder, and was totally adsorbed within 24 hours.

Figure 1 Sulfur compounds are stable in SilcoNert 2000 treated stainless steel systems - 17ppbv hydrogen sulfide in 500mL cylinders[1]
Data courtesy of Restek® Corp.

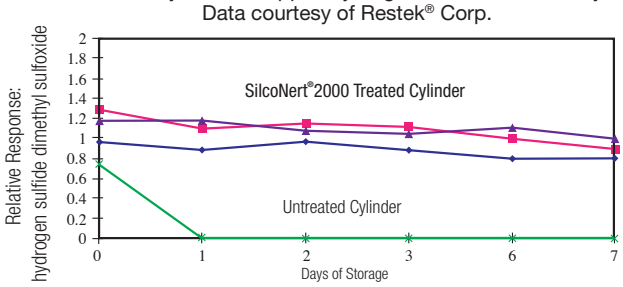
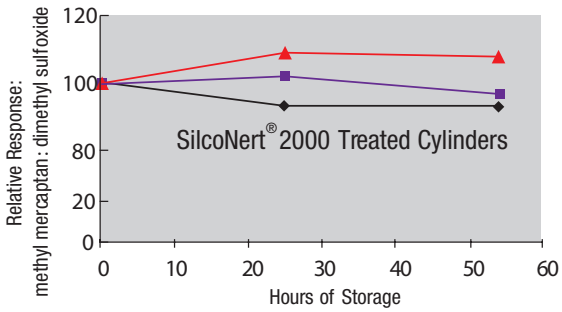


Figure 2 summarizes the results of a similar study in which gas containing 18.8 ppbv methyl mercaptan was stored for 60 hours in SilcoNert 2000 treated sample cylinders. Again, recovery of the active sulfur gas was accurate at the low ppbv concentration, confirming that the sample was stored in contact with an inert surface.

Figure 2 18.8ppbv methyl mercaptan is stable for over 60 hours in 300mL SilcoNert 2000 cylinders[1]



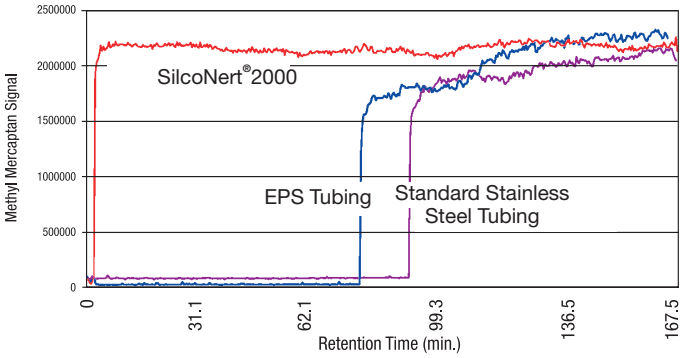
SilcoTek®
225 PennTech Dr. | Bellefonte, PA 16823
814-353-1778 | Fax 814-353-1697
www.SilcoTek.com

Adsorption of Sulfur Compounds to Tubing Surfaces under sample transfer conditions

Comparison of the transport properties of SilcoNert 2000 treated electropolished stainless steel tubing, and raw commercial grade stainless steel tubing show only SilcoNert 2000 treated electropolished stainless steel has the inertness necessary to transfer sulfur compounds at low ppmv to low ppbv concentrations in sample streams.

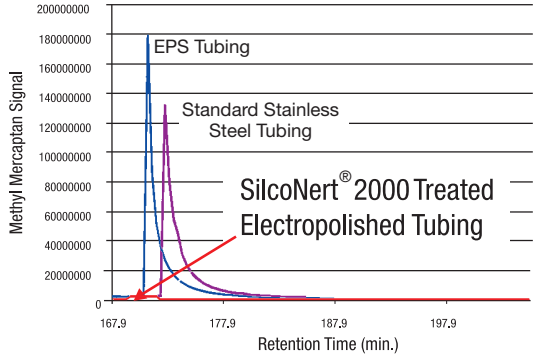
Figure 3 demonstrates uptake of the sulfur compound by the three surfaces. The performance of the SilcoNert 2000 treated, electropolished surface is quite dramatic in comparison to that of untreated electropolished tubing. SilcoNert 2000 treated electropolished tubing did not adsorb methyl mercaptan to any measurable extent, delivering a representative sample with no delay. The untreated electropolished tubing, in contrast, totally adsorbed methyl mercaptan for more than 75 minutes, and the sulfur gas level did not stabilize until approximately 130 minutes. Conventional 316L seamless tubing totally adsorbed methyl mercaptan for more than 90 minutes, and the sulfur gas level did not stabilize until approximately 140 minutes.

Figure 3 SilcoNert 2000 treated electropolished stainless steel tubing (red) does not adsorb methyl mercaptan (500ppbv) compared to untreated seamless stainless steel tubing (blue and violet). Data courtesy of Shell Corp. and O'Brien Corp.



The "memory" of adsorbed active compounds can cause long delays in equilibrating a sample stream. Figure 4 demonstrates the memory effects of the three types of tubing used to transfer streams containing sulfur compounds. The SilcoNert 2000 treated tubing shows less retention of sulfur compounds by several orders of magnitude, indicating very high inertness.

Figure 4 Sulfur memory is prolonged in raw commercial grade stainless steel tubing. SilcoNert2000 treated electropolished tubing; shows no memory effects (500ppbv methyl mercaptan in helium). Data courtesy of Shell Corp. and O'Brien Corp.



Value of an Inert Pathway

SilcoNert 2000 treated sampling and transfer equipment results in more accurate sampling and faster cycle times. Improved accuracy and reliability of data for sulfur, achieved using SilcoNert 2000 treated transfer and sampling equipment, mean downstream processes can be more precisely controlled, resulting in significant cost savings. Shorter cycles translate directly into more samples collected and analyzed in a given period of time. Typical savings can be calculated by looking at the average per-hour cost of operating a process that relies on accurate quantification of sulfur compounds.(1) For example, a 1 hour delay can cost: 800,000 tpy ethylene plant: $50,000; 250,000 tpy LDPE unit: $36,000; 250,000 tpy EBSM styrene plant: $33,000; 200,000 tpy anti-freeze process: $3,600

In Summary Our treatments maximize the performance of your product the first time, every time while saving you thousands in improved yields, better test cycle times and improved system reliability! To learn more visit our web site at www.SilcoTek.com or call us at 814-353-1778.

Reference 1. D. Smith, D. Shelow, G. Barone; "Instrument and Sampling Equipment Passivation Requirements to Meet Current Demands for Low-Level Sulfur Analysis"; Presented at Gulf Coast Conference, 2001; Restek Corporation, Bellefonte, PA 16823.
2. Application of TrueTube™ in Analytical Measurement Cardinal UHP August 2004. The authors thank the staff at Shell Research and Technology Centre, Amsterdam, for data used in evaluating sulfur gas uptake and memory effects of tubing substrates.

SilcoTek.
225 PennTech Dr. | Bellefonte, PA 16823
814-353-1778 | Fax 814-353-1697
www.SilcoTek.com

Improve Corrosion Resistance of Stainless Steel Tenfold or More in Produced Water Applications

Reduce downtime and extend system lifetime with Silcolloy® 1000 treatment.

Managing produced water has become a major challenge for the oil and gas industry. As wells age, water production increases and is expected to swell 50% in offshore applications alone over the next 10 years. Along with increased volume, drillers must contend with a severely corrosive environment of high salinity, acids, and temperature.

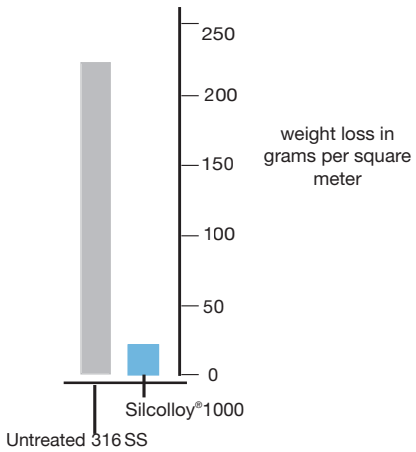
Improve corrosion resistance with Silcolloy®

Silcolloy®1000 (a corrosion resistant, high purity silicon coating from SilcoTek®) can improve the corrosion performance of stainless steels used in produced water environments by an order of magnitude or more. Silcolloy 1000 is a proprietary, patented multi-layer silicon coating designed to improve the corrosion resistance of stainless steel and many alloys in a wide range of corrosive environments (visit www.SilcoTek.com for a complete listing of compatibility).

Independent Laboratory Testing

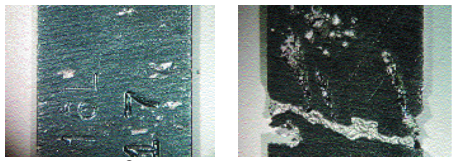
Corrosion testing of Silcolloy 1000 treated 316L stainless steel and untreated 316L stainless steel according to ASTM G 48, Method B2 (72-hour ferric chloride pitting and crevice corrosion testing), shows corrosion of the treated stainless steel is reduced by an order of magnitude, as measured by weight loss (Figures 1 and 2).

Figure 1 Silcolloy 1000 treated stainless steel outperforms uncoated metal by an order of magnitude (ASTM G 48, Method B).



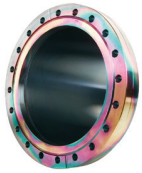
Testing of Silcolloy 1000 treated coupons in neutral and acidic chloride solutions, according to ASTM G 61,[2] shows Silcolloy 1000 treatment reduces corrosion rates by an impressive 50x, compared to untreated 316L stainless steel.

Figure 2 Silcolloy 1000 treated coupon show significantly less corrosion attack compared to an untreated stainless steel coupon.



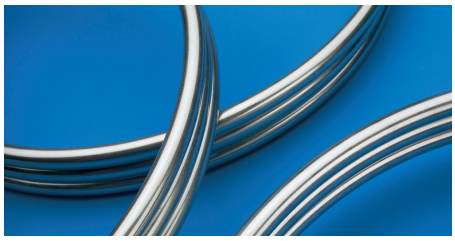
Silcolloy® 1000 treated **untreated**

Improve System Performance



Silcolloy 1000 maintains high system purity, demonstrates extreme heat capability and allows for leak-tight system performance when applied to steel, stainless steel and alloy systems. Silcolloy 1000 is durable and flexible and thin enough to maintain tight machine tolerances. This allows the customer to improve the corrosion resistance of existing components or to add additional corrosion resistance to existing designs without having to allow for tolerance changes during machining.

The unique non-line-of-sight chemical vapor deposition (CVD) process produces a high purity, flexible amorphous silicon layer that is diffused into the metal lattice. The layer will conform to the most intricate surface while maintaining high dimensional tolerances. The Silcolloy 1000 layer will deform with tubing surfaces, allowing leak-free seals and radius bends in tubing.



Silcolloy 1000 treatment adds value to your process:

- **Improve corrosion performance of produced water equipment by 10x.**
- **Reduce material cost by 80%.**
- **Improve performance without costly component redesign.**

SilcoTek®
225 PennTech Dr. | Bellefonte, PA 16823
814-353-1778 | Fax 814-353-1697
www.SilcoTek.com

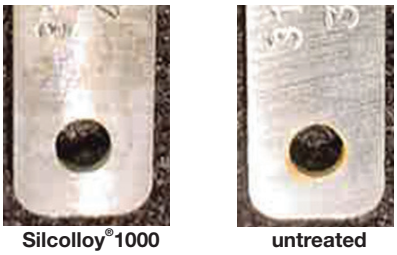
Lit Cat # ST009

Improved Performance in Marine or Acidic Environments

Silcolloy 1000 treatment is effective in acidic or salt corrosive environments, in which the user demands extended service life for an existing process without using high-priced alloys.

4000-hour salt spray testing (salt spray accelerated weathering test ASTM B117) shows Silcolloy 1000 treated stainless steel coupons exhibit no surface corrosion, while untreated coupons shows surface corrosion and accelerated corrosion at the coupon hole (Figure 3).[2]

Figure 3 Silcolloy 1000 treated 316L stainless steel coupons show no sign of attack after 4000-hour salt spray exposure, per ASTM B117 (note rust at aperture)



Silcolloy®1000 treated **untreated**

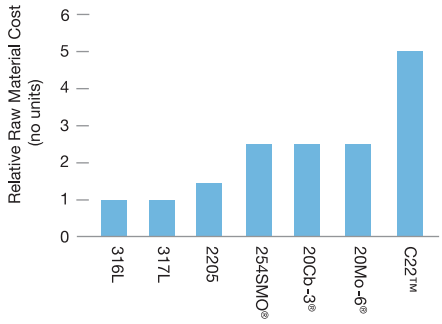
Free Sample

See for yourself! Try Silcolloy 1000 in your environment risk-free. To request a free sample coupon, visit our website at www.SilcoTek.com or contact our technical service team at 814-353-1778.

Improve reliability and reduce costs

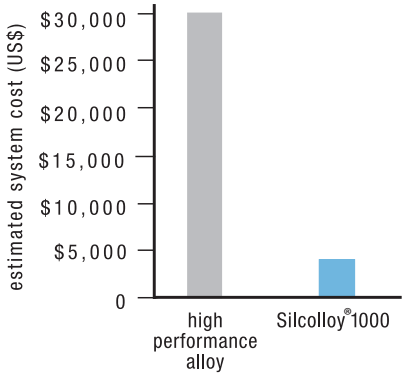
Substituting a high performance alloy for 316L stainless steel in a produced water system can increase the cost of the system by as much as five-fold (Figure 4).[1]

Figure 4 High performance alloys substantially increase the cost of a produced water system.



By improving the corrosion resistance of 316L stainless steel by up to 10x, Silcolloy 1000 treatment reduces costly maintenance and field failures due to system corrosion. Figure 2 compares the cost of Silcolloy 1000 treatment versus Hastelloy® C22™ construction in a typical oil in water monitoring system. Silcolloy1000 treatment demonstrates significant life cycle cost savings, compared to unprotected stainless steel or stainless steel alloys.

