UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

BERKSHIRE HATHAWAY ENERGY COMPANY
and PACIFICORP,
Petitioners

v.

BIRCHTECH CORP.
Patent Owner

DECLARATION OF INVENTOR JOHN PAVLISH

I, John Pavlish, declare and say as follows:

1. I am a citizen of the United States and am over 18 years of age. I have personal knowledge of the matters stated in this declaration.

2. I make this declaration to describe the conception and reduction to practice of invention of U.S. Patent No. 10,668,430 ("the '430 Patent,") and U.S. Patent No. 10,589,225 ("the '225 Patent").

3. Additionally, I have reviewed the Petitions and the Board's preliminary findings in its institution decision, and I hereby provide responses to certain of the statements and positions made by the Board and the Petitioners.

4. Although I make this declaration on behalf of ME2C, my employer, other than the regular salary I receive from my employment duties, I am not being compensated for this declaration.

Personal Background

5. I have been the Chief Technology Officer and Senior Vice President of Midwest Energy Emissions Corporation since November 16, 2014. Prior to this, I served as an Executive Consultant Advisor to Midwest Energy Emissions Corporation. Prior to joining Midwest Energy Emissions Corporation, I was a Senior Research Advisor and the Director of the Center for Air Toxic Metals Program at the Energy & Environmental Research Center in Grand Forks, North Dakota.

6. I have over 30 years of mercury-related experience and am regarded as an international expert on the topic of mercury. My primary areas of interest and expertise include research, technical consultation and development of mercury control technologies, in particular, for coal combustion and gasification systems. I am an inventor of a number of patented mercury control technologies and have

years of experience in development and testing of these technologies for commercial applications.

7. I have served on numerous professional and technical committees and am a U.S. Representative on the Mercury Emissions from Coal International Experts Working Group on Reducing Emissions from Coal and a member of the United Nations Environment Programme Global Mercury Partnership, Reduction of Mercury Releases from Coal Combustion. I have published over 200 papers, articles, and reports on various mercury-related topics and issues.

8. I also have years of power plant experience and have worked for an engineering/consulting company, Black & Veatch, where I served as Unit Leader/System Engineer. I am a professional engineer, a member of the American Society of Mechanical Engineers, and a member of the Air & Waste Management Association (A&WMA).

The EPA Calls for New Mercury Removal Technology in the 1990s

9. The background story for this technology begins with the Clean Air Act Amendments of 1990. That law required the U.S. Environmental Protection Agency (EPA) to study the impact of various hazardous air pollutants, including mercury.[1] To assist in the research, in 1992, the EPA established a National Center for Excellence at the Energy & Environmental Research Center (EERC) referred to as the Center for Air Toxic Metals (CATM). It is through the EERC that my fellow co-inventors and I would eventually discover the inventions claimed in the ’430 and ’225 patents. Our research focused heavily on developing new methods for detecting, measuring, and ultimately, removing mercury from coal-fired power plant exhaust gas.

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[1] Ex. 2025, EPA Clean Air Act Overview, https://www.epa.gov/clean-air-act-overview/1990-clean-air-act-amendment-summary-title-iii.

10. In 1997 and 1998, the EPA issued two reports to Congress: *Mercury Study Report to Congress* (issued December 1997)[2] and *Study of Hazardous Air Pollutant Emissions from Electric Utility Steam* (issued February 1998).[3] As an outcome of these studies, the EPA found a pressing need for regulation of mercury pollution from power plants. Unfortunately, EPA also found that no existing technologies were up to the task of significantly reducing the mercury pollution from those plants.[4]

11. In the wake of these reports, various governmental and industry organizations injected millions of dollars into basic scientific research and experimental studies in search for new mercury removal technologies. The EERC was one of those groups.

The EERC's Pilot Test Combustor

12. By the early 2000s, my co-inventors (Edwin Olson and Michael Holmes) and I had already spent several years studying mercury emissions testing and capture technologies at the EERC. As part of this work, we conducted various tests at the EERC's Pilot Test Combustor ("PTC"). The PTC is a coal combustion chamber with emission control equipment similar to that used at coal plants

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[2] Ex. 2026, United States Environmental Protection Agency, "Mercury Study Report to Congress, Volume I: Executive Summary", EPA-452/R-97-003, December 1997, https://www.epa.gov/mercury/mercury-study-report-congress

[3] Ex. 2024, United States Environmental Protection Agency, "Study of Hazardous Air Pollutant Emissions from Electric Utility Steam Generating Units -- Final Report to Congress", United States Office of Air Quality EPA-453/R-98-004a, Environmental Protection Planning and Standards, February 1998, https://www.epa.gov/mats/study-hazardous-air-pollutant-emissions-electric-utility-steam-generating-units-final-report

[4] Ex. 2024, Footnote 3 reference at ES-19, "Regarding potential methods for reducing mercury emissions, the EPA has not identified any demonstrated add-on control technologies currently in use in the U.S. that effectively remove mercury from utility emissions."

through out the United States. This system is designed to simulate the flue gas and emissions controls of much larger commercial scale combustors, and allow for testing of new technologies without posing risks to private coal plants that are connected to the electrical grid. Test experience on the PTC has shown that it produces flue gas that is representative of larger full-scale coal-fired power plants.

13. An image of the PTC is shown below. This is an accurate reflection of at least a portion of the system as it appeared in 2002:[5]

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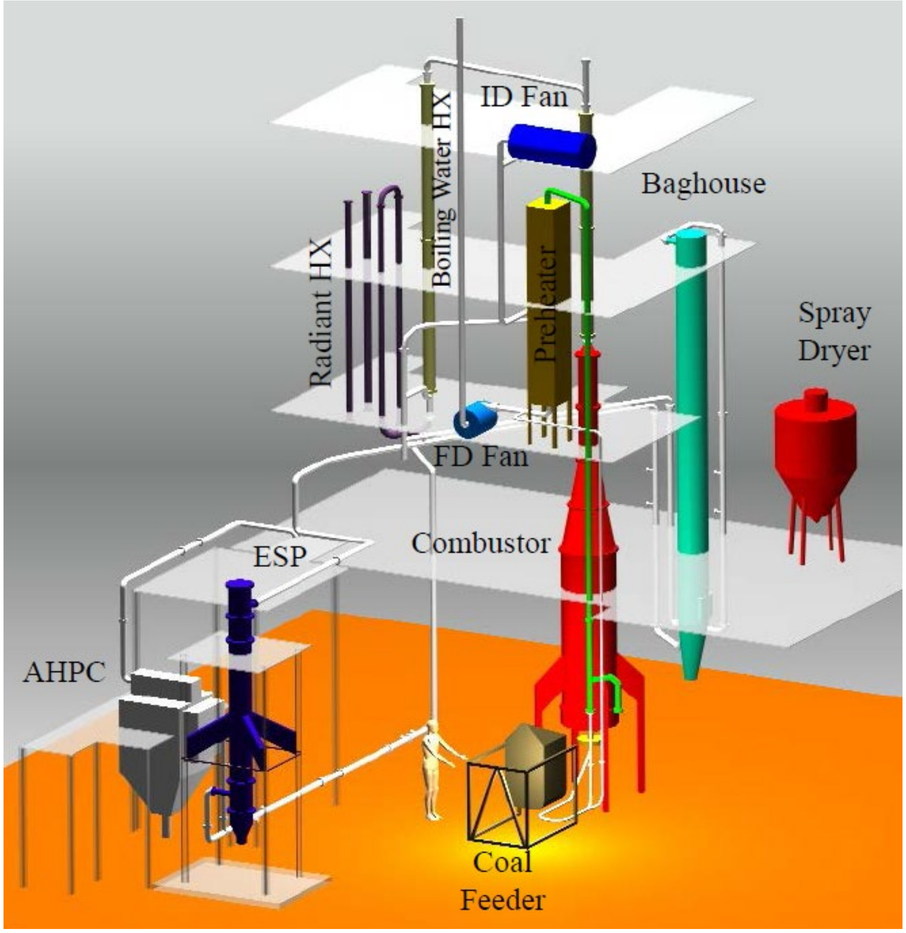
[5] Ex. 2027, EERC presentation, "Description of Test Facilities Particulate Test Combustor"

14. The diagram below reflects the PTC layout as of 2002.[7] A process flow diagram is shown below for the PTC, with additional equipment added such as a dry scrubber:

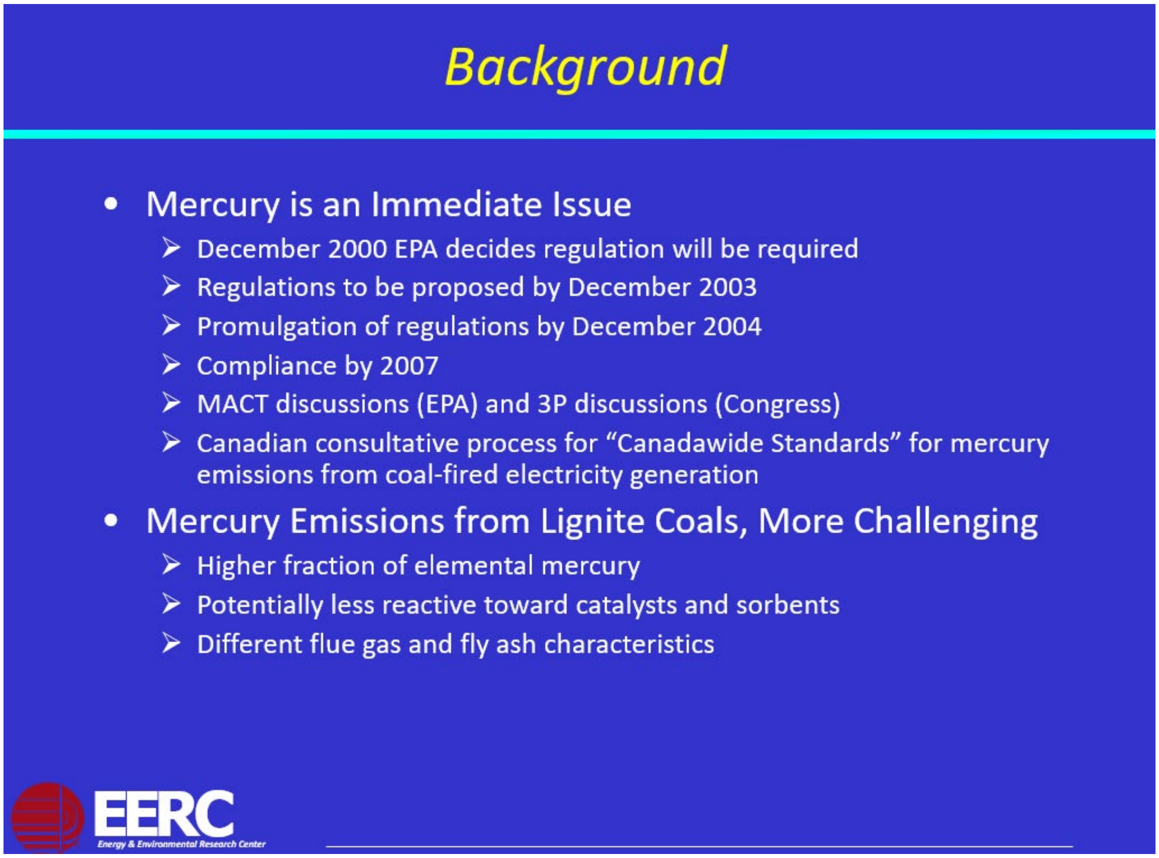


15. As shown above, the PTC included a coal feeder that could feed coal to the combustor. Emission gas from the combustor was channeled through various emission control equipment (*e.g.*, electrostatic precipitator, baghouses, dry scrubber). Various sample ports were placed throughout the PTC to conduct gas measurements (including mercury measurements), and to provide an entry point for injecting materials such as activated carbon sorbent.

16. As described below, my co-inventors and I developed and tested the patented technology using the PTC.

The EERC Kicks Off DOE-Funded Research into Coal Additives and Sorbents

17. By 2001, we had decided to focus on testing and evaluating various sorbents for use in mercury capture. However, PTC testing was relatively expensive, and thus we needed to obtain funding to perform in depth testing. In December 2001, we held a project meeting at the EERC to discuss overall project strategy and funding. The overall project goals were memorialized in the slides below from that meeting:[6]



Background

- Mercury is an Immediate Issue
  - December 2000 EPA decides regulation will be required
  - Regulations to be proposed by December 2003
  - Promulgation of regulations by December 2004
  - Compliance by 2007
  - MACT discussions (EPA) and 3P discussions (Congress)
  - Canadian consultative process for "Canadawide Standards" for mercury emissions from coal-fired electricity generation
- Mercury Emissions from Lignite Coals, More Challenging
  - Higher fraction of elemental mercury
  - Potentially less reactive toward catalysts and sorbents
  - Different flue gas and fly ash characteristics

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[6] These slides are attached as Exhibit 2028.

Project Goals

Develop, Test, and Demonstrate Sorbent-Based Technologies for Utilities Burning Lignite Coal

- Increase the scientific understanding of mercury / flue gas interactions leading to more effective design of sorbents
- Test a range of sorbent-based technology options
- Determine and demonstrate optimum conditions and sorbents for Hg capture in pilot facility
- Field demonstrate sorbent-based technology to prove and quantify effectiveness, performance, and cost

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Focus on Sorbent-Based Technology

- Most plants are equipped with particulate control devices
- Sorbent injection can be easily added to these plants at relatively low cost as compared to other mercury control options
- Preliminary bench- and pilot-scale tests indicate that carbon-based sorbents may be effective for mercury capture under certain conditions. More data needed under different conditions
- For units equipped with scrubbers, catalytic oxidation may be an option. Some sorbents have the potential to facilitate oxidation.

18. As shown above, by December 2001, we had already determined to focus on sorbent-based technology, and in particular, carbon-based sorbents. Moreover, we had recognized that under certain conditions, a catalyst could be used so that the sorbent would both oxidize and capture mercury.

19. By February 2002, the EERC obtained a commitment from the Department of Energy ("DOE") to provide funding for the project. This funding was provided pursuant to a Cooperative Agreement with the EERC (No. DE-FC26-98FT40321), and designated for JV Task 45 – Mercury Control Technologies for Electric Utilities Burning Lignite Coal. Based on the success of this project, this work would later be referred to the Phase I bench- and pilot-scale testing. The results of the projected were later summarized in a report provided to the DOE.[7]

20. The EERC held a kickoff meeting to discuss the project on February 28, 2002. During this meeting we discussed the project timeline and overall strategy. As shown below,[8] part of the focus of the project was to identify sorbents and oxidation options. In particular, we had identified a reaction between chlorine[9] and activated carbon that we intended to study further.[10]

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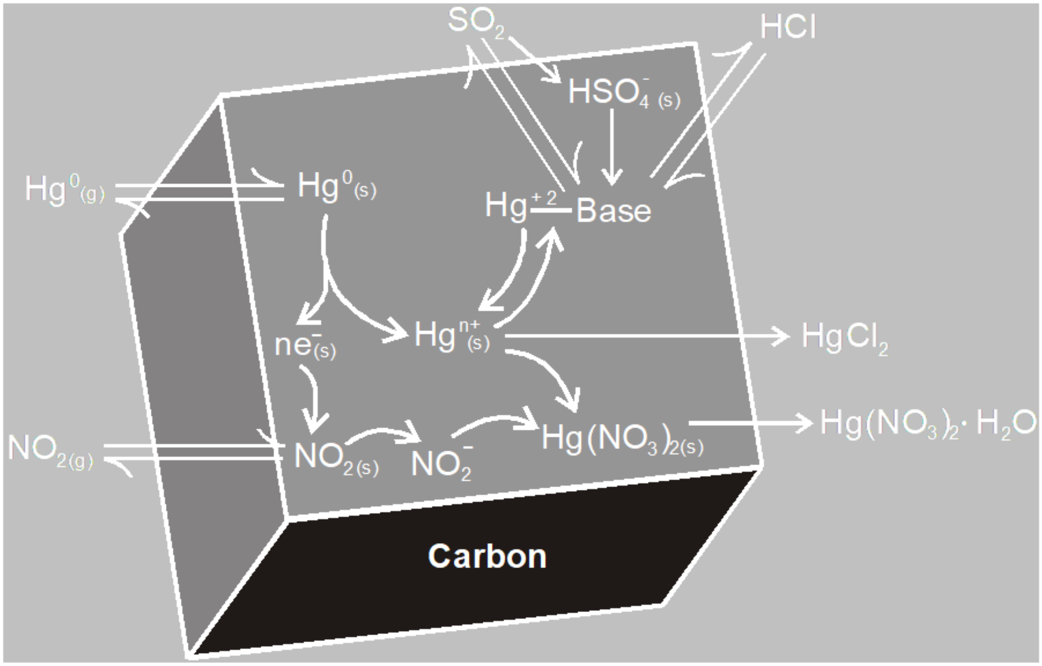
[7] Ex. 2032, "JV TASK 45 – MERCURY CONTROL TECHNOLOGIES FOR ELECTRIC UTILITIES BURNING LIGNITE COAL, PHASE I BENCH- AND PILOT-SCALE TESTING Final Report" (Oct. 2003) (the "October 2003 Report").

