Long-Term Carbon Injection Field Test for >90% Mercury Removal for a PRB Unit with a Spray Dryer and Fabric Filter

Quarterly Progress Report
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EXECUTIVE SUMMARY

The power industry in the U.S. is faced with meeting new regulations to reduce the emissions of mercury compounds from coal-fired plants. Injecting a sorbent such as powdered activated carbon into the flue gas represents one of the simplest and most mature approaches to controlling mercury emissions from coal-fired boilers. The purpose of this test program is to evaluate the long-term mercury removal capability, long-term mercury emissions variability, and O&M costs associated with sorbent injection on a configuration being considered for many new plants. Testing will be conducted at Rocky Mountain Power's Hardin Station. The Hardin Station is a new and relatively small plant (116 MW) that was first brought on line in December of 2005. Hardin fires a PRB coal and is configured with an SCR for NO_x control, an SDA for SO_2 control, and a fabric filter for particulate control. Based upon previous testing at PRB sites with SCRs, very little additional mercury oxidation from the SCR is expected at Hardin. In addition, based upon results from DOE/NETL Phase II Round I testing at Holcomb Station and results from similarly configured sites, low native mercury removal is expected across the SDA + FF.

This project will use sorbent injection to economically and effectively achieve mercury control of at least 90% beyond baseline capture for a period of 10 to 12 months. A short-term evaluation that includes mercury removal enhancements associated with coal additives and blending with western bituminous coal is also included in the program. A commercial-grade activated carbon injection system will be installed at Hardin and integrated with a new-generation mercury analyzer to allow automatic feedback control on outlet mercury emissions. In addition to the mercury control target, this project will fill a data gap for this plant configuration: a unit firing PRB coal with an SCR, an SDA, and an FF.

This is the first Quarterly Progress Report for this project. This report includes an overview of the plans for the project and an overview of the progress to date. Field testing is scheduled to begin next quarter.

During the first reporting period, April through June 2006, progress on the project was made in the following areas:

- A site kickoff meeting was held at RMP Hardin for the test team.
- Duct inspection, measurement, and injection port installation.
- Compiled material list to achieve testing goals.
- Signed Cooperative Agreement with DOE/NETL.
- Signed Host Site Agreement with RMP and Hardin Station.
- Test Plan and Quality Assurance Plan drafts reviewed by ADA-ES and RMP.
- Issued purchase order for two Thermo Electron Mercury analyzers.
- Identified a suitable commercial-grade silo for use during testing.
- Identifying goals of co-benefit testing with RMP.

INTRODUCTION

This project will use sorbent injection to effectively achieve mercury control of at least 90% beyond baseline capture for a period of 10 to 12 months. A short-term evaluation that includes mercury removal enhancements associated with coal additives and blending with western bituminous coal is also included in the program. A commercial-grade activated carbon injection system will be installed at Hardin and integrated with a new-generation mercury analyzer to allow automatic feedback control on outlet mercury emissions. In addition to the mercury control target, this project will fill a data gap for this plant configuration: a unit firing PRB coal with an SCR, an SDA, and an FF.

Table 1. Key Parameters of the Hardin Station.

Test Period	8/06–4/08
Unit	1
Size (MW)	116
Coal	PRB, Absaloka Mine
Particulate Control	Fabric Filter
Gas Flow Rate, full load (acfm) at injection location	~ 550,000
Sulfur Control	Spray Dryer with recycle
Ash Reuse	Disposal
Test Portion (MWe)	116
Typical Inlet Mercury ($\mu g/dNm^3$)	10–12 (est.*)
Typical Native Mercury Removal	0–13% (est.*)

* *Stack measurement pending*

A detailed Technical Report will be prepared at the conclusion of this project for tests conducted at this test site. Quarterly Progress Reports will be used to provide project overviews, status, and technology transfer information.

