Comparison of Surface Composition on Stability of Mercury Transfer and Holding

Gary Barone, Marty Higgins

SilcoTek™ Corporation

Outline

- Need for inert system components
- Mercury emissions, environmental impact, regulations, and sampling
- Mercury loss during holding
- Mercury loss during transfer
- Conclusion

Inert System components

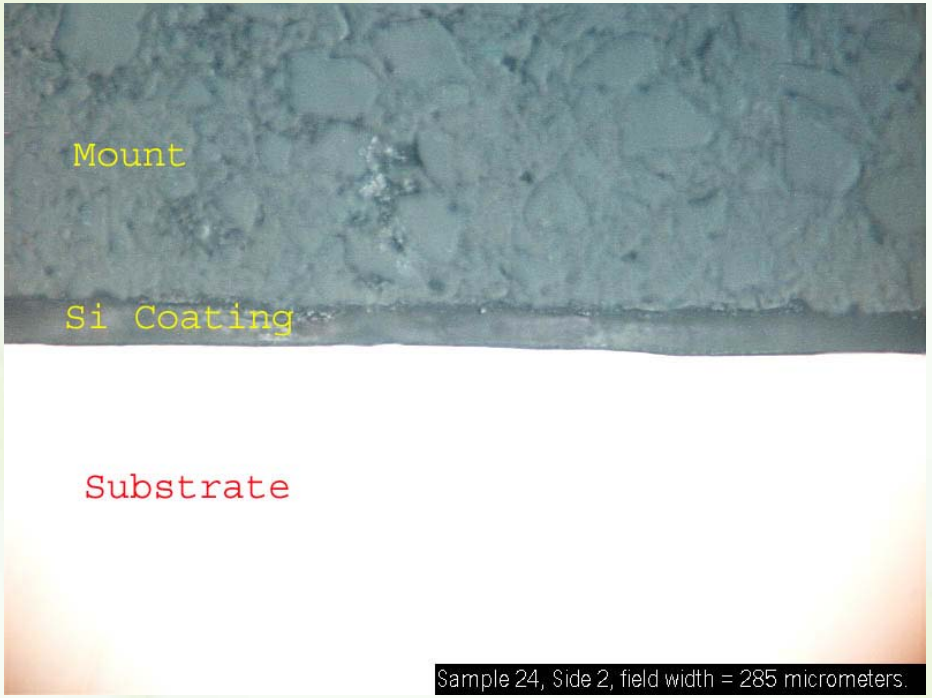
- System loss must be addressed
- Several alternatives exist:
  - Stainless steel
  - Coatings such as silicon and Teflon®
- Focus on silicon based coating versus Stainless Steel