[8] These slides are attached as Exhibit 2029.

[9] For ease of reading, references in this declaration to "chlorine" and "bromine" generally use these terms to refer to chemical compounds that contain chlorine and bromine atoms.

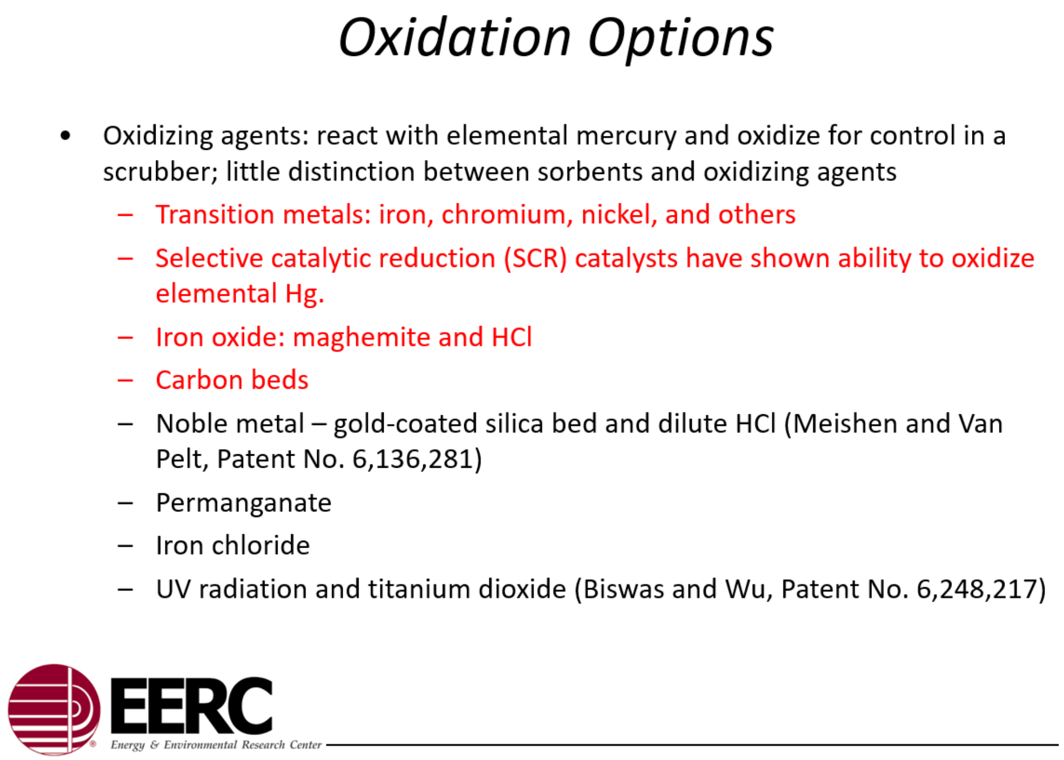
[10] These slides are attached as Exhibit 2030.

Mechanism of Mercury Capture with Carbon Sorbents



Sorbent Options

- Sorbents – injection and capture with particulate control
  - Carbons: activated carbons derived from coal, impregnated with iodine, sulfur, and other materials
  - Metal oxides: oxides of iron, manganese, and other metals
  - Calcium silicates – derived from fly ash or slag
  - Lime/activated carbon
  - Na_2S_4-impregnated activated carbon
  - Activated carbon derived from tires (Wojtowicz and Serio, Patent No. 6,322,613)
  - Iron chloride
  - Titania with added metals/oxides
  - Palladium chloride
  - Noble metals: gold, tin, zinc, copper, lead, cadmium, silver
  - Corn fibers
  - Fly ash reinjection (Knowles, Patent No. 5,787,823).



Oxidation Options

- Oxidizing agents: react with elemental mercury and oxidize for control in a scrubber; little distinction between sorbents and oxidizing agents
  - Transition metals: iron, chromium, nickel, and others
  - Selective catalytic reduction (SCR) catalysts have shown ability to oxidize elemental Hg.
  - Iron oxide: maghemite and HCl
  - Carbon beds
  - Noble metal – gold-coated silica bed and dilute HCl (Meishen and Van Pelt, Patent No. 6,136,281)
  - Permanganate
  - Iron chloride
  - UV radiation and titanium dioxide (Biswas and Wu, Patent No. 6,248,217)

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21. Following this kickoff meeting, we tested various sorbents, additives, and other variations at the PTC. Much of this initial work focused on the use of chlorine-based additives and activated carbon sorbents. One of the discoveries consistently demonstrated through that testing was the beneficial effect of combining a coal additive upstream of the combustor, and a sorbent used downstream of the combustor.

22. These results were memorialized, for example, in slides prepared for a post-testing review meeting held on February 3, 2003.[11] As shown in the slides below, comparative testing of sorbents and additives demonstrated an improvement over merely using sorbents, and a significant improvement over baseline testing:

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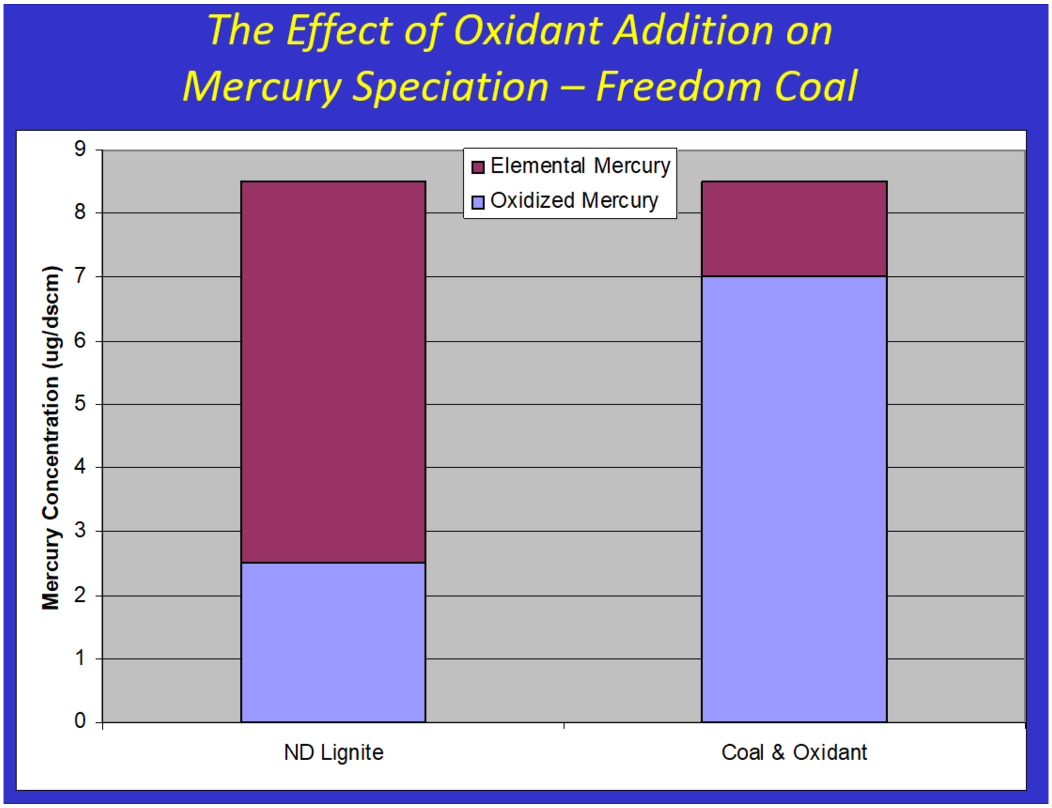
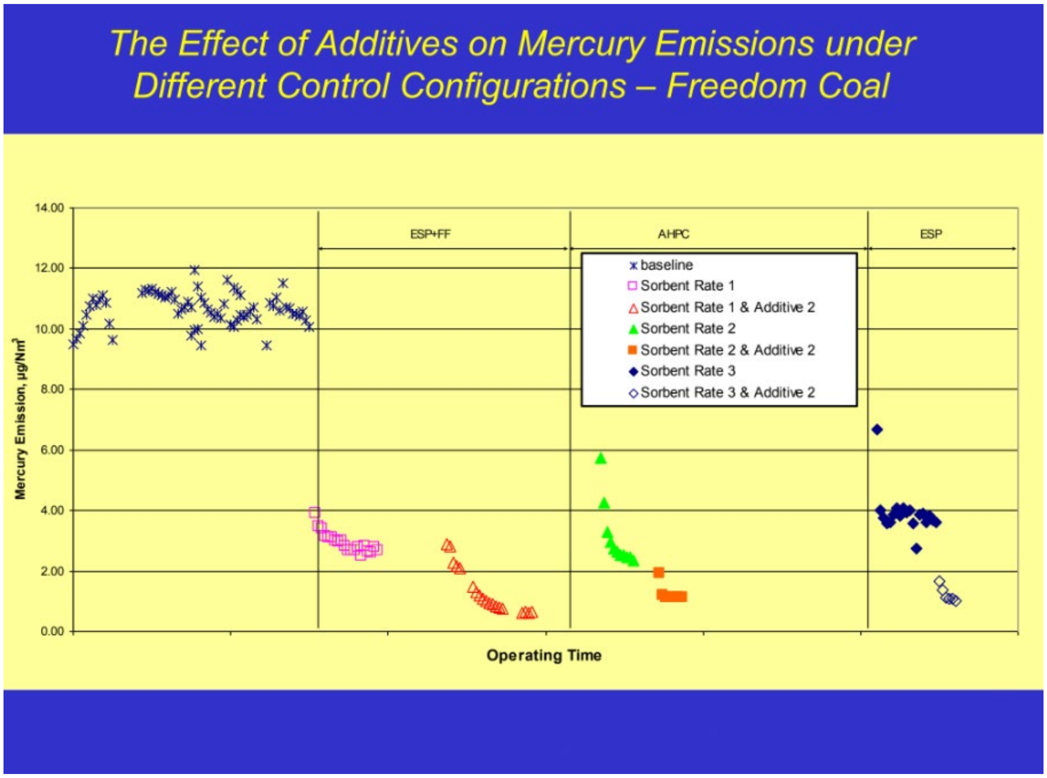
[11] These slides are attached as Exhibit 2031.



The Effect of Oxidant Addition on Mercury Speciation – Freedom Coal



The Effect of Additives on Mercury Emissions under Different Control Configurations – Freedom Coal

23. The testing described above was conducted during the summer and fall of 2002. I, along with others at the EERC, compiled and analyzed the results of this work into a report provided to the DOE—The October 2003 Report.[12]

24. By the end of the fall of 2002 funding for that PTC testing had been exhausted. Nonetheless, our work had demonstrated sufficiently promising results such that additional funding for PTC testing was procured.

25. Specifically, funding was sought under the CATM program (approval of research at the September 9, 2002 Research Advisory Council meeting for the Center for Air Toxic Metals) and a new round of funding through a North Dakota led initiative to test mercury control technologies. Through this effort a project entitled "Pilot- and Full-Scale Demonstration of Advanced Mercury Control Technologies for Lignite-Fired Power Plants" was funded through an EERC-DOE Cooperative Agreement No. DE-FC26-03NT41897.[13] This round of funding was used for PTC testing conducted in 2003.

Conception and Initial Reduction to Practice of Bromine as the Coal Additive

26. As described in the October 2003 report, by the time of the 2002 PTC testing, my co-inventors and I had conceived of using a pre-boiler additive to boost the performance of post-boiler, injected activated carbon sorbent.[14] Testing coal additives was just one portion of the work we (the EERC) were doing for the DOE project. At least initially, our work focused on the use of chlorine (chlorides, chlorine, chlorine compounds, chlorine salts, etc.) as the additive. This is because the role of chlorine (chlorides, chlorine, chlorine compounds, etc.) in combustion

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[12] Ex. 2032.

[13] Ex. 2012, "PILOT- AND FULL-SCALE DEMONSTRATION OF ADVANCED MERCURY CONTROL TECHNOLOGIES FOR LIGNITE-FIRED POWER PLANTS," (Feb. 2004) (the "February 2004 Report").

[14] Ex. 2032, October 2003 Report at 51.

had already been studied to some degree. Thus, testing with chlorine was viewed as a logical extension of chlorine-related research and a reasonable approach for a government-funded project.

27. However, on some occasions, after we had completed the required testing, we had some additional time with the PTC when we could experiment with more speculative approaches. It is during one of these "after hours" tests that we first tested the use of a bromine-based additive provided on the coal and injecting activated carbon downstream of the combustor. This decision was by no means obvious as I explained in my testimony submitted during prosecution of the U.S. Patent No. 10,343,114.[15] In fact, we were surprised and impressed with the results even if they were based on limited data at the time. However, because this testing was not a part of an officially funded project, we did not keep as detailed records of the testing.

28. I have attempted to locate documents to pinpoint when we conceived of using bromine as the additive, and when we conducted these after-hours tests with bromine. As part of that search, I located a list of potential research ideas that I had compiled in preparation for a September 9, 2002 Research Advisory Council meeting for the Center for Air Toxic Metals. This was an internal document that was used to keep track of potential research projects that I would oversee as Director of the CATM program.[16] The metadata for this document indicates that I last edited it on August 30, 2002:[17]

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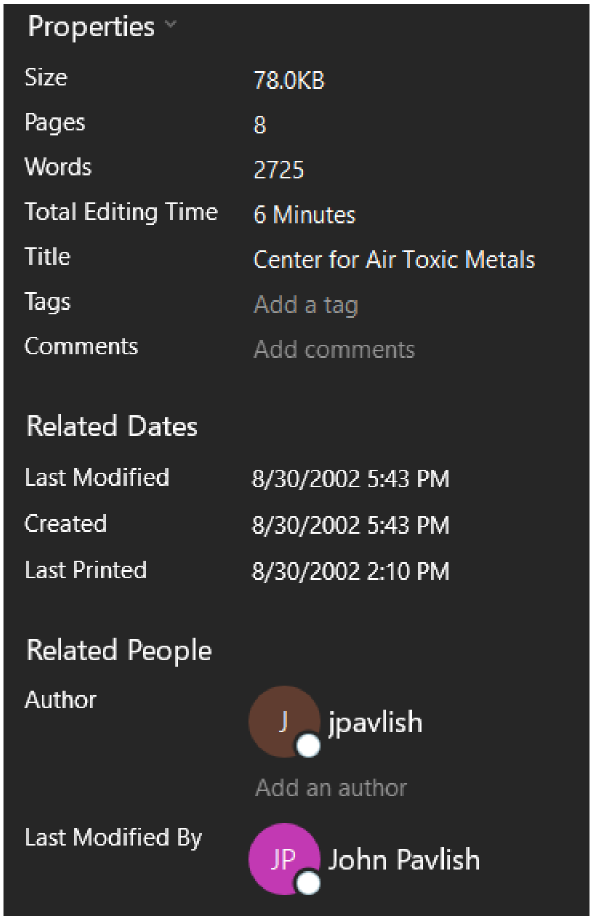
[15] Ex. 1026, '114 file history at 1775–1819.

[16] This document is attached at Ex. 2015.

[17] An image of this metadata is attached at Ex. 2016.