Figure 5 Silcolloy1000 demonstrates significant cost savings, compared to high-performance alloys (US dollars).



Summary

Test data show that Silcolloy 1000 treatment is effective in extending the corrosion resistance of stainless steel in produced water environments while reducing overall system maintenance cost. Because Silcolloy 1000 treatment can be applied to a majority of existing process components, process equipment life is extended without significant re-engineering.

To learn more about how Silcolloy 1000 treatment can improve the corrosion performance of your process system, visit SilcoTek on the web at www.SilcoTek.com or contact our technical service group at 814-353-1778.

References

1. 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
2. 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

225 PennTech Dr. | Bellefonte, PA 16823
814-353-1778 | Fax 814-353-1697
www.SilcoTek.com

SilcoTek treatments are available worldwide!

SilcoTek offers treatments on a custom basis direct from our facility. Just follow 2 easy steps to maximize the performance of your product!

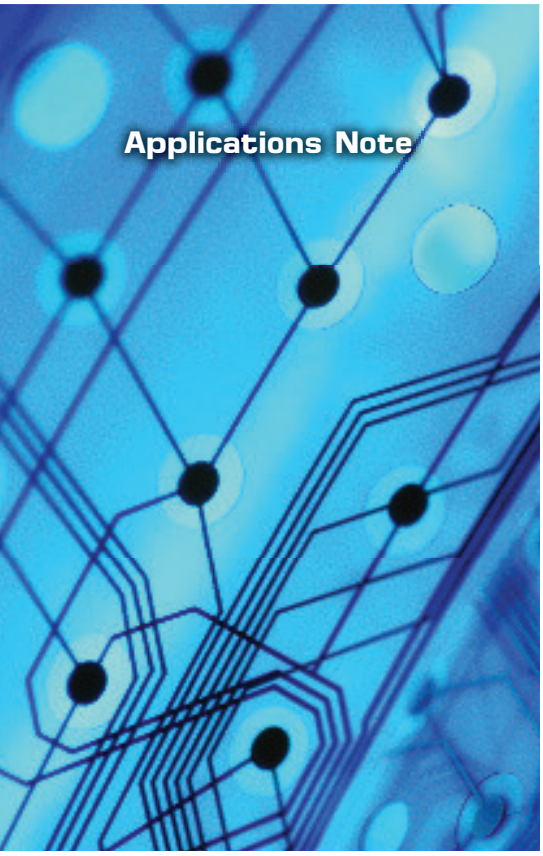
Step 1 - Get a quote!
We make it easy with quote options to fit your needs visit our website at www.SilcoTek.com and complete our on-line quote request form or fax your quote request to Quotes at 814.353.1697 or e-mail it to Silcod@SilcoTek.com. We'll get a quote out to you within 24 hours!

Step 2 - Send in your parts!
Mailing instructions, shipping labels and service number will be forwarded to you along with your quotation. Box up your parts and send them to us. Your order will be processed in 10 working days or less.

Our 2 touch system means zero disappointments. We'll notify you when we receive your parts and when your order is ready to ship.

SilcoTek treatments are available worldwide through representatives in analytical instrumentation, tubing specialists, fitting manufacturers, and other technology industries. For a complete listing of where you can purchase SilcoTek treated products, go to our website www.SilcoTek.com

Lit Cat # ST009



Greatly Enhance Semiconductor Process Performance

with SilcoTek® Coatings

- **Save money** - reduce corrosion maintenance cost by up to 65%.
- **Improve process yields** - reduce moisture and ion contamination.
- **Save process time** - reduce vacuum pump-down time by 2.5X.
- **Simple!** - improve performance of existing components with SilcoTek's custom coating service.

Pathways in semiconductor process systems require high corrosion resistance, low moisture content, and high purity. The current substrate of choice in semiconductor manufacturing, electropolished VIM/VAR (vacuum induction melt/vacuum arc melt) 316L stainless steel, fails to perform in many demanding process environments. The result is increased periodic maintenance, prolonged equilibration times, system contamination, and inaccurate analytical results.

SilcoTek's patented non-line-of-sight chemical vapor deposition (CVD) processes produce a high purity, flexible, amorphous silicon layer, diffused into the base metal lattice. The layer will conform to the most intricate surface. The SilcoTek® surface will deform with tubing surfaces, allowing radius bends and leak-free seals.

Silcolloy®1000 treatment improves corrosion resistance

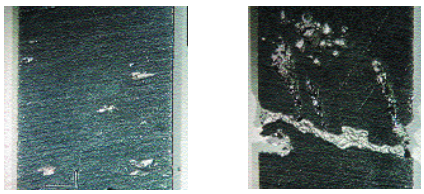
Independent laboratory testing shows Silcolloy®1000 treatment improves corrosion resistance by up to 10x over untreated 316L stainless steel (Figure 1a &1b).[1] Silcolloy1000 treatment is compatible with many chemicals used in the semiconductor industry. Visit us online at www.SilcoTek.com for a complete list of common semiconductor chemicals and their compatibility.

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 five-fold.[2]

By improving the corrosion resistance of 316L stainless steel by up to 10x, Silcolloy1000 treatment reduces costly maintenance and field failures due to system corrosion. Figure 2 compares the cost of Silcolloy1000 treatment versus Hastelloy™ C22 construction in a typical gas delivery system. Silcolloy1000 treatment demonstrates significant life-cycle cost savings, compared to unprotected stainless steel or stainless steel alloys.

Figure 1a 316L stainless steel shows significant crevice corrosion; a Silcolloy®1000 treated coupon shows only minor pitting (ASTM G 48, Method B).



Silcolloy®1000 treated | **untreated**

Figure 1b Silcolloy1000 treated stainless steel outperforms uncoated metal **by an order of magnitude** in chloride environments.

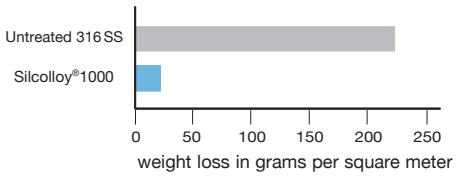
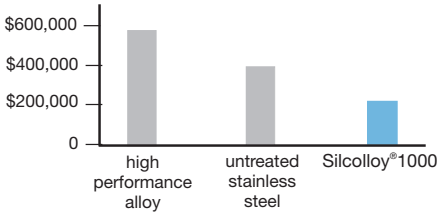


Figure 2 Silcolloy1000 significantly lowers the life cycle cost of stainless steel or alloys (US dollars).



SilcoTek Surface Treatments

We offer surface treatments that enhance performance in many applications:

Silcolloy®1000 A corrosion resistant layer that increases the lifetime of system components in acidic environments.

SilcoGuard®1000 Greatly reduces outgassing from components of ultra-high vacuum systems.

SilcoNert®1000 A general-purpose passivation layer for steel and stainless steel.

SilcoNert®2000 The ultimate passivation for treated components, from glass to high nickel alloys of steel. A required treatment for metal components when analyzing for parts-per-billion levels of organo-sulfur compounds.

SilcoKlean®1000 Dramatically reduces carbon buildup on stainless steel components.

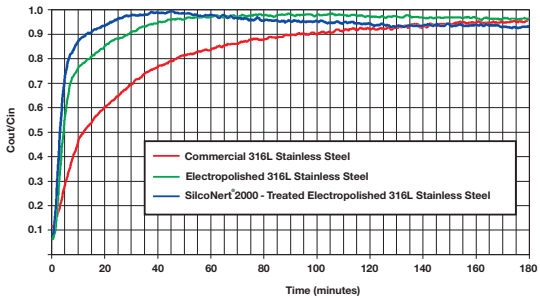
SilcoTek®
225 PennTech Dr. | Bellefonte PA 16823
814-353-1778 | Fax 814-353-1697
www.SilcoTek.com

Lit Cat # ST007

Accelerate moisture dry-down with SilcoNert®2000 treatment

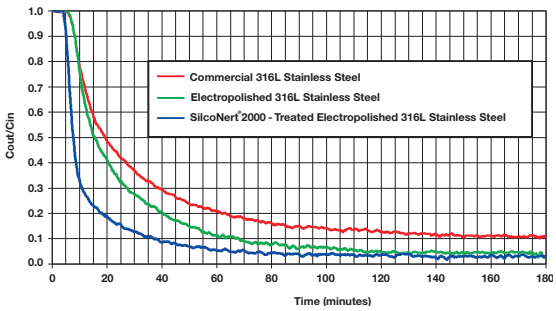
Gas transfer systems serving the semiconductor industry require low moisture content. Data for wet-up and dry-down experiments, measuring the relative response time for moisture content change in treated electropolished stainless steel tubing and standard 316L stainless steel tubing, demonstrate a significant advantage in using SilcoNert®2000 treated versus untreated tubing.

Figure 3 SilcoTek treated electropolished tubing stabilizes at 1ppm moisture much faster than conventional surfaces.[3]



Wet-up curves for SilcoNert2000 treated electropolished, untreated electropolished, and standard tubing are compared in Figure 3. Treated electropolished tubing reached the 98% saturation limit in 30 minutes, compared to 60 minutes for electropolished tubing. Standard tubing could only achieve a 96% uptake, after 180 minutes.[2] Moisture dry-down curves show SilcoNert2000 treated electropolished tubing achieved dry-down in 35 minutes, electropolished tubing required 65 minutes, and standard tubing required 175 minutes. Figure 4 compares the dry-down performance for tubing saturated with 10ppm of moisture.

Figure 4 SilcoTek treated electropolished tubing dries much faster than conventional surfaces.[3]

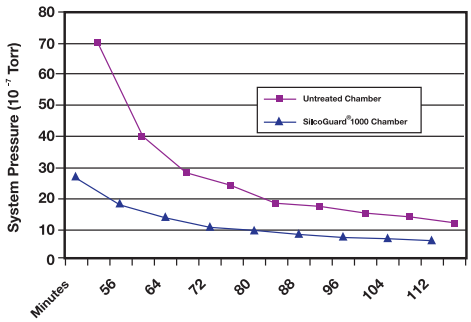


SilcoGuard®1000 treatment cuts pump-down time

Semiconductor processes requiring frequent pump-downs can realize dramatic productivity improvements by treating vacuum chambers with SilcoGuard®1000.

The slow outgassing of water vapor and other contaminants in process vacuum chambers can greatly hinder evacuation rates, process throughput, and ultimate base pressures. The application of SilcoGuard1000 throughout exposed surfaces of vacuum systems can dramatically reduce outgassing rates and provide a productivity advantage to process chambers that require more rapid and efficient evacuations.

Figure 5 compares pump-down rates for a SilcoGuard1000 treated vs. an untreated chamber. SilcoGuard1000 will reduce pump down times by 2.5x or more, compared to untreated chambers.[4]



Conclusion

SilcoTek can help semiconductor manufacturers meet cost and productivity challenges by improving the surface performance of stainless steel:

- **Silcolloy®1000 improves corrosion resistance by 10x or more.**
- **SilcoNert®2000 eliminates moisture contamination by 50% or more.**
- **SilcoGuard®1000 improves chamber productivity by 2.5x or more.**

SilcoTek treatments can be applied to existing process components. Custom treatment is available for process-specific components and applications. To learn more about how SilcoTek can improve the performance of your system, go to www.SilcoTek.com or call us! 814-353-1778

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
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
3. Relative Response Time of True Tube™ when Measuring Moisture Content in a Sample Stream Test Report, Haritec Scientific & Engineering Support, Calgary, Alberta, Canada, May 2004. Courtesy of O'Brien Corporation, available on request from Restek.
4. D. Smith; M. Higgins; B. Kendall; Low Outgassing of Silicon-Based Coatings on Stainless Steel Surfaces for Vacuum Applications; Presented at annual SVC meeting, Restek Corporation/Elvac Laboratories (2005).

SilcoTek®
225 PennTech Dr. | Bellefonte, PA 16823
814-353-1778 | Fax 814-353-1697
www.SilcoTek.com

SilcoTek treatments are available worldwide!

SilcoTek offers treatments on a custom basis direct from our facility. Just follow 2 easy steps to maximize the performance of your product!

Step 1 - Get a quote!
We make it easy with quote options to fit your needs visit our website at www.SilcoTek.com and complete our on-line quote request form or fax your quote request to Quotes at 814.353.1697 or e-mail it to Silcod@SilcoTek.com. We'll get a quote out to you within 24 hours!

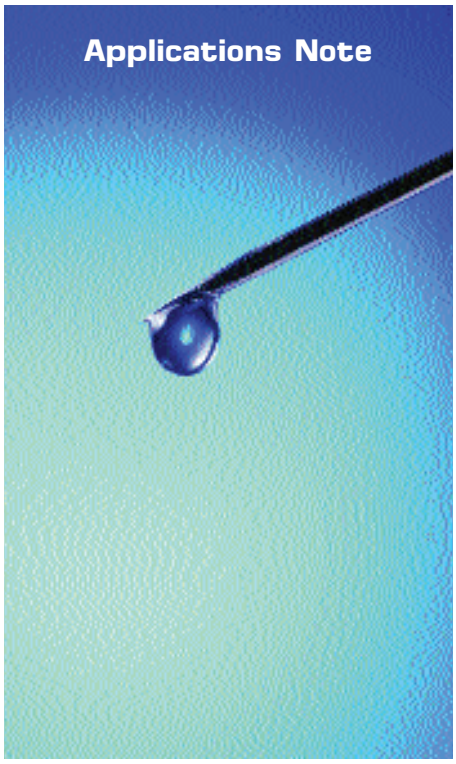
Step 2 - Send in your parts!
Mailing instructions, shipping labels and service number will be forwarded to you along with your quotation. Box up your parts and send them to us. Your order will be processed in 10 working days or less.