APPROACH

Objectives

The purpose of this test program is to evaluate the long-term mercury removal capability, long-term mercury emissions variability, and O&M costs associated with sorbent injection on a configuration considered for many new plants. Testing will be conducted at Rocky Mountain Power's Hardin Station. Hardin fires a PRB coal and is configured with an SCR for NO_x control, an SDA for SO_2 control, and a fabric filter for particulate control. Based upon testing at PRB sites with SCRs, very little additional mercury oxidation is expected at Hardin. In addition, based upon results from DOE/NETL Phase II Round I testing at Holcomb Station and results from similarly configured sites, low native mercury removal is expected across the SDA + FF. This project will use sorbent injection to cost-effectively achieve mercury control of at least 90% beyond baseline capture for a period of 10 to 12 months. A short-term evaluation that includes mercury removal enhancements associated with coal additives and blending with western bituminous coal is also included in the program. A commercial-grade activated carbon injection system will be installed at Hardin and integrated with a new-generation mercury analyzer to allow automatic feedback control on outlet mercury emissions. In addition to the mercury control target, this project will fill a data gap for this plant configuration: a unit firing PRB coal with an SCR, an SDA, and an FF.

Scope of Work

To achieve the objectives stated above, ADA-ES will design and procure a mercury sorbent injection system and a mercury CEM system for installation at the Hardin Generating Station. This equipment, in conjunction with temporary field test equipment, will provide the means to conduct a series of co-benefit enhancements, baseline, and parametric tests to assess the potential for reducing mercury emissions by at least 90%. The co-benefits analysis will characterize the range of mercury removal achievable by varying the operation of the SCR and SDA and the effectiveness of coal additives to enhance mercury oxidation across the SCR and subsequent removal in the SDA + FF. During parametric testing, the effectiveness of sorbent injection for mercury control will be evaluated in conjunction with and without enhanced co-benefit mercury removal. Should a mercury control scheme be identified which satisfies the test objectives, DOE/NETL may approve an 11-month long-term test to establish steady-state operation and assess any maintenance and operational problems that may develop. Upon completion of the test phase of this project, ADA-ES will compose a comprehensive test report and participate in all required DOE/NETL functions, including technology transfer to the industry.

Tasks

The work plan will effectively accomplish the objectives and perform long-term testing at the optimum conditions. The program will be accomplished by following a series of technical tasks:

- Task 1. Site Coordination, Kickoff Meetings, Develop Test Plan and QA/QC Plan
- Task 2. Design, Procure, and Install Equipment
  - Task 2.1. System Design and Procurement
  - Task 2.2. Installation
- Task 3. Field Testing
  - Task 3.1. Baseline Tests
  - Task 3.2. Co-Benefits Analysis
  - Task 3.3. Parametric Tests
  - Task 3.4. Choose Long-Term Test Parameters
  - Task 3.5. Long-Term Test
- Task 4. Coal, Ash, and By-Product Sample Evaluation
- Task 5. Technology Transfer
- Task 6. Management and Reporting

The components of Task 3, the field-testing tasks, are the heart of the program where mercury controls are actually tested and operating experience is gained. A brief description of each task follows.

Task 1. Site Coordination, Kickoff Meetings, Develop Test Plan and QA/QC Plan

Efforts within this task include planning the tests with the host site, DOE/NETL and contributing team members. The planning process includes meeting with plant personnel, corporate, and environmental personnel to discuss and agree upon the overall scope of the program for the site, the potential impact on plant equipment and operation, and to gather preliminary information necessary to develop a detailed draft test plan and scope of work. Efforts include identifying any permit requirements, developing a QA/QC plan, identifying potential mercury sorbents and coal additives, finalizing the scope for each of the team members, and putting subcontracts in place for manual measurement services.

Task 2. Design, Procure, and Install Equipment

Task 2.1. System Design and Procurement

Some components are site-specific and, by necessity, will be designed for the host utility. These components must be sized and designed for the specific plant arrangements and ductwork configurations. Site-specific equipment includes the sorbent distribution manifold

and sorbent injectors. Required site support includes installation of the injection and sampling ports (if not available), installation of required platforms and scaffolding, compressed air, electrical power, wiring plant signals including boiler load to the injection skid and control trailer, and balance of plant engineering.