Size	78.0KB
Pages	8
Words	2725
Total Editing Time	6 Minutes
Title	Center for Air Toxic Metals
Tags	Add a tag
Comments	Add comments

Related Dates

Last Modified	8/30/2002 5:43 PM
Created	8/30/2002 5:43 PM
Last Printed	8/30/2002 2:10 PM

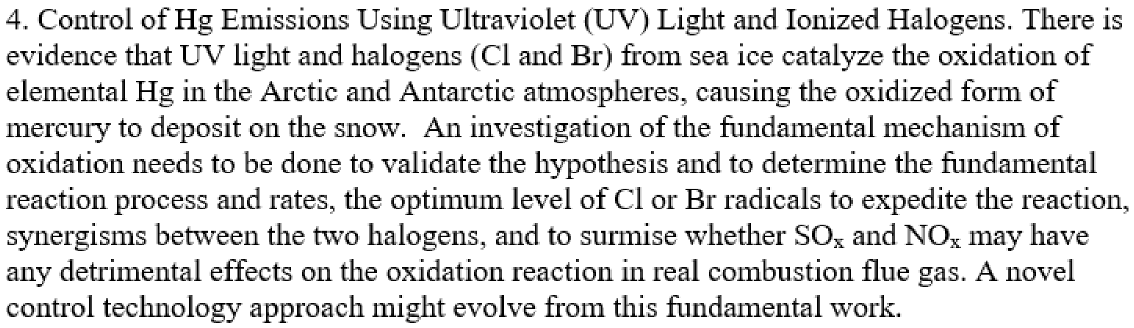
Related People

Author	jpavlish Add an author
Last Modified By	John Pavlish

29. This document notes our discovery that chlorine (chlorides, chlorine, chlorine compounds, chlorine salts, etc.) or other additives can enhance the effectiveness of sorbents:

> 1. Evaluate various chlorine (or other) additives for enhancement of sorbent reactivity/effectiveness. Recent pilot and field data suggest that introducing low-cost additives may significantly improve sorbent effectiveness, leading to better sorbent utilization. Additives to the fuel, sorbent, or directly to the flue gas should be considered.

30. It also identifies the need for studying the use of bromine (bromides, bromine, bromine compounds, bromine salts, etc.) to expedite mercury oxidation:



4. Control of Hg Emissions Using Ultraviolet (UV) Light and Ionized Halogens. There is evidence that UV light and halogens (Cl and Br) from sea ice catalyze the oxidation of elemental Hg in the Arctic and Antarctic atmospheres, causing the oxidized form of mercury to deposit on the snow. An investigation of the fundamental mechanism of oxidation needs to be done to validate the hypothesis and to determine the fundamental reaction process and rates, the optimum level of Cl or Br radicals to expedite the reaction, synergisms between the two halogens, and to surmise whether SO_x and NO_x may have any detrimental effects on the oxidation reaction in real combustion flue gas. A novel control technology approach might evolve from this fundamental work.

31. Thus, at least by August 30, 2002, we had conceived of using bromine as the additive to coal combustion systems. As discussed above and throughout, in the months that followed and continuously during this period, we worked dilligently to secure funding to conduct additional PTC tests.

32. Once we had received funding and were able to conduct the next round of testing at the PTC, we planned to perform at least some tests using a pre-boiler bromine-based additive with post-boiler activated carbon sorbent.

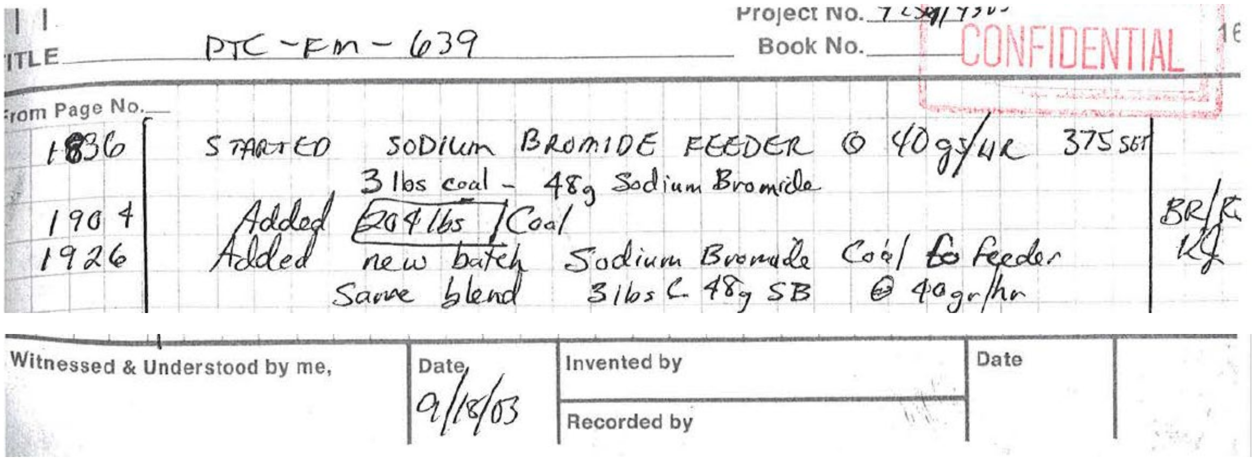
Testing Bromine Additive Combined with Activated Carbon Sorbent

33. The next round of PTC testing began in 2003. Of particular relevance here, from September 8, 2003, to September 19, 2003, we tested various coal additives and sorbents, including the combined use of bromine additive and activated carbon sorbent. Those tests were recorded in PTC run logbooks that described and documented the conditions, activities, and procedural steps followed during each test.

34. The purpose of the logbook was to document that a test (or a series of tests) had been performed on the PTC on a specific date and time and to record real time events that accurately described: how the test (s) were conducted, the actual operating conditions of the test unit and any problems or upset that may have occurred as the test (s) proceeded, specific test parameters (such as injection rate of bromine, injection rate of sorbents, etc.), sample collection, data collection, and general observations. The date, operating conditions, test parameters, and events

of testing are important for interpreting and understanding the data acquired from the testing. Access and input to the logbook was limited to the technicians and operators running the test on the PTC. For the September 2003 testing described here, those technicians and operators were working at the direction of myself and my co-inventors. These logbooks are provided at Exhibit 2017.

35. The logbook entry for September 18, 2003, at 18:36 records the addition of sodium bromide to the coal:



Project No.
TITLE PTC - EM - 639
Book No.
CONFIDENTIAL

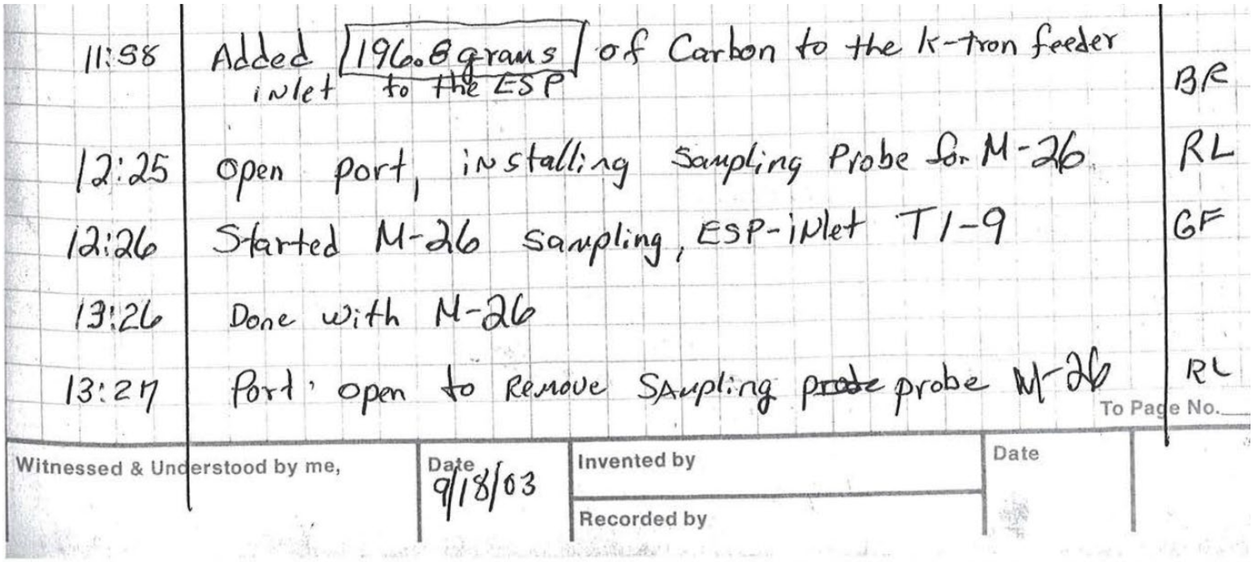
From Page No.

1836 STARTED SODIUM BROMIDE FEEDER @ 40 gs/HR 375 SET
3 lbs coal - 48g Sodium Bromide
1904 Added 204 lbs Coal
1926 Added new batch Sodium Bromide Coal to feeder
Same blend 3 lbs C. 48g SB @ 40 gr/hr

BR/K
KJ

Witnessed & Understood by me,	Date	Invented by	Date
	9/18/03	Recorded by	

36. The logbook also records several additional times when a halide such as sodium bromide was added. In addition, the logbook records the use of activated carbon sorbent:



11:58	Added 196.8 grams of Carbon to the k-tron feeder inlet to the ESP	BR
12:25	Open port, installing Sampling Probe for M-26	RL
12:26	Started M-26 sampling, ESP-inlet T1-9	GF
13:26	Done with M-26	
13:27	Port open to Remove Sampling ~~prode~~ probe M-26	RL

To Page No.

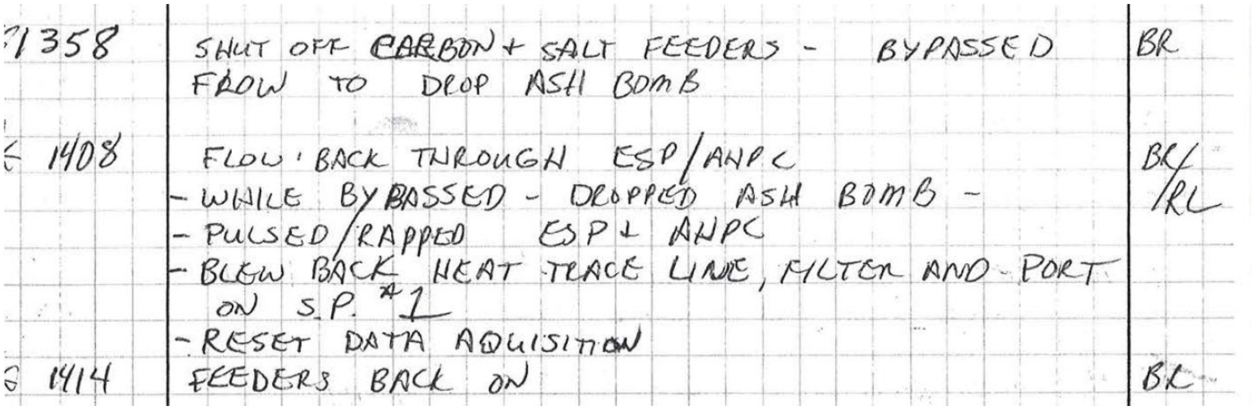
Witnessed & Understood by me,

Date 9/18/03

Invented by

Recorded by

Date



1358	SHUT OFF CARBON + SALT FEEDERS - BYPASSED FLOW TO DROP ASH BOMB	BR
1408	FLOW BACK THROUGH ESP/AHPC - WHILE BYBASSED - DROPPED ASH BOMB - - PULSED/RAPPED ESP + AHPC - BLEW BACK HEAT TRACE LINE, FILTER AND PORT ON S.P. #1 - RESET DATA AQUISITION	BR/RL
1414	FEEDERS BACK ON	BR

0950	START SODIUM BROMite NaBr 5 lbs COAl/80 gRMS Bromite 10 grams/hour. Setting 074	DR
1005	BLEW BACK SAMPLE PORT # 1	BR/RL
10:28	start Norit FGD carbon 14 g/hr 20 rpm	Ve
1106	DRAINED ice bath condensoR	JH
1131	Shut off CARBON Feedor	JH/Ve
1152	Added CoAL $\boxed{270 \text{ lbs}}$	JH/KJ
11:57	start EERC HCl pre-treat sorbent 14 g/hr 20 rpm (396.1 g total Volume added)	Ve
1306	Blew Out SAmple port #1 Probe - O2's weRe coming close togetheR O2 on SAmple port #3 was dRopping off INDicating A plug ON #1	KJ

To Page No.____

Witnessed & Understood by me,

Date 9-19-03

Invented by

Date

Recorded by

451	Started CARbon Injection 10 g/hr (Br treated)	Ve Idem
1459	Zero & Spanned SO2 Sample port #1	KJ
15:18	Increase Br treated carbon to 15 g/hr	Ve
1542	Added COAL $\boxed{122 \text{ lbs}}$	JH/KJ
4:59	Started ~~feeder~~ NaBr, 10 g/hr. → 10 gr per hour Sodium Bromide	Ve

To Page No.____

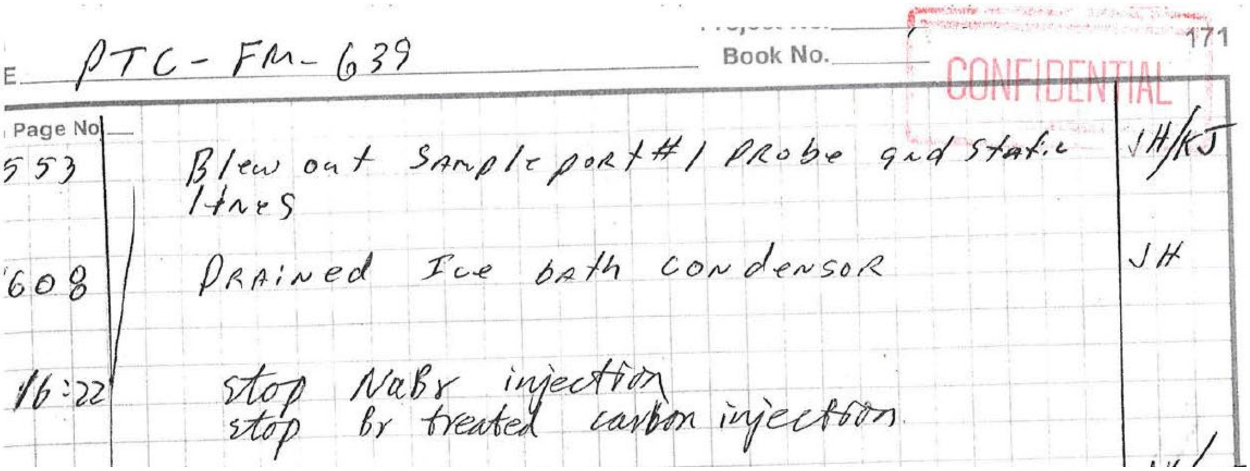
essed & Understood by me,

Date 9-19-03

Invented by

Date

Recorded by



E PTC-FM-639 Book No. 171

CONFIDENTIAL

Page No

553 Blew out sample port #1 probe and static lines JH/KJ

608 Drained Ice bath condensor JH

16:22 stop NaBr injection
stop Br treated carbon injection

37. Note that the title in this logbook for this test is “PTC-FM-639.” As explained below, the results of this testing were later reported to the DOE.