Our 2 touch system means zero disappointments. We'll notify you when we receive your parts and when your order is ready to ship.

green TECHNOLOGY

SilcoTek treatments are available worldwide through representatives in analytical instrumentation, tubing specialists, fitting manufacturers, and other technology industries. For a complete listing of where you can purchase SilcoTek treated products, go to our website www.SilcoTek.com

Lit Cat # ST007



Economical solutions for ultra-high purity streams

- **SilcoNert.** treated surfaces improve moisture wet-up or dry down performance by up to 3x compared to conventional surfaces.
- **Silcolloy.** improves corrosion resistance tenfold, or more – increases component lifetime and maintains pure product stream.
- **Custom services:** can be applied to existing equipment.

For more information about SilcoNert and Silcolloy, visit us online at www.SilcoTek.com or call us! 814-353-1778.

225 PennTech Dr. | Bellefonte, PA 16823
814-353-1778 | Fax 814-353-1697
www.SilcoTek.com

Lit Cat # ST008

Improve Moisture Dry-Down and Corrosion Resistance with SilcoTek®

SilcoNert®2000 (Siltek®/Sulfinert®) treated tubing and system components offer improved analytical reliability and longer lifetimes.

Introduction

Gas transfer systems serving industry often require low moisture content and high resistance to corrosion. SilcoTek® coatings provide significant added value to conventional stainless steel substrates, by greatly reducing wet-up and dry-down times and dramatically improving corrosion resistance.

SilcoNert® 2000 is an amorphous silicon layer deposited onto, and into, the steel surface through a patented chemical vapor deposition (CVD) process. The SilcoNert® 2000 process (US Patent #6,444,326), has been optimized to reduce moisture hold-up and improve surface inertness.

Data for wet-up and dry-down experiments, measuring the relative response time for moisture content change in SilcoNert 2000 treated electropolished stainless steel tubing, untreated electropolished stainless steel tubing, and standard 316L stainless steel tubing, demonstrate a significant advantage in treated versus untreated substrates.[1] Tubing used in the wet-up / dry-down experiments was supplied by Cardinal UHP (St. Louis, MO). All tubing was tested as 100 foot coils of 1/4" OD x 0.020" wall 316L stainless steel. Electropolished tubing had a surface roughness of 10 to 15 micro-inches. SilcoNert 2000 treated tubing is finished with up to 0.5µm of amorphous silicon, followed by a surface functionalization that increases inertness and hydrophobicity.

Wet-up curves for SilcoNert 2000 treated electropolished, conventional electropolished, and standard tubing are compared in Figure 1. Treated electropolished tubing reached the 98% saturation limit in 30 minutes, compared to 60 minutes for electropolished tubing. Standard tubing could only achieve a 96% uptake, after 180 minutes.

After the tubing was stabilized with 1ppm of moisture, dry-down properties were measured. Moisture dry-down curves for the three tubing treatments show treated electropolished tubing achieved dry-down in 35 minutes, electropolished tubing required 65 minutes, and standard tubing required 175 minutes (Figure 2). Table 1 compares time to various dry-down levels for tubing saturated with 10ppm of moisture.

Figure 1 SilcoTek treated electropolished tubing stabilizes at 1ppm moisture much faster than conventional surfaces.[1]

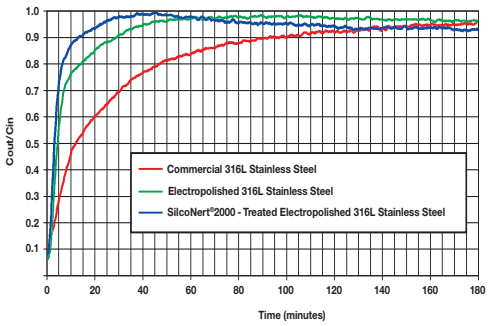


Figure 2 SilcoTek treated electropolished tubing dries much faster than conventional surfaces.[1]

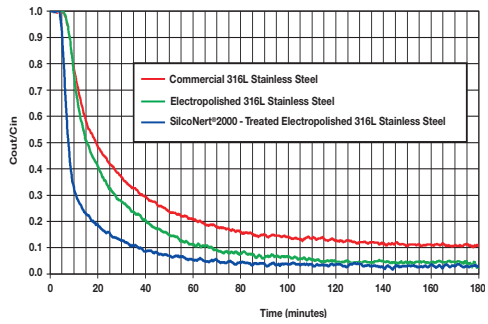


Table I SilcoTek treated electropolished tubing provides the shortest drying times.[1]

Moisture Concentration From	To	SilcoNert2000 Treated Electropolished Tubing	Untreated Electropolished Tubing	Standard Tubing
		Time Required to Detect Change (min.)		
10ppm*	5ppm	4	5	13
5ppm	1ppm	22	46	71
1ppm	500ppb	40	63	96
500ppb	100ppb	80	103	153
100ppb	50ppb	98	121	---

*Initial moisture concentration.

Improve corrosion resistance with Silcolloy (Silcosteel®-CR)

In addition to rapid wet-up and dry-down, the other key advantage of SilcoTek treatment for 316L stainless steel is a dramatic improvement in corrosion resistance. The amorphous silicon layer is insoluble in many acidic environments encountered in industry. Figures 3, 4, and 5 briefly summarize the results of corrosion testing by ASTM methods. Comparisons between treated and untreated test samples illustrate the improvements in corrosion resistance offered by Silcolloy® 1000 treatment. For more information about corrosion resistance, request an information packet, or visit our website, www.SilcoTek.com.

Figure 3 In chloride environments, Silcolloy 1000 treated stainless steel outperforms untreated metal by an order of magnitude (ASTM G 48, Method B).

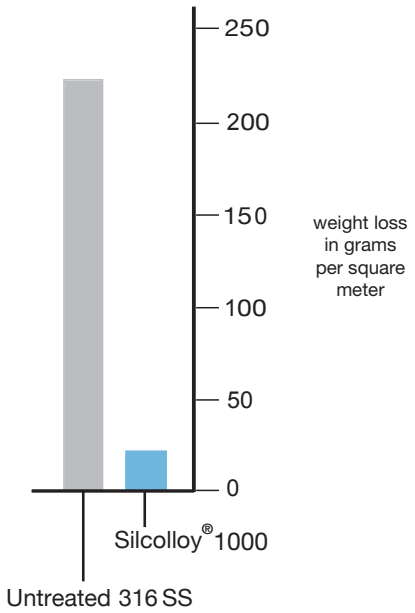
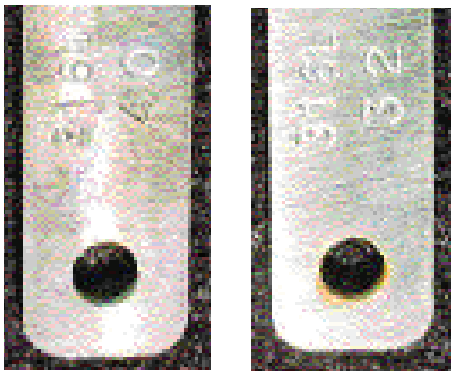
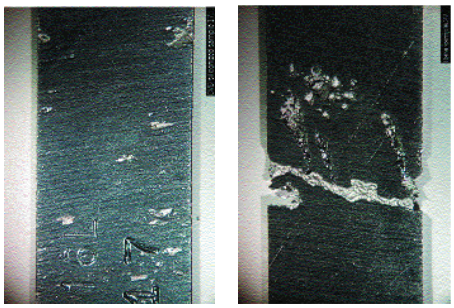


Figure 4 Silcolloy 1000 treated 316L stainless steel coupons show no sign of attack after 4000-hour salt spray exposure, per ASTM B117.



Silcolloy1000 treated **untreated**

Figure 5 Silcolloy1000 treated 316L stainless steel coupons show no crevice corrosion and only slight pitting corrosion after 72-hour exposure to ferric chloride; untreated coupons exhibit severe crevice corrosion.



Silcolloy1000 treated **untreated**

Free Literature

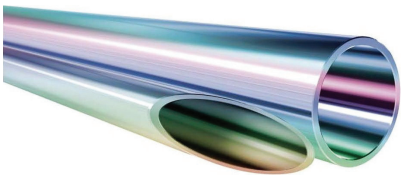
Learn more about our precisely applied, highly durable surface treatments, go to our website www.SilcoTek.com or Call us! 814-353-1778

Summary

When moisture considerations and corrosion concerns arise in transfer of ultra-high purity gas streams, SilcoTek treated tubing and system components will dramatically improve dry-down, reduce contamination from moisture carryover, and extend periodic maintenance cycles.

SilcoTek Treated Electropolished Tubing

- Exceptional inertness.
- Improved reliability and reproducibility; longer lifetime.
- Use with treated fittings for the most inert sample pathway available.



Reference
1. Relative Response Time of True Tube™ when Measuring Moisture Content in a Sample Stream Test Report, Haritec Scientific & Engineering Support, Calgary, Alberta, Canada, May 2004.
Reference courtesy of O'Brien Corporation, available on request from Restek.

SilcoTek®
225 PennTech Dr. | Bellefonte, PA 16823
814-353-1778 | Fax 814-353-1697
www.SilcoTek.com

SilcoTek treatments are available worldwide!

SilcoTekoffers treatments on a custom basis direct from our facility. Just follow 2 easy steps to maximize the performance of your product!

Step 1 - Get a quote!
We make it easy with quote options to fit your needs visit our website at www.SilcoTek.com and complete our on-line quote request form or fax your quote request to Quotes at 814.353.1697 or e-mail it to Silcod@SilcoTek.com. We'll get a quote out to you within 24 hours!

Step 2 - Send in your parts!
Mailing instructions, shipping labels and service number will be forwarded to you along with your quotation. Box up your parts and send them to us. Your order will be processed in 10 working days or less.

Our 2 touch system means zero disappointments. We'll notify you when we receive your parts and when your order is ready to ship.

green TECHNOLOGY

SilcoTek treatments are available worldwide through representatives in analytical instrumentation, tubing specialists, fitting manufacturers, and other technology industries. For a complete listing of where you can purchase SilcoTek treated products, go to our website www.SilcoTek.com

Lit Cat # ST008

Reliable sampling at the well or in the refinery

SilcoTek® surface treatments improve sampling and transfer component performance

- **Economical** - Low cost corrosion resistance compared to specialty alloys, more durable than traditional stainless steels.
- **Productive** - Superior analytical performance allows characterization of parts-per-billion level sulfurs in the field or lab.
- **Versatile** - Suitable in a variety of environments and at extreme temperature ranges.
- **Simple** - Can be applied to existing equipment.

When corrosion and surface activity are a concern, solutions must be engineered using special alloys or surface treatments. SilcoTek offers a family of surface treatments that address reactivity and corrosion concerns over a wide spectrum of applications. Table 1 lists applications in which SilcoTek treatments minimize corrosion or prevent adsorption of active compounds.

Table 1 Applications in which SilcoTek treated sample pathway components minimize corrosion** or prevent adsorption of active compounds*.

Sulfur compounds in:*
automotive exhaust
diesel fuels
ethylene
liquefied petroleum gas
oil & gas exploration
refining
wines and beers
beverage grade CO2
environmental samples
gasoline
natural gas (odorants)
propylene
stack gas emissions

Nitric oxide (NOx) compounds in:*
automotive exhaust
stack gas emissions

Mercury compounds in:*
crude oil refiningenvironmental samples
exhaustoil & gas exploration
stack gas emissions from coal fired electric power plants

Corrosive environments:**
hydrochloric acidhydrogen peroxide
off-shore platformsrefining
seawater

Moisture hold-up in high purity sampling lines**
sample systems
gas delivery systems
process systems

*SilcoNert®2000 treatment. **Silcolloy®1000 treatment.

Detect process upsets

Accurate sampling every time with SilcoNert 2000 (Siltek/Sulfinert) treated components.

Reduce capital costs

Silcolloy (Silcosteel®-CR) treated compenents cost up to 85% less than super alloys.

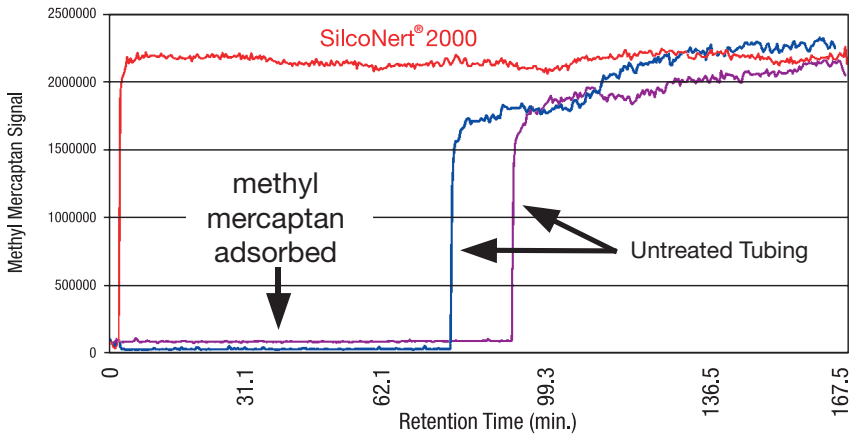
Reduce maintenance costs

Increase component life by 10X over untreated stainless steel.

Accurate feedstock or process sampling the first time, every time with SilcoNert® 2000(Siltek®/Sulfinert®) tubing and fittings.

Adsorption problems in sample pathways often can be traced to the tubing and fittings used to transfer the sample to the analytical instrument. Always use treated tubing and fittings for applications involving active compounds. For special requirements, ensure maximum inertness and minimal surface area by applying SilcoTek treatments to electropolished tubing. Figure 1 shows uptake and release curves for 500ppbv of methyl mercaptan, an active sulfur compound, in a gas stream passing through a variety of tubing substrates.[1] SilcoNert 2000 (Siltek/Sulfinert) treated tubing reduces uptake by orders of magnitude, relative to untreated stainless steel tubing.

Figure 1 SilcoNert 2000 treated tubing allows for rapid detection.