Task 2.2. Installation

A scope of work will be developed and installation responsibilities will be divided between ADA-ES and RMP.

Task 3. Field Testing

Field testing shall cover a period of 20 months, and shall include baseline measurements, analysis of SCR and SDA co-benefits and enhancement additives, parametric tests, and long-term tests. Performance will be measured by obtaining plant data, such as combustion parameters, back-end parameters, and CEMS data, and flue gas measurements, including real time and periodic mercury measurements and solids samples. Operating parameters to be evaluated will include, at a minimum, flow rates, temperatures, pressures, and emission levels.

The nature of all sorbents and chemical additives to be tested under this project shall be provided to the DOE Project Officer prior to testing. The proprietary nature of such data shall be protected by DOE/NETL. All sorbents and chemical additives must receive prior approval by the DOE Project Officer prior to being tested under this project.

Task 3.1. Baseline Tests

After installation of the mercury CEMS, a series of baseline tests will be conducted to establish the mercury removal during typical plant operating conditions. There shall be no injection of either mercury sorbent or other chemical additive.

Baseline measurements shall include one set of full suite of flue gas and solid sample measurements. These shall include SDA inlet and FF outlet mercury CEM measurements, particulate, halogens, and ammonia measurements. The accuracy of the mercury CEM will be verified during these tests with an appropriate reference method, such as the Ontario Hydro method. If a mercury CEM is approved as an instrumental reference method under 40 CFR Part 75.22 by the EPA Administrator, such instrumental method may be substituted for the Ontario Hydro measurements in this project with permission of DOE and team members.

Task 3.2. Co-Benefits Analysis

The first efforts to improve mercury capture shall be to evaluate potential changes to plant operating practices and additives to increase the effectiveness of the SCR to oxidize mercury and increase overall mercury removal through subsequent capture in the SDA and FF. A short series of tests will also be conducted to determine the potential of blending Western bituminous coal with PRB coal for enhanced mercury removal across the system. The mercury CEM will be the basis for all co-benefit test results.

Task 3.3. Parametric Tests

The goal of the parametric tests is to evaluate the best candidate sorbents under various operating conditions. Parametric tests occur at full scale by directly injecting the identified sorbent into the flue gas ductwork upstream of the SDA. Parameters to be varied include:

- Mercury sorbents
- Mercury sorbent injection concentrations
- Unit combustion parameters
- Co-benefits enhancement additives

The mercury CEM system will be the basis for all parametric test results.

Task 3.4. Choose Long-Term Test Parameters

Upon completion of the parametric test series, ADA-ES will review results with the project team and identify the most promising one or two options to achieve greater than 90% mercury removal. Each option will be tested for at least two days to verify performance measured during parametric testing. Following these tests, ADA-ES will compile an informal report summarizing the results and conclusions of the testing to date. This report will provide the data and analysis necessary to guide the project team and DOE in choosing the system parameters for the long-term test.

Task 3.5. Long-Term Test

After approval from the DOE Project Officer, the selected sorbent identified in Task 3.4 will be continuously injected into the flue gas over a period of eleven months. This shall be done in conjunction with any operating changes or enhancement additives agreed to in Task 3.4. This test period shall evaluate whether the mercury control scheme develops any long-term operational problems and whether mercury control is sustainable. Potential operational impacts that will be monitored include degradation of SDA or FF performance, injection system performance, or SCR performance if enhancement additives are used.

Long-term test measurements shall include a full suite of flue gas and solid sample measurements. These shall include SDA inlet and FF outlet mercury CEM measurements, particulate, halogens, and ammonia measurements. The accuracy of the mercury CEM will be verified during these tests with an appropriate reference method, such as the Ontario Hydro method. It is the intent of the test team to operate the stack CEM as a compliance mercury CEM using the QA/QC procedures outlined in the CAMR and compliance monitoring requirements included in 40 CFR Part 60.49a. If the analyzer does not meet all certification requirements, the reference method check will be conducted at least three times during the long-term program. If a mercury CEM is approved as an instrumental reference method under 40 CFR Part 75.22 by the EPA Administrator, such instrumental method may be substituted for the Ontario Hydro measurements in this project with permission of DOE and team members.