38. Below is an image of the additive apparatus used to supply additive to the coal feeder during these tests:

39. Below is an image of the activated carbon injection system used to inject sorbent during these tests:

40. The results from this September 2003 testing were significant. They confirmed that the use of bromine additive on the coal combined with activated carbon injection downstream from the combustion chamber provided significantly improved mercury capture as compared to methods employing chlorine additive or activated carbon without bromine addition.[18] As a result, the EERC initially

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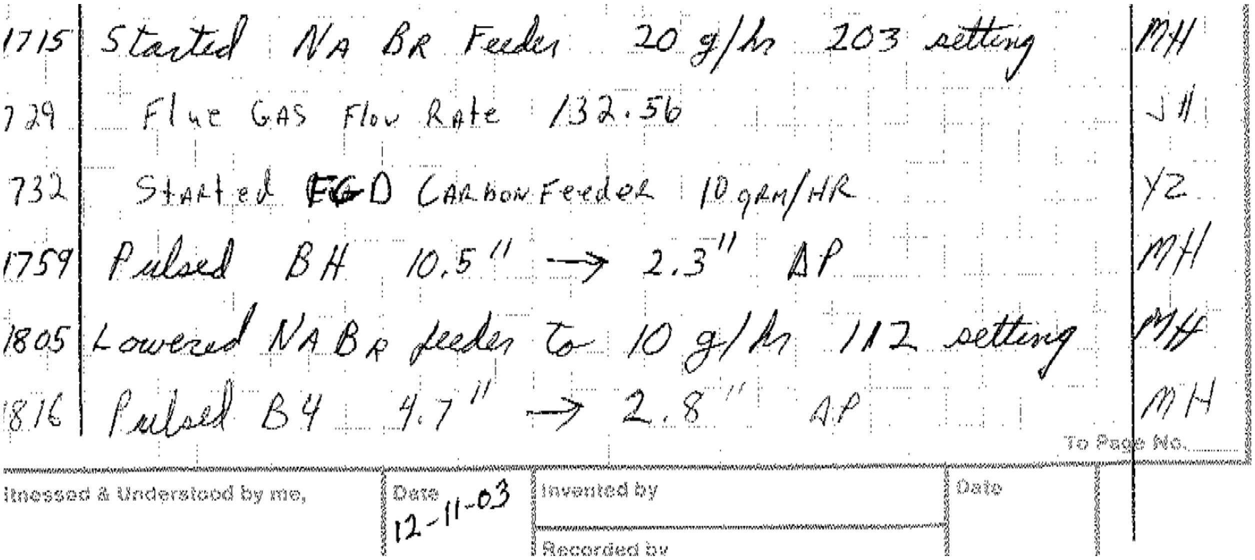
[18] We understood that these results would not only apply to sodium bromide, but that they would be replicated if the sodium bromide were replaced with any other bromine-containing substances, including bromine liquid (*e.g.*, Br2), bromides (*e.g.*, Br-), other bromine compounds (*e.g.*, HBr), and bromine salts (*e.g.*, CaBr2). We understood that all bromine and bromine-containing compounds have boiling point temperatures much lower than the extremely high temperatures in a coal-fired power plant's boiler combustion and that any bromine containing substance would be reduced to bromine atoms in the high temperature combustion flame zone.

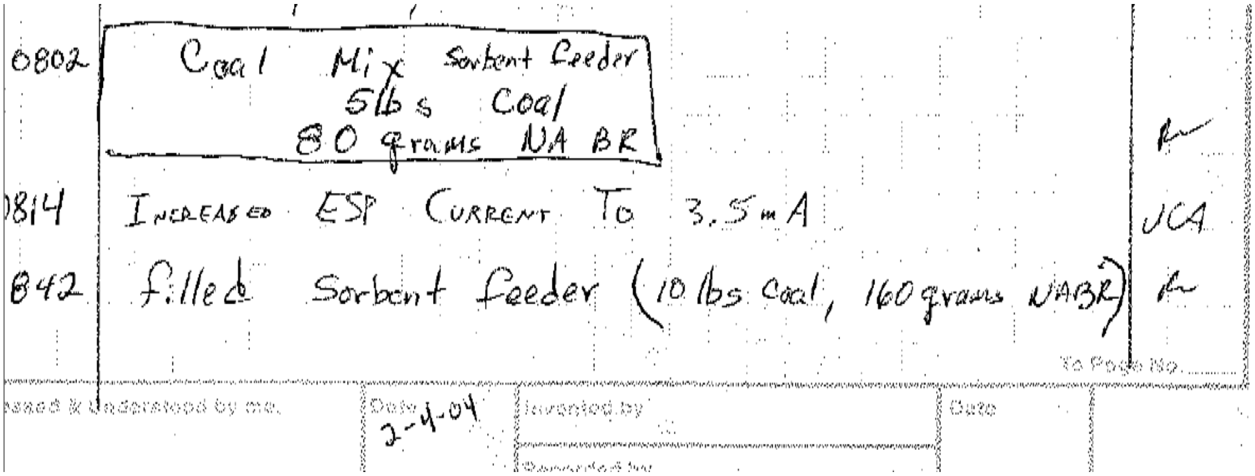
decided to maintain the use of bromine as an in-situ treatment as proprietary intellectual property.

41. The EERC also conducted additional follow up testing in late 2003, early 2004, and spring/summer of 2004. Some samples of log book entries from those tests are shown below:



1715 Started NA BR Feeder 20 g/hr 203 setting MH
729 Flue GAS Flow Rate 132.56 JH
732 Started FGD Carbon Feeder 10 gram/HR YZ
1759 Pulsed BH 10.5" → 2.3" ΔP MH
1805 Lowered NA BR feeder to 10 g/hr 112 setting MH
816 Pulsed B4 4.7" → 2.8" ΔP MH
To Page No.

itnessed & Understood by me, Date 12-11-03
Invented by
Recorded by
Date



0802 Coal Mix Sorbent Feeder
5lbs Coal
80 grams NA BR
814 Increased ESP Current To 3.5 mA JCA
842 Filled Sorbent Feeder (10 lbs Coal, 160 grams NABR)
To Page No.

ssed & Understood by me, Date 2-4-04
Invented by
Recorded by
Date

From Page No.

0852	BYPASS ESP - RAPPED ESP + DUMPED ASH	
0853	BACK ON LINE	
0857	Ash weight 4.97 lbs Sample taken T 11	
0902	Started Sorbent feeder setting 110 (T 12) 10grams Na BR. / hour	BR
0945	Note! ** Recalculate $CaCl_2$ injection Rates from 02/03/04	DME
0950	VIBRATOR QUIT - GOT IT GOING AGAIN	BR/KL
NOTE	ABOUT 9:30 WENT OUT TO ID STACK AND RAPPED ON PIPE. THERE WAS QUITE A BIT OF ASH COMING OUT OF STACK.	BR
0958	BY PASS FLOW - RAPPED ESP	
0959	FLOW BACK THROUGH ESP Dumped Ash 2.46 lbs Sample Taken (T 12)	BR RL
1028	Started Carbon feeder 44 RPM = 25 grams/hour NABR Started T 13	RL
1031	Adjusted secondary Air (Lowered) to account for the Air going in at the Carbon feeder	RL
11:52	Added Coal 178 lbs	RL BR
1206	Changed the carbon feeder to 26 RPM (15 grams/hour) T 14 Started	BR
12:54	Started O-H Sampling inlet and outlet of the ESP	RL

To Page No.

Witnessed & Understood by me, Date 2/4/04

Invented by Date

Recorded by

Project No. 4884
Book No. TITLE PTC-CA-641

Page No.

14:55	Sorbent feed turned off Done with O-H Sampling T-14	
1512	Bypassed flow, Power off Rapped	MH KJ
1515	ESP back on Line dumped Ash | 10.75 lbs | Took sample	MA/KJ
534	Finished Adding coal | 500 lbs |	KJ/mH
550	Started Sorbent ~~feed~~ Nabr 5 grams per hour | 78 set pt |	KJ/DM
16 40	Had problems with O_2. Found that when Int was repaired they had changed some of the Input signales & Reading right now	DK MH JA
1646	Installed probe	GF
1647	Start of T-15 Method 29 inlet	GF MH
1747	E.O.T.-15 Method 29 inlet	GF MH
1749	Removed Sample probe	GF
1751	Reduced Sorbent feed Na br To | 60 set pt | 2.5 g/hr.	MH
1845	Shut off Sorbent feeder | Nabr |	KJ/Dm
1857	Cleaned out Sorbent feeder Then put in 1.25 g of Na BR / $CaCl_2$ lbs/hr Setting on feeder of 110 ≈ 285 g/hr of the mix 10 grams NaBR 13.24 g $CaCl_2 \cdot 2H_2O$ 5 lbs coal	MH KJ

To Page No.

Witnessed & Understood by me. Date 2/4/04 Invented by Date

Recorded by

In particular, in February 2004 we performed additional testing with greater variation in the ratios of bromine (bromides, bromine, bromine compounds, bromine salts, etc.) to activated carbon. This additional testing demonstrated that even relatively small amounts of added bromine could significantly improve mercury capture, despite other theorized reactions that could potentially occur and consume bromine in coal combustion flue gas.

EERC Reports the Results to the DOE

42. Following the testing described above, the EERC prepared various reports to the DOE describing tests conducted by the EERC, and interpretation of the data obtained from these tests. My co-inventors and I received support from others at the EERC in preparing these reports. I do not believe that any of those individuals contributed to the actual inventions claimed in the applications that ultimately led to the ’430 and ’225 patents.

43. In February 2004, the EERC delivered a report to the DOE describing the results of our September 2003 testing (the “Feb. 2004 Report”).[19] This report explained that coal and additives were added to the PTC (i.e., upstream of the combustor) and sorbent was injected downstream of the combustor. Mercury levels were monitored both before and after the emission gas passed through an electrostatic precipitator (ESP) by using a continuous mercury monitor (CMM):

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[19] *See* Ex. 2012, Feb. 2004 Report at 12 (providing coal analysis for “PTC-FM-639,” the PTC testing identifier from the logbooks described above); *id.* at 17 (explaining that this testing occurred in September 2003).

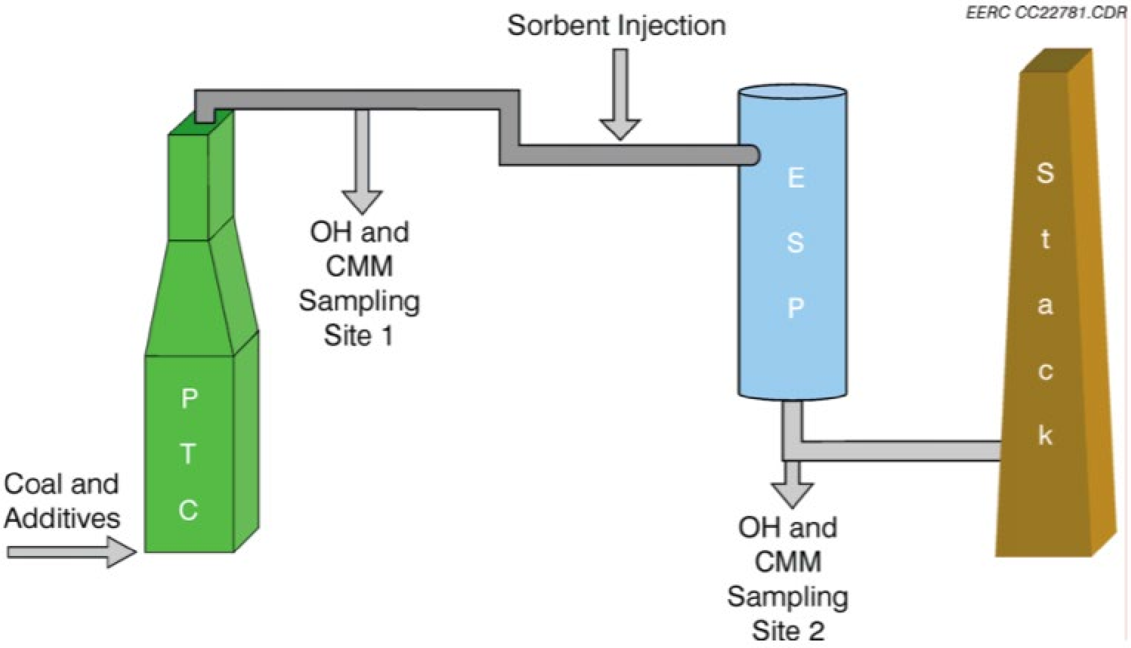


Figure 4. Injection and sampling schematic of the PTC with an ESP.

44. The report also described the 14 tests conducted during the September tests:

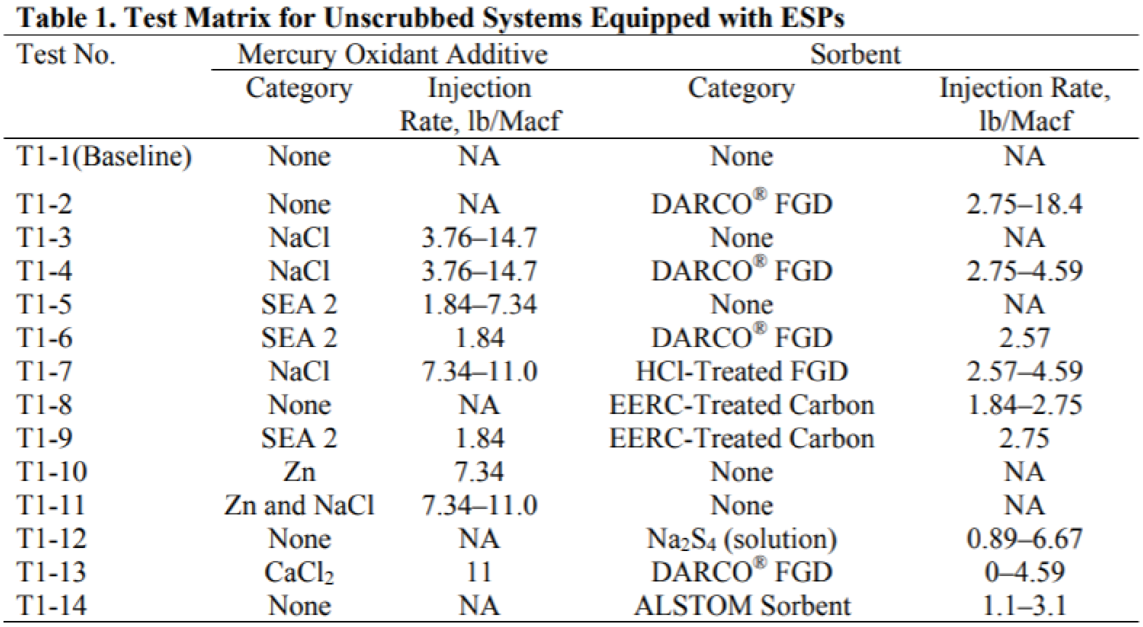


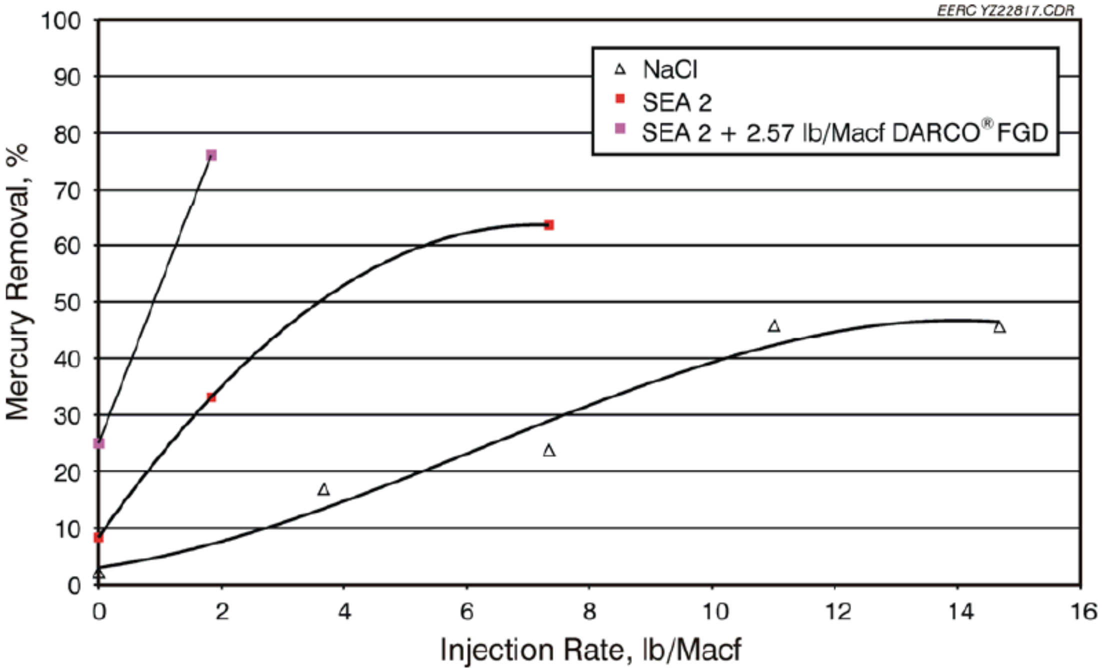
Table 1. Test Matrix for Unscrubbed Systems Equipped with ESPs

Test No.	Mercury Oxidant Additive		Sorbent	
	Category	Injection Rate, lb/Macf	Category	Injection Rate, lb/Macf
T1-1(Baseline)	None	NA	None	NA
T1-2	None	NA	DARCO® FGD	2.75–18.4
T1-3	NaCl	3.76–14.7	None	NA
T1-4	NaCl	3.76–14.7	DARCO® FGD	2.75–4.59
T1-5	SEA 2	1.84–7.34	None	NA
T1-6	SEA 2	1.84	DARCO® FGD	2.57
T1-7	NaCl	7.34–11.0	HCl-Treated FGD	2.57–4.59
T1-8	None	NA	EERC-Treated Carbon	1.84–2.75
T1-9	SEA 2	1.84	EERC-Treated Carbon	2.75
T1-10	Zn	7.34	None	NA
T1-11	Zn and NaCl	7.34–11.0	None	NA
T1-12	None	NA	Na_2S_4 (solution)	0.89–6.67
T1-13	$CaCl_2$	11	DARCO® FGD	0–4.59
T1-14	None	NA	ALSTOM Sorbent	1.1–3.1

45. This test matrix indicates that test T-6 employed the additive SEA2 and the sorbent DARCO FGD. DARCO FGD is the trade name for a powdered activated carbon product from Cabot (formerly Norit Americas). "SEA2" was a code name for the sodium bromide additive because, at the time, the EERC maintained the

specific chemical composition of SEA2 as proprietary. Nonetheless, as noted above from the logbook, this additive was sodium bromide.