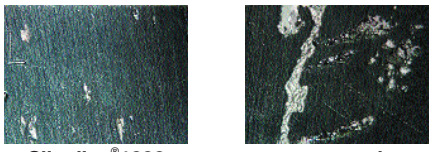
SilcoTek®
112 Benner Circle | Bellefonte, PA 16823
814-353-1778 | Fax 814-353-1697
www.SilcoTek.com

Lit Cat # ST010

Reduce maintenance cost, extend stainless steel system life with Silcolloy®1000 Treated tubing and fittings.

In corrosive environments, Silcolloy®1000 treatment is an excellent alternative to expensive alloys. Silcolloy 1000 treatment extends component life while reducing the frequency of preventive maintenance and ensuring the purity of the process or sample stream.† Silcolloy 1000 improves corrosion resistance by up to 10X over untreated 316 stainless steel (per ASTM G48 Method B, Figure 2).

Figure 2 Silcolloy 1000 treated 316L stainless steel coupons show no crevice corrosion and only slight pitting corrosion after 72-hour exposure to ferric chloride; untreated coupons exhibit severe crevice corrosion (per ASTM Method G48, Method B).



Silcolloy®1000 treated **untreated**

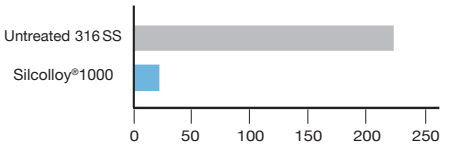
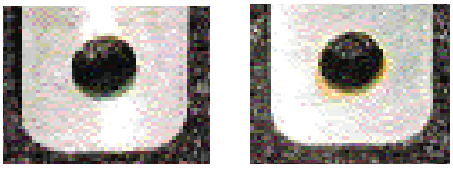


Figure 3 shows the results of a 4000-hour salt spray test on Silcolloy 1000 treated 316L stainless steel and untreated 316L stainless steel. The Silcolloy 1000 treated material exhibited virtually no change.

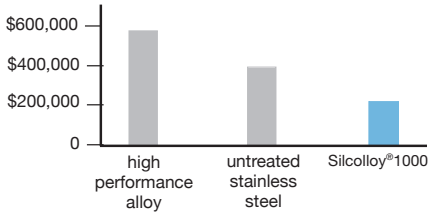
Figure 3 Silcolloy 1000 treated 316L stainless steel coupons show no sign of attack after 4000-hour salt spray exposure, per ASTM B117.
Note rust at aperture on untreated coupon.



Silcolloy 1000 treated **untreated**

Figure 4, a comparison of lifetime costs in a typical process system, shows Silcolloy 1000 treatment can reduce the overall lifetime cost of the system by hundreds of thousands of dollars. While the initial cost of an unprotected stainless steel system is lower than that of a comparable Silcolloy 1000 system, the overall lifetime cost, considering replacement cost due to corrosion, is nearly double that of a Silcolloy 1000 treated system. Conversely, high performance alloy systems offer superlative corrosion performance, but the initial material cost can be up to six times that of a comparable stainless steel system. Silcolloy 1000 treatment has extended the life of process systems in oil and gas production, oil refining, petrochemical processing, aerospace equipment, food and beverage processing, and laboratory testing.

Figure 4 Silcolloy 1000 demonstrates significant cost savings, compared to untreated stainless steel or alloys (US dollars).



Treat the entire sample pathway for maximum effect.

Fittings, valves and other system components can significantly contribute to adsorbtion and corrosive attack. SilcoTek treatment of the entire pathway will reduce costly sample loss or corosion.

Fittings

Connections can be a source of adsorption and sample loss, and there is benefit to using SilcoTek surface treatment on many of these components. For example, in corrosive environments, Silcolloy 1000 treatment will extend the useful life of system fittings, and tubing.

Valves

The sample flow path through a valve can be tortuous, prolonging contact between the sample stream and the valve components. SilcoTek surface treatments have been applied to many valve geometries, to eliminate adsorption to bodies, stems, diaphragms, or other components.

Filters

Frits and other filtering devices trap particles and prevent them from entering the analytical instrument, but they also very effectively adsorb active components in sample streams. Their large surface areas can increase sample/system contact by orders of magnitude. SilcoNert 2000 (Siltek/Sulfinert) treatment of frits and filters creates an inert flowpath. Our chemical vapor deposition technology ensures the treatment penetrates even the smallest pores in sintered metal frits.

Sample Vessel Equipment

When samples are taken from a process stream and are transported to the laboratory for evaluation, it is critical to use SilcoTek treated sampling containers, to prevent active components from adsorbing to vessel, valve, or outage tube surfaces.

Probes

Sampling probes are used in a variety of applications, including sampling natural gas or other process streams. An untreated probe contributes to the active surface area in the system, and this should be considered when identifying potential adsorption sites during active stream transfer.

Heated Lines

A heated "trace line" consists of standard grade or electropolished tubing that has been insulated and bundled with heating devices to ensure the sample is transferred at a consistent temperature. Such lines are used in many gas stacks and other remote sampling points at which a sample is transported through the outdoor environment. Active compounds in the sample quickly can be adsorbed onto the tubing. SilcoTek surface treatment prevents adsorption of active compounds.

Summary

Surface treatments from SilcoTek prevent corrosion or adsorption of active compounds in process systems, and should be considered in applications in which corrosive or active streams are to be sampled, transferred, or analyzed. To learn more about how SilcoTek can improve the performance of your system, go to www.SilcoTek.com or call us! 814-353-1778.

Free evaluation

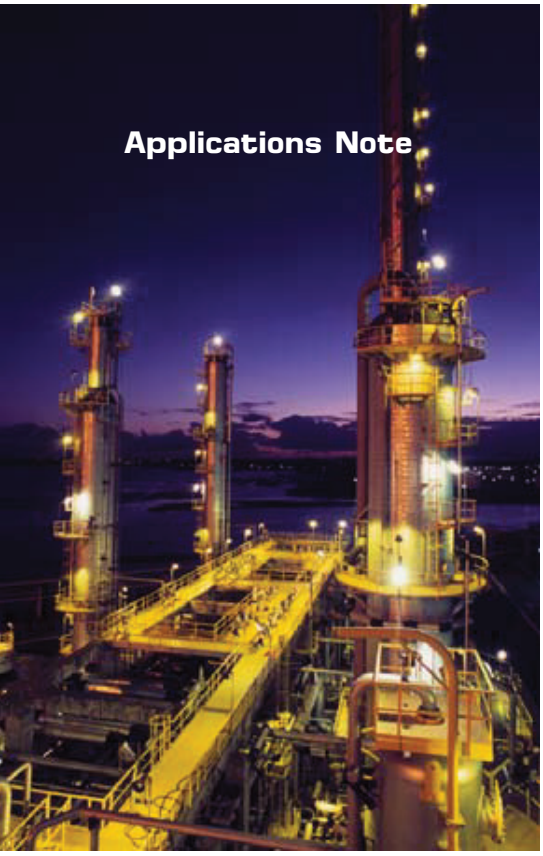
For a free treated 316L stainless steel test coupon, visit www.SilcoTek.com. Or call us at 800-356-1778 to arrange treatment of your existing components.

† Note that with any corrosive stream, regular inspections are needed to confirm there are no leaks or breakthroughs.

1. Application of TrueTube™ in Analytical Measurement Cardinal UHP August 2004

SilcoTek.
225 PennTech Dr. | Bellefonte, PA 16823
814-353-1778 | Fax 814-353-1697
www.SilcoTek.com

Lit Cat # ST010



Sulfur Compound Sampling, Storage, and Transfer using SilcoNert® 2000, The Ultimate Inert Coating

- Accurate sulfur & H_2S sampling
- Faster cycle times
- Improve process yields, detect ppb levels of H_2S
- Improve productivity
- Achieve low parts per billion sulfur & H_2S sampling

SilcoNert 2000 coating eliminates surface adsorption of active compounds like hydrogen sulfide (H_2S), methyl mercaptan or other sulfur containing compounds.

Accurate analysis of part-per-million and part-per-billion levels of sulfur containing compounds like H_2S and methyl mercaptan in petrochemical streams and down hole samplers are critical to meeting new regulations for low level sulfur. Many organo-sulfur compounds, like hydrogen sulfide (H_2S), methyl mercaptan, and ethyl mercaptan, adsorb to metal surfaces.

SilcoNert® 2000

Accurate sulfur sampling every time

* ***Detect costly process upsets*** in a fraction of the time
* ***Prevent catalyst contamination*** by eliminating reactor wall effects
* ***Assure regulatory compliance***
  - Rule 1118
  - Ultra-low sulfur diesel and gasoline standards

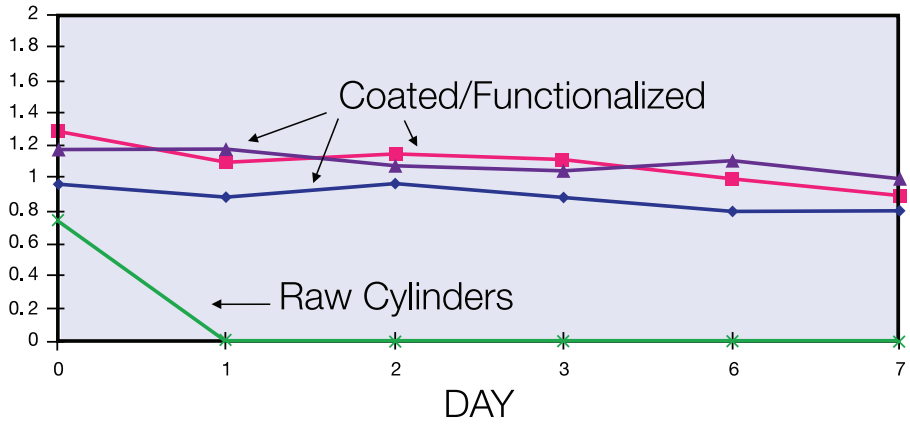


Figure 1: Sulfur compounds are stable in SilcoNert 2000 treated stainless steel systems- 17ppbv hydrogen sulfide in 500ml cylinders[1].

Ensure accurate feedstock or process sampling of sulfur, hydrogen sulfide (H_2S), methyl mercaptan or other sulfur containing compounds the first time, every time with SilcoNert 2000.

Figure 1 depicts performance results from a comparison of sample cylinders (typically used in refinery or down hole sampling) in which a gas containing 17 parts-per-billion (ppbv) hydrogen sulfide (H_2S) was stored for 7 days in untreated and SilcoNert 2000 treated stainless steel high pressure sample cylinders. The SilcoNert 2000 treated sample cylinder demonstrated superior sulfur/H_2S inertness and will reliably store low levels of active sulfur compounds for long periods of time. In contrast, H_2S degraded rapidly in the untreated cylinder, and was totally adsorbed within 24 hours.

SilcoTek®
225 PennTech Dr. | Bellefonte, PA 16823
814 353 1778 | Fax 814 353 1697
www.SilcoTek.com

Lit Cat # SN-010

SilcoNert 2000 is a proprietary (U.S. Patent #6,444,326), silicon, chemical vapor-deposited (CVD) coating, specifically designed to improve the sulfur inertness and chemical inertness of steel, stainless steel, alloys, glass, and ceramics. The unique non line-of-site CVD process produces a flexible, high temperature capable, amorphous silicon layer that diffuses into the metal lattice. The coating will conform to the most intricate surfaces while maintaining high dimensional tolerances. SilcoNert 2000 will deform with tubing surfaces allowing for radius bends and will not interfere with threaded or compression joints; making SilcoNert 2000 the ideal coating for process sampling, refinery gas sampling, and down hole sampling applications.

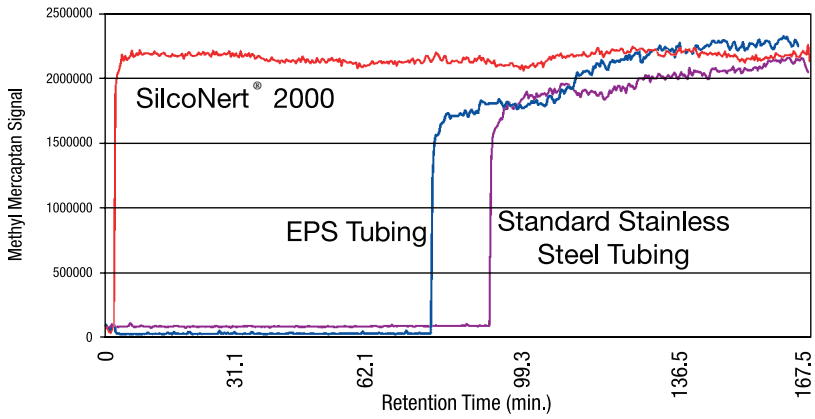
SilcoNert 2000 is an inert, chemically protective barrier of amorphous silicon material inter-diffused with the host substrate resulting in a 100-250 nm coating. The surface is further passivated with covalently bonded hydrocarbon molecules (as described in US Patent #6,444,326) as verified by an average surface contact angle value greater than 75° using deionized water on a process control coupon or GC inlet liner.

Sample Transfer: Adsorption of Hydrogen Sulfide (H_2S) and Other Sulfur Compounds to Tubing Surfaces

Figures 2 and 3 compare the sulfur transport properties of 100 foot (30.5 meter) lengths of SilcoNert 2000 treated, electropolished, and raw commercial grade 1/8in OD x 0.020" wall stainless steel tubing. Figure 2 demonstrates uptake of 500 ppmv methyl mercaptan sulfur compound by the 3 tube surfaces.

The SilcoNert 2000 treated electropolished tubing did not adsorb the methyl mercaptan to any measurable extent, delivering a representative sample with no delay. The untreated electropolished tubing totally adsorbed methyl mercaptan for more than 75 minutes, the sulfur gas level did not stabilize until 130 minutes. Conventional 316L seamless tubing totally adsorbed methyl mercaptan for more than 90 minutes; the sulfur gas level did not stabilize until 140 minutes.

