GeoBrom®

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Calcium Bromide for Mercury Control

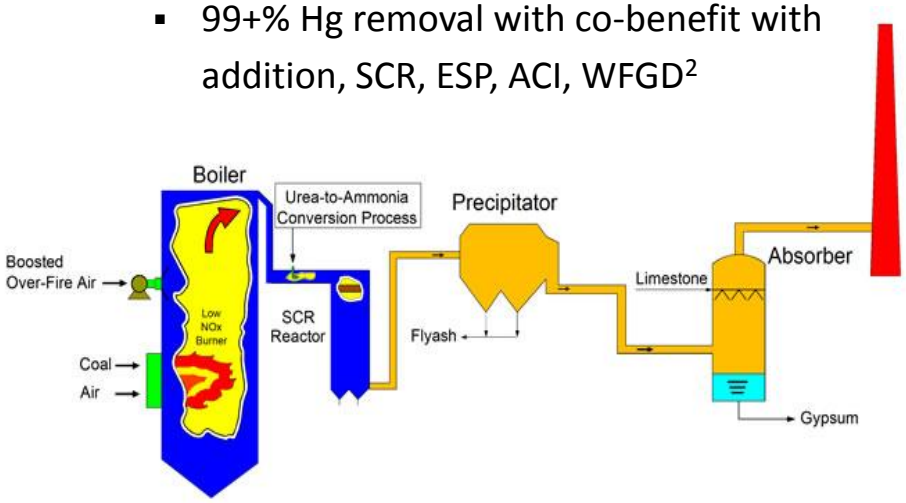



CaBr – Effective and Efficient

Emissions Control (Mercury) - GeoBrom®

- Added to coal in the boiler to oxidize mercury in the combustion zone for downstream capture in WFGD or on particulate in ESP, Fabric Filter
  - $Hg^0 \rightarrow Hg^{+2}$
- Technology developed – intellectual property
  - Chem Mod
  - Nalco Ecolab
  - Dr. Bernhard Vosteen
- Survey of 70 Units by EPRI[1]
  - 37 Section 45 Refined Coal Tax Credit - US
  - 16 U.S. state regulation compliance
  - 3 Section 45 and U.S. state regulation compliance
  - 14 test units – parametric testing
  - Various configurations of air pollution control devices

- Improve co-benefit of existing APC devices – improve SCR ability to oxidize mercury
- Operating and capital cost efficient process
- Typically effective for high mercury, low halogen coals (e.g., U.S. Powder River Basin)
- 94% Hg removal co-benefit with addition, SCR, ESP, WFGD[2]
- 99+% Hg removal with co-benefit with addition, SCR, ESP, ACI, WFGD[2]



[1] Dombrowski, Katherine (URS), Arambasick, Katie (URS), Srinivasan, Nanda, (EPRI). "Bromine Balance of Plant Study." Air Quality Conference IX. Washington, D.C. October 2013.

[2] Van Otten, Brydger, Adams, Bradley (Reaction Engineering International). "Evaluation of Mercury Control Strategies in the Presence of SO^3 Using the MerSim™ Model." McIlvaine Hot Topic Webinar. February 27, 2014.

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Benefits of using CaBr – Support of Technologies

- Longer life of SCR catalyst – provide buffer if SCR used for oxidation (avoid catalyst depletion)
- Reduce requirements for carbon – additional bromide for oxidation
  - Lower operating costs
  - Reduced risk of impact to fly ash for sales
  - Option vs. halogenated carbon – two levers to adjust for operations
  - Reduced cost potential for units with particulate control devices at capacity
- Assist with co-benefit technologies to allow for oxidation
- Allows for adjustment due to fuel blending variations, load adjustments, and other operational variables
- Make use of unburned carbon (LOI) in fly ash that exists for baseline capture
- Provide general buffer for meeting MATS limits in plants that operate close to compliance requirements

