

**MINNESOTA POWER PROGRESS REPORT ON OUR
MERCURY VOLUNTARY AGREEMENT
SUBMITTED TO THE MINNESOTA POLLUTION CONTROL AGENCY
JANUARY 24, 2003**

1. INTRODUCTION

Minnesota Power ("MP") supports the Minnesota Mercury Contamination Reduction Initiative, and the Advisory Council recommendations that culminated from that effort. One recommendation of the Advisory Council was for mercury sources to enter into voluntary agreements with the Minnesota Pollution Control Agency ("MPCA") that detail action items to reduce or work towards reducing mercury releases. MP submitted a Mercury Voluntary Agreement to the MPCA on July 6, 2000 that described our commitment to explore additional opportunities to further reduce mercury. MP submitted a progress report on August 15, 2001. MP submits this second progress report to outline the activities that have been implemented since the previous report, and any additional activities that are planned for the future or are being evaluated at this time.

For many years, MP has had a mercury reduction program. MP has been and continues to be actively involved in trying to develop solutions to the mercury issue. Past activities include such things as voluntary emissions testing and environmental monitoring, co-sponsoring mercury control technology studies, and various mercury product and waste management programs for MP and our customers. These activities are summarized in more detail in the Mercury Voluntary Agreement document referenced above.

2. EFFORTS TO ADDRESS STACK MERCURY EMISSIONS

Efforts that MP has undertaken over the past year to address stack emissions of mercury are summarized below. These efforts focused on control technology research aimed at finding solutions for longer-term, more significant mercury emission reductions while continuing to achieve feasible short-term emission reductions.

2.1 Control Technology Research

2.1.1 Laskin Control Technology Study

As described in the August 2001 progress report, MP worked with EPRI (formerly the Electric Power Research Institute) in the year 2000 to assess mercury emissions from our Boswell Energy Center ("Boswell") and conduct control technology experiments. The objectives of the study were to evaluate flue gas mercury concentration, mercury speciation, and removal effectiveness for the existing air pollution control equipment at Boswell, assess potential options to further reduce stack mercury emissions to different levels, and project feasibility and cost impacts.

As a follow up to our work at Boswell, MP partnered with Xcel Energy, EPRI, Apogee Scientific and URS to conduct full scale mercury control technology studies at our Laskin Energy Center ("Laskin"). These studies consisted of three phases, including chemical additives/fuel blending, activated carbon injection, and Mercury Capture by

Amalgamation Processes (“MerCAP™”). Our initiatives are some of the first actual, full-scale mercury control efforts in the nation.

2.1.1.1 Chemical Additives/Fuel Blending

It is known that the speciation of mercury in flue gas affects the ability of scrubbers to remove mercury. Oxidized mercury has been assumed to be water soluble, and scrubbers tend to be effective at removing oxidized mercury. Elemental mercury, on the other hand, is insoluble and is not readily removed by wet scrubbers. It is also known that the form of mercury depends to a degree on the chloride content of the coal. Bituminous coals tend to have higher chloride content, and the mercury tends to be primarily in the oxidized form. Sub-bituminous coals, on the other hand, tend to be quite low in chloride content and the mercury is primarily in the elemental form. MP facilities burn primarily low sulfur, low mercury sub-bituminous coals as a compliance coal for SO₂ emissions. The purpose of this study was to evaluate the effect of adding chloride to sub-bituminous coal, either through chemical addition or blending with bituminous coal, on the mercury speciation and subsequent capture by the existing scrubber. The studies were conducted in May 2002.

The chemical additives study, conducted on Unit 2 at Laskin, consisted of adding chloride compounds at varying rates to the coal feed. Two different chloride compounds were tested. Tests were designed to evaluate the effect of chloride source as well as feed rate on mercury speciation and capture. Most tests were conducted over a 24-hour period, with the whole study lasting approximately two weeks. Speciated mercury measurements were made using EPRI’s semi-continuous mercury analyzers both before and after the wet scrubber, to assess the amount of formation of oxidized mercury, and capture across the scrubber. Support data were also collected (e.g., trace metals, hydrogen chloride, and plant operation data).

