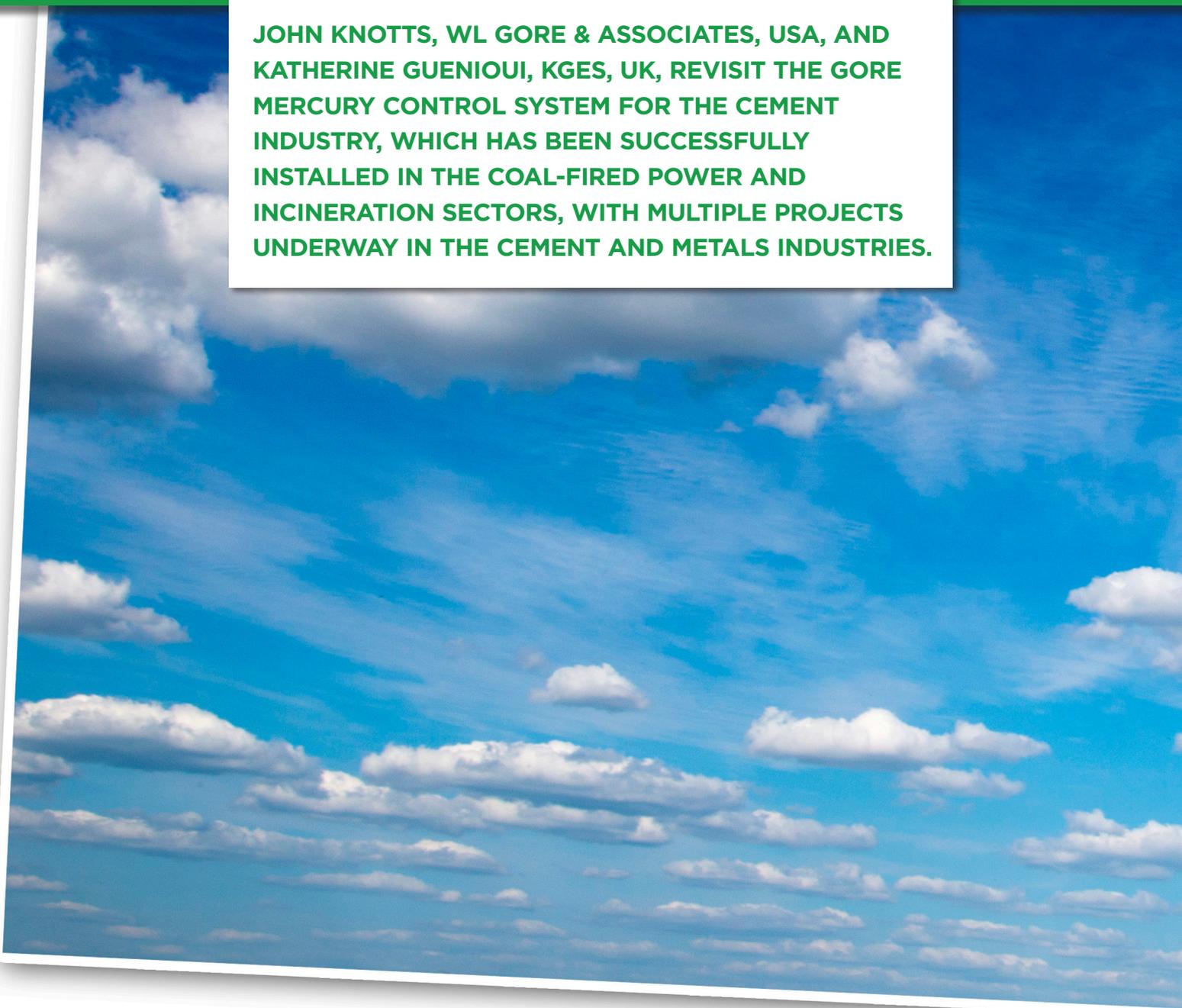




A COMPLETE MERCURY CONTROL SYSTEM



**JOHN KNOTTS, WL GORE & ASSOCIATES, USA, AND
KATHERINE GUENIOUI, KGES, UK, REVISIT THE GORE
MERCURY CONTROL SYSTEM FOR THE CEMENT
INDUSTRY, WHICH HAS BEEN SUCCESSFULLY
INSTALLED IN THE COAL-FIRED POWER AND
INCINERATION SECTORS, WITH MULTIPLE PROJECTS
UNDERWAY IN THE CEMENT AND METALS INDUSTRIES.**



What if production increases put operators out of compliance?