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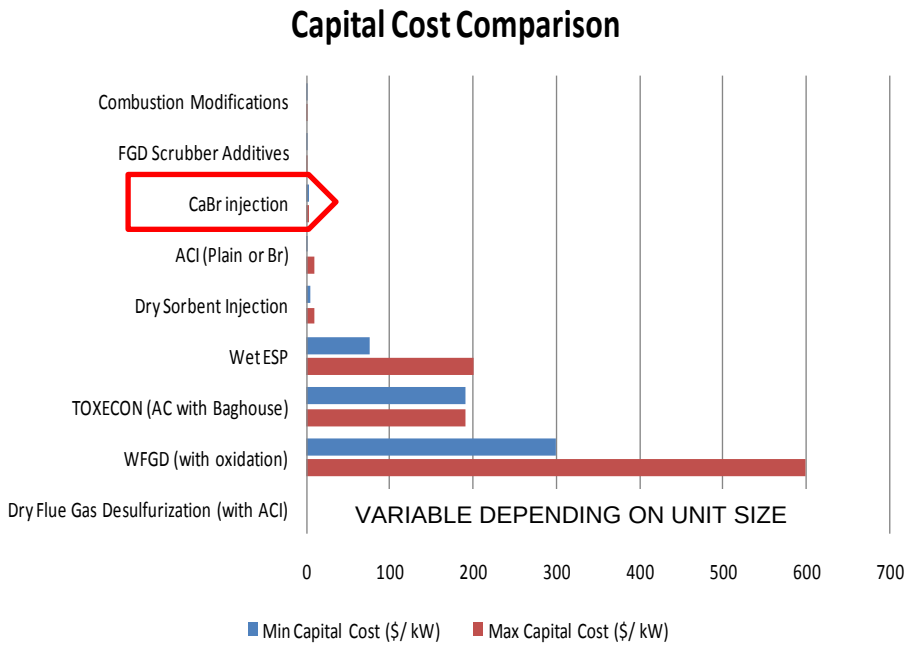
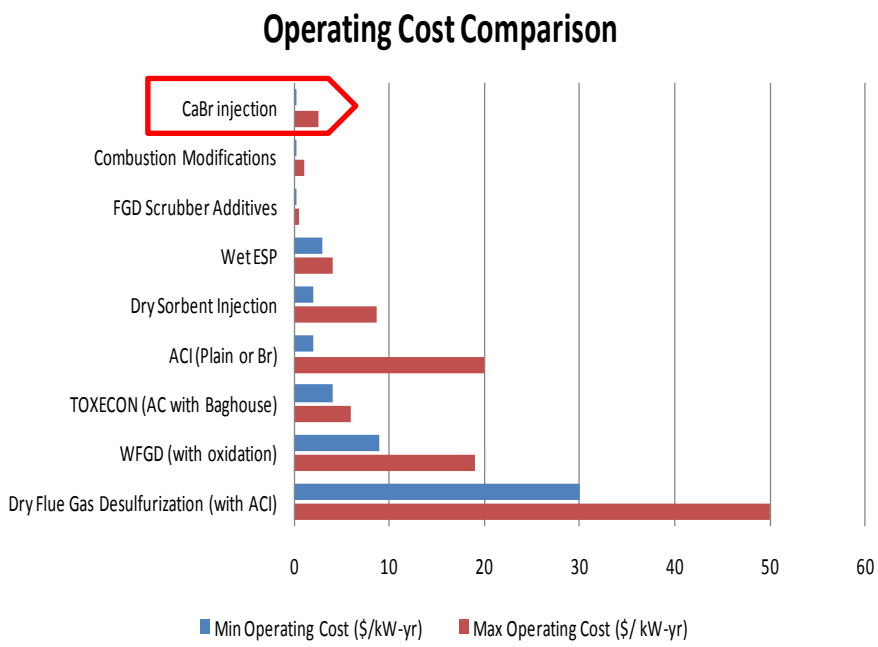
Cost of Use and Capital for Associated Mercury Control





