Taconite Industry Mercury Reduction Overview

Annual Statewide Mercury TMDL Implementation Plan Oversight Committee Meeting

October 1, 2019
Meeting Agenda

- Background on Minnesota Mercury TMDL and Rule
- History of Taconite Mercury Reduction Research
- Technology Evaluation Process
- Summary
Background on Minnesota Statewide Mercury TMDL and Rulemaking
Background on Hg TMDL and Rulemaking—
Mercury Source Contributions

• “Mercury can be carried great distances on wind currents before it is brought down to earth in rain and snow. As a result, about 90% of the mercury deposited on Minnesota comes from other states and countries.”

Source: MPCA Mercury Source Summary Publication, p-p2s4-06, February 2013
Reference – Interaction Needed with EPA and States to meet TMDL Target - From Section 4.6 of the 2009 TMDL Implementation Plan

Reference – Minnesota TMDL Reduction Targets Based on Achieved National Emission Reductions – From Section 11.4.2 of the 2007 TMDL
Background on Hg TMDL and Rulemaking – Mercury Emissions Reduction Target

- **Pre-TMDL Voluntary Reductions:**
  - 2,901 lb of mercury in devices removed from taconite plants between 1990 and 2005
  - 2009 TMDL Implementation Plan goal for the statewide category of “Sale, Use & Disposal of Mercury-containing Products” was to reduce emissions by 88 lbs.

- **MPCA TMDL (2007) and TMDL Implementation Plan (2009):**
  - Voluntary collaboration with stakeholders
  - Research and testing of potential technologies
  - The 2007 TMDL goal of “achieving the 75% mercury reduction target will incorporate the concept of Adaptive Management.” The technology must:
    - “be technically and economically feasible;”
    - “not impair pellet quality;” and
    - “not cause excessive corrosion to pellet furnaces and associated ducting and emission-control equipment”

- **Minnesota Mercury Air Emission Reduction and Reporting Rules (2014)**
  - By 12/31/2018, taconite facilities are required to evaluate Hg reduction technologies capable of achieving a 72% reduction by 1/1/25. If no technology exists, the facilities may submit an alternative reduction plan.
  - Evaluations incorporated the concept of Adaptive Management:
    - “The MPCA and its stakeholders have always viewed the strategy as objectives or criteria for the companies when making decisions in the development of control technologies; that as research continues and as technology improves, each decision will evaluate whether the technology meets the companies objectives related to cost, pellet quality, and the potential for furnace corrosion.”

  Source: MPCA Response to Comments on Mercury Rule (7/14/14)
History of Mercury Reduction Research and Testing
1. Pre-TMDL Implementation Plan DNR Research (Pre-TMDL research), 1997 - 2009
2. Phase I – Minnesota Taconite Mercury Control Advisory Committee (Phase I), 2009 - 2012
3. Phase II – Extended Testing of ACI (Phase II), 2013
5. Site-specific Pilot Testing and Evaluations, 2016 – 2018
## History of Research – 1. Pre-TMDL Implementation Research

<table>
<thead>
<tr>
<th>Date Tested</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>1997</td>
<td>Mercury Emissions from Taconite Pellet Production</td>
</tr>
<tr>
<td>2001</td>
<td>Mercury Removal from Induration Off Gas by Wet Scrubbers</td>
</tr>
<tr>
<td>2003</td>
<td>Distribution of Mercury in Taconite Plant Scrubber Systems</td>
</tr>
<tr>
<td>2004</td>
<td>Mercury Capture at Taconite Processing Facilities</td>
</tr>
<tr>
<td>2003</td>
<td>Mercury Release from Taconite Processing</td>
</tr>
<tr>
<td>2005</td>
<td>Mercury Transport in Induration Furnaces</td>
</tr>
<tr>
<td>2005</td>
<td>Mercury Vaporization Characteristics of Taconite Pellets</td>
</tr>
<tr>
<td>2005</td>
<td>Mercury Chemistry of Iron Oxides during Taconite Processing</td>
</tr>
<tr>
<td>2005</td>
<td>Fate of Mercury Captured by Wet Scrubber</td>
</tr>
<tr>
<td>2006</td>
<td>Mercury Oxidation by NaCl Addition to Greenball</td>
</tr>
<tr>
<td>2007</td>
<td>Mercury Oxidation by Focused Halide Injection</td>
</tr>
<tr>
<td>2007</td>
<td>In-Scrubber Mercury Oxidation</td>
</tr>
<tr>
<td>2007</td>
<td>Mercury Separation from Scrubber Solids</td>
</tr>
<tr>
<td>2008</td>
<td>High Energy Dissociation Technology (HEDT) for Mercury Oxidation and Capture</td>
</tr>
<tr>
<td>2009</td>
<td>Demonstration of Mercury Capture in Fixed Bed</td>
</tr>
<tr>
<td>2009</td>
<td>Assessment of Potential Corrosion Induced by Bromine Species</td>
</tr>
<tr>
<td>2007-2009</td>
<td>Mercury Control from Bromine Injection into Taconite Induration Furnaces</td>
</tr>
</tbody>
</table>
Minnesota Taconite Mercury Control Advisory Committee (MTMCAC) formed in 2009