Having navigated both an economic downturn and the introduction of stringent emissions regulations, the US cement industry has had a tough few years. Now, however, things are looking up. Consumption is on the rise and forecasts are positive. Increased volumes mean more efficient production, and that can only be a good thing for margins. With all the tools to comply with NESHAP regulations in place, most manufacturers can relax a little, knowing that the hard years are behind them – at least until the next set of regulations rears its head, which seems unlikely to happen under the current administration.

For a relative few manufacturers, however, the increase in production may have given rise to some unforeseen challenges. Dust shuttling works well up to a point, but if the raw feed is mercury rich, it has its limitations. No one wants to be in a situation of curtailing production simply because there is too much dust and no economical method of disposal. Similarly, while sorbent injection has proved very effective, it, too, has limitations. With more mercury going into the system, it is difficult to prevent more mercury from escaping the stack. Besides which, the cost and waste burdens associated with sorbent injection rise in line with production increases. With the market picking up and environmentalists on high alert – more in some states than others – now is not the time to fall out of compliance.

GORE has developed a system that provides peace of mind for cement producers concerned that existing measures may not provide a complete solution. The GORE Mercury Control System (GMCS) is unlike other

options available to the industry: there are no operational concerns, minimal running costs, no maintenance issues and, critically, no reagents to deal with. That means no reagents to buy, store, handle, or waste. Once installed, the GMCS is guaranteed to achieve compliance with current mercury emissions limits for several years with no additional input from the operator. The spent modules can then be disposed of in a lined landfill with no fear of the mercury leaching out into the environment.

How does it work?

Sorbent injection systems work by injecting a sorbent into the flue gas stream. The GMCS inverts this concept, pushing the gas past the sorbent. The major difference is that the sorbent is not a throwaway item, but is embedded in a specially developed, long-life material called Sorbent Polymer Catalyst (SPC). The SPC, which is one of GORE's range of filled ePTFE fabrics, is arranged in an open channel design and affixed in modules measuring approximately 2 ft x 2 ft x 1 ft high. These can be stacked in parallel or in series depending on gas volume and mercury

reduction requirement, respectively. Put simply, the more modules that are installed, the greater the mercury reduction achieved. The gas flows through the system at velocities as high as 18 ft/sec., giving the mercury considerable contact time with the sorbent, which is what makes the GMCS effective at reducing mercury emissions. Critically, the SPC is designed to capture both elemental and oxidised mercury and sequester it in the form of stable mercury compounds. The unique structure of the SPC gives it a storage capacity that can be measured in years, not hours.

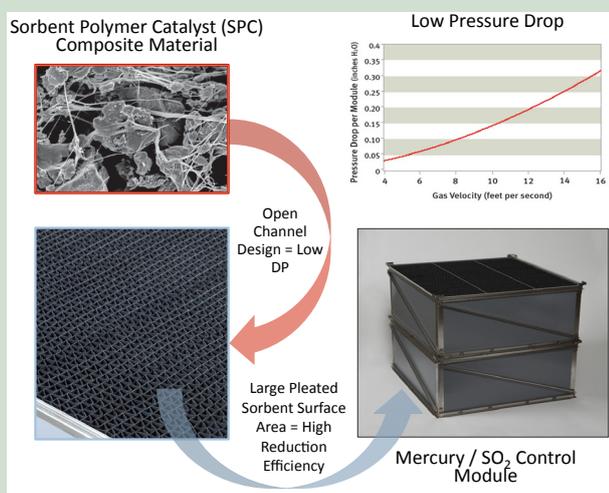
A co-benefit of the system is SO₂ polishing, thanks to a catalytic reaction with the SPC that converts SO₂ to sulfuric acid, which is then expelled as condensate and washed away or stored for other process use. Since SO_x is included in the NESHAP rule for cement producers, this is a significant advantage. Working together with a regular water wash, the sulfuric acid also helps to keep the modules free of pore-clogging contaminants and submicron process dust carryover from the baghouse.