Task 4. Coal, Ash, and By-Product Sample Evaluation

In conjunction with each of the baseline and parametric tests, solid samples of coal and ash will be taken for analysis. Select coal samples shall be analyzed for ultimate, proximate, and calorific analyses as well as mercury and chlorine content. Fly ash and bottom ash samples shall be analyzed for mercury content and LOI. At least one ash sample from baseline testing and one sample from baseline and one ash sample from long-term testing will be tested for stability. These tests will include leaching of mercury and any chemical additive (in the coal or on the activated carbon) using the synthetic groundwater leaching procedure. Thermal desorption tests will also be conducted.

In addition to the collection and analysis of samples needed for ADA-ES' own analyses, samples shall be collected in accordance with DOE/NETL requirements. These shall include fly ash samples taken from both ESPs during both the baseline and long-term tests. Such samples shall be made available for analysis at DOE/NETL's discretion. Bottom ash samples will not be taken for this purpose, as all chemical injection will occur outside of the furnace.

Task 5. Technology Transfer

Presentations will be made at selected conferences, with DOE approval, to increase exposure of the test results and receive comments on the applicability of the technology to the industry. Transferring the information generated during this program to the coal-fired utility customers will be an important part of the program. The ultimate goal of technology transfer is to make results available to the public as quickly, comprehensively and accurately as possible.

Task 6. Management and Reporting

This task provides time for overall program management, and preparation of financial and administrative reports. Upon completion of the field testing and receipt of the subsequent laboratory analyses, ADA-ES will issue a formal test report. The report will summarize all testing activities, results, initial economic analyses, and conclusions. Periodic meetings with DOE to discuss progress and obtain overall direction of the program from the DOE project manager will also be supported

Critical Path Milestones (Milestone Plan/Status)

A Milestone Plan will be used as a planning tool to establish the time schedule for accomplishing the planned work. The Milestone Plan serves as the baseline for tracking performance of the project and identifies critical path project milestones (no less than 2 per calendar year) for the entire project. The initial Milestone Plan is listed below for this 21-month project. Any changes required as the project advances will be submitted to the DOE Project Officer for review and approval.

Table 2. Project Milestones.

Milestones	Target Date
1. Complete Equipment Design	February 2007
2. Install Injection and Measurement Equipment	March 2007
3. Complete Baseline Tests	November 2006
4. Complete Parametric Tests	May 2007
5. Initiate Long-Term Testing	May 2007
6. Complete Long-Term Testing	May 2008
7. Submit Final Report	Within 90 days of completion of project

RESULTS AND DISCUSSION

Task 1. Site Coordination, Kickoff Meetings, Develop Test Plan and QA/QC Plan

- Kickoff meeting held at Hardin Generating Station in Hardin, Montana. (6/26/06)
- Draft Test Plan and QA Plan released to RMP for review. (6/26/06)
- Developed Site Sampling Plan and Installation Plan. (6/26/06)
- Signed Cooperative Agreement and Host Site Agreement. (4/27/06)
- Contract for Services Agreement with RMP under review.
- Release of Draft Test Plan and QA Plan to DOE scheduled for August 2006.
- DOE Kickoff meeting scheduled for July 2006.
- Thermo Electron CEM scheduled for startup in September 2006.

Task 2. Design, Procure and Install Equipment

- Plans developed for silo location and injection system requirements.
- Acquired two (2) Thermo Electron Mercury CEM analyzers for use at RMP.
- Entered into agreement to acquire a commercial grade silo to support testing.
- Designed and acquiring components to support sorbent injection.
- CEM installation scheduled for September 2006.
- Silo and sorbent injection system installation scheduled for March 2007.

Task 3. Field Testing

- No activities this quarter.

Task 4. Coal, Ash, and By-Product Sample Evaluation

- No activities this quarter.