Preliminary results indicate that the addition of chloride compounds have the potential to increase the oxidation of mercury, and subsequent capture, although the results are mixed. Under baseline conditions, the oxidized mercury fraction averaged approximately ten percent at the inlet to the scrubber, with approximately eight percent total mercury removal across the scrubber. Mercury oxidation in the flue gas generally increased as the chloride compound feed rate increased. Addition of chloride compound #1 resulted in over 80% oxidation at the highest feed rate. However, with this particular chloride compound, there was no apparent increase in mercury capture with the increase in mercury oxidation. Addition of chloride compound #2 resulted in up to 50% oxidation, with over 30% mercury capture at the highest feed rate. These results indicate that the type of chloride compound may impact the ability of the wet scrubber to remove the oxidized mercury.

Significant operational impacts were observed during the testing. Opacity tended to increase with increased chloride compound feed rate. Hydrogen chloride (“HCl”) in the flue gas increased with increased chloride compound addition, although the wet scrubber was effective at removing most of the added HCl. This increased the chloride concentration in the scrubber liquor. It is not known what impact this increase in chloride

would have on operations over the long term. Another unknown is whether addition of chloride, with subsequent formation of HCl in the flue gas, would result in significant corrosion impacts in the boiler. Long term testing would be needed to be able to assess this issue.

In addition to the chloride compound addition study, MP looked at blending bituminous coal with sub-bituminous as a way to increase chloride content. Three fuel blends were assessed, 33%, 67%, and 100% bituminous coal. Tests were run for approximately 36 hours, with time in between to allow for conditions to return to baseline. Mercury oxidation at the inlet to the scrubber increased with increased bituminous coal fractions. At 100% bituminous, the mercury speciation was approximately 60% oxidized mercury, with approximately 30% removal across the scrubber. However, at the 33% and 67% blends, even though there was significant mercury oxidation, test results indicate negative removal across the scrubber. These unusual results are still being evaluated. There are some indications from this and tests at other sites that not all oxidized mercury species formed can be removed in a scrubber, or some scrubbed mercury species may be re-emitted. Operational impacts included a ceramic type buildup in the bottom of the boiler, which required an outage to remove.

To summarize, the results of the chemical additives and fuel blending study indicate that addition of chloride, through either chloride compound addition or blending with higher chloride bituminous coal, may result in an increase in mercury oxidation and subsequent removal across the wet scrubber. However, there are significant operational issues that would need to be addressed.

2.1.1.2 Activated Carbon Injection

Activated carbon injection (“ACI”) upstream of baghouses and electrostatic precipitators is currently the most promising control option for mercury removal from flue gas. However, no data existed for the effectiveness of ACI before a wet scrubber. The purpose of this series of tests was to evaluate the effectiveness of ACI in conjunction with a wet particulate scrubber. Parametric testing was conducted with four activated carbons. An extended injection test was also conducted with one of the carbons. Semi-continuous mercury measurements were made both upstream and downstream of the scrubber. The full scale testing was conducted at Laskin Unit 2 over an 8-day period in August 2002.

Preliminary results indicate that for three of the carbons tested, mercury removal was relatively poor (<15 percent mercury removal). However, for the activated carbon treated with iodine (a much more expensive type of activated carbon), the results were more promising, at the highest injection rate mercury removal across the scrubber was greater than 50 percent during the short-term test. The results of this phase of the study are still being evaluated.

2.1.1.3 MerCAP™

MerCAP™ is a novel technology that uses plates coated with thin layers of gold materials to capture mercury in the flue gas. This technology has shown promise when

applied to low dust conditions (located after the primary particulate removal device). However, this technology may not be compatible with a wet particulate scrubber due to the wet flue gas conditions typically found after the scrubber (previous results from the Boswell Unit 3 study, where MerCAP™ was installed after the scrubber, were not promising). The purpose of this test was to evaluate the effectiveness of MerCAP™ under high dust conditions (prior to the scrubber).

A preliminary screening test indicated some removal (approximately 37 percent). However, initial testing with a 10-foot probe inserted in the duct upstream of the scrubber indicated poor removal (< 20 percent). The results from longer term testing with the probe are still being evaluated.

