# Technical Bulletin

# Mercury Control in the Industrial Boiler Sector

## Introduction

Airborne mercury from numerous combustion and other sources settles into our water systems, and when consumed by fish, becomes a readily metabolizable form of mercury (methyl-mercury). Consumption of fish containing this form of mercury can affect pregnant women and the early brain development of children, costing society untold dollars each year. Pressure to increase mercury regulation continues to grow, affecting many different sources. This article discusses the impacts on the industrial boilers source.

## History

For over 20 years, flue gas from municipal waste combustors has been regulated for mercury. The sources of mercury include broken thermometers, thermostats and many other household items containing mercury that are disposed in municipal waste. The regulations that were implemented in 1995 resulted in the reduction of nearly 50 tons of mercury annually. The best available control technology for mercury removal for this application is dry activated carbon injection into the flue gas. The mercury is adsorbed by the activated carbon and subsequently collected in the particulate control device. Removal efficiencies of greater than 90% are common.

More recently, regulations have been promulgated at the state level for mercury reduction in coal fired power plants. The state regulations vary in removal requirements. Illinois' regulation is targeting a 90% removal across nearly all coal fired units and is already in place. A number of northeast states require 80% or greater removal. Other states have less stringent rules for the time being, but move to higher requirements within a few years. A federal regulation, the Clean Air Mercury Rule (CAMR) was promulgated in 2005 and then later vacated by the DC Circuit Court of Appeals in early 2008. The result of this vacatur is that the EPA has been mandated to write a regulation under Section 112 of the Clean Air Act requiring a MACT standard for mercury removal. This will likely also require the control of other Hazardous Air Pollutants (HAPs) including a broad spectrum of chemical species and metals. The EPA is in process of regulating industrial boilers for mercury. It is anticipated that the forthcoming Industrial Boiler regulation will also contemplate the removal of these additional HAPs. In anticipation of a federal regulation for coal fired power plants, a substantial amount of research and development began in 1999 and has provided meaningful information that can be used for the industrial boiler industry.

Mercury is a natural element of the coal that when burned, is released into the boiler flue gas. Each boiler system has its own unique combination of boiler type or configuration, fuel source(s), and air pollution control (APC) equipment (sulfur scrubbing, nitrogen oxides reduction, and particulate control). This provides a highly variable chemistry in the flue gas, which makes for a challenging environment for a predictable removal of mercury. Adding to this variability, the largest coal-fired utility boiler is

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approximately twenty times the size of the smallest utility boiler. In contrast, the largest industrial boiler is perhaps 200 times the size of the smallest industrial boiler in terms of the amount of coal (burn/consumed). This variance range, in conjunction with the limitless combination of fuels and APC configurations creates an even greater removal challenge for the industrial boiler segment.

## Compare and Contrast – Utility and Industrial Boilers

The work completed by both the Department of Energy and private industry over the last 10 years for utility boilers has focused on identifying the key factors that affect mercury removal within broad groups of fuel and APC configurations. Listed in Table 1 are some of the major areas of study that have been undertaken.

As can be noted from the items in Table 1, most have material significance to the coal-fired industrial boiler applications. There are 500-700 Industrial boilers expected to be affected by an industrial boiler regulation. At this writing, an EPA Information Collection Request (ICR) is in process, collecting current detailed information on Industrial boilers. This will provide the first extensive assessment from which we can gauge expectations from a regulation, but generalizations can be made from the experience we have to date.

Some typical material differences exist between the utility boilers and the industrial boilers that create greater challenges for removing mercury from industrial boilers.

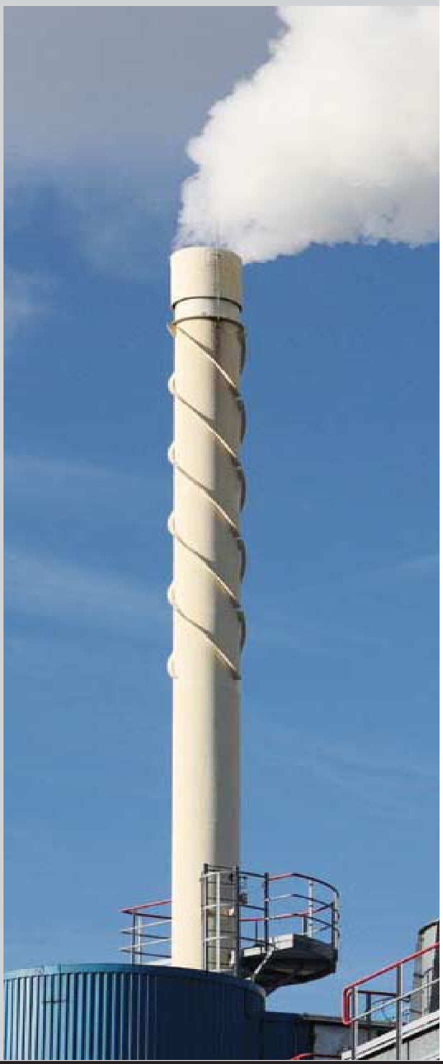
1. Operating temperatures – although highly variable, the smaller boiler systems typically have higher operating temperatures at a typical injection point than utility boilers often due to reduced heat recovery configurations.