Chemical Vapor Deposition Process: Creating silicon based coatings

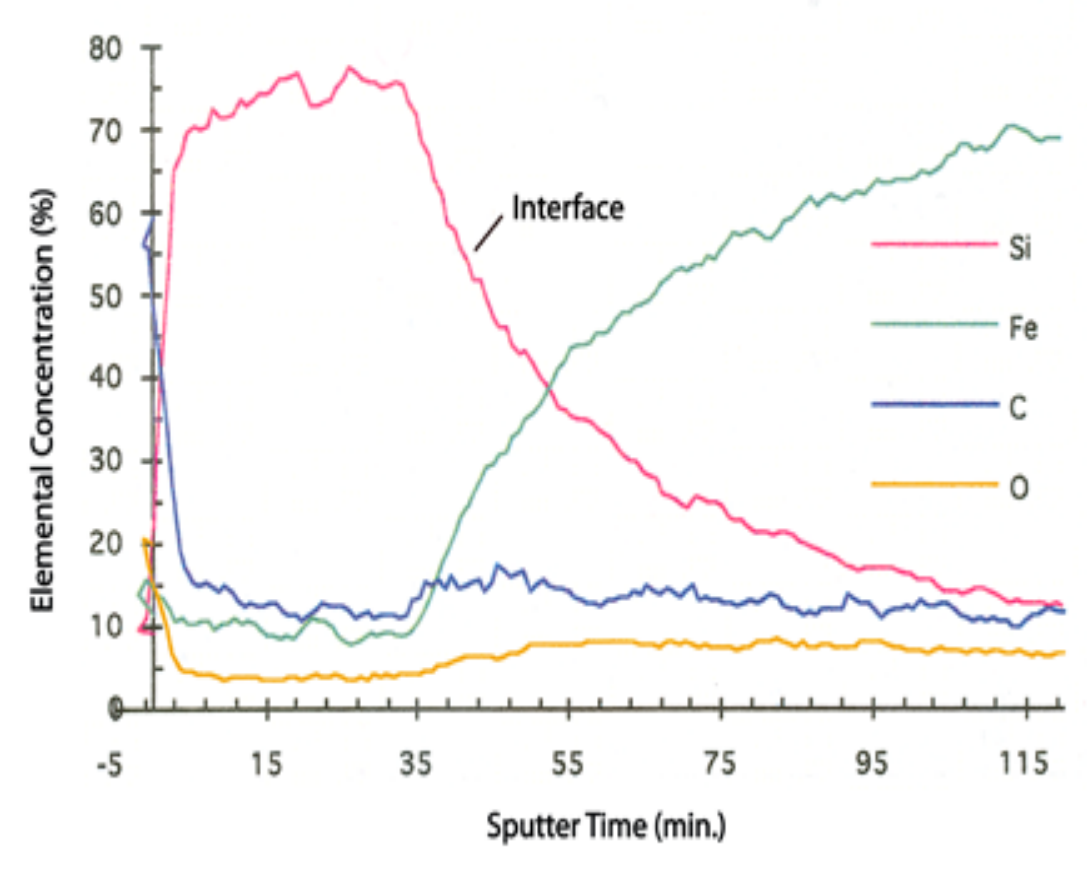
- Thermal decomposition of silanes
- Functionalizing silicon surface
- Process
  - Clean (caustic surfactant; ultrasonic)
  - Vacuum
  - 400ºC
  - Applied in vessel or oven chamber
- Total 3D coverage, not line-of-sight

Coating Cross Section

SEM micrograph of the silicon coating over a 316L stainless steel substrate



Auger Depth Profile



Silicon penetration into surface provides adhesion

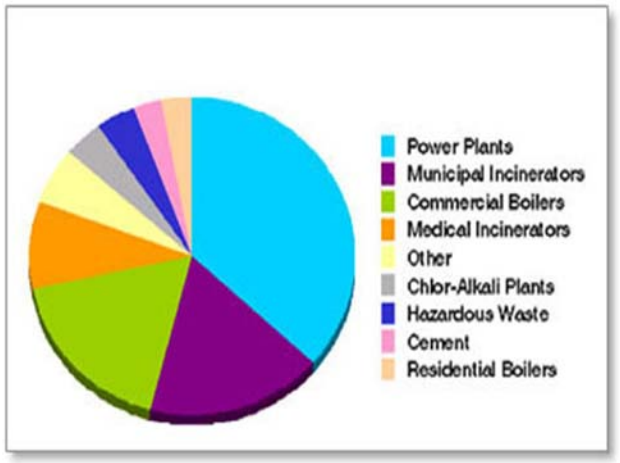
Coating Appearances

Common Coated Components

Sampling Systems
Transfer Tubing
Valves
Particle Filters
Tube Fittings and Adaptors
Sample Cylinders; Outage Tubes
Analyzer components
Continuous Mercury Monitoring Systems.(CMMS)

Mercury:

- Significant impact to human health and environment
- Effects nerve, brain, heart, kidney, lung, and immune systems.
- Coal powered plants emit 48 tons of mercury per year
- Monitoring levels in ocean and lakes
- Levels in consumed fish species
- Being discovered in natural gas wells
- Natural emissions from volcano's