2.1.2 EnviroScrub

EnviroScrub is a proprietary process that has been shown to be very effective at removing SO₂ and NO_x from utility flue gas, based on a demonstration unit tested extensively at our Boswell Energy Center and elsewhere. MP worked with EnviroScrub to also test the effectiveness of the process for mercury removal from flue gas. Preliminary tests are promising. A proposal has been submitted to the Department of Energy to scale up the technology, likely at Boswell. If the proposal gets funded, mercury testing will be included as a part of the project.

2.1.3 Mercury Removal Research and Demonstration Project

In late 2001, the Natural Resources Research Institute (“NRRRI”) Coleraine Minerals Research Laboratory (“CMRL”) was awarded a three-year, \$1.2 million grant for mercury removal research from industrial stack gases. The primary focus of this project is to develop a low cost, mineral based sorbent system to remove all forms of mercury from industrial stack gases. Minnesota Power offered our Boswell Energy Center as a host site for conducting relevant portions of the research and demonstration project. A Right of Entry Agreement between MP and NRRRI/CMRL allows the researchers to install mercury removal equipment and implement technologies utilizing a slipstream of flue gas from one of the operating units at Boswell. This option allows for a unique opportunity to test several promising mercury reduction alternatives under actual power plant conditions. In addition to providing the testing locations, MP will provide plant services, including technical support, as needed.

Work so far has focused on getting the analytical and gas sampling system installed and operating as well as completing the installation of a bench-scale, flue gas simulator system. NRRRI/CMRL has recently begun to test various sorbents with the simulated gas stream.

NRRRI/CMRL has also signed a non-disclosure agreement with MP and EnviroScrub to look at ways to develop and test mercury removal techniques in conjunction with EnviroScrub’s system for SO₂ and NO_x removal.

Future Planned Activities: Testing of the various sorbents using a slip-stream of actual flue gas at Boswell is anticipated to begin in the second quarter of 2003. In the

meantime, screening tests of various sorbents at the bench scale with simulated flue gas will continue to be conducted in the lab. Longer-term plans call for construction and installation of a larger pilot-scale mercury removal system at Boswell.

2.1.4 EERC Mercury Control Technology Study

MP is a co-sponsor of a 3-year, two-phase project to develop and demonstrate mercury control technologies for utilities that burn lignite coal, which is being conducted by the Energy and Environmental Research Center (“EERC”). The objectives of Phase I (currently underway) are to gain a better understanding of mercury interactions with flue gas constituents, test sorbent-based technologies targeted at removal of elemental mercury, and do pilot scale demonstrations of the most promising technologies. The objective of Phase II will be to quantify sorbent effectiveness, performance and cost at an actual lignite-fired power plant.

2.1.5 Ash Leachability Study

One of the outstanding issues that needs to be further assessed, is whether mercury which is captured in pollution control devices is stable in the by-product. MP has volunteered to participate in a study to assess the leachability and volatility of mercury from the by-product using standard leaching tests. We will provide coal and ash in the near future from Boswell unit 1 or 2, both of which have baghouses that demonstrate good mercury capture.

2.1.6 Research Support

MP continues to support additional mercury control technology research as a funding member of the Integrated Controls Target of EPRI.

2.2 Utilization of Lower Mercury Coal

One aspect of our short-term strategy is to consider mercury coal content when making coal procurement decisions. Characterization of coals for mercury content indicates that coal switching is not likely to be a viable means to achieve significant, long-term reductions in mercury emissions. However, as described in our August 2001 progress report, MP was able to take advantage of an opportunity to achieve modest mercury reductions in the short term through our choices in coal supply. Through coal blending, MP was able to achieve roughly a fifteen to twenty percent reduction in mercury emissions beginning in 2000. These reductions were demonstrated through stack testing, and verified through coal mercury analysis.

Many factors are considered when making coal procurement decisions, including price, availability, transportation costs, sulfur content, ash, Btu content, and other parameters which may impact operations. As part of our Voluntary Agreement with the MPCA, MP has committed to including coal mercury content as one parameter to consider in making coal procurement decisions, now and into the future.

Future Planned Activities: MP intends to continue burning the lower mercury coal in amounts comparable to the year 2000. MP will also continue to consider mercury along

with other environmental and operational factors when making coal supply decisions in the future.