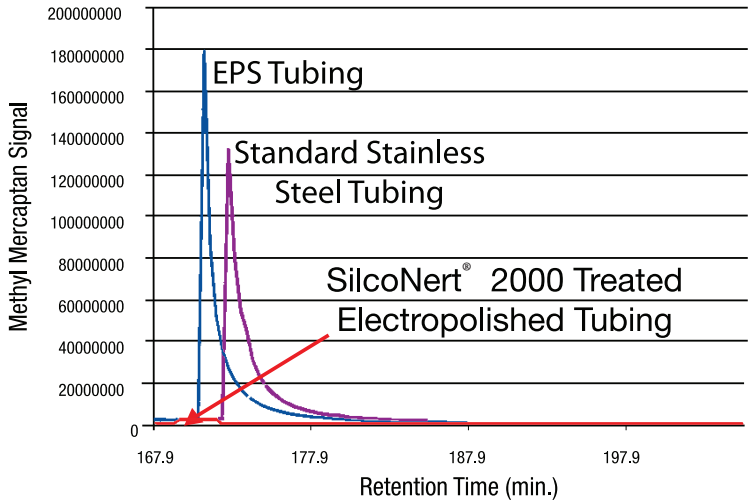
Figure 2: SilcoNert 2000 treated tubing does not adsorb methyl mercaptan (500ppbv) compared to electropolished and standard stainless steel tubing. (Data courtesy of Shell Corp. and O'Brien Corp.)[2]



SilcoNert 2000 eliminates memory effects in Sulfur Analysis

When adsorption of sulfur-containing compounds is prolonged, desorption from the surface can slowly cause disruptive false readings in process, refining and down-hole sampling applications. This "memory" of adsorbed sulfur compounds can cause long delays in equilibrating a sample stream. Figure 3 demonstrates the memory effects of the three types of tubing used to transfer streams containing sulfur compounds. The SilcoNert 2000 treated tubing shows less retention of sulfur compounds by several orders of magnitude, indicating very high sulfur inertness. SilcoNert 2000 treated sample pathways can eliminate costly refinery product losses due to false or delayed readings.

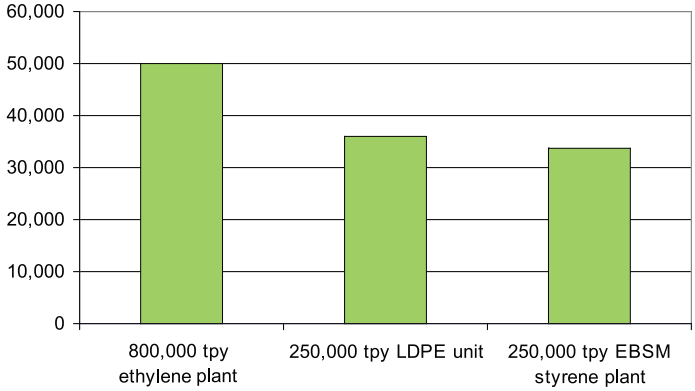
Figure 3: SilcoNert 2000 treated electropolished tubing shows no memory effects. Sulfur memory is prolonged in raw commercial grade stainless steel tubing. (500ppmv methyl mercaptan in helium). (Data courtesy of Shell Corp. and O'Brien Corp.)[2]



Value of an Inert Pathway

SilcoNert 2000 treated sampling and transfer equipment results in more accurate sampling and faster cycle times. Shorter sampling cycles translate directly into more samples collected and analyzed in a given period of time. Process upsets can be detected faster while false readings can be eliminated. Typical savings can be calculated by looking at average per-hour cost of operating a process that relies on accurate quantification of sulfur compounds. A 1 hour delay in operations can cost an 800,000 tpy ethylene plant $50,000. A 250,000 tpy LDPE unit will cost operations $36,000 for a 1 hour upset while an EBSM styrene plant will cost $33,000 (See Figure 4).

Figure 4: Estimates losses resulting from 1 hour delay in operations due to sulfur adsorption in sample and transfer systems.



Direct Line Partners

Interested in sourcing products that have benefited from SilcoTek coating? The following list of partners and OEM's supply SilcoTek coated products.

Fittings, Valves, Regulators and Sample Cylinders:

Swagelok Company www.swagelok.com
For SilcoNert 2000 (Siltek®/Sulfinert®) treated fittings, ask your local Swagelok distributor to add the following suffix to your part number: Fittings: add -JA Valves and sample cylinders: add -12457

Concoa www.concoa.com
Ask your Concoa representative for SilcoNert 2000 (Siltek®/Sulfinert®) treated regulators.

Emerson/Tescom www.tescom.com
Ask your Emerson/Tescom representative for SilcoNert 2000 (Siltek®/ Sulfinert®) treated regulators.

Parker www.parker.com
Ask your Parker distributor for SilcoNert 2000 (Siltek®/Sulfinert®) treated fittings and valves.

Tubing and Heat Trace Tubing:

O'Brien Corporation www.obrien-analytical.com
Ask your O'Brien representative for EPS tubing

Thermon-The Heat Tracing Specialists® www.thermon.com
Ask your Thermon representative for SilcoNert 2000 (Sulfinert®) treated tubing.

Constant Pressure Sampling Cylinders:

Welker Engineering www.welkereng.com
Sampling natural gas streams or other pressure sensitive chemicals? Welker Engineering offers SilcoNert treated sample systems to insure complete inertness.

Chromatography Products:

Restek® Corporation www.restek.com
Find everything you need for your laboratory or life sciences application.

Summary

SilcoNert 2000 treated sampling and transfer systems allow oil and gas exploration, chemical, petrochemical and refineries to obtain accurate sulfur data the first time, every time with no delay, sample errors, or false readings. Analysts charged with monitoring sulfur levels in process streams can save thousands in improved yields, better test cycle times and improved system reliability. To learn more or to get a quotation for sending your parts to SilcoTek for coating services, visit our web site at www.SilcoTek.com or call us at 814-353-1778.

1. D. Smith, D. Shelow, G. Barone; "Instrument and Sampling Equipment Passivation Requirements to Meet Current Demands for Low-Level Sulfur Analysis"; Presented at Gulf Coast Conference, 2001; Restek Corporation, Bellefonte, PA 16823.
2. Application of TrueTube(tm) in Analytical Measurement Cardinal UHP, August 2004. The authors thank the staff at Shell Research and Technology Centre, Amsterdam, for data used in evaluating sulfur gas uptake and memory effects of tubing substrates.

SilcoTek®
225 PennTech Dr. | Bellefonte, PA 16823
814 353-1778 | Fax 814 353 1697
www.SilcoTek.com

Prevent Mercury Loss During Transport and Storage with SilcoNert® 2000

To ensure accurate analysis of low levels of mercury in streams sampled from flue stacks, sampling systems must be inert. Laboratory testing and field results have proven that SilcoNert 2000 treated sampling and testing equipment is inert to active compounds such as mercury and mercury species down to levels as low as 1 ppb.

As regulations and guidelines for monitoring and controlling mercury emissions are developed and implemented, proper equipment will be needed for accurate sampling and analysis. The most popular methods of sampling will be based on continuous mercury monitoring systems (CMMS) and sorbent tube samplers. These systems are often degraded or compromised by the loss of mercury species due to reactions and adsorption of mercury species on the inner surfaces of transfer and monitoring equipment.

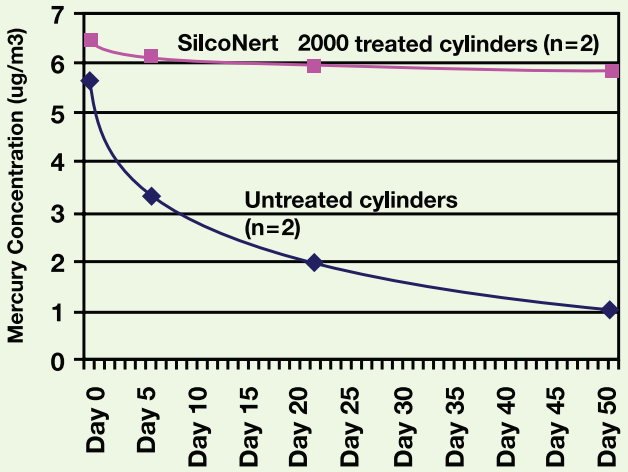
SilcoNert 2000:
The most inert surface available for mercury sampling

Unlike fluoropolymers, the SilcoNert 2000 layer will not contaminate systems when used in high temperature applications. SilcoNert 2000 is a proprietary (U.S. Patent #6,444,326), silicon, chemical vapor-deposited (CVD) coating, specifically designed to improve the chemical/mercury inertness of steel, stainless steel, alloys, glass, and ceramics. The unique non line-of-site CVD process produces a flexible, high temperature capable, amorphous silicon layer that diffuses into the metal lattice. The coating will conform to the most intricate surfaces while maintaining high dimensional tolerances. SilcoNert 2000 will deform with tubing surfaces allowing for radius bends and will not interfere with threaded or compression joints; making SilcoNert 2000 the ideal coating for process sampling and stack sampling in coal fired generators.

- Improve analytical sensitivity and reliability for mercury, SOx, or NOx compounds
- Eliminate costly retests
- Maximize scrubber performance
- Meets system inertness requirements
- Rugged, withstands temperatures up to 450°C
- Won't contaminate system like fluoropolymers

The data in figure 1 compares SilcoNert 2000 treated 304 grade stainless steel gas sampling cylinders (Swagelok®, Solon OH) and untreated sample cylinders. Each cylinder was filled with 8 ug/m^3 of elemental mercury (approximately 1 part per million) (Spectra Gases, Alpha NJ). The mercury in each cylinder was measured over time to determine the changes in concentration.

Figure 1: SilcoNert 2000 treated cylinders and sampling components provide an inert sample path which prevents adsorption of active compounds like mercury and ensures accurate sampling. [1]



SilcoTek®
225 PennTech Dr. | Bellefonte, PA 16823
814-353-1778 | Fax 814-353-1697
www.SilcoTek.com

Lit Cat # SN-012

The data demonstrates that SilcoNert 2000 treated stainless steel surfaces provide superior mercury inertness performance compared to untreated stainless steel. Results show that SilcoNert 2000 treatment is ideal for components and tubing exposed to mercury samples in CMMS and sorbent tube mercury sampling systems.

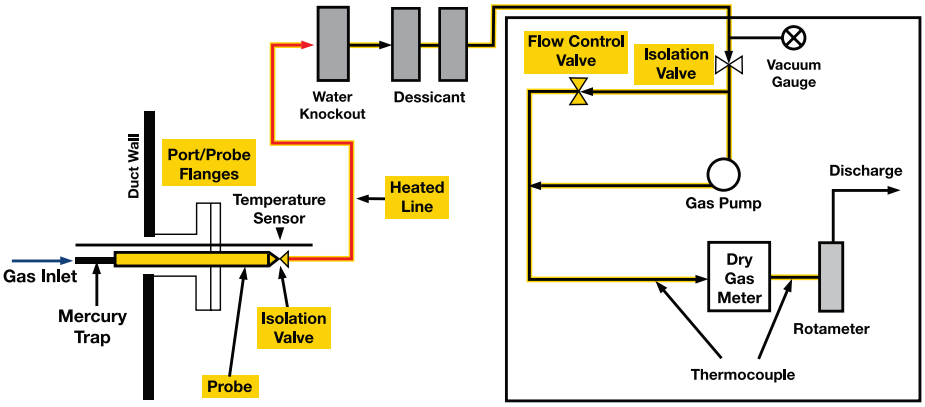
Apply SilcoNert 2000 to the entire mercury sampling pathway to ensure ultimate mercury sampling inertness

SilcoNert 2000 is an inert barrier coating that can be applied to the entire surface of stainless steel monitoring equipment, regardless of geometry. It can be applied to many of the components in a mercury sampling stream, including

- probe tubing
- impingers
- fittings
- filters
- housings
- transfer tubing
- valves

A typical sampling train schematic is shown in figure 2. Application of SilcoNert 2000 to all of the components of a stack or continuous emission monitoring system will greatly improve analytical reliability and sensitivity, and will be needed as regulations are promulgated and emission quotas are enforced.

Figure 2: Typical schematic of a mercury sampling system.[1] SilcoNert 2000 dramatically improves mercury inertness for all exposed surfaces.[2]



Summary

SilcoNert 2000 provides a stable surface for accurate mercury analysis the first time, every time. Based on laboratory and field testing, SilcoNert 2000 dramatically improves analytical reliability of continuous mercury monitoring systems and sorbent tube mercury sampling systems. To learn more about how SilcoNert 2000 can improve the performance of your system, visit our web site at www.SilcoTek.com, or call us! 814-353-1778.

References

1. Higgins, Martin; Barone, Gary; Smith, David; Restek Corporation; Neeme, Ted; Spectra Gases Inc., "A Comparison of Surface Adsorption Effects in Mercury and Sulfur Analyzer Systems" ISA Symposium, 2007.
2. Proposed Method 324. Determination of Vapor Phase Flue Gas Mercury Emissions from Stationary Sources Using Dry Sorbent Trap Sampling. United States Environmental Protection Agency. Washington, D.C. P. 5.

