Bromine-based Products for Mercury Emissions Reduction
Great Lakes Solutions, A Bromine Leader

For close to a century, we have helped our customers meet their needs with a broad portfolio of products and solutions. We manufacture and market flame retardants, bromine and brominated derivatives.

<table>
<thead>
<tr>
<th>Key Products</th>
<th>Key End-Use Markets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bromine &amp; Derivatives</td>
<td>Clean Energy</td>
</tr>
<tr>
<td>Flame Retardants</td>
<td>Electronics</td>
</tr>
<tr>
<td></td>
<td>Building &amp; Construction</td>
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<td></td>
<td>Oilfields</td>
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<td></td>
<td>Agriculture</td>
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<td></td>
<td>Pharmaceuticals</td>
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<td></td>
<td>Catalyst for Polymer Production</td>
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</tbody>
</table>

Key Drivers for Growth:

› Mercury control regulation
› Greener innovation
› Flame retarded energy efficient thermal insulation
› Increased global fire safety standards
Great Lakes Solutions: GeoBrom®
Mercury Control for a Cleaner, Greener Future

- Coal-fired boiler operations striving to reduce mercury emissions to meet federal clean air regulations can rely on Great Lakes Solutions GeoBrom® product line for a U.S. supply of brominated products for mercury control.

- Our proven commitment as a global, sustainable supplier in the United States includes more than $100 million of American infrastructure investment, with an additional $170 million planned for 2013-2015, along with an experienced organization able to provide superior customer support.
# Brominated Technologies: Most Successful and Most Widely Used

<table>
<thead>
<tr>
<th>Technology</th>
<th>Mercury Control%</th>
<th>Preferred Coal Type</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activated Carbon</td>
<td>Up to 80%</td>
<td>Bituminous</td>
<td>Limited by mercury oxidation; fly ash impacts for resale; particulate control required</td>
</tr>
<tr>
<td>Br Activated Carbon</td>
<td>Up to 95%</td>
<td>Sub-bituminous Lignite</td>
<td>Issues with SO$_3$ impacts; fly ash Impacts for resale; particulate control required</td>
</tr>
<tr>
<td>Nalco$^3$ CaBr</td>
<td>Up to 95%</td>
<td>Sub-bituminous Lignite</td>
<td>Scrubber or particulate control required</td>
</tr>
<tr>
<td>Alstom$^2$ (Vosteen) CaBr</td>
<td>Up to 95%</td>
<td>Sub-bituminous Lignite</td>
<td>Scrubber or particulate control required</td>
</tr>
<tr>
<td>Chem Mod$^1$ CaBr</td>
<td>Up to 95%</td>
<td>Sub-bituminous Lignite</td>
<td>Scrubber or particulate control required</td>
</tr>
<tr>
<td>48% HBr</td>
<td>Up to 90%</td>
<td>Sub-bituminous Lignite</td>
<td>Dry sorbent injection; particulate control required</td>
</tr>
<tr>
<td>Other Br Sorbents</td>
<td>Up to 75%</td>
<td>Bituminous</td>
<td>Particulate control required</td>
</tr>
<tr>
<td>Sulfur Technology</td>
<td>Up to 75%</td>
<td>Bituminous</td>
<td>Scrubber technology</td>
</tr>
<tr>
<td>Dry Sorbent Injection</td>
<td>Co-benefit</td>
<td>Bituminous</td>
<td>Particulate control required</td>
</tr>
</tbody>
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3. Reference: Nalco Case Study CH-980
4. GeoBrom® is intended for general mercury control application. Great Lakes Solutions does not endorse any particular emission control technology. Please consult your technology provider regarding proper application and technology rights.

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The GeoBrom® product line has been demonstrated in all three major calcium bromide technologies at commercial scale and is approved for use in manufacture of brominated sorbents.
Our Portfolio has a Product for Every Technology

GeoBrom® HG 520
  • *Calcium Bromide solution (52% by weight aqueous product)*

GeoBrom® HG 52S
  • *Calcium Bromide dry powder product*

GeoBrom® HG 400
  • *Sodium Bromide solution (40% by weight aqueous product)*

GeoBrom® HG 40S
  • *Sodium Bromide dry powder product*

GeoBrom® HG 480
  • *Hydrobromic Acid (48% by weight aqueous product)*

Other Bromine Derivative products available
  • *Other concentrations of Sodium Bromide solutions, inorganic bromides*
GeoBrom® Performs in All Mercury Control Technologies

Effective in the boiler, on activated carbon products, and in other downstream addition technologies.
GeoBrom® Storage System

*Follow all equipment manufacturer recommendations

- Circulate Tank Contents
- Tank insulation
- Line and Pump insulation
- Heat applied to tank jacket

* Pressure relief device setting (75 psig)
Great Lakes Solutions recommends unloading pressure limit (40 psig)
Equipped with vacuum relief

- Pressure (p) needed to lift product: \[ p = \text{specific weight} \times \text{height} = 106.2 \, \text{lb} / \text{cu ft} \times h \]
i.e. height of 20ft \[ p = 2,124 \, \text{lb/sq ft} \text{ or } 14.8 \, \text{psig} \]
Main Points of Storage/Transfer System

- Products non-regulated for transport
- Railcar recommended transfer from dip-tube, truckload from bottom valve
- Proper PPE for employees
- Secure connections and monitor transfer
- Density and crystallization temperature – HG520 (14.2 ppg and est. 10-20 °F) and HG400 (12.5 ppg and est. 27 °F)
- Properly insulate and/or circulate the tank in colder regions
- Materials of construction – equipment available off-the-shelf
- Air pressure or pump to lift to desired height
- Adequate back-flow prevention
- Great Lakes Solutions on-site support and expertise available
Great Lakes Solutions
We Build Customer/Partner Relationships

- Domestic supply
  - Great Lakes Solutions has the strongest U.S. bromine position
  - Secure, established U.S. operations
  - More than $100M in investments 2009-2011 in the U.S., and plans for another $170M in the future

- Supply Security and Sustainability
  - Multiple carrier options
  - Inventory in multiple strategic locations
  - Three U.S. bromine plants, two additional bromine sources
  - Multiple sources for calcium bromide plants in the U.S.

- Expertise with CaBr and NaBr Products
  - Equipment and training
  - Handling and technical support
  - More than 30 years experience handling tens of thousands of tons/year

- Flexibility and Customization of Solutions
  - Ease of order process
  - Delivery accommodation
  - Logistics and product support for test trials
  - Flexibility with logistics
  - Product expertise to support customer facilities
  - Customer service - assigned representatives for each customer
  - Ability to support site specific storage where required
  - Broad package range: drums to bulk in trucks and railcars

We will be here for you for the long haul...
The Value of GeoBrom® and Great Lakes Solutions for Mercury Control

GeoBrom® products have been designed for incorporation into new technologies that use bromine or brominated derivatives products for the efficient reduction of toxic mercury emission from coal-fired boilers and power plant installations.

The GeoBrom® product line provides sustainable, secure, U.S. manufactured brominated products for mercury control by a company with proven ability to solve complex customer logistical challenges and requirements.

- Effective and proven at commercial scale in technologies
- Reliable U.S. supply
- Cost-effective solutions for mercury control
- Flexibility to meet customer needs
- Customer support and creativity for all facets of the order and delivery process
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