- industry, state, and academic technical experts

Funded by six taconite facilities, MN DNR Environmental Cooperative Research Program (ECR), and the US Environmental Protection Agency - Great Lakes Restoration Initiative (EPA-GLRI)

MTMCAC selected six projects for evaluation

- Focused on testing of activated and brominated carbon sorbents

Research conducted between 2010 and 2012
## History of Research – 2. Phase I - Technology Screening

<table>
<thead>
<tr>
<th>Project Number</th>
<th>Technology Tested or Project Description</th>
<th>Testing Contractor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1*</td>
<td>Activated carbon injection and scrubber additives</td>
<td>University of North Dakota</td>
</tr>
<tr>
<td>2</td>
<td>Activated carbon injection</td>
<td>Albemarle</td>
</tr>
<tr>
<td>3</td>
<td>Fixed activated carbon beds</td>
<td>ADA - Environmental Solutions</td>
</tr>
<tr>
<td>4*</td>
<td>Activated carbon injection with a baghouse</td>
<td>Energy &amp; Environmental Research Center</td>
</tr>
<tr>
<td>5</td>
<td>Activated carbon addition to greenballs</td>
<td>University of North Dakota</td>
</tr>
<tr>
<td>6</td>
<td>Corrosion potential of bromide injection</td>
<td>Energy &amp; Environmental Research Center</td>
</tr>
</tbody>
</table>

* Results from these tests were the most promising and were further evaluated
3. Phase II - Extended Testing of ACI

- Phase II on-site testing began in October 2012 and was funded by the 6 taconite facilities.
- Some mercury reduction observed with ACI, but did not consistently meet the 72% reduction objective.
- Increased particulate-bound mercury emissions were observed, i.e. potential for increased local deposition.
  - “Ultimately, the M30B method results show that ACI reduces gaseous mercury but that a substantial amount of particle bound mercury is formed during ACI injection and some of this particulate fraction escapes the wet scrubber and is emitted at the stack.”
  - “Despite the four criticisms mentioned above, the reports do provide relatively strong evidence that the re-emission of particulate bound mercury is a pervasive issue that must be solved before brominated activated carbon injection methods can be considered suitable for the taconite industry.”

Reference: 10/31/14 Letter from Michael Berndt, MNDNR, to Hongming Jian, MPCA, re: Review of Phase II Hg Control Reports.

- Although no facility exceeded particulate matter (PM) limits, significantly higher PM emissions were observed.
History of Research –

4. GORE™
Extended in-plant testing occurred for 1-3 months at
- ArcelorMittal Minorca
- United Taconite
- U. S. Steel Minntac

Some mercury reductions occurred, but varied significantly

Mercury reduction efficiency decreases with decreasing $SO_2$ concentrations, i.e. when utilizing natural gas instead of coal.

The facilities observed increased differential pressure and plugging in the air handling ducts and scrubbers (similar to testing at Xcel Sherco). May require additional membrane washing.

The membrane washwater contained high levels of sulfate and mercury and would require additional wastewater treatment systems.
5. Site Specific Testing and Gap Filling

- The taconite facilities conducted additional site-specific testing of ACI, halide injection, and scrubber solids removal.

- Testing was conducted to gather additional data for facilities to finalize their Mercury Reduction Plan evaluations including:
  - Hg removal rates,
  - Technical feasibility,
  - Adverse environmental impacts, and
  - Corrosion effects.