SilcoTek®
225 PennTech Dr. | Bellefonte, PA 16823
814-353-1778 | Fax 814-353-1697
www.SilcoTek.com

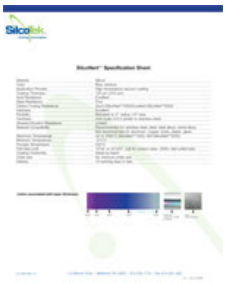
Lit Cat # SN-012

Application Solutions: Coating Care and Material Properties

Material compatibility

SilcoNertÂ® Material Properties

DursanÂ® Material Properties

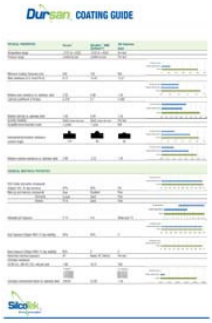


Application Guide

Recommended Care

Sample Cylinder Care

Dursan Material Comparison



SilcoTek® Driving Innovation

Application Guide

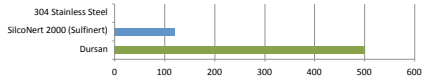
If you have any questions about your application, contact us at 814-353-1778 or visit us online at www.SilcoTek.com

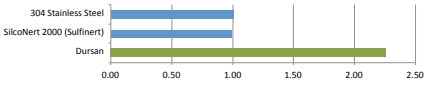
	SilcoNert 2000 Siltek®/Sulfinert®	Silcolloy Silcosteel®-CR	Dursan
Ammonia environments, testing	●		
Analytical equipment transfer tubing	●		
Automotive exhaust testing	●		●
Beverage-grade CO2 testing	●		
Coking application (jet fuels, automotive fuels, petrochemical)			●
Environmental sampling	●		
Hydrochloric acid-containing streams		●	●
Liquid propane gas	●		
Moisture control environments	●		●
Natural gas testing	●		
Nitric acid-containing streams		●	●
NOx monitoring	●		
Odorant testing	●		
Seawater environments		●	●
Semi-conductor gas transfer		●	●
SOx monitoring	●		●
Stack gas monitoring	●	●	
Sulfuric Acid environments, testing			●
Sulfur dioxide	●	●	
Sulfurs in petroleum streams (levels above 1ppm)	●		●
Sulfurs in petroleum streams (levels below 1ppm)	●		

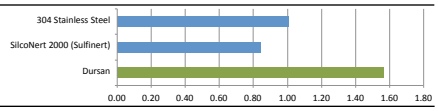
If you have questions, please call Tech Service at 814-353-1778 or e-mail us at Silcod@SilcoTek.com

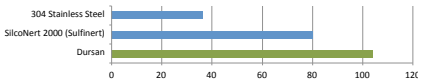
Dursan® COATING GUIDE

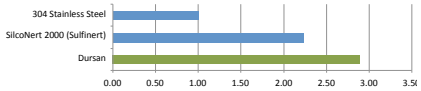
PHYSICAL PROPERTIES	Dursan®	SilcoNert® 2000 (Sulfinert®)	304 Stainless Steel
Temperature range	-210C to +450C	-210C to +450C	Per tool
Pressure range	Limited by tool	Limited by tool	Per tool
Minimum Coating Thickness (nm)	500	120	N/A
Wear resistance (x10-5mm3/N m)	6.13	14.00	13.81
Relative wear resistance vs. stainless steel	2.25	0.99	1.00
Lubricity (coefficient of friction)	0.378	0.7	0.589
Relative lubricity vs. stainless steel	1.56	0.84	1.00
Ductility, flexibility	Good, flexible with steel	Good, flexible with steel	Per tool
Durability/recommended cycles	x cycles	1 cycle	N/A
Hydrophobicity/moisture resistance (contact angle)	 104	 80	 36
Relative moisture resistance vs. stainless steel	2.89	2.22	1.00



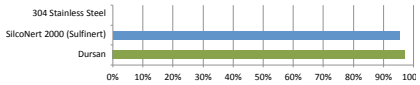


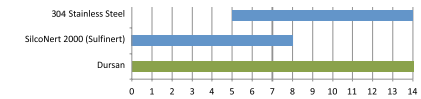


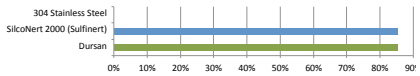


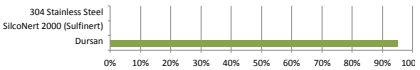


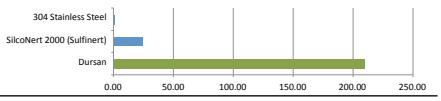
CHEMICAL INERTNESS PROPERTIES			
H2S/ Sulfur and sulfur compounds (50ppm H2S, 30 day recovery)	97%	95%	0%
Mercury and mercury compounds	Fair	Excellent	Poor
Ammonia	Good	Good	Poor
Arsenic	N/A	Good	Poor
Allowable pH exposure	0-14	0-8	Weak acid-14
Acid Exposure (50ppm MSH 12 day stability)	85%	85%	0
Base Exposure (50ppm MSH 12 day stability)	95%	0	0
Restricted chemical exposure	HF	Bases, HF, Sulfuric	Per tool
Corrosion resistance ASTM G31, 6M HCl 22C, mils per year	1.86	16.31	389
Corrosion improvement factor vs. stainless steel	Treated  209.80	23.90	Un-treated  1.00











SilcoTek® Driving Innovation

SilcoTek® Driving Innovation

Inert CVD Coatings Material Compatibility with SilcoTek® Process

– Corrosion – Antifouling
– Inertness – Ulta-high vacuum

	Recommended	Marginal/Poor	Not Treatable	
300 series stainless steel	●			Extensive experience with 316 and 304 grades
400 series stainless steel	●			Good results but limited experience
Carbon steel	●			Requires special processing
Hastelloy®	●			Good results but limited experience
Inconel®	●			Good results but limited experience
Monel®		●		Poor results, limited experience
Platinum	●			Good results but limited experience
Gold			●	Not treatable, process temp will damage part
Silver			●	Not treatable, process temp will damage part
Aluminum		●		Process temp can damage part
Borosilicate Glass	●			Breakage may occur during processing
Nickel			●	Not treatable
Brass			●	Not treatable
Copper & Copper alloys			●	Not treatable
Zinc			●	Not treatable
Bronze			●	Not treatable
Plastics			●	Not treatable
Plated materials			●	Process temp can damage plating
Carbon	●			Good results but limited experience
Ceramics	●			Good results but limited experience
Lead & Lead Alloys			●	Not treatable
Titanium	●			Good results
Surface Finish				
Electropolished Surface	●			Impurities from e-polish process may interfere with process
Polished Surface	●			Excellent results
Bead Blasted	●			Excellent results, coating appearance proportional to surface roughness
Machined	●			Excellent results, coating appearance proportional to surface roughness
Cast Surface	●			Good results, cast surface requires thicker film to ensure coverage
Painted/Coated surface			●	Not treatable, process temp will damage painted/coated surface
Welded or Brazed Areas				
Vacuum-Nickel Brazing	●			Excellent results
TIG/MIG Weld	●			Acceptable, may see coating variance at weld
Silver Solder		●		Solder outgassing, poor results
Bronze Solder			●	Not compatible with treatment process
Common Lead/Tin Solder			●	Not treatable, process temp will melt solder

Hastelloy is a trademark of Haynes International, Inc.
Inconel and Monel are trademarks of Inco Alloys International, Inc.

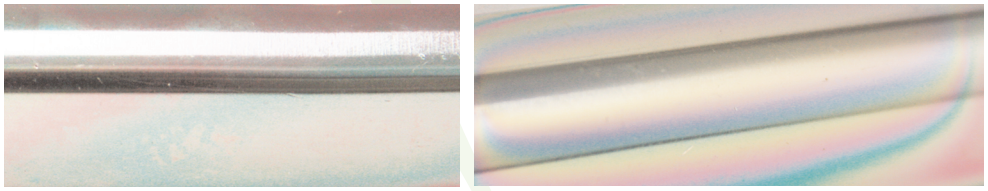
If you have questions, please call Tech Service at 814-353-1778 or e-mail us at Silcod@SilcoTek.com

SilcoTek® Driving Innovation

Dursan® Specification Sheet

Material	Carboxysilicon
Color	Luminescent rainbow
Application Process	High temperature vacuum coating
Coating Thickness	0.4 Ìm (400 nm) to 1.6um (1600nm) nominal
Acid Resistance	Excellent, pH 0
Base Resistance	Excellent, pH 14
Carbon Fouling Resistance	Unknown
Inertness	Excellent (low part-per-million sensitivity)
Flexibility	Bendable to 4'' radius 1/4" tube
Wear/Abrasion/Scratch Resistance:	Excellent, 6.129 x10-5mm3/N m (1/2 wear rate of stainless steel)
Material Compatibility	Recommended for stainless steel, steel, steel alloys, nickel alloys, glass. Not recommended for aluminum, copper, brass, Monel, silver, gold or plastic.
Maximum Temperature	Up to 450°C
Minimum Temperature	-210°C
Process Temperature	300°C to 450°C
Part Size Limit	Call for custom sizes or longer tube coils
Coating Conformity	Varies by batch
Order size	No minimum order size
Delivery	10 working days or less

Colors associated with layer thickness:



Luminescent rainbow minimum 400nm (0.4um)

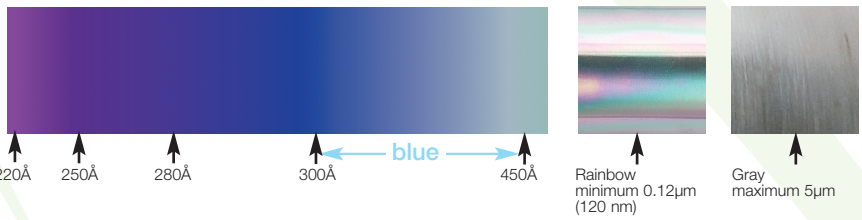
If you have any questions, please call Tech Support at 814-353-1778 or email us at Silcod@SilcoTek.com

SilcoTek® Driving Innovation

SilcoNert® Specification Sheet

Material	Silicon
Color	Blue, rainbow
Application Process	High temperature vacuum coating
Coating Thickness	0.1um to 0.5um (100 nm to 500 nm) nominal
Acid Resistance	Excellent
Base Resistance	Poor
Carbon Fouling Resistance	Good (SilcoNert® 1000) Excellent (SilcoNert® 2000)
Inertness	Excellent
Flexibility	Bendable to 4'' radius 1/4" tube
Hardness	moh scale of 6.5 (similar to stainless steel)
Abrasion/Scratch Resistance	Limited
Material Compatibility	Recommended for stainless steel, steel, steel alloys, nickel alloys, glass
	Not recommended for aluminum, copper, brass, plastic
Maximum Temperature	Up to 1000°C (SilcoNert® 1000) 450°(SilcoNert® 2000)
Minimum Temperature	-210°C
Process Temperature	300°C - 410°C
Part Size Limit	10"x5' or 24"x42" *Call for custom sizes 2000+ feet coiled tube*
Coating Conformity	Varies by batch
Order size	No minimum order size
Delivery	10 working days or less

Colors associated with layer thickness:



If you have any questions, please call Tech Support at 814-353-1778 or email us at Silcod@SilcoTek.com

SilcoTek® Treatment Processes

SilcoTek passivation and surface protection layers are deposited using a patented chemical vapor deposition (CVD) process. The reaction layer penetrates into the lattice of the treated piece and binds solidly. Consequently, it is possible to work a piece, such as bending a length of treated tubing, without creating cracks, flakes, or other flaws which would compromise the layer. Layer thickness ranges from 100nm to 1600nm.

SilcoTek surface treatment processes do not rely on line-of-sight deposition. The chemical vapor deposition process ensures all surfaces are treated uniformly—even at corners, holes, and machined ridges. Our current capacity enables us to treat items up to 6 feet in length. Evacuated items, such as gas chambers, can have a volume of up to 43 cubic feet.

About Us

SilcoTek's involvement with surface coatings began in 1987, when we developed a treatment that made stainless steel surfaces inert to low-level reactive organic compounds. Since this initial project, SilcoTek's coating experts have developed a family of surface treatments to address other specific needs and thereby enhance the performance of system components. These treatments are:

- SilcoNert®1000 (Silcosteel®)— A general purpose passivation layer for steel and stainless steel. (US patent 6,511,760.)
- Silcolloy®1000(Silcosteel®-CR) — A corrosion resistant layer that increases the lifetime of system components in acidic environments containing hydrochloric, nitric, or sulfuric acid, or seawater. (US patent 7,070,833.)
- SilcoGuard®1000(Silcosteel®-UHV)— Used to reduce outgassing by components of ultra-high vacuum systems. (US patent 7,070,833.)
- SilcoKlean®1000(Silcosteel®-AC) — Dramatically reduces carbon buildup (coking) on stainless steel components. (US patent 6,444,326.)
- SilcoNert®2000(Siltek®)—Provides the ultimate passivation of treated components, from glass to high nickel alloys of steel. (US patent 6,444,326.)
- SilcoNert®2000(Sulfinert®)—A required layer on metal components when analyzing for parts-per-billion levels of organo-sulfur compounds. (US patent 6,444,326.)
- Dursan®—A high durability, corrosion resistant, inert coating ideal for refinery, chemical process, oil & gas applications. (US patent pending)

SilcoTek®surface treatments are now used in many applications, spanning multiple industries and market areas. Let us solve your surface activity problems. Contact us at 814-353-1778, e-mail Silcod@SilcoTek.com or visit us online at www.SilcoTek.com.

Go to the website to see our coating specifications at www.SilcoTek.com/specifications

225 PennTech Drive | Bellefonte, PA 16823 | 814-353-1778 | Fax: 814-353-1697

SilcoTek® Driving Innovation

Recommended Care of Treatment Layers

225 PennTech Drive | Bellefonte, PA 16823 | 814-353-1778 | Fax: 814-353-1697

Congratulations!

You have purchased the finest in performance surface treatments! Since 1987, the SilcoTek Team has been offering leading edge passivation and barrier coating technology to the scientific, analytical, and process markets. Please e-mail TechService@SilcoTek.com if you have questions regarding the appearance, performance, and maintenance of the treated surface. Here are a few tips to keep your treated products working at peak performance.

Appearance

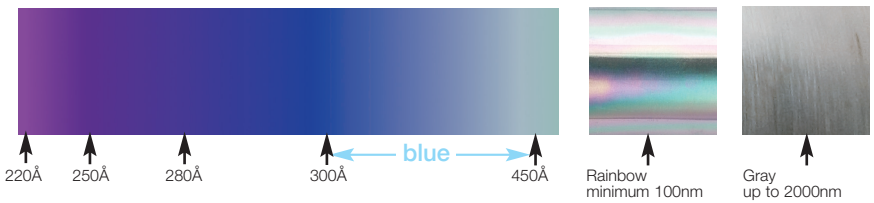
Layer appearance and surface finish can vary from lot to lot. Small variations in surface thickness can impact layer appearance. The surface finish should be bright and free of defects, but original surface condition can have a major impact on final surface quality.