46. In February 2005, the EERC provided a further report to the DOE with additional analysis of this testing (the "Feb. 2005 Report").[20] It noted: "The significant improvement by DARCO® FGD–SEA2 is not merely an additive effect but more a synergistic response. The SEA2 addition in the combustion zone not only enhances gaseous mercury conversion to particulate-associated mercury, but also improves DARCO® FGD carbon reactivity with mercury species." It also reported that the combination of SEA2 and activated carbon performed significantly better than alternative approaches:



47. This report also described additional testing performed with SEA2 and activated carbon in December 2003, as noted in the PTC logbook shown below.

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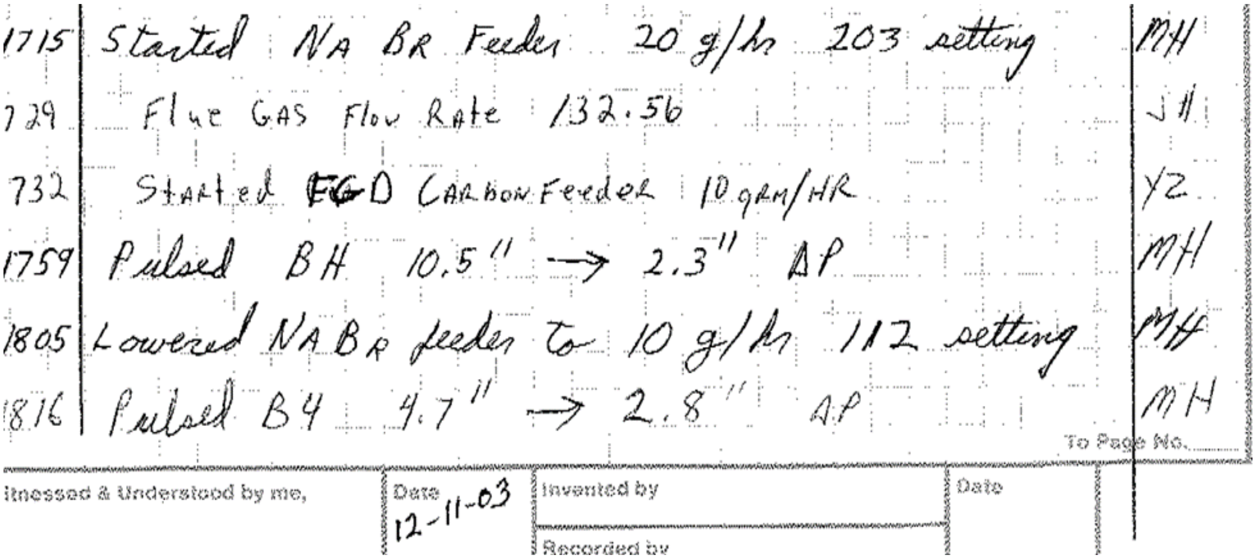
[20] *See* Ex. 2013, Feb. 2005 Report at 10 (providing coal analysis for "PTC-FM-639," the PTC testing identifier from the logbooks described above); *id.* at 9 (explaining that this testing occurred in September 2003).



1715	Started NA BR Feeder 20 g/hr 203 setting	MH
729	Flue GAS Flow Rate 132.56	JH
732	Started FGD Carbon Feeder 10 gram/HR	YZ
1759	Pulsed BH 10.5" → 2.3" ΔP	MH
1805	Lowered NABR feeder to 10 g/hr 112 setting	MH
1816	Pulsed B4 4.7" → 2.8" ΔP	MH

To Page No.

itnessed & Understood by me,

Date 12-11-03

Invented by

Date

Recorded by

The results of the December 2003 tests are shown below (Feb. 2005 Report at 23, 25, 28):

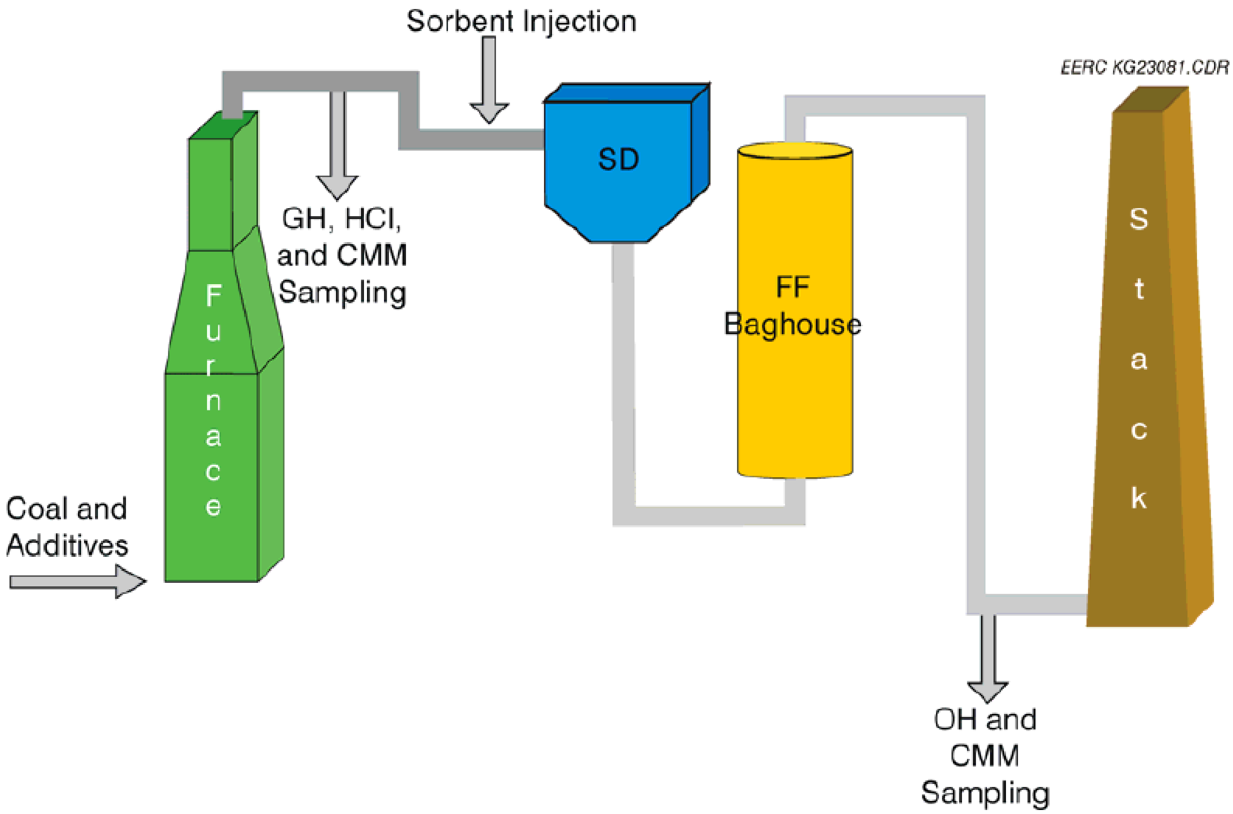


Table 10. Mercury Control Test Matrix

Coal Additive	Feed Rate, lb/Macf	Sorbent	Injection Rate, lb/Macf
None	NA	None	NA
None	NA	DARCO® FGD	1.84, 3.67, 7.35, and 11.0
None	NA	EERC-treated FGD	1.84, 3.67, and 7.35
None	NA	Amended Silicate™	7.35
NaCl	3.67, 7.35, and 11.0	None	NA
NaCl	3.67, 7.35, and 11.0	DARCO® FGD	3.67
SEA2	1.84 and 3.67	None	NA
SEA2	1.84 and 3.67	DARCO® FGD	1.84
$CaCl_2$	3.67, 7.35, and 11.0	None	NA
$CaCl_2$	3.67, 7.35, and 11.0	DARCO® FGD	3.67

48. The chart below provides an exemplary description of the effect of varying SEA2 and carbon addition rates on mercury capture:

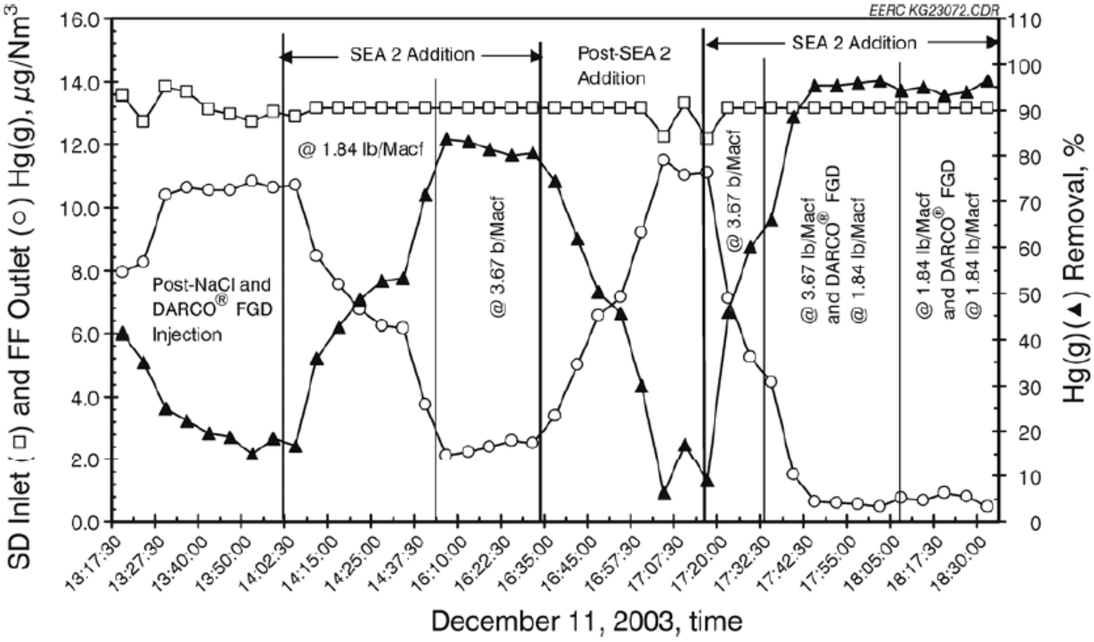


Figure 40. SDA inlet and FF outlet CMM results and SDA–FF Hg(g) removal efficiencies before, during, and after SEA2 additions and DARCO® FGD injection into the Center lignite coal and combustion flue gas, respectively.

49. An October 2005 Report described further testing conducted in February 2004 (the "Oct. 2005 Report"):[21]

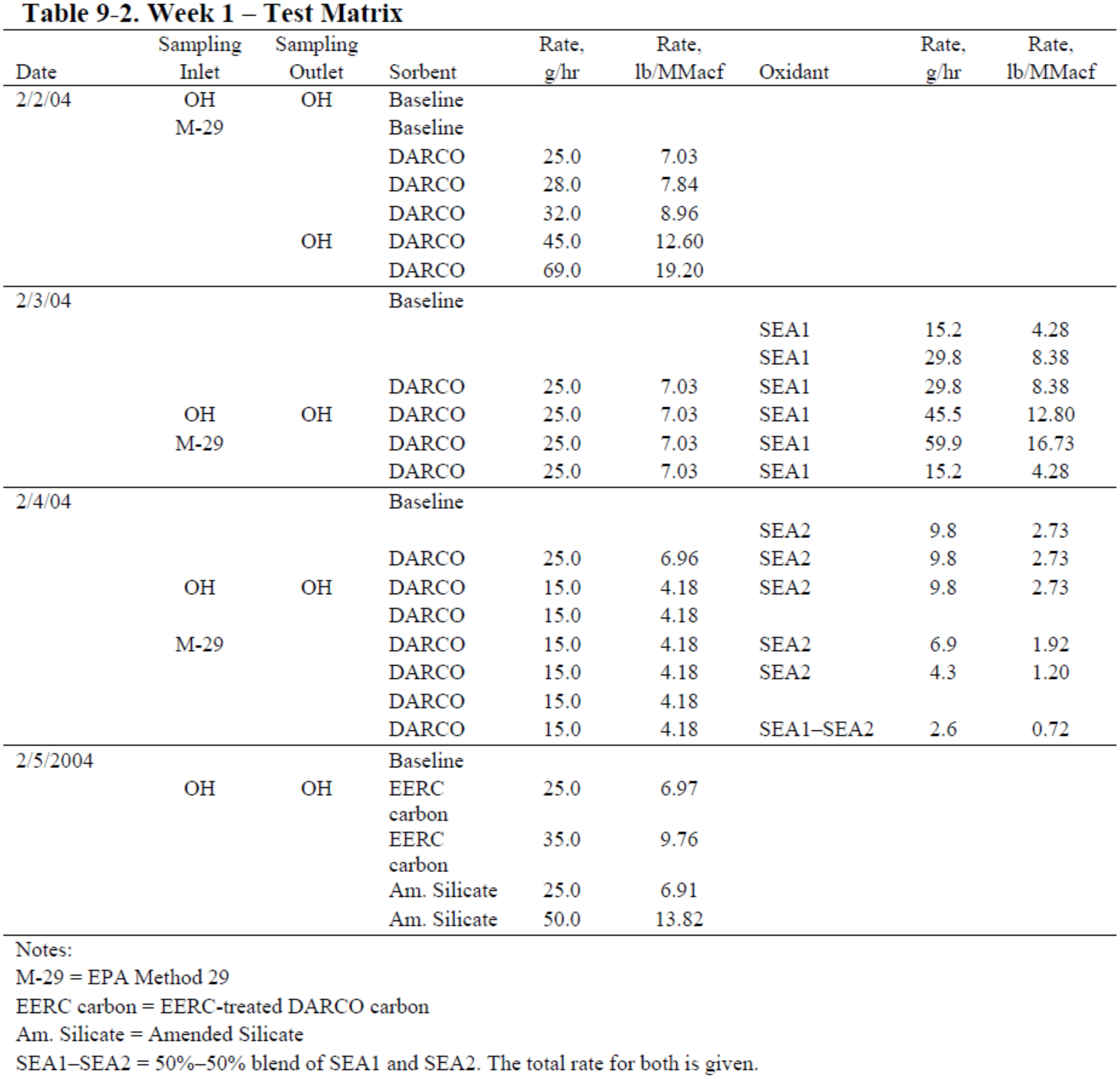


Table 9-2. Week 1 – Test Matrix

Date	Sampling Inlet	Sampling Outlet	Sorbent	Rate, g/hr	Rate, lb/MMacf	Oxidant	Rate, g/hr	Rate, lb/MMacf
2/2/04	OH	OH	Baseline					
	M-29		Baseline					
			DARCO	25.0	7.03			
			DARCO	28.0	7.84			
			DARCO	32.0	8.96			
		OH	DARCO	45.0	12.60			
			DARCO	69.0	19.20			
2/3/04			Baseline					
						SEA1	15.2	4.28
						SEA1	29.8	8.38
			DARCO	25.0	7.03	SEA1	29.8	8.38
	OH	OH	DARCO	25.0	7.03	SEA1	45.5	12.80
	M-29		DARCO	25.0	7.03	SEA1	59.9	16.73
			DARCO	25.0	7.03	SEA1	15.2	4.28
2/4/04			Baseline					
						SEA2	9.8	2.73
			DARCO	25.0	6.96	SEA2	9.8	2.73
	OH	OH	DARCO	15.0	4.18	SEA2	9.8	2.73
			DARCO	15.0	4.18			
	M-29		DARCO	15.0	4.18	SEA2	6.9	1.92
			DARCO	15.0	4.18	SEA2	4.3	1.20
			DARCO	15.0	4.18			
			DARCO	15.0	4.18	SEA1–SEA2	2.6	0.72
2/5/2004			Baseline					
	OH	OH	EERC carbon	25.0	6.97			
			EERC carbon	35.0	9.76			
			Am. Silicate	25.0	6.91			
			Am. Silicate	50.0	13.82			

Notes:
M-29 = EPA Method 29
EERC carbon = EERC-treated DARCO carbon
Am. Silicate = Amended Silicate
SEA1–SEA2 = 50%–50% blend of SEA1 and SEA2. The total rate for both is given.