Mercury Regulations

- Coal fired plants required to monitor Hg emissions
- Portland Cement Kilns
- Natural Gas sampling

Coal Stack Emissions: A Complex Mix

- Stack mercury emissions exist in 3 forms
  - Elemental mercury (Hg)
  - 2^+ Oxidation state (Hg^{++})
  - Attached to particulate matter
- Hg^{++} reacts with stack compounds and stainless steel surfaces making analysis unreliable

Mercury in oil and gas wells

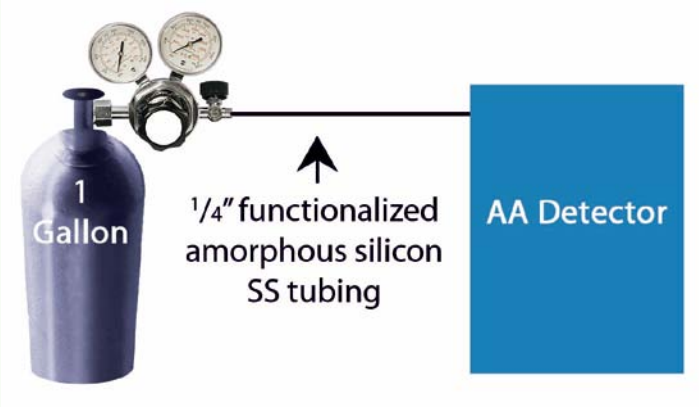
- Common in many geographic areas
- Mercury damages aluminum heat exchangers, pump vanes, pipeline equipment
- Cumulative effect so monitor very low levels (0.01ug/m3)

Improve Sampling and Storage

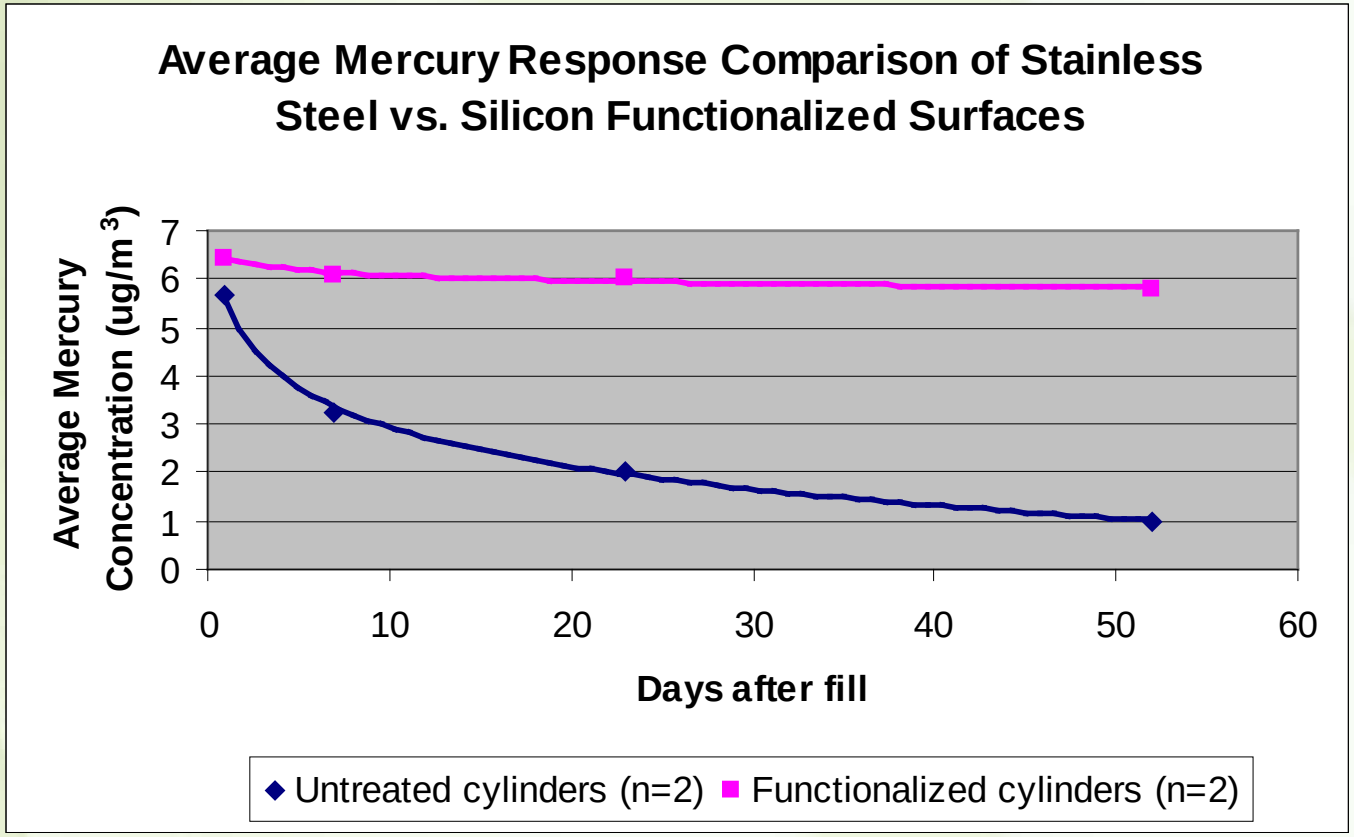
- Problem: Steel surfaces result in loss
- Improved by sound analytical design
  - Heat trace tube
  - Short tube runs
  - Eliminate dips/pockets
  - Maintain target flow
- Electropolished Surfaces
  - Reduce surface area for adsorption
- Coated stainless steel
  - Eliminate adsorptive effects of SS tubing & containers