Your parts are cleaned after treatment; however, the surface may contain some trace silicon (black particles) as a by-product of the treatment process. Residual silicon can be removed by rinsing with a solvent or by sonication in water.

General thickness ranges are:

Product	Coating Thickness	Color
SilcoNert®1000 (Silcosteel®) SilcoNert®2000(Siltek®/Sulfinert®) SilcoKlean®(Silcosteel®-AC)	100-500nm	Rainbow
Silcolloy®(Silcosteel®-CR)	180nm to 800nm	Gray
SilcoGuard®(Silcosteel®-UHV)	180nm to 600nm	Gray
Dursan®	400nm to 1600nm	Rainbow

Colors associated with layer thickness are:



Thick depositions used in our Silcolloy® process range up to 800nm thick and have a silver/metallic grey appearance. The photos above show colors created by SilcoNert®2000 (rainbow) and Silcolloy® (gray) deposition.

Cleaning

When cleaning a treated part, rinse with a solvent that will dissolve probable surface contaminants (i.e., use a nonpolar solvent to remove hydrocarbon contaminants, or a more polar solvent to remove more active contaminants).

Avoid using cleaners containing abrasives as they can scratch the layer. Mild sonication may assist in contaminant removal, but do not oversonicate—this could damage the layer.

Solids can be removed with a soft nylon bristle brush using light pressure.

Caution! Do not use basic solutions or soaps with pH>8.

Do not steam clean any SilcoTek® treated components or line(s), as this could damage the layer.

Galling

Galling can occur when two parts of similar material are connected under compression and the heat generated "cold welds" the parts together. Customers have observed galling when two Silco'd treated compression fittings or NPT fittings are assembled. For that reason SilcoTek does not recommend coating the nuts or ferrules from compression fittings and recommends that the coating either be removed with Scotch Brite® or apply PTFE tape when two NPT fittings are connected. Galling has never been reported when a non coated and Silco'd coated fitting is mated. If both mating parts must be coated, then SilcoTek recommends using anti-seize compounds made from silver, moly or nickel: For sample cylinder applications refer to the instructions pertaining to the use of PTFE tape on the valve NPT prior to installation.

Treatment Layer Troubleshooting

Under normal use, your treated items should deliver outstanding performance for years to come. However, effective lifetime is dependent on the severity of the environment. Factors that can reduce performance are:

Contamination Failure to properly clean the surface can allow increased surface activity. If performance changes, thoroughly clean the surface and inspect the layer for damage.

Erosion Contact with abrasives can accelerate surface wear.

Bases Contact with a base (pH 8 or higher) can accelerate deterioration of the layer.

Surface finish and color should stay consistent throughout the life of the product. Changes in the finish or color may indicate a partial loss of the layer. To prevent further loss, ensure no exposure to bases or abrasives.

For additional information about SilcoTek®treatments and to view our demonstration and process videos, visit our website at www.SilcoTek.com. Contact our technical service department at 814-353-1778, or e-mail TechSupport@SilcoTek.com.

SilcoTek® Treatment Processes

SilcoTek passivation and surface protection layers are deposited using a patented chemical vapor deposition (CVD) process. The reaction layer penetrates into the lattice of the treated piece and binds solidly. Consequently, it is possible to work a piece, such as bending a length of treated tubing, without creating cracks, flakes, or other flaws which would compromise the layer. Layer thickness ranges from 100nm to 500nm.

SilcoTek surface treatment processes do not rely on line-of-sight deposition. The chemical vapor deposition process ensures all surfaces are treated uniformly—even at corners, holes, and machined ridges. Our current capacity enables us to treat items up to 6 feet in length. Evacuated items, such as gas chambers, can have a volume of up to 43 cubic feet.

About Us

SilcoTek's involvement with surface coatings began in 1987, when we developed a treatment that made stainless steel surfaces inert to low-level reactive organic compounds. Since this initial project, SilcoTek's coating experts have developed a family of surface treatments to address other specific needs and thereby enhance the performance of system components. These treatments are:

- SilcoNert®1000 (Silcosteel®)— A general purpose passivation layer for steel and stainless steel. (US patent 6,511,760.)
- Silcolloy®1000(Silcosteel®-CR) — A corrosion resistant layer that increases the lifetime of system components in acidic environments containing hydrochloric, nitric, or sulfuric acid, or seawater. (US patent 7,070,833.)
- SilcoGuard®1000(Silcosteel®-UHV)— Used to reduce outgassing by components of ultra-high vacuum systems. (US patent 7,070,833.)
- SilcoKlean®1000(Silcosteel®-AC) — Dramatically reduces carbon buildup (coking) on stainless steel components. (US patent 6,444,326.)
- SilcoNert®2000(Siltek®)—Provides the ultimate passivation of treated components, from glass to high nickel alloys of steel. (US patent 6,444,326.)
- SilcoNert®2000(Sulfinert®)—A required layer on metal components when analyzing for parts-per-billion levels of organo-sulfur compounds. (US patent 6,444,326.)
- Dursan®—A high durability, corrosion resistant, inert coating ideal for refinery, chemical process, oil & gas applications. (US patent pending)

SilcoTek®surface treatments are now used in many applications, spanning multiple industries and market areas. Let us solve your surface activity problems. Contact us at 814-353-1778, e-mail Silcod@SilcoTek.com or visit us online at www.SilcoTek.com.

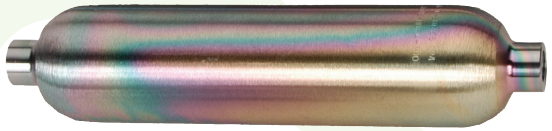
Go to the website to see our coating specifications at www.SilcoTek.com/specifications

225 PennTech Drive | Bellefonte, PA 16823 | 814-353-1778 | Fax: 814-353-1697

Lit Cat # ST-006-B

www.SilcoTek.com

SilcoTek®
Driving Innovation



SilcoNert®2000 (Sulfinert®) Treated Sample Cylinders Assembly & Maintenance Guidelines

225 PennTech Drive | Bellefonte, PA 16823 | 814-353-1778 | Fax: 814-353-1697

www.SilcoTek.com

Congratulations!

You have purchased the finest in performance surface treatments! Since 1987, the SilcoTek Team (formerly Restek Performance Coatings) has been offering leading-edge passivation and barrier coating technology to the scientific, analytical, and process markets. Please e-mail TechService@SilcoTek.com if you have questions regarding the appearance, performance, and maintenance of the treated surface. Here are a few tips to keep your treated products working at peak performance.

SilcoNert®2000 (Sulfinert®)-Treated Sample Cylinders

- Stable storage of samples containing low concentrations of sulfur compounds.
- Cylinders D.O.T. rated to 1800psi at room temperature.

SilcoNert®2000-treated sample cylinders ensure sulfur compounds or other active compounds will be stable during transport from the field to the laboratory. They are ideal for applications that demand only inert surfaces contact the sample, such as sampling natural gas or testing beverage-grade carbon dioxide.

Assembling the Sample Cylinder and Valve
We recommend using a new valve with your new cylinder. If a valve has been used previously, the threads might be damaged and may not make a seal.

1. Clean the threads on the valve, then examine the threads for damage such as burrs, dents, nicks, or gouges. Reject or repair a valve or cylinder with threads showing these defects.
2. Apply 3 wraps of PTFE tape to the valve threads, leaving the first (lead) thread exposed.
3. Install the valve onto the cylinder by inserting and hand tightening to engage at least 2 but no more than 3 threads. If the valve fails to start easily, examine to confirm the valve threads are compatible with the cylinder threads.
4. Secure the valve and cylinder assembly in a holding device, using protective material around the cylinder to prevent gouging of the sidewall. Using a torque wrench, tighten the valve to 8 to 10 foot-pounds, maximum. This torque should produce another 2 to 3 threads engagement, for a total engagement of 4 to 6 threads.

Cleaning Silco'd Surface

To clean a treated part, rinse with a solvent that will dissolve probable surface contaminants (i.e., use a nonpolar solvent to remove hydrocarbon contaminants, or a more polar solvent to remove more active contaminants). Avoid using cleaners containing abrasives as they can scratch the surface layer. Mild sonication might assist in removing contaminants, but do not oversonicate—this could damage the surface layer. **Caution: Do not use basic solutions or soaps with pH>8 or the coating layer will be damaged.**

Do not steam clean any SilcoNert treated system components or line, as this could damage the surface layer.

Treatment Layer Appearance

The appearance of a SilcoTek treated surface can vary from lot to lot. Small variations in surface thickness (measured in angstroms) affect layer appearance. The surface finish should be bright and free of defects, but original surface condition can have a major impact on final surface quality. Your parts are cleaned after treatment; however, the surface may contain some trace silicon (black particles) as a by-product of the treatment process. Residual silicon can be removed by rinsing with a solvent or by sonication in deionized water (do not oversonicate).

Galling

Galling can occur when two parts of similar material are connected under compression and the heat generated "cold welds" the parts together. Customers have observed galling when two Silco'd treated compression fittings or NPT fittings are assembled. For that reason SilcoTek does not recommend coating the nuts or ferrules from compression fittings and recommends that the coating either be removed with Scotch Brite® or apply PTFE when two NPT fittings are connected. Galling has never been reported when a non coated and Silco'd coated fitting is mated. If both mating parts must be coated, then SilcoTek recommends using anti-seize compounds made from silver, moly or nickel:
For sample cylinder applications refer to the instructions pertaining to the use of PTFE tape on the valve NPT prior to installation.

Treatment Layer Troubleshooting

Under normal use, your treated items should deliver outstanding performance for years to come. However, effective lifetime is dependent on the severity of the environment. Factors that can impede performance are:

Contamination	Failure to properly clean the surface can allow increased surface activity. If performance changes, thoroughly clean the surface and inspect the layer for damage.
Erosion	Contact with abrasives can accelerate surface wear.
Bases	Contact with a base (pH 8 or higher) can accelerate deterioration of the layer.

Surface finish and color should stay consistent throughout the life of the product. Changes in the finish or color may indicate a partial loss of the layer. To prevent further loss, ensure no exposure to bases or abrasives. For additional information about SilcoTek contact our technical service department at 814-353-1778, e-mail TechSupport@SilcoTek.com or visit our website at **www.SilcoTek.com.**

Custom coating without custom prices!

GET A QUOTE.
By phone at 814-353-1778, e-mail: Silcod@SilcoTek.com or on the web at www.SilcoTek.com.

SEND US YOUR PARTS.
We'll process your parts in 10 working days or less.

SAVE!
Install your parts and experience less downtime.

FAQ for Inert, Corrosion Resistant, High Performance Coatings

Questions? Call Us!

How do I select the most appropriate treatment for my application?
The following definitions explain the various treatments currently available and their recommended applications:

- **SilcoNertÂ® 1000** (SilcosteelÂ®)
  A general-purpose passivation layer for steel and stainless steel.
- **SilcoNertÂ® 2000** (SiltekÂ®/SulfinertÂ®)
  The ultimate passivation of treated surfaces, from glass to high nickel alloys of steel. A required treatment for metal components when analyzing for parts-per-billion levels of organo-sulfur compounds & mercury.
- **SilcolloyÂ® 1000** (SilcosteelÂ®-CR)
  A corrosion resistant layer that increases the lifetime of system components in acidic environments containing hydrochloric acid, nitric acid, or seawater.
- **SilcoKleanÂ®1000** (SilcosteelÂ®-AC)
  Dramatically reduces carbon buildup on stainless steel components.
- **SilcoGuardÂ® 1000** (SilcosteelÂ®-UHV)
  Greatly reduces outgassing from components of ultra-high vacuum systems.
- **DursanÂ®** Our newest coating! A high durability, wear resistant, corrosion resistant, and inert coating. Great for field sampling, process, Oil & Gas appications.

[back to top]

What materials can be surface treated?
Virtually all alloys of stainless steel, ceramic, and most glass materials can be treated. Some other metallic materials, such as nickel, brass, copper, and aluminum, are incompatible with the high (400Â°C) temperatures used in the process, and should not be treated.

Note: carbon steel, F22 or similar carbon steel, is not recommended for coating in corrosion resistant applications. Treated carbon steel may rust in corrosive environments. Avoid corrosive environments when using treated carbon steel in inert sampling applications.

[back to top]

Can ferrules be treated?
SilcoTek does not recommend coating ferrules as we have found this may lead to leaking problems after coating.

What a
Maximu
tempera
Dursan
(former
SilcoGu

SilcoTekÂ® coatings are stable to the following temperatures in an inert atmosphere:

SilcoNertÂ® 2000	450Â°C
SilcoNertÂ® 1000	600Â°C
SilcolloyÂ®	600Â°C
SilcoGuardÂ®	600Â°C
SilcoKleanÂ®	600Â°C
DursanÂ®	450Â°C

[back to top]

How can I receive pricing for custom surface treatment?
To request a quotation for custom surface deactivation of sample pathway components, inlet liners, etc., complete the **following form** and submit it to us. Please forward a scaled drawing or photograph detailing the product to be treated. Upon receipt of this completed worksheet, SilcoTek's Technical Staff will contact you with a quotation, typically within 1-2 business days. When you are ready to send items to SilcoTek for treatment, contact technical support at 814-353-1778 to request service number. When submitting parts for treatment, remember that parts must be completely dissembled, and components that cannot withstand the high (400Â°C) temperatures associated with the process (rubber o-rings, brass, etc.) must be removed. Note that SilcoTek cannot assume liability for warping of stainless regulators due to process heat.

[back to top]

How will SilcoTek surface treatments work in my acidic environment?
SilcoNert 1000 and SilcoNert 2000 treated materials have improved corrosion resistance, but Silcolloy (formerly SilcosteelÂ®-CR) and Dursan surface treatments are optimized to enhance resistance to many common acids; providing a 10-fold improvement in corrosion resistance, compared to untreated stainless steel, and a 4-fold improvement compared to SilcoNert 1000 coated stainless steel.