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[21] Ex. 2014, Oct. 2005 Report at 20 ("EPA Method 29 was used for trace element sampling of the flue gas during Week 1 (February 2–4, 2004) testing of Caballo coal. Samples were collected at the ESP inlet upstream of the carbon injection location during three different conditions: baseline and SEA1 and SEA2 additions. The objective was to determine the effects of SEA additions on trace metal concentrations and particle–gas partitioning."); *id.* at 27.

Responses to Statements Regarding Conception and Reduction to Practice

50. I have reviewed the Board's institution decisions, which have explained that Patent Owner's evidence of reduction to practice may be insufficient because Patent Owner did not "explain how disclosure of sodium bromide (NaBr) in its antedating documents supports the full scope of what is claimed, i.e., 'Br2, HBR, a bromide compound, or a combination thereof.'" *See, e.g.*, IPR2025-00422, Paper 34 at 38.

51. As explained above, my co-inventors and I understood that the above-described test results would not only apply to sodium bromide, but that they would be replicated if the sodium bromide were replaced with other bromine-containing substances, including molecular bromine (*e.g.*, Br2), bromides (*e.g.*, Br-), or HBr.

52. These other bromine-containing compounds have boiling point temperatures much lower than the extremely high temperatures in a coal-fired power plant's boiler combustion, and it was understood that they would be reduced to bromine atoms in the high temperature combustion flame zone.

Responses to Statements Regarding Non-Obviousness of the Invention

53. I understand that the Board stated that "a POSITA would have had a reason to modify the teachings of Vosteen589[22] with either of Starns[23] or Mass-EPA[24]"

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[22] "Vosteen589" refers to U.S. Patent Publication No. 2004/0013589, issued to B. Vosteen. Ex. 1005.

[23] "Starns" refers to Starnes, Travis, et al., *Full-Scale Test of Mercury Control with Sorbent Injection and an ESP at Wisconsin Electric's Pleasant Prairie Power Plant*, Session AE1-C, Paper No. 43249, AIR & WASTE MANAGEMENT'S ASSOCIATION'S 95TH ANNUAL CONFERENCE, June 23–27, 2002. Ex. 1008.

[24] "Mass-EPA" refers to Massachusetts Dep. of Environmental Protection, Bureau of Waste Prevention, *Evaluation of the Technological and Economic Feasibility of Controlling and Eliminating Mercury Emissions from the Combustion of Solid Fossil Fuel*, Dec. 2002, available at https://web.archive.org/web/20030411074158/http:/www.state.ma.us/dep/bwp/daqc/files/mercfeas.pdf and at https://www.mass.gov/doc/evaluation-of-

such that, together, those publications teach a representative claim of the ’430 and ’225 Patents. *See, e.g.*, IPR2025-00422, Paper 34 at 27.

54. Respectfully, I disagree. Conventional wisdom would not have drawn others in the coal-fired power plant industry to combine pre-combustion addition of bromine with post-combustion injection of activated carbon.

55. Instead, researchers in the field—including the EPA—explored research into methods for pre-treating sorbents with various additives, including chlorine, and then injecting those pre-treated sorbents downstream of the boiler. *See* Ex. 2043 at 5-33 to 5-34. This approach also ensured that the sorbent additive would have plenty of time to react with the sorbent: the EPA explained that, for many plants, injected sorbents would have only a few seconds to find and react with mercury present in the flue gas, with high and costly carbon-to-Hg ratios needed to achieve adequate mercury removal. *Id.*

56. Thus, at the time my co-inventors and I conceived of and reduced our invention to practice (and subsequently filed a provisional patent application), the conventional wisdom was that pre-treating the sorbent with halogens or halides was a worthy topic of research, but it was not clear that the two-step process would be a promising solution. Indeed, that is why I was so surprised and excited with the test results described above.

Conclusion

57. As explained above, my co-inventors and I conceived of the inventions of the ’430 and ’225 patents at least as early as August 2002. We reduced those inventions to practice at least by September 2003 as documented in testing logbooks and EERC reports to the DOE.

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technologicaleconomic-feasibility-of-controlling-eliminating-mercuryemissions/download. Ex. 1009.

58. A claim chart comparing these documents to the claims of the '430 and '225 patents is attached to this declaration.

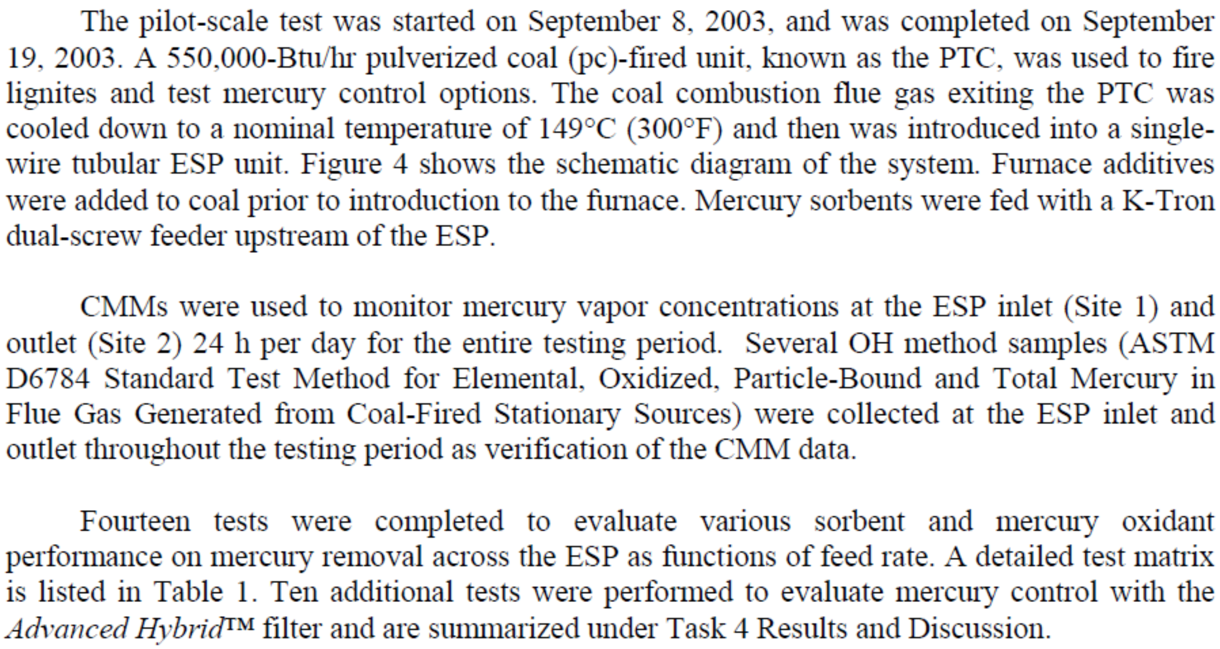
59. I further declare that all statements made herein of my own knowledge are true, and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by a fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the patents at issue in these proceedings.

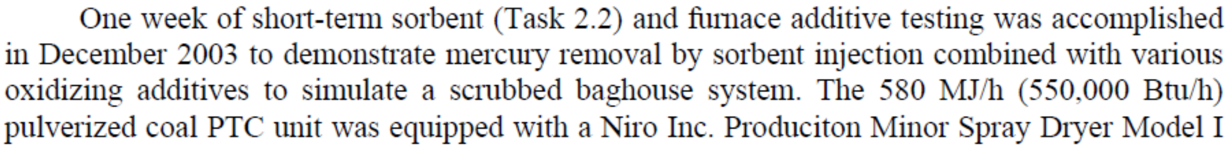
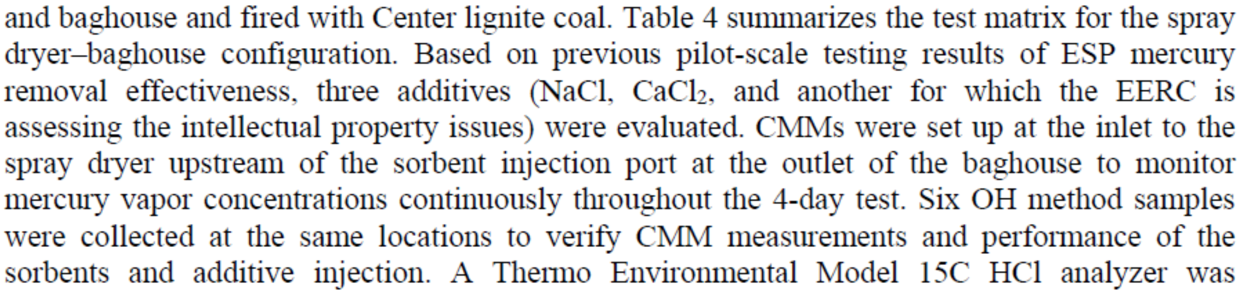
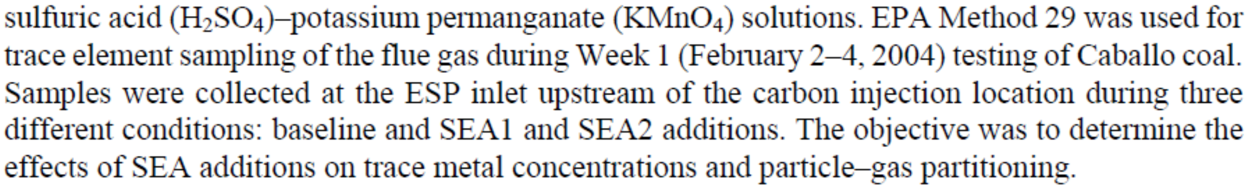
Dated: 1-20-2026

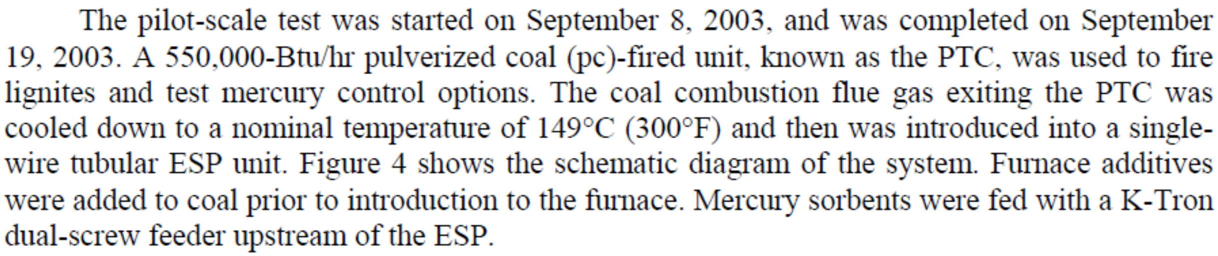
By: John Pavlish

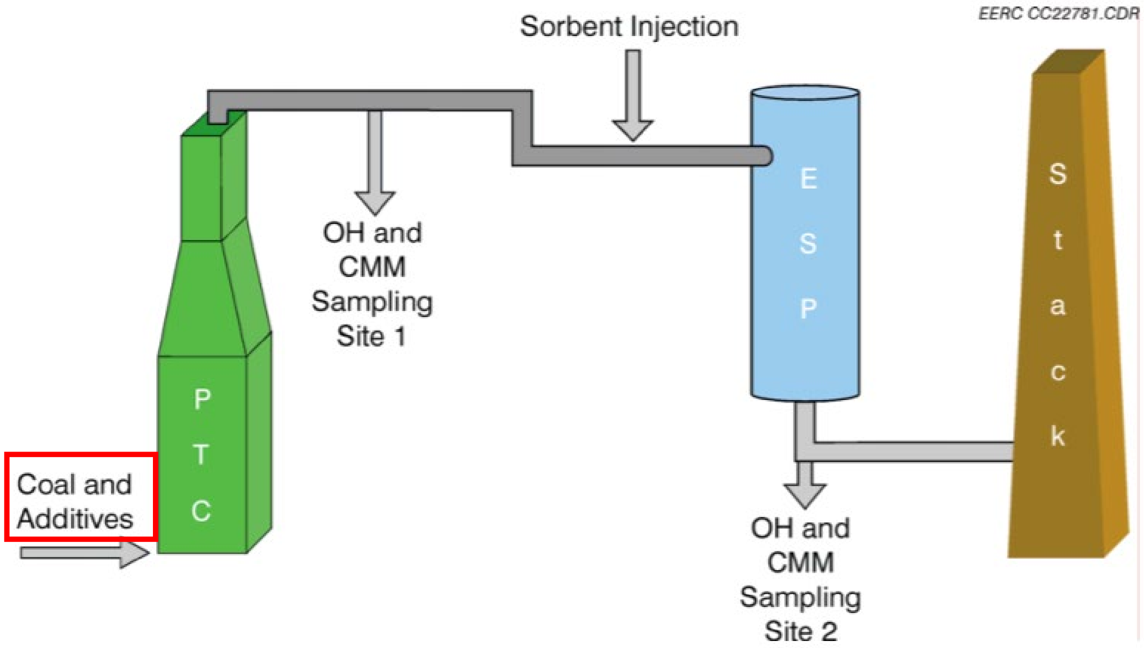
John Pavlish

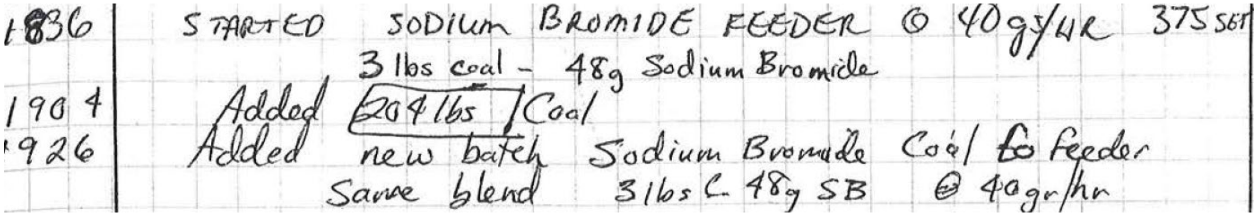
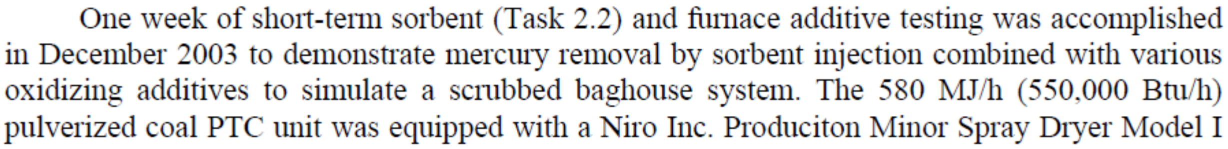
’430 Claim Chart