Task 5. Technology Transfer

- No activities this quarter.

Task 6. Management and Reporting

- No activities this quarter.

CONCLUSIONS

None this reporting period.

STATUS REPORTING

Cost Status

COST PLAN / STATUS REPORT DE-FC26-06NT42774											
Baseline Report Quarter	Project Year 1 Start: 05/01/06 End: 03/31/07				PY 2 Start: 04/01/07 End: 03/31/08				PYear 3 Start: 04/01/08 End: 10/31/08		
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11
	05/01/06 - 06/30/06	07/01/06 - 09/30/06	10/01/06 - 12/31/06	01/01/07 - 03/31/07	04/01/07 - 06/30/07	07/01/07 - 09/30/07	10/01/07 - 12/31/07	01/01/08 - 03/31/08	04/01/08 - 06/30/08	07/01/08 - 09/30/08	10/01/08 - 12/31/08
Baseline Cost Plan											
Federal Share	$204,754	$204,753									
Non-Federal Share	$9,401	$127,101									
Total Planned (Federal and Non-Federal)	$214,155	$331,854									
Cumulative Baseline Cost	$214,155	$546,009									
Actual Incurred Costs											
Federal Share	$14,920										
Non-Federal Share	$685										
Total Incurred Costs - Quarterly (Federal and Non-Federal)	$15,606										
Cumulative Incurred Cost	$15,606										
Variance											
Federal Share	$189,834										
Non-Federal Share	$8,716										
Total Variance - Quarterly (Federal and Non-Federal)	$198,550										
Cumulative Variance	$198,550										
Notes											
1. Figures above do not match SF-424A found in Cooperative Agreement.											
The SF-424A in the Cooperative Agreement assumed full project funding from DOE as originally budgeted.											
2. The figures above are based on the actual limited funding authorized by DOE at the time of this report.											
The limited funding by DOE is assumed to cover project costs for DOE Fiscal Year 2006.											
The limited Federal Share Funding authorized by DOE as of the date of this report is $412,550.											
3. Figures beyond the current DOE Fiscal Year are not shown due to the uncertainty in funding and of funding levels for future quarters.											
4. Plan figures in this report will be adjusted each reporting quarter as funding authorizations are approved by DOE.											

Figure 1. Cost Plan/Status Report.

Milestone Status

Milestone Plan/Status Report DE-FC26-06NT42774																
Task/ Subtask Number	Critical Path Project Milestone Description	Project Start: 05/01/06								Project End: 10/31/08			Planned Start Date	Planned End Date	Actual Start Date	Actual End Date
		Project Year (PY) 1				PY2				PY3						
		Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11				
		04/01/06 - 06/30/06	07/01/06 - 09/30/06	10/01/06 - 12/31/06	01/01/07 - 03/31/07	04/01/07 - 06/30/07	07/01/07 - 09/30/07	10/01/07 - 12/31/07	01/01/08 - 03/31/08	04/01/08 - 06/30/08	07/01/08 - 09/30/08	10/01/08 - 12/31/08				
3.1	Complete Baseline Tests			X										11/30/06		
	Complete Equipment Design				X									02/28/07		
	Install Injection and Measurement Equipment				X								09/01/06	03/31/07		
3.3	Complete Parametric Tests					X								05/31/07		
3.5	Initiate Long-Term Testing					X							05/31/07			
	Complete Long-Term Testing									X				05/31/08		
	Submit Final Report (Within 90 days of completion of project)													01/30/09		

Figure 2. Milestone Status.

LIST OF ACRONYMS AND ABBREVIATIONS

ACI	Activated carbon injection
CEM	Continuous emission monitor
DOE	Department of Energy
FF	Fabric filter
MW	Megawatt
NETL	National Energy Technology Laboratory
O&M	Operating and Maintenance
PAC	Powdered activated carbon
PC	Pulverized coal
PRB	Powder River Basin
RMP	Rocky Mountain Power
SCR	Selective catalytic reduction
SDA	Spray dryer absorber
SSD	Sorbent screening device