Research has shown that the lower the waste gas temperature, the better the efficiency of mercury capture systems, so that, at temperatures below 130°C (266°F), it is possible to capture more than 90% of mercury.¹ The GMCS is therefore designed to operate in the lower-temperature gases downstream of a particulate collection system. This is an aggressive, moisture-rich environment, but the hydrophobic structure of the SPC prevents flooding. Its resilient properties also leave it unaffected by SO₃ in the gas stream, which can be a problem for other mercury sorbents. The GMCS can be installed as a standalone system, but also works when integrated into an existing wet scrubber above the mist eliminator or as part of the baghouse outlet ducting. This is how the system was incorporated into the process at FirstEnergy's Fort Martin generating plant, the first full-scale installation in the US.

What is SPC?

This fluoropolymer composite material was specially developed by GORE to have the following characteristics:

- Chemisorption of gas phase mercury (even in wet gas stream).
 - Elemental and oxidised mercury capture.
 - High capacity for mercury storage.
 - Does not require regeneration.
- Catalytic conversion of SO₂ (without generating solid waste).
 - Dilute sulfuric acid solution created.
 - Highly hydrophobic structure expels acid to SPC outer surfaces.
 - Continuous sulfuric acid weeping helps minimise impact of solids.



A closer look at the SPC.

Case study: Fort Martin

Fort Martin is a two-unit coal-fired power plant in West Virginia. The two units were installed in 1967 and 1968, respectively, and generate a combined 1107 MW, using about 2.8 million tpy of coal. Both units have two electrostatic precipitators in series and a wet limestone forced oxidation scrubber with wastewater treatment facility.

With the US Environmental Protection Agency's (EPA) Mercury Air Toxic Standards (MATS) regulations coming into play for the power generation industry in April 2015, FirstEnergy had put out a bid for mercury abatement solutions in 2012. The company was exploring various options, including activated carbon injection, duct sorbent injection, and mercury re-emission chemicals. The GMCS bid came via a contractor, and offered an alternate solution to meet FirstEnergy's requirements: a completely passive system

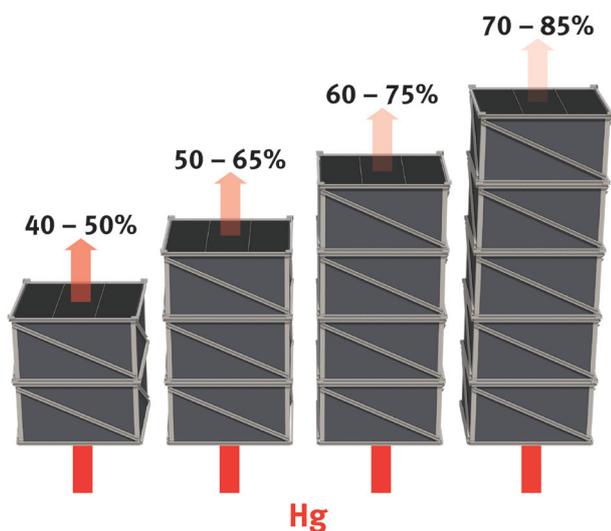


Figure 1. Example of mercury removal efficiencies in typical gas velocities of 8 – 16 ft/sec.



Figure 2. The arrangement of modules at the top of the FGD scrubber at Fort Martin.

with no ongoing reagent costs, guaranteed to meet MATS limits.

FirstEnergy evaluated the bids based on technical feasibility, capital cost, reagent cost, and operating and maintenance costs. Ultimately, the GMCS was selected as the best and most economical option. Installation on unit one was completed during a scheduled outage in the Fall of 2014, with unit two following in Spring 2016.

Mark Scaccia, Manager, Major Projects, was in charge of the project and the very tight schedule – particularly challenging for the first unit, since it was the first project of its kind for all parties involved. “Getting the unit back into service and generating electricity again depended upon us meeting our schedules,” he explained. “The first time we did it we were very concerned because it was all new things we were doing. In the end we were a couple of days ahead of schedule.”