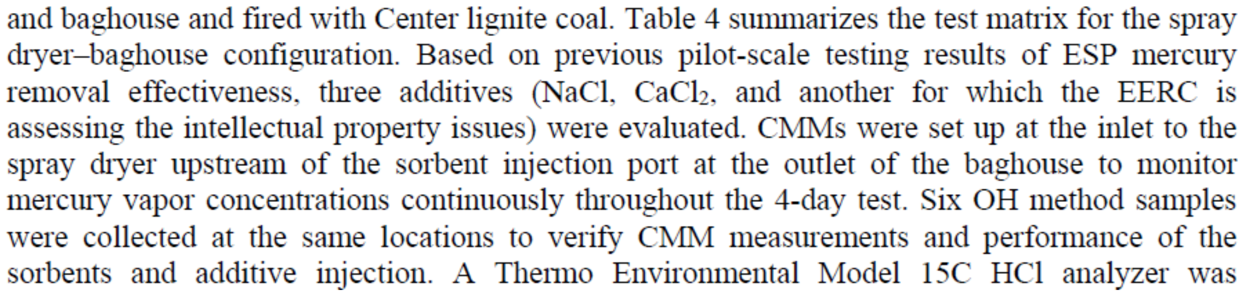
No.	’430 Claim Element	Evidence of Reduction to Practice
1a	A method of separating mercury from a mercury-containing gas, the method comprising:	The Feb. 2004 Report (Ex. 2012) describes the September 2003 testing (page 10):  The pilot-scale test was started on September 8, 2003, and was completed on September 19, 2003. A 550,000-Btu/hr pulverized coal (pc)-fired unit, known as the PTC, was used to fire lignites and test mercury control options. The coal combustion flue gas exiting the PTC was cooled down to a nominal temperature of 149°C (300°F) and then was introduced into a single-wire tubular ESP unit. Figure 4 shows the schematic diagram of the system. Furnace additives were added to coal prior to introduction to the furnace. Mercury sorbents were fed with a K-Tron dual-screw feeder upstream of the ESP. CMMs were used to monitor mercury vapor concentrations at the ESP inlet (Site 1) and outlet (Site 2) 24 h per day for the entire testing period. Several OH method samples (ASTM D6784 Standard Test Method for Elemental, Oxidized, Particle-Bound and Total Mercury in Flue Gas Generated from Coal-Fired Stationary Sources) were collected at the ESP inlet and outlet throughout the testing period as verification of the CMM data. Fourteen tests were completed to evaluate various sorbent and mercury oxidant performance on mercury removal across the ESP as functions of feed rate. A detailed test matrix is listed in Table 1. Ten additional tests were performed to evaluate mercury control with the *Advanced Hybrid*™ filter and are summarized under Task 4 Results and Discussion. The Feb. 2004 Report(Ex. 2012) also describes additional testing in December 2003 (page 14-15):

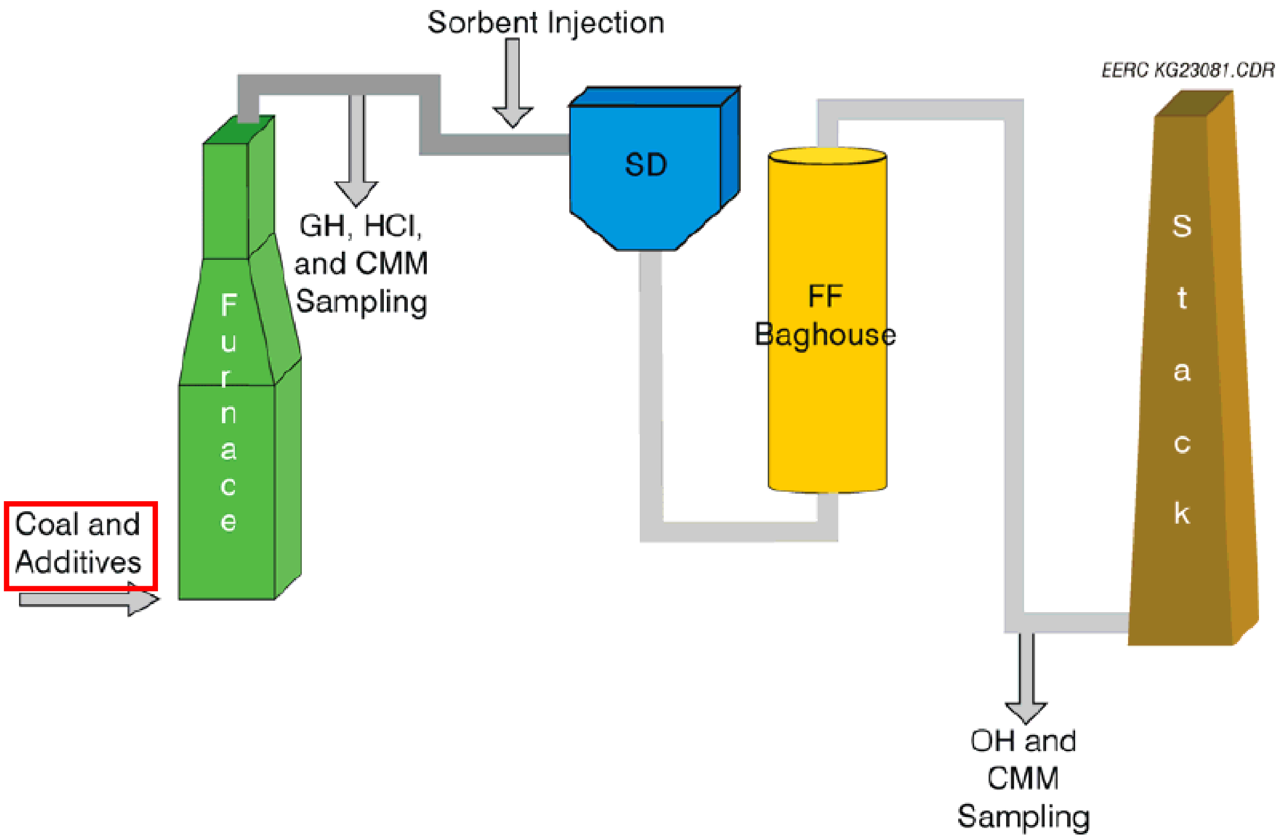
No.	’430 Claim Element	Evidence of Reduction to Practice
		 One week of short-term sorbent (Task 2.2) and furnace additive testing was accomplished in December 2003 to demonstrate mercury removal by sorbent injection combined with various oxidizing additives to simulate a scrubbed baghouse system. The 580 MJ/h (550,000 Btu/h) pulverized coal PTC unit was equipped with a Niro Inc. Produciton Minor Spray Dryer Model I  and baghouse and fired with Center lignite coal. Table 4 summarizes the test matrix for the spray dryer–baghouse configuration. Based on previous pilot-scale testing results of ESP mercury removal effectiveness, three additives (NaCl, $CaCl_2$, and another for which the EERC is assessing the intellectual property issues) were evaluated. CMMs were set up at the inlet to the spray dryer upstream of the sorbent injection port at the outlet of the baghouse to monitor mercury vapor concentrations continuously throughout the 4-day test. Six OH method samples were collected at the same locations to verify CMM measurements and performance of the sorbents and additive injection. A Thermo Environmental Model 15C HCl analyzer was The October 2005 Report describes additional testing in February 2004 (page 20):  sulfuric acid (H_2SO_4)–potassium permanganate ($KMnO_4$) solutions. EPA Method 29 was used for trace element sampling of the flue gas during Week 1 (February 2–4, 2004) testing of Caballo coal. Samples were collected at the ESP inlet upstream of the carbon injection location during three different conditions: baseline and SEA1 and SEA2 additions. The objective was to determine the effects of SEA additions on trace metal concentrations and particle–gas partitioning.
1b	combusting coal in a combustion chamber, to	The Feb. 2004 Report explains that coal was combusted in a 550,000-Btu/hr pc-fire combustor (known as the PTC) (page 10):

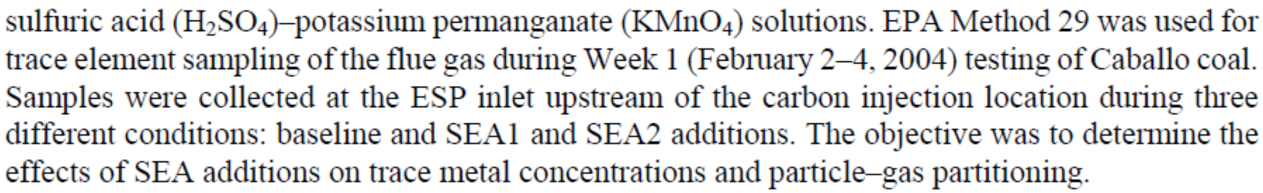
No.	’430 Claim Element	Evidence of Reduction to Practice
	provide the mercury-containing gas,	 The pilot-scale test was started on September 8, 2003, and was completed on September 19, 2003. A 550,000-Btu/hr pulverized coal (pc)-fired unit, known as the PTC, was used to fire lignites and test mercury control options. The coal combustion flue gas exiting the PTC was cooled down to a nominal temperature of 149°C (300°F) and then was introduced into a single-wire tubular ESP unit. Figure 4 shows the schematic diagram of the system. Furnace additives were added to coal prior to introduction to the furnace. Mercury sorbents were fed with a K-Tron dual-screw feeder upstream of the ESP.
1c	wherein the coal comprises an additive comprising Br_2, HBr, a bromide compound, or a combination thereof, wherein the additive is added to the coal before the coal enters the combustion	The Feb. 2004 Report describes adding coal and additives (including SEA 2) to the combustion chamber during the September 2003 testing (page 18): SEA 2 is noted as NaBr in the PTC logbooks, and when combusted with coal, produces a mercury-containing gas comprised of a bromine halogen or halide promoter.

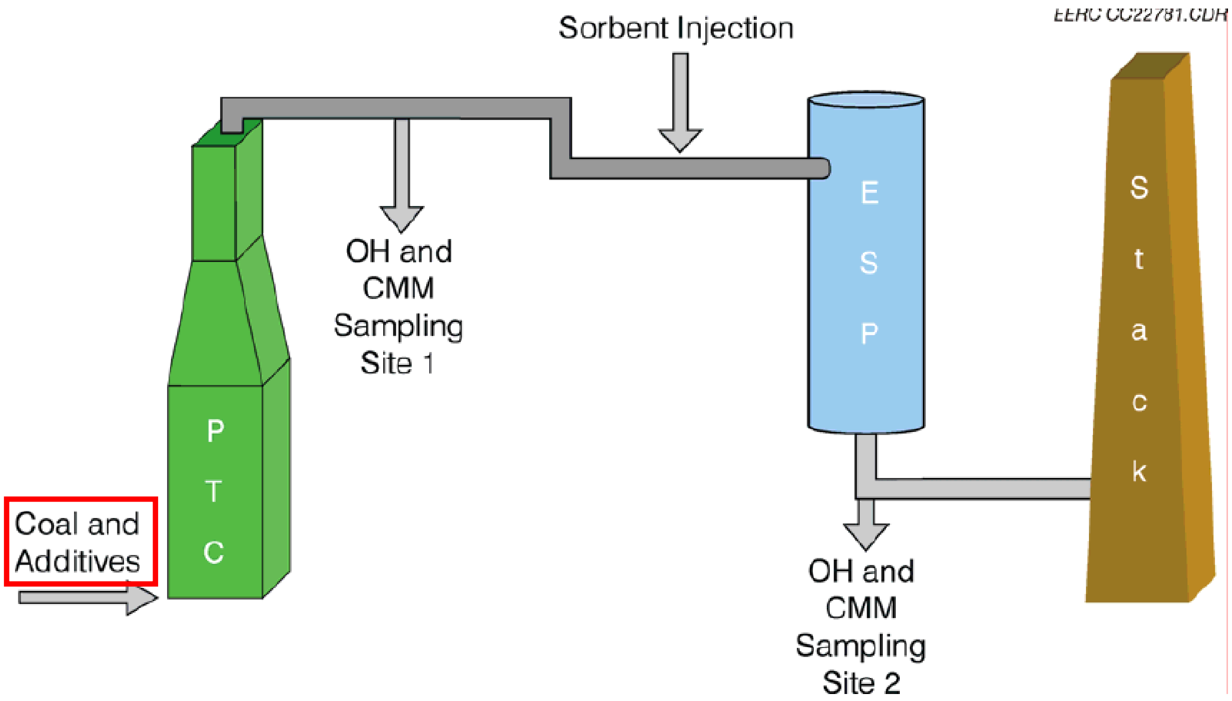
No.	’430 Claim Element	Evidence of Reduction to Practice
	chamber, or the combustion chamber comprises an additive comprising Br_2, HBr, a bromide compound, or a combination thereof or a combination thereof;	 Figure 4. Injection and sampling schematic of the PTC with an ESP. *See also* Feb. 2004 Report at 17 (“mercury oxidants including NaCl, SEA 2, and zinc were examined for their impacts on mercury removal.”); 15 (“Based on previous pilot-scale testing results of ESP mercury removal effectiveness, three additives (NaCl, CaCl2, and another for which the EERC is assessing the intellectual property

No.	’430 Claim Element	Evidence of Reduction to Practice
		issues) were evaluated.”); Final Report at 25 (“SEA2 is a proprietary Hg^0 oxidizing agent effective at addition rates on the order of 1/10 of those for SEA1.”) The PTC Log Book identifies the SEA2 additive used as sodium bromide, which includes Br^-. Thus, the mercury-containing gas, the coal, and the combustion chamber comprised HBr, Br2, and Br^-.  1836 STARTED SODIUM BROMIDE FEEDER @ 40gs/HR 375 SET 3 lbs coal - 48g Sodium Bromide 1904 Added \boxed{204 lbs} /Coal 1926 Added new batch Sodium Bromide Coal to feeder Same blend 3lbs C. 48g SB @ 40gr/hr SEA2 and activated carbon were similarly used during the December 2003 testing. *See* Feb. 2004 Report at 15:  One week of short-term sorbent (Task 2.2) and furnace additive testing was accomplished in December 2003 to demonstrate mercury removal by sorbent injection combined with various oxidizing additives to simulate a scrubbed baghouse system. The 580 MJ/h (550,000 Btu/h) pulverized coal PTC unit was equipped with a Niro Inc. Produciton Minor Spray Dryer Model I

No.	’430 Claim Element	Evidence of Reduction to Practice
		 and baghouse and fired with Center lignite coal. Table 4 summarizes the test matrix for the spray dryer–baghouse configuration. Based on previous pilot-scale testing results of ESP mercury removal effectiveness, three additives (NaCl, $CaCl_2$, and another for which the EERC is assessing the intellectual property issues) were evaluated. CMMs were set up at the inlet to the spray dryer upstream of the sorbent injection port at the outlet of the baghouse to monitor mercury vapor concentrations continuously throughout the 4-day test. Six OH method samples were collected at the same locations to verify CMM measurements and performance of the sorbents and additive injection. A Thermo Environmental Model 15C HCl analyzer was *See* Feb. 2005 Report at 25 (“Pilot-scale Hg control testing was conducted December 8–11, 2003, using a 580-MJ/hr (550,000-Btu/hr) pc-fired unit equipped with a Niro Inc. Production Minor Spray Dryer Model I and baghouse.”); at 27 (“Nine tests were completed to evaluate the effectiveness of potential Hg sorbents (DARCO® FGD, EERC-treated FGD, and Amended Silicate™) and Hg0 oxidation and sorbent enhancement additives (NaCl, SEA2, and CaCl2) to remove Hg using a SDA and FF.”); at 25:

No.	’430 Claim Element	Evidence of Reduction to Practice
		 SEA2 and activated carbon were also used in the February 2004 testing. Oct. 2005 Report at 20:

No.	’430 Claim Element	Evidence of Reduction to Practice
		 sulfuric acid (H_2SO_4)–potassium permanganate ($KMnO_4$) solutions. EPA Method 29 was used for trace element sampling of the flue gas during Week 1 (February 2–4, 2004) testing of Caballo coal. Samples were collected at the ESP inlet upstream of the carbon injection location during three different conditions: baseline and SEA1 and SEA2 additions. The objective was to determine the effects of SEA additions on trace metal concentrations and particle–gas partitioning. Oct. 2005 Report at 26:

