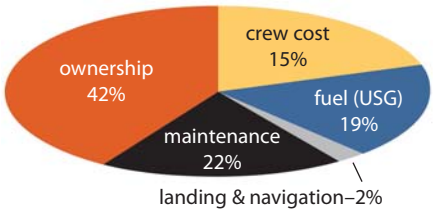
Improve Engine & Process Performance with Silcosteel®-AC Surface Treatment

Reduce coking up to 8-fold, using Silcosteel®-AC treated components

High performance engines continue to push the envelope of efficiency and power. In order to maintain high efficiency and low emissions, these engines are designed to operate at higher temperatures. Whether the engine is a commercial aircraft CFM56, a diesel generator set, or a long haul truck engine, proper engine maintenance is crucial to continued fuel-efficient operation and long engine life. A typical aircraft engine maintenance program can represent as much as 22% of an airline's operating budget (Figure 1).[1]

Figure 1 Engine maintenance can represent almost one quarter of an airline's operating budget.[1]



An important contributor to high maintenance costs is carbon fouling, or coking—a buildup of carbon-based deposits on or in combustion engine components or process systems. Aircraft maintenance personnel are discovering significant coking in fuel lines, oil lines, and nozzles. Coking has been responsible for engine failures, shortened maintenance cycles, and unplanned repairs. Diesel engine manufacturers have determined that coking on pistons is a contributor to shortened engine life and costly rebuilds (Figure 2).[2]

Figure 2 A Silcosteel®-AC-treated piston (left) shows dramatically less coke buildup than an untreated diesel piston (right).[2]

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 is shut down, when there is no coolant flow to carry away excess heat.[3]

Significantly reduce plant maintenance costs associated with downtime

Plant costs as a result of coking can be significant. Below are estimated manufacturing costs due to coke buidup:

- A one-hour delay in an 800,000 tpy ethylene plant can cost $50,000
- An LDPE unit producing 250,000 tpy can sustain a production loss of $36,000/hour
- A 250,000 tpy EBSM styrene plant stands to lose $33,000/hour
- Even for a 200,000 tpy anti-freeze grade production process, loss can amount to $3,600/hour

Reduce coke formation 8-fold with Silcosteel®-AC surface treatment

There are 4 types of coke buildup: pyrolytic (gas-solid deposition), spherulitic (gas-liquid-solid deposition), carbides, and filamentous. The latter type causes the most concern. At elevated temperatures, dissolved oxygen in the fuel can oxidize fuel components, and exposed metal surfaces can catalyze fuel into carbon filaments that grow on the surfaces. Although by weight only 10% of total carbon coking, filamentous coking is the most troublesome because, as the filaments grow, fuel or oil flow becomes obstructed. Eventually, this causes inefficient operation, or engine damage.

By passivating coking-susceptible surfaces with an inert, amorphous, high temperature-tolerant silicon layer, Silcosteel®-AC surface treatment greatly retards the catalytic coking process. The silicon layer is a barrier to the catalytic action that creates filamentous coking. Studies at The Pennsylvania State University and at Wright-Patterson Air Force Base have shown that Silcosteel®-AC treatment reduces carbon fouling on stainless steel up to 8-fold (Figure 3).[4,5]

A Silcosteel®-AC-treated surface not only prevents the formation of filamentous coke, it

Increase efficiency, protect equipment

Silcosteel®-AC treatment adds value to your process:

- Longer component lifetimes.
- Decreased maintenance costs.
- Higher thermal efficiency.
- Will withstand temperatures to 550ºC.
- Apply to existing equipment.

Restek *Performance* Coatings
110 Benner Circle • Bellefonte, PA 16823
800-356-1688 • 814-353-1300 • fax: 814-353-1309
www.restekcoatings.com

simplifies removal of other types of coke that typically bind to a heated surface (Figure 4). Studies have shown that carbon deposits can be removed from a Silcosteel®-AC treated surface simply by sonicating the surface in common solvents, thus dramatically simplifying maintenance procedures and extending maintenance cycles.[5]

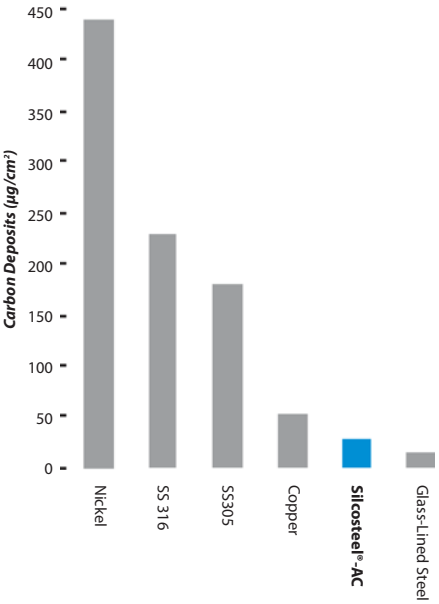
Apply Silcosteel®-AC treatment to engine components susceptible to coking