The FGD scrubber systems on Fort Martin units one and two went into service in late 2009. Though it made sense for the GMCS to be installed inside the scrubber,

there was not sufficient space in the existing layout, and so it was necessary to redesign the scrubber internals. The mist eliminators, wash piping, and support trusses were removed to make way for a new shorter support truss, with a more compact mist eliminator and wash system, so that the GMCS could be installed over the top. A new support truss was designed for the GORE modules and wash piping. The additional weight of the GMCS necessitated the installation of vertical supports on the outside of the vessel. These were installed before the unit outage, but the rest of the work had to be carried out within the scheduled outage period. It took 10 days to wash, install scaffolding, and remove the existing mist eliminators, wash piping, and support truss. The new mist eliminator and support truss, along with the GORE support truss, wash piping, and modules were installed in just five weeks. External wash piping and valves were also installed during the outage. Finally, a coating contractor coated the inside of the scrubber vessel to protect the shell materials from sulfuric acid attack.

“This was a very complicated project, with very limited space to use for construction and a very tight work area. In addition, this was the first of its kind and all firms (engineering, construction, and coating) developed unique construction practices to limit the outage duration,” continued Scaccia. “We had multiple design and construction meetings to develop unique solutions to the engineering and construction issues.”

Going into the second GMCS installation, everyone was a lot more confident. “We learned all of our lessons on unit one and fixed those things on unit two,” said Scaccia. “Little access things, how to get to the pipes, where to put the bends in, and [where to] remove elbows so you don’t have any type of wear: there were a lot of lessons learned. We implemented those on unit two and actually it is performing just a tad better than unit one.”

One of the key lessons learned on unit one was the benefit of adding a second wash header. Though the unit was in compliance without it, the addition of an intermediary wash header brought mercury emissions down to about 50 – 55% of compliance limits by removing particulate carryover from the SPC surface. The intermediary wash header was included as part of the design for the second unit.

“The beauty of the system is that, now that it has been installed, it basically just sits there and does its thing,” concluded Scaccia. “We’re not adding anything into our gas stream. We’re not adding anything into our water stream. We don’t have to take anything out in the wastewater stream. The operators virtually don’t know it’s there.”

Application in the cement industry

Of course, the cement industry is not the same as the power industry: the process is arguably more complex, given the variation in the raw materials and fuels used.

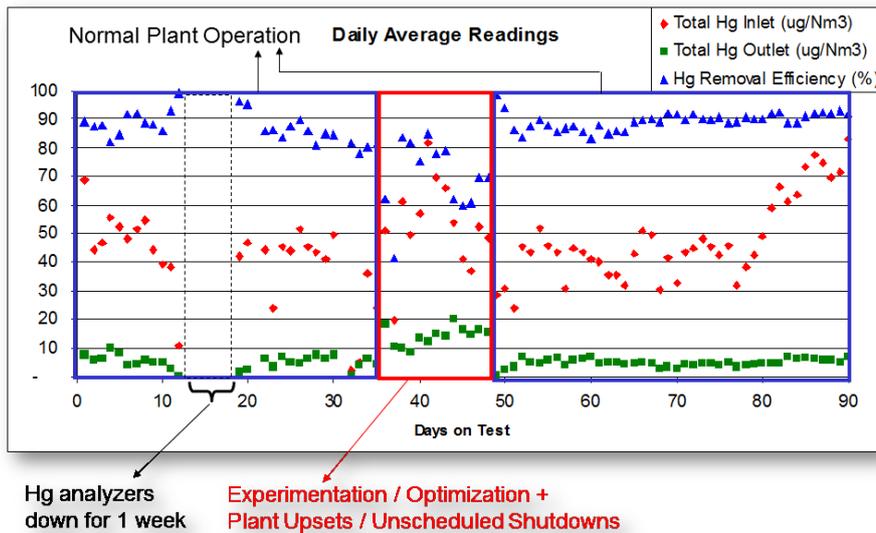


Figure 3. Data from a cement plant with a four-module stack over a 90-day period. It is evident that the mercury removal efficiency is generally above 80% and outlet emissions remain below 10 mg/Nm³ without any adjustments to the system.