Source: Assessment of Technology Options for Available to Achieve Reductions of Hazardous Air Pollutants, URS Corporation, April 5, 2011

- Bromine technologies - operating and capital cost competitive
- Scrubbers are high capital, but co-benefit with other mercury control technologies
- Wide range of operating costs for ACI due to range of injection rates

Brominated Products Demonstrated and Proven Cost Efficient and Cost Competitive

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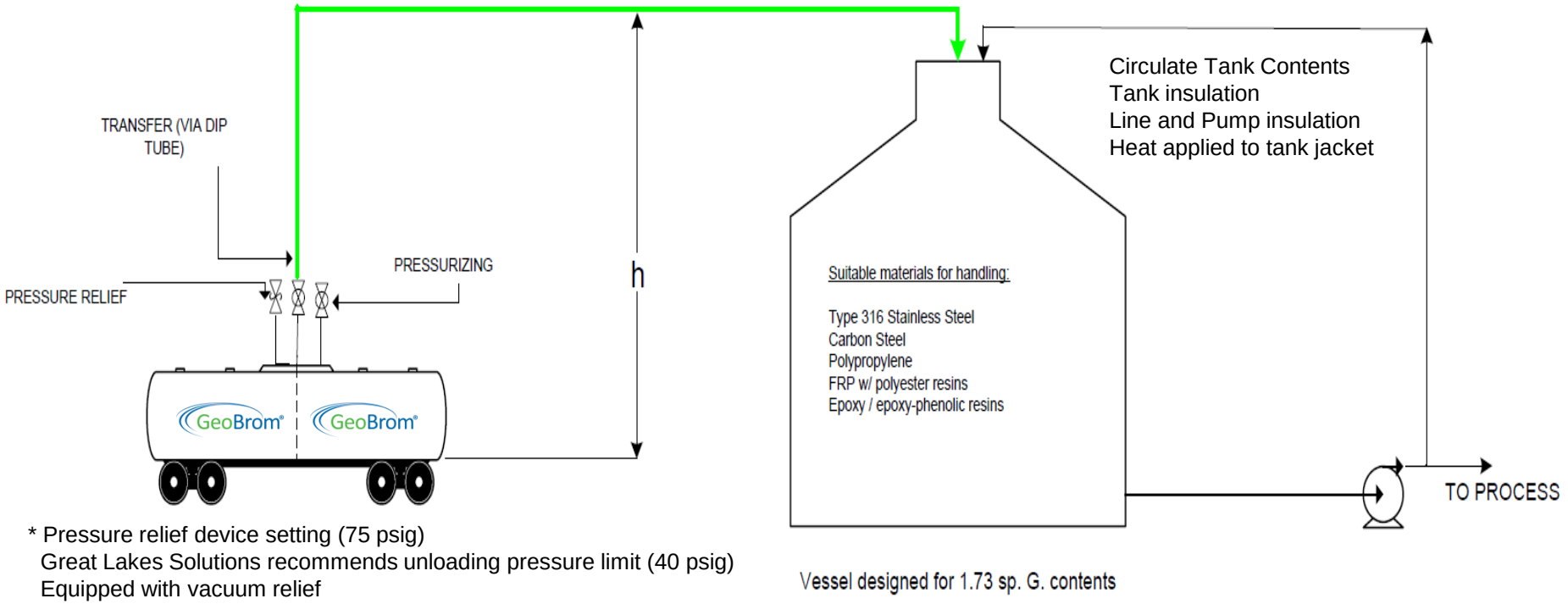
GeoBrom® Storage System – Simple and Available

*Follow all equipment manufacturer recommendations



* 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 = specific weight X height = 106.2 lb_f / cu ft X h
  i.e. height of 20ft p = 2,124 lb/ sq ft or 14.8 psig

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