2.3 Routine Coal Mercury Monitoring

MP participated in the 1999 EPA Information Collection Request (ICR), where we gathered numerous coal samples representing shipments from the various coal providers throughout the year for mercury analysis. Since then, MP has voluntarily monitored coal mercury content on a routine basis to determine if there are any changes in coal mercury content over time from the various suppliers. Two samples from each coal supplier have been collected and analyzed on a quarterly basis beginning in March 2000. However, coal mercury analysis was suspended in mid-2002 due to changes in coal sampling procedures. The coal analysis shows the same relative mercury concentrations of the various coals we burn as we saw in the ICR data.

MP also conducts coal mercury analysis from potential new coal sources to aid in future decisions on coal procurement.

Future Planned Activities: There are currently no plans to continue coal analysis for mercury due to the changes in coal sampling mentioned above. However, a review will be conducted in late 2003 to determine whether it makes sense to resume coal sample analysis for mercury, and if so, how the sampling protocol can be designed to ensure the samples are representative of the coal that we actually burn. MP will continue to include mercury on the list of parameters to test for when assessing potential new coal sources.

3. EFFORTS TO ADDRESS MERCURY IN PRODUCTS

In our August 2000 report, we summarized several efforts that MP undertook as part of our commitment to address mercury in products. These activities included a product use inventory and labeling at Boswell and Laskin, updating the MP purchase policy for mercury-containing products, and an employee mercury thermometer exchange. Since then, MP has continued to remove bulk mercury and mercury containing products from within company facilities for proper disposal.

3.1 Mercury Waste Management

In late 2000, MP purchased the Taconite Harbor Energy Center. As part of a facility cleanup following our purchase, we collected and recycled approximately 31 pounds of elemental mercury. From our other facilities, MP also recycled over 50 pounds of bulk mercury in 2002. In addition, MP recycled over 265 pounds of mercury-containing materials in 2002, including thermometers, wetted contacts, batteries, floats, and other devices. Much of the bulk mercury and mercury-containing devices were removed from our Hibbard Energy Center, where a concerted effort was initiated to remove all mercury and mercury devices that were not essential.

Future Planned Activities: MP will continue to implement our mercury policy, responsibly remove and recycle unwanted mercury, and evaluate ways that we can further reduce our dependence on mercury containing products.

3.2 Community Education and Waste Management Program Evaluation

Through the St. Louis River Watershed TMDL Partnership, MP is participating in a WLSSD grant for developing educational materials on mercury sources and identifying gaps in mercury collection efforts in the Lake Superior Basin. Also, MP is on the planning committee of the Lake Superior Binational Forum, developing a workshop for 2003 on mercury sources and potential reduction efforts

Future Planned Activities: MP will continue to be involved in these activities. The information gathered might be useful in determining where MP could assist the public in furthering mercury reduction efforts.

4. RELATED RESEARCH AND INVENTORY ACTIVITIES

Summarized below are activities that MP has participated in that will not in and of themselves directly result in mercury reductions. However, these activities will enhance the understanding of the sources, cycling, and fate of mercury in Minnesota.

4.1 Fish Tissue Monitoring

As described in our 2001 progress report, MP has voluntarily conducted fish tissue monitoring for mercury over the past several years on the headwater reservoirs of the St. Louis River watershed.

Future Planned Activities: MP will continue to conduct fish tissue monitoring on our reservoirs.

4.2 Mercury Watershed Assessment Model Development

MP has been spearheading an effort to develop a watershed assessment model to be able to integrate point and non-point source data (including atmospheric deposition) related to water quality standards. The focus of the effort at this time is to take the Watershed Analysis Risk Management Framework (“WARMF”) model, created by EPRI, and customize it for addressing mercury sources to the Lake Superior watershed. MP has pulled together a wide range of sponsors, including the Western Lake Superior Sanitary District, Minnesota Sea Grant, City of Superior, St. Louis River Watershed TMDL Partnership, and other interested parties. Efforts are also underway to incorporate the education program NEMO so that local communities, stakeholders, and other regulatory agencies can readily use the model results to make informed land use decisions regarding mercury. Information developed and provided in this manner will be useful to state and local governments and others involved in management and protection of watershed resources and compliance with water quality criteria for mercury. The model is currently being customized for mercury, and relevant data for populating it for the Lake Superior watershed is being pulled together.

Future Planned Activities: MP will continue to work with others to broaden the participation in this effort. Also, there are plans to have the current version of the model customized for mercury to be peer reviewed.