No.	’430 Claim Element	Evidence of Reduction to Practice
		
1d	injecting a sorbent comprising activated carbon	The Feb. 2004 Report describes injecting Darco FGD activated carbon into the mercury-containing gas downstream of the combustion chamber during the September 2003 testing (page 11):

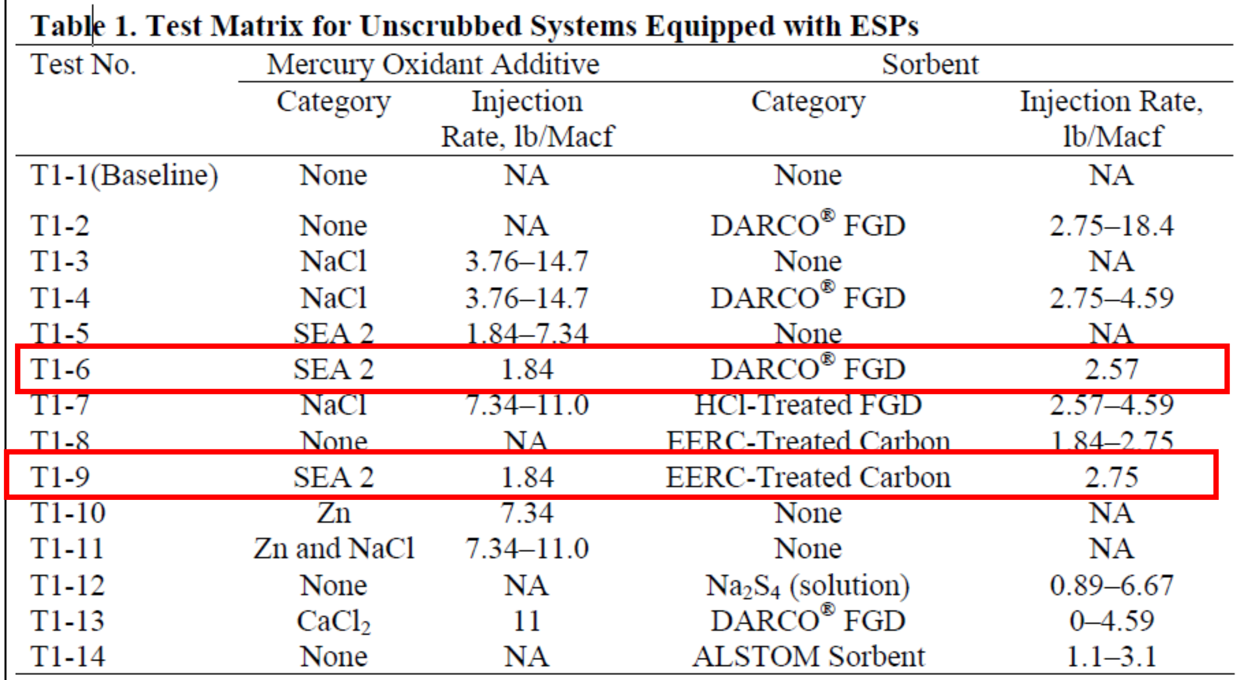
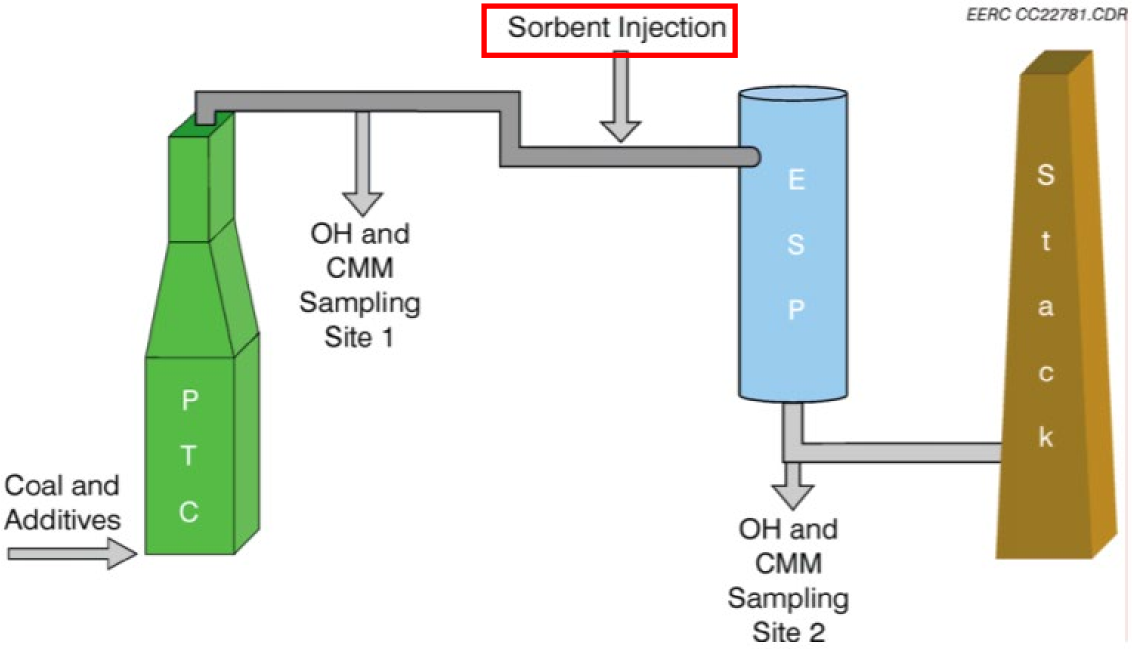
<table>
<tr><th>No.</th><th>’430 Claim Element</th><th>Evidence of Reduction to Practice</th></tr>
<tr><td></td><td>into the mercury-containing gas downstream of the combustion chamber;</td><td>


Table 1. Test Matrix for Unscrubbed Systems Equipped with ESPs

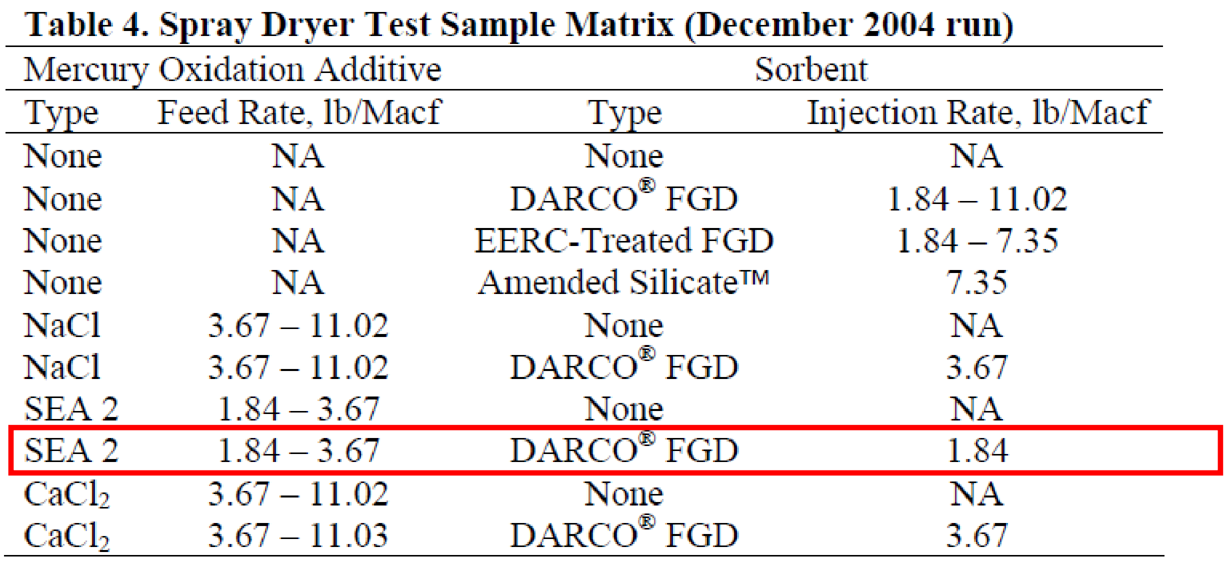
<table>
<tr><th>Test No.</th><th colspan="2">Mercury Oxidant Additive</th><th colspan="2">Sorbent</th></tr>
<tr><th></th><th>Category</th><th>Injection Rate, lb/Macf</th><th>Category</th><th>Injection Rate, lb/Macf</th></tr>
<tr><td>T1-1(Baseline)</td><td>None</td><td>NA</td><td>None</td><td>NA</td></tr>
<tr><td>T1-2</td><td>None</td><td>NA</td><td>DARCO® FGD</td><td>2.75–18.4</td></tr>
<tr><td>T1-3</td><td>NaCl</td><td>3.76–14.7</td><td>None</td><td>NA</td></tr>
<tr><td>T1-4</td><td>NaCl</td><td>3.76–14.7</td><td>DARCO® FGD</td><td>2.75–4.59</td></tr>
<tr><td>T1-5</td><td>SEA 2</td><td>1.84–7.34</td><td>None</td><td>NA</td></tr>
<tr><td>T1-6</td><td>SEA 2</td><td>1.84</td><td>DARCO® FGD</td><td>2.57</td></tr>
<tr><td>T1-7</td><td>NaCl</td><td>7.34–11.0</td><td>HCl-Treated FGD</td><td>2.57–4.59</td></tr>
<tr><td>T1-8</td><td>None</td><td>NA</td><td>EERC-Treated Carbon</td><td>1.84–2.75</td></tr>
<tr><td>T1-9</td><td>SEA 2</td><td>1.84</td><td>EERC-Treated Carbon</td><td>2.75</td></tr>
<tr><td>T1-10</td><td>Zn</td><td>7.34</td><td>None</td><td>NA</td></tr>
<tr><td>T1-11</td><td>Zn and NaCl</td><td>7.34–11.0</td><td>None</td><td>NA</td></tr>
<tr><td>T1-12</td><td>None</td><td>NA</td><td>Na_2S_4 (solution)</td><td>0.89–6.67</td></tr>
<tr><td>T1-13</td><td>$CaCl_2$</td><td>11</td><td>DARCO® FGD</td><td>0–4.59</td></tr>
<tr><td>T1-14</td><td>None</td><td>NA</td><td>ALSTOM Sorbent</td><td>1.1–3.1</td></tr>
</table>

See also Feb. 2004 Report at 15 (describing “DARCO® FGD activated carbon, supplied by NORIT Americas, Inc.; an EERC-treated activated carbon”)
</td></tr>
</table>

No.	’430 Claim Element	Evidence of Reduction to Practice
		 Figure 4. Injection and sampling schematic of the PTC with an ESP. The Feb. 2004 Report also describes injecting activated carbon sorbent during the December 2003 testing:[25]

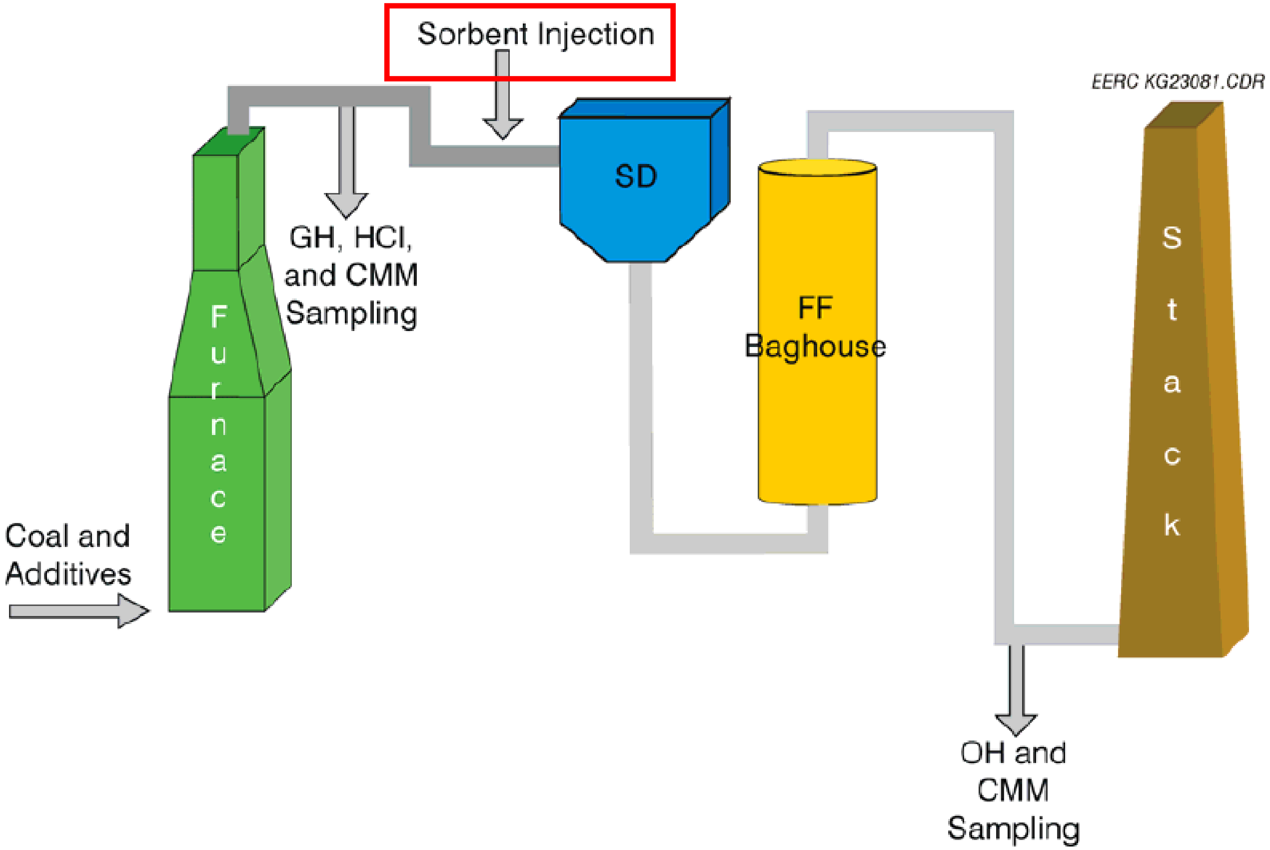
---

[25] This table refers to a “December 2004 run,” which is a typo. It should refer to a December 2003 run as noted in the preceding paragraph. Final Report at 14 (“One week of short-term sorbent (Task 2.2) and furnace additive

<table>
<tr><th>No.</th><th>’430 Claim Element</th><th>Evidence of Reduction to Practice</th></tr>
<tr><td></td><td></td><td>
Table 4. Spray Dryer Test Sample Matrix (December 2004 run)
<table>
<tr><th colspan="2">Mercury Oxidation Additive</th><th colspan="2">Sorbent</th></tr>
<tr><th>Type</th><th>Feed Rate, lb/Macf</th><th>Type</th><th>Injection Rate, lb/Macf</th></tr>
<tr><td>None</td><td>NA</td><td>None</td><td>NA</td></tr>
<tr><td>None</td><td>NA</td><td>DARCO® FGD</td><td>1.84 – 11.02</td></tr>
<tr><td>None</td><td>NA</td><td>EERC-Treated FGD</td><td>1.84 – 7.35</td></tr>
<tr><td>None</td><td>NA</td><td>Amended Silicate™</td><td>7.35</td></tr>
<tr><td>NaCl</td><td>3.67 – 11.02</td><td>None</td><td>NA</td></tr>
<tr><td>NaCl</td><td>3.67 – 11.02</td><td>DARCO® FGD</td><td>3.67</td></tr>
<tr><td>SEA 2</td><td>1.84 – 3.67</td><td>None</td><td>NA</td></tr>
<tr><td>SEA 2</td><td>1.84 – 3.67</td><td>DARCO® FGD</td><td>1.84</td></tr>
<tr><td>$CaCl_2$</td><td>3.67 – 11.02</td><td>None</td><td>NA</td></tr>
<tr><td>$CaCl_2$</td><td>3.67 – 11.03</td><td>DARCO® FGD</td><td>3.67</td></tr>
</table>
<i>See also</i> Feb. 2005 Report at 25:</td></tr>
</table>

---

testing was accomplished in December 2003 to demonstrate mercury removal by sorbent injection combined with various oxidizing additives to simulate a scrubbed baghouse system.”). This is also evidence based on the fact that the Final Report was prepared in February 2004.

No.	’430 Claim Element	Evidence of Reduction to