A Silcosteel®-AC layer can be applied to new or existing engine components. Silcosteel®-AC is a chemical vapor-deposited (CVD) layer, designed specifically to reduce coking of steel, stainless steel, specialty alloys, and aluminum. 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. A Silcosteel®-AC layer will deform with the metal surface, allowing radius bends in tubing, or leak-free seals, even at the most demanding temperatures.

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

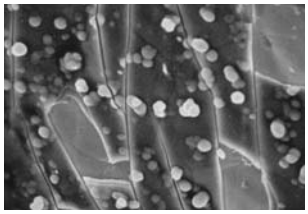
- fuel injection nozzles
- fuel and oil lines
- jet engine nozzles
- pistons
- EGR valves
- valves
- turbine shafts
- heat exchangers

Figure 3 Silcosteel®-AC treatment reduces coking up to 8-fold.[5]

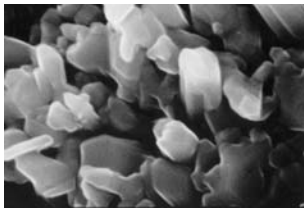


Contact us! Restek will treat your **tubing, fittings, and more** with Silcosteel®-AC.

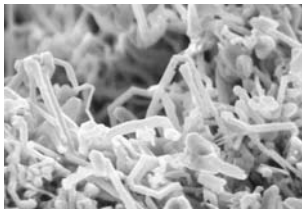
Figure 4 Carbon deposit from JP-8 fuel on various types of tubing (500°C, 500psi, 1cc/min. flow rate).



Silcosteel®-AC



304 Stainless Steel



Competitor A

In Summary

Test data show that Silcosteel®-AC treatment is highly effective in reducing catalytic coking, by as much as a factor of 8. Because Silcosteel®-AC treatment can be applied to existing components, maintenance cycles can be extended without significant re-engineering. Silcosteel®-AC treatment is a proprietary (U.S. patent 6,444,326), custom service, offered exclusively by Restek Performance Coatings. To learn more about how Silcosteel®-AC treatment can reduce coking in your engine fleet, visit Restek Performance Coatings on the web at www.restekcoatings.com or contact our technical service group at 800-356-1688, ext. 4.

References

1. Steinetz, B., R. Hendrics, J. Munson, *Advanced Seal Technology Role in Meeting Next Generation Turbine Engine Goals* NASA/TM-1998-206961; National Aeronautics and Space Administration, Cleveland, OH; Allison Engine Company, Indianapolis, IN (1998).
2. Perez, J., A. Boehman, *Penn State Multi-Discipline Tribology Group and Energy* Institute Studies The Pennsylvania State University, University Park, PA (1998).
3. Oil Coking EMAL-TT7-1201, ExxonMobil Corporation (2001).
4. 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).
5. 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).

for more **info**

Learn more about our precisely applied, highly durable surface treatment, Silcosteel®-AC: request information packet 59047.

Restek Surface Treatments

We offer many surface treatments that enhance performance in many applications:

Silcosteel®	A general-purpose passivation layer for steel and stainless steel. U.S. patent 6,511,760.
Silcosteel®-AC	Dramatically reduces carbon buildup on stainless steel components. U.S. patent 6,444,326.
Silcosteel®-CR	A corrosion resistant layer that increases the lifetime of system components in acidic environments containing hydrochloric acid, nitric acid, sulfuric acid, or seawater. Patent pending.
Silcosteel®-UHV	Greatly reduces outgassing from components of ultra-high vacuum systems. Recognized as one of the 100 most technologically significant products by *R&D* magazine. Patent pending.
Siltek™	The ultimate passivation for treated components, from glass to high nickel alloys of steel. U.S. patent 6,444,326.
Sulfinert®	A required treatment for metal components when analyzing for parts-per-billion levels of organosulfur compounds. U.S. patent 6,444,326.

Restek *Performance* Coatings

110 Benner Circle • Bellefonte, PA 16823
800-356-1688 • 814-353-1300 • fax: 814-353-1309
www.restekcoatings.com

Lit. Cat.# 580024