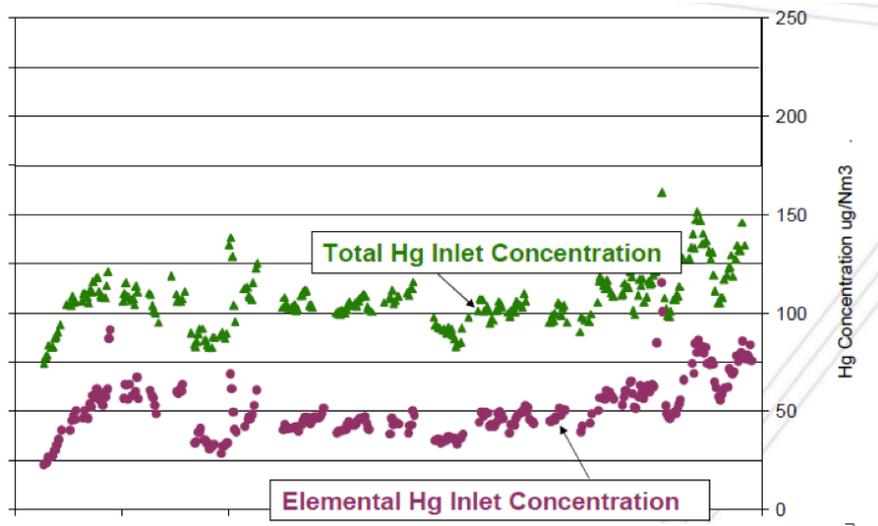


Figure 4. Cement plant mercury speciation analysis. While other technologies struggle to capture elemental mercury, the GMCS captures both oxidised and elemental mercury.

Despite this, the GMCS offers a consistent solution for mercury abatement. Because the technology is placed at the end of the line, the industry is, effectively, irrelevant. It deals with air, gas, and mercury – not cement, coal, or steel. The system requires a low gas temperature and a velocity below 18 ft/sec. Given that, the mercury will be taken care of.

Working either in addition to – or instead of – carbon injection and dust shuttling, the GMCS provides consistent reduction efficiencies in both raw mill on and raw mill off operation. There are none of the contamination issues of the other technologies: the sorbent does not enter the process, and the mercury is entirely sequestered in the SPC. There are no storage requirements and no question of where the captured mercury is likely to reappear. Once it is sequestered in the SPC, it is there to stay. For anyone concerned about potential future liability related to mercury in the

cement mix, this is a significant advantage. There are also the aforementioned benefits of low operating costs, no moving parts, and very simple operation.

To date, three pilot projects have been undertaken at cement plants in the US, with great success. Figure 3 shows 90 days of Tekran CEMS data taken toward the end of the 9 month technology demonstration. For the most part, the mercury removal efficiency is over 80%. Mercury concentrations at the outlet are consistently maintained below the regulation limits without any adjustments to the system. Figure 4 shows a cement plant mercury speciation analysis, which demonstrates the significant concentration of elemental mercury. This is where the GMCS system has a major advantage over other mercury abatement methods: thanks to the unique structure of the SPC and the prolonged exposure of the low-temperature gas stream to the modules, the GMCS captures both elemental and oxidised mercury with great efficiency.

Conclusion

For those manufacturers concerned that their existing abatement solutions will be rendered ineffective by expected production increases, it is worth considering additional measures. Failing to meet emissions limits

can mean big fines, a loss of business, and even legal action. More importantly, mercury is a toxin, and the less of it that is released into the environment, the better.

The GMCS is a complete, low-maintenance system with minimal running costs, very little waste, and no reagents. It offers SO₂ polishing as a co-benefit and can also be tailored to reduce HCl levels. While the GMCS is not necessary for every plant, for those producers with higher levels of mercury in their raw material and high production volumes going through the plant, who may need extra help keeping their mercury output within legal limits, the GMCS offers a low-OPEX solution with high mercury removal efficiency. 🌍

References

1. <http://www.mercuryconvention.org/Portals/11/documents/BAT-BEP%20draft%20guidance/Cementclinkerproduction.pdf>, p.30.