Mercury Adsorption by Stainless Steel

- 10 ug/m^3 Hg Standard
  - Spectra Gases Inc.
- 1 Gallon Sample Cylinder 1800psi DOT rated
  - Swagelok Corp
- NIST Traceable
- Nominal Temp. 70° F
- Test Cycle Day 0,7,19,50
- Direct Interface Gas Sampling
- Atomic Absorption Detector
- Silicon Regulator and Tube



Mercury 50 Day Stability



Comparison of Hg Stability

Test Day	Avg response 304 SS cylinders ug/m3	Loss vs. Day 0	Avg response Functionalized Silicon ug/m3	Loss vs. Day 0
0	5.65	-	6.45	-
7	3.25	42%	6.1	5%
19	2.05	64%	6	7%
50	1	82%	5.8	10%

Current Applications

- Mercury, Sulfurs and Moisture
  - Inert and Corrosion Resistant
- Coal Fired Power Plants
  - Improve CMMS performance
- Natural Gas; LPG
  - Detect trace Mercury and H_2S levels
- Moisture
  - Eliminate effects on sampling systems

Mercury Transfer

- 20 foot tubing sections
  - 316L Seamless Stainless Steel
  - Silicon Coated stainless steel
  - EP 316L Stainless Steel
  - Silicon Coated Stainless steel
- 10ug/m3 Hg Standard
- Direct interface Atomic Absorption
- 4 liters/minute flow, makeup gas, air (Fast Residence of ~0.01 seconds)

Transfer Data

Tubing	Certified Concentration ug/m3	Analyzed ug/m3
EP Si coated	10.0	10.0
316L Si coated Seamless	10.0	9.9
316 L EP	10.0	9.9
316L Seamless	10.0	10.0

Conclusion

- Silicon surfaces improve mercury CMMS
- Reduce mercury losses by 70% in static containment systems
- Moisture dry down performance improved by 50%
- Provide corrosion resistance

Acknowledgements

- Spectra Gases

- O’Brien Corporation