- Testing included refined data collection and stack testing methodology.
Mercury Reduction Plan Evaluations

Best Available Mercury Reduction Technology
The operating taconite facilities conducted an evaluation of potential mercury control technologies (control equipment, processes, materials or work practice standards) to determine if a 72% mercury reduction is technically achievable.

Similar process as other regulatory technology evaluations:
- Best Available Retrofit Technology (BART) analysis - utilized by EPA and MPCA
- Best Available Control Technology (BACT) analysis – utilized by EPA and MPCA
- Mercury Best Available Control Technology (MBACT) analysis, utilized by Idaho

Incorporated adaptive management criteria as included in 2009 TMDL Implementation Plan and 2014 Mercury Rule development.
- the control technology must be technically feasible;
- it must be economically feasible;
- it must not impair pellet quality; and
- it must not cause excessive corrosion to pellet furnaces or associated ducting or emission control equipment
# Mercury Reduction Plan - Potential Control Technologies Evaluated

<table>
<thead>
<tr>
<th>Control Technology</th>
<th>Basis of Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mercury Capture by Wet Scrubber and Solids Disposal</td>
<td>Oxidized mercury can be captured in wet scrubbers. To prevent captured mercury from re-entering the system, the scrubber solids need to be disposed.</td>
</tr>
<tr>
<td>Mercury Oxidation for Capture by Wet Scrubber</td>
<td>Halide injection increases mercury oxidation and subsequent capture.</td>
</tr>
<tr>
<td><strong>Halide Injection</strong></td>
<td>Generation of reactive halogens at high temperatures outside of the process prior to injection downstream of the furnace, which aid in mercury oxidation and subsequent capture.</td>
</tr>
<tr>
<td>High Energy Dissociation Technology (HEDT)</td>
<td></td>
</tr>
<tr>
<td>Activated Carbon Injection</td>
<td>Injection of powdered activated carbon (PAC) adsorbs mercury and is then removed by particulate control equipment. Several injection locations and PAC types, including brominated PAC (which also aids mercury oxidation), have been tested.</td>
</tr>
<tr>
<td>Fixed Bed Carbon Adsorption</td>
<td>Flue gas from the wet scrubber is routed through a carbon bed which adsorbs the mercury.</td>
</tr>
<tr>
<td>GORE™</td>
<td>GORE™ technology is a fixed sorbent polymer composite, which doesn’t require injection of powder sorbents or chemicals, capturing both elemental and oxidized mercury in particulate and gas phase.</td>
</tr>
</tbody>
</table>
Mercury Reduction Plan - Best Available Mercury Reduction Technology

- Step 1 – List potentially available control technologies
- Step 2 – Is the technology commercially available?
- Step 3 – Does the technology operate without impairing pellet quality or production?
- Step 4 – Does the technology cause excessive corrosion to pellet furnaces, associated ducting or emission control equipment?
- Step 5 – Does the technology present unacceptable environmental impacts?
- Step 6 – Can the technology consistently meet the 72% reduction per the rule?
- Step 7 – Is the technology cost effective?
- Step 8 – Determine BAMRT
- Step 9 – If Steps 1-7 are not satisfied, conduct Alternative Mercury Emissions Reduction evaluation
Sources of Hg in Mn

• 90% of Hg deposition in Minnesota originates from international and out-of-state sources
• 10% of Hg deposition from Minnesota sources, with Taconite contributing approx. 2%
• Taconite furnaces emit primarily elemental Hg which does not deposit locally

Hg – R&D

• Taconite R&D efforts on-going since 1997
• Millions of Taconite dollars invested in R&D as well as thousands of staff hours
• Detailed engineering evaluations performed using EPA BACT/BART-like top-down analysis

Results

• Each Taconite facility submitted detailed reports in December 2018 (~1,400 pages each)
• 72% reduction via control technology is not technically achievable
• Some incremental reductions are feasible (e.g., NSM 72% red.; scrubber solids removal at Minorca)

Context

• Taconite furnaces are unique and not comparable to EGUs
• Indurating furnaces have a high volume of hot gases with low concentrations of Hg
• Reduction technology using ACI or oxidizing chemicals in scrubbers would cause adverse environmental impacts through local deposition
• Reducing mercury emissions must be addressed on a national and global level. Even if Hg emissions from all Minnesota sources were eliminated, the TMDL goal (remove Hg impairments from MN waters) would not be achieved
Conclusion