Note: carbon steel, F22 or similar carbon steel, is not recommended for coating in corrosion resistant applications. Treated carbon steel may rust in corrosive environments. Avoid corrosive environments when using treated carbon steel in inert sampling applications.

[back to top]

What is SilcoNert 2000?
SilcoNert2000 (U.S. patent 6,444,326) is a passivation process that applies an inert, integral layer to components used for chromatographic analysis. Unlike traditional deactivations, it is not susceptible to cleavage or formation of active silanols and, therefore, greatly reduces bleed, and breakdown or adsorption of active components, compared to conventional surface coatings.

[back to top]

What are the unique benefits of SilcoNert 2000 deactivation?
SilcoNert2000 creates a unique surface with an inertness range that surpasses all other known surface deactivations used in gas chromatography. In sensitive analyses, SilcoNert2000 deactivated system components provide outstanding results.

[back to top]

Does anyone else offer an equivalent to SilcoNert 2000 deactivation?
No. SilcoNert 2000 deactivation was created exclusively by SilcoTek and is protected by a US patent (Pat. No. 6,444,326).

[back to top]

Why is SilcoNert 2000 on glass gold in color?
The color of a surface coating is an expression of the light diffraction qualities and thickness of the layer. The thickness of a SilcoNert 2000 layer determines the degree of darkness, secondary reflectivity, and/or final color of the item. The color can range from light golden-brown (thin coatings) to reflective silver (heavier coatings). We deposit a layer that provides a gold color on liners to aid analysts in inspecting for cleanliness. Chromatographic performance does not depend on the thickness of the layer.

[back to top]

How thick is the SilcoNert 2000 layer?
Depending on the item, the SilcoNert 2000 layer can be as much as 2,500 Angstroms (250 nanometers) thick. At this thickness, the layer exhibits a reflective silver color on treated glass surfaces or a rainbow on metal surfaces. Chromatographic performance does not depend on the thickness of the layer.

[back to top]

What is tl

Maximu
tempera
maximu

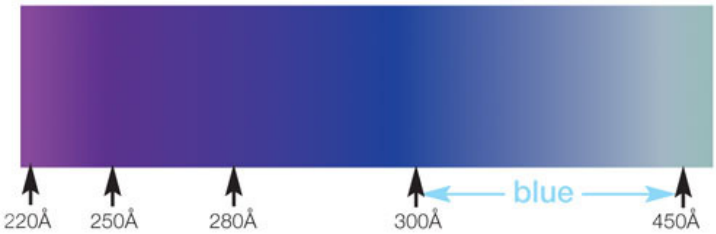
[back t

00

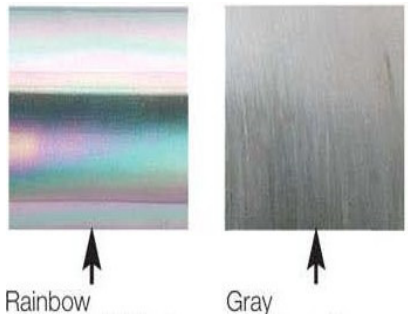
Does SilcoTek offer custom SilcoNert treatment?
We are always interested in your specific surface passivation needs. Surface deactivation of glass or metal with a SilcoNert 2000 layer is available on a custom basis, and liner deactivation has become popular with some customers. Please keep in mind that treated surfaces must be able to withstand temperatures up to 400Â°C, as well as vacuum and pressure environments. It is important to remove any o-rings, seals, or other materials that will not withstand the treatment environment prior to sending items to SilcoTek for coating.
Our SilcoTek Group can provide a quote. Please submit a quote or contact us at 814-353-1778.

[back to top]

Why do Silco'dâ„¢ treated pieces have different colors?
The different colors observed on Silco'd treated parts indicate different layer thicknesses. A blue color corresponds to a 300 to 450 Angstrom layer while a rainbow color indicates a coating of at least 1200 Angstroms (120 nanometers).
Colors associated with layer thickness are:



Depositions used in our Silcolloy and SilcoGuard processes are up to 1Âµm and have a silver/metallic gray appearance. The photos below show colors created by SilcoNert 1000 (left) and Silcolloy 1000 (right).



[back to top]

Can you coat my Varian ion trap with a SilcoNert 1000 layer?
Components of Varian ion traps are SilcoNert 1000 treated, through a service we provide for Varian. End-users should deal directly with Varian for ion trap replacement. Varian receives the parts, and subjects them to a proprietary cleaning and pre-treatment process, before sending them to us for SilcoNert 1000 treatment.

[back to top]

Will you re-deactivate my SilcoNert 2000 treated glass liners or SilcoNert 1000 metal liners after I clean them?
Request re-deactivation of SilcoNert 2000 treated glass liners by contacting SilcoTek's Customer Service department at 814-353-1778. Requesting SilcoNert 2000 re-deactivation of customer supplied liners. A minimum of ten liners is required. Metal inlet liners are designed as inexpensive, disposable products and it is not cost effective to re-treat them. We recommend discarding them when they are no longer serviceable.

[back to top]

Are secondary deactivations available for SilcoNert 2000 treated materials?
There are no secondary deactivations available for SilcoNert 2000 products at this time.

[back to top]

How tightly can the tubing be bent?

OD	Min. Bend Radius
<= 1/16"	1" (2.5cm)
1/8"	2" (5.1cm)
1/4"	4" (10,2cm)

[back to t

Can SilcoTek coat valves, regulators, and flow controllers?
Absolutely! SilcoTek can coat the internal and external metal pathways for most flow regulating and metering devices to enhance their inertness and provide corrosion resistance. In order to coat the surfaces, all valves, regulators, and flow meters should be dissembled and all seals or parts which cannot be exposed to temperatures of approximately 400Â°C must be removed. Disassembly should only be performed by qualified personnel with the appropriate seal kits, tools, and training OR damage or failure to the device will occur. For these reasons, SilcoTek cannot take on the responsibility of disassembly or reassembly of any valve, regulator, or flow meter. If you do not have the experience and parts necessary to dissemble these devices, we recommend that you get in touch with Swagelok, Parker, or your valve manufacturer and order the coating treatment directly from them. SilcoTek has business relationships with most manufacturers and routinely coats the internal and external surfaces of valves, regulators, and flow meters for them. The manufacturer will send the parts prior to assembling to SilcoTek for coating and will assemble the parts at their factory under the guidance of their quality systems.

[back to top]

Where do I order coated valves, regulators, and flow controllers?
The following companies routinely provide coated parts:

- **Swagelok** â€" Find your local distributor at **www.swagelok.com**
  - For SilcoNert 2000 (Siltek/Sulfinert) treated fittings ask your local Swagelok distributor to add the following suffix to your part number:
    + Fittings: add â€"JA
    + Valves & sample cylinders: add -12457
- **Parker** â€" Find your local distributor at **www.parker.com**
  - Ask your Parker distributor for SilcoNertâ„¢ 2000 (Siltek/Sulfinert) treated fittings and valves
- **Valco** - **www.vici.com**
  - Ask your Valco distributor for SilcoNert 2000 (Siltek/Sulfinert) treated fittings and valves
- **Emerson/Tescom** - **www.tescom.com**
  - Ask your Emerson/Tescom representative for SilcoNert 2000 (Siltek/Sulfinert) treated regulators.
- **Concoa** - **www.concoa.com**
  - Ask your Concoa representative for SilcoNert 2000 (Siltek/Sulfinert) treated regulators.

[back to top]

Will brazing impact the quality of the coating?
Yes, brazed joints will outgas during the coating process and will negatively impact the coating quality. SilcoTek does not recommend coating over brazed joints. Coated brazed joints appear as a matte brown finish and can have increased activity/reactivity at the brazed joint. SilcoTek recommends vacuum brazing or welding of joints for best coating quality. Vacuum brazing is a high temperature, flux-free brazing process that results in a contamination free joint. SilcoTek recommends vacuum brazing services from Solar Atmospheres Inc.

[back to top]

Do I need to pre-clean my parts prior to sending them to SilcoTek for coating?
Your parts are precision cleaned by SilcoTek prior to processing. Additional pre-cleaning by the customer is often unnecessary and at times can be detrimental to our coating process.

In order to provide the highest quality coating and fastest processing; notify SilcoTek of any prior chemical exposure (regardless of whether the part is new or used). Chemicals like cutting oils, pickling acids, solvents, water based cleaning compounds or other hazardous or non hazardous chemicals may impact the coating process. Many times the customer's cleaning process or chemical exposure can be eliminated, saving the customer time and money. Before sending parts to SilcoTek, contact your SilcoTek representative at **silcod@SilcoTek.com** or call us at (814) 353-1778

Can SilcoTek coat fritted liners?
SPECIAL NOTE: Coating of glass fritted liners: SilcoTek would prefer that all glass liners be sent without deactivation (e.g. silanization) since the deactivation layer will prevent our intermolecular coatings from bonding to the surface. For most glass liners, our cleaning process will remove all prior deactivants. However, SilcoTek cannot put fritted liners through our cleaning process without damaging the frit.

Fritted liners are special because there is no effective way of cleaning glass frits or stripping the coating in case of failure. As we continue to gain experience with glass frits and tailor our processes, we will get better. Our major hurdle is being able to "test" fritted liners prior to coating to ensure they are clean. We continue to work on this aspect of our operation.

[back to top]

SilcoTek
Driving Innovation

Your Quote Number is

Document #: R-20-06
Initiated: 6/25/07
Revised: 7/513

Domestic and International Shipping

Customer is responsible for all shipping, customs fees, duties, and taxes where applicable.

Domestic & International	Remittance Address	SilcoTek Customs Broker
Ship to: Chromalytic Technology 232 Forest Rd, Boronia VIC 3155 03 9762 2034	***Mail to:*** Chromalytic Technology via Pay PAL Invoice or Bank Transfer	Export & return via Chromalytic - pre-arranged

Packaging

Help us protect your parts! Please identify any critical surfaces, finishes, or sealing surfaces that require special handling or protection during processing.

- SilcoTek will re-use customer packaging when applicable in an effort to re-cycle and minimize waste. However, we will use new packaging if your package is received in damaged to ensure safe transportation back to you.
- Please be sure to package heavy parts properly to avoid any part-to-part contact that may result in damage to your parts in transportation. Packaging peanuts and bubble wrap may not be sufficient to protect your parts.
- Please inform us of any special handling requirements you may have for your parts.

Cut here and place in package *Cut here and place in package* *Cut here and place in package*

Please complete this ticket and include this documentation with your shipment.

Total Pieces: _____ Brief Description: _____

Special Handling Requirements/Comments _____

Quote Number

Shipping and insurance charges are pre-paid and added to invoice:
Please provide the insurance value of the parts for return shipment. $_____

Unless otherwise instructed, SilcoTek will add the **coating cost** to the above listed value of the parts to determine the total insurance value for return shipping.

PO #_____ Preferred Shipping Method: _____ Freight Account # _____

Order Contact:_____ Phone: _____ Email: _____

Cut here and place shipping label on box *Cut here and place shipping label on box* *Cut here and place shipping label on box*

From:_____
_____
_____

Do NOT return items without an RA
RETURN AUTHORISATION NUMBER (from Chromalytic)

Document #: R-20-06
Initiated: 6/25/07
Revised: 7/5/13

Methods of Payment

SilcoTek accepts the following payment methods.

- Payment terms - Net 30 when credit is established
- Credit cards - We accept Visa, MasterCard, American Express, and Discover
- Electronic funds transfer

Cleaning

When cleaning a treated part, rinse with a solvent compatible with the contaminants you intend to remove (i.e., use non-polar solvents with hydrocarbon surface contaminants, more polar solvents with more active contaminants). Do not use basic solutions with pH>8.

- Avoid using cleaners containing abrasives as they can scratch the layer. Mild sonication may assist in contaminant removal, but do not oversonicate- this could damage the layer.
- Avoid steam cleaning of components and lines as this can damage the layer.

Galling

Galling can occur when two parts of similar material are connected under compression and the heat generated "cold welds" the parts together. Customers have observed Galling when two Silco'd treated compression fittings or NPT fittings are assembled. For that reason SilcoTek does not recommend coating the nuts or ferrules from compression fittings and recommends that the coating either be removed with Scotch Brite or Teflon tape when two NPT fittings are connected. Galling has never been reported when a non coated and Silco'd coated fitting is mated. If both mating parts must be coated, then SilcoTek recommends using anti Seize compounds made from Silver, Moly or Nickel: For sample cylinder applications refer to the instructions pertaining to the use of Teflon tape on the valve NPT prior to installation

Nuts / Ferrules

- It has been noted that coated ferrules in conjunction with coated tubing unions increase the likelihood for a leak.
- Tube sections sent for coating with pre-seated ferrules increase the likelihood for leaks. Please send tubing sections without nuts and ferrules pre-set.

Coiled Tubing

- Coiled tubing is processed internally only and requires that we attach process leads to each end using standard tube fittings, nuts and ferrules to attain a gas-tight seal. Please allow an extra six inches of tubing on both ends for us to use in processing and to remove the nuts and ferrules after processing. Tubing ends will be cut with a standard tubing cutter after processing and capped for return shipment.
- Coiled tubing that is processed internally will be returned to you with the outside of the tubing appearing brown. This change in color is due to the processing and is oxidation of the exterior caused by exposure to high temperatures.
- Please send tubing on a metal spool or bound as wooden spools cannot be placed into the processing ovens.



Valves, Regulators & other parts (Must be disassembled)

SilcoTek will coat all stainless steel wetted surfaces of your disassembled valve. Please only send stainless steel components that will be coated.

Please be sure to remove all Teflon seats or o-rings. Please be sure to protect critical surfaces during transport to SilcoTek.

Please be sure to check internal cavities for pressed in Teflon seals that need to be removed before coating.