Using Mercury Capture Systems with Fly Ash for Cement Manufacturing

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CONFERENCE: 2017 World of Coal Ash – (www.worldofcoalash.org)

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ABSTRACT

Mercury Capture Systems has a proven system to thermally desorb and chemically capture mercury from materials such as fly ash and cement kiln dust (CKD). Mercury concentrations of fly ash, CKD, and activated carbon have been reduced by more than 99%. The fly ash can then be used as a cement plant raw material, with virtually no contributions to plant mercury emissions.

Recent National Emission Standards for Hazardous Air Pollutants (NESHAP) and upcoming Commercial or Industrial Solid Waste Incinerator (CISWI) regulations limit mercury emissions from cement manufacturers. Some cement plants are limited on mercury inputs as well. Using Mercury Capture Systems to process a mercury laden fly ash allows that ash to be utilized as a raw material. Depending on the cement plant, removing mercury from a raw material is a more effective emissions control solution than dust shuttling or sorbent injection.

This technology utilizes a reagent, not activated carbon or sorbents for mercury control. The same technology can beneficiate ponded or impounded coal combustion products (CCP) for use in a cement kiln or reducing LOI for use in ready mix concrete.

THE MERCURY CAPTURE PROCESS

Mercury Capture Systems was initially developed to capture the mercury emitted by cement kilns originating from the volatilization of mercury inherent in the raw materials and fuels. This was achieved by processing cement kiln dust (CKD) as it functions as a partial sorbent of mercury from the exhaust gas stream.

MCS has two steps; in the first step, mercury is thermally desorbed from CKD, and the second step chemically captures the mercury from the resulting vapor stream. These steps are achieved in the Thermal Desorber Gas Reactor, which can also process coal fly ash, sorbents or any other industrial powder. The feed material temperature is raised to 356°C in the Thermal Desorber while generating very little nuisance dust. Elemental
mercury and ionic mercury are volatilized and released from the feed. Extensive testing with CKD has shown mercury reduction values of greater than 99%.

The Thermal Desorber creates a small concentrated heavy metal gas stream. The gas stream passes through a high temperature baghouse to the Gas Reactor. The reagents utilized in the Gas Reactor combine with the mercury and any other heavy metals on a molar basis. Sorbent trap testing has confirmed an average mercury capture rate of more than 95%. The reaction forms a precipitate that is separated from the gas stream and collected independently. The precipitate has been tested and confirmed to be non-leachable even with high concentrations of heavy metals.

The Gas Reactor is a modified scrubber originally designed to remove particulate from an exhaust gas. Unreacted reagent is returned to the Gas Reactor. As the reagent is spent, additional reagent is added to the system to maintain the over 95% mercury capture efficiency. There is no liquid effluent generated. Air emissions consist primarily of water vapor and very low concentrations of H₂S.

As previously mentioned, the technology is useful for fly ash, sorbents and other powders. Those materials have been process and the Thermal Desorber data is shown in Table 1. Activated carbon and fly ash both had mercury removal rates over 99%, similar to CKD results.

Table 1. Summary of Desorption Results for Several Materials.

<table>
<thead>
<tr>
<th>Feed Material</th>
<th>Total Hg</th>
<th>Mercury Removal Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average Desorber Inlet ppm</td>
<td>Average Desorber Outlet ppm</td>
</tr>
<tr>
<td>Cement Kiln Dust (0.4 – 41 ppm)</td>
<td>2.16</td>
<td>non-detect</td>
</tr>
<tr>
<td>Activated Carbon (max. 240 ppm)</td>
<td>171.74</td>
<td>1.48</td>
</tr>
<tr>
<td>Fly Ash (0.2 – 1.5 ppm)</td>
<td>1.50</td>
<td>non-detect</td>
</tr>
</tbody>
</table>

MCS technology can be applied not only to CKD, but also to fly ash used as a raw material in a cement plant. Table 2 details several different fly ashes tested in the Thermal Desorber and shows mercury reductions of over 98% to non-detect values. Loss on ignition (LOI) values were encouraging at less than 2%. What had previously had been an high LOI fly ash with added sorbent can be processed with MCS and used as a raw material in cement plant or as an added value supplementary cementitious material. Ponded or impounded CCP can be reclaimed using the technology.
In addition, the Gas Reactor can be used independently of the Thermal Desorber. This has implications for gas streams containing volatilized mercury and volumes less than 3,000 cfm. One potential application is mercury emissions reductions from gypsum kettles.

Mercury Capture Systems has been field tested at an operating cement plant and confirmed the thermal desorption and mercury capture rates of over 95%. The most recent installation is shown in Figure 1.

![Figure 1: Mercury Capture System Cement Plant Installation](image-url)

Table 2: Fly Ash Processing Results at 10 and 15 Minutes

<table>
<thead>
<tr>
<th>Group</th>
<th>Temperature Range</th>
<th>Initial Mercury Content (ppb)</th>
<th>Final Mercury Contents (ppb)</th>
<th>Initial LOI (%)</th>
<th>Final LOI Range (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1</td>
<td>482 - 510 °C 900 - 950 °F</td>
<td>1,370</td>
<td>&lt; 20</td>
<td>8.1</td>
<td>1.0 - 1.8</td>
</tr>
<tr>
<td>Group 2</td>
<td>482 - 510 °C 900 - 950 °F</td>
<td>1,500</td>
<td>&lt;20</td>
<td>9.7</td>
<td>0.5 - 2.0</td>
</tr>
<tr>
<td>Group 3</td>
<td>427 - 482 °C 800 - 900 °F</td>
<td>&lt; 60</td>
<td></td>
<td>2</td>
<td>0.1 - 0.3</td>
</tr>
</tbody>
</table>
SUMMARY

Mercury Capture Systems has developed an innovative method of assisting the cement industry in its compliance with recent mercury emissions limits. Using a reagent, volatilized mercury that has been thermally desorbed from CKD is chemically captured and bound. The precipitate is non-leachable and water insoluble. Desorption rates are over 99% and mercury capture rates exceed 95%. CKD is returned to the cement kiln, and the removed mercury is eliminated from potential stack emission.

This technology is transferrable to other mercury containing powders. Testing has shown that thermal desorption with activated carbon and fly ash is greater than 98%. These materials can be reused or further processed with the knowledge that they are virtually mercury free.

In addition to processing other powders, the Gas Reactor can be used to remove mercury vapor from low volume gas streams. Industrial processes that calcine materials such as synthetic gypsum may result in mercury emissions. Those gas streams containing mercury with volumes less than 3,000 cfm can be processed with the Gas Reactor to remove over 95% of the mercury content.