**TABLE 1**

| Area of Study | Driver |
|---|---|
| Low sulfur bituminous fuels | Very common east coast fuels |
| High sulfur bituminous fuels | Difficult application for activated carbon/also common east coast |
| Sub-bituminous Fuels | Early PAC trials showed limited removals, solved with halogenated PACs |
| Lignite Fuels | Early PAC trials showed limited removals, solved with halogenated PACs |
| ESP Applications | Distribution and opacity concerns/high temperature applications (hot-side) |
| Baghouse Applications | Function of bags with additional loading/efficiency/design requirements |
| Contact times | Many sites have limited injection points with minimal contact time |
| Effect of SCR/Wet Scrubber | Can combination be used without additional mercury removal |
| Temperature effects | What are the useful temperature ranges of sorbents in flue gas. |

2. Fuel characteristics – the majority of the projects have been implemented on boilers firing bituminous fuels and a disproportional number have been with fuels higher in sulfur. This presents the additional challenge of dealing with higher levels of sulfur tri-oxide, which makes mercury more difficult to remove.

3. Configuration challenges – with the lower air flows, the equipment is scaled down and distribution of an injection media becomes more difficult to predict. Also the points at which a sorbent can be injected may also be more limited.



4. APC equipment challenges – particulate control devices in the industrial boiler sector are often venture scrubbers and mechanical collectors. This may provide an additional challenge of effective collection of the fine activated carbon.

5. Duty cycle – industrial boilers often are in more variable duty cycle service, presenting higher variability in the flue gas conditions.

These distinctions will help drive research and product development efforts for this market. Although both sulfur tri-oxide resistance and improved performance in higher temperature applications have been a topic for utility boilers, the prevalence in the industrial sector will drive it further.

## Key Technologies for Mercury Control

Many sub-applications for mercury removal exist within the broad category of industrial coal fired boilers. Listed below are a number of the key technologies that have promise for mercury control for industrial boilers.

1. Powdered activated carbon (PAC): PAC has been the most thoroughly tested and is the most commercially available technology of all the technologies to date. It has been proven to successfully removal mercury up to 90% in many configurations. Additionally, activated carbon also is successful in removing numerous other HAPs present in the gas streams, although research will be required to quantify its capacity on these other species. It is more effective in baghouses than in ESPs and in general is more efficient in lower temperature application than in high temperatures. Mercury needs to be in its oxidized form for best removal, and thus the fuels should provide an oxidizer for greatest success. This usually takes the form of chlorine in the coal. It has challenges in several areas.

    a. Sulfur tri-oxide tolerance – the presence of sulfur tri-oxide adversely affects the ability of the activated carbon to remove mercury. Research is being completed by several activated carbon suppliers to provide products with the required tolerance. Pre-treatments or co-treatments with basic materials such as lime, soda ash and trona in the flue gas prior to the activated carbon injection have shown positive impacts on this issue.

    b. Fly-ash compatibility – The presence of activated carbon in the fly-ash can result in the loss of salability of the fly ash for use in concrete mixes. This is due to the adsorption of air entrainment agents necessary to increase certain strength characteristics of the finished concrete products. Most activated carbon suppliers have created new products reducing or eliminating the interference of the activated carbon. Color can still be an issue.

    c. High Temperature Applications: Adsorption by activated carbon has a kinetic component by nature. The higher the temperature, the more that the process is shifted toward desorption, hence lower removal efficiency. As the industrial boilers seem to have a higher average temperature at the treatment point, increased research will be required to improve efficiency in these applications. Some installations have evaluated retro-fit cooling technologies to aid mercury removal efficiency in these cases.

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2. Co-benefits with other scrubbing applications: Mercury removal has been very successfully demonstrated in wet sulfur scrubbing installations. It has been particularly successful when used in conjunction with selective catalytic reduction (SCR). It is doubtful that the smaller industrial boilers will utilize SCRs in their treatment train and wet scrubbing is less common than dry, but other scrubbing methods have shown mercury removal ability and will need to be looked at more closely.

3. Fluidized bed boilers: Testing has been completed of some of the newer style fluidized bed boiler designs and mercury emissions have been found to be very low. This is suspected to be due to reactions in combination with the sulfur scrubbing that takes place in the "inert" bed material when limestone is used.

4. Fixed bed activated carbon applications: Work is currently underway in the use of fixed activated carbon beds for removal of mercury. The typically smaller scale and gas flow rates of the industrial boiler are more favorable to the implementation of such a process.

5. Catalytic Removal: This technology has been evaluated in a utility boiler. Although there were several technical difficulties, once again smaller scale may make this technology more viable.

The industrial boiler user will face a number of challenges when approaching the technologies they will utilize in removal of mercury and other HAPs. Other air pollution control devices will have a role and influence the pathway chosen to meet any individual sites needs. As was the case in the coal-fired utility boilers, it is expected that industry will bring new technologies and improved and more targeted applications of current technologies to industrial boiler users. It will be important to follow closely the developments and expectations as the ICR data is completed and released to the public domain.

**Norit Americas Inc.**
Norit Americas is a wholly owned subsidiary of Norit N.V., which is based in The Netherlands. Norit is one of the largest producers of activated carbon in the world and has led the way in technical development in the application of its products in a number of industries. Norit has been in the business of manufacturing activated carbons for more than 90 years and offers the most complete product line to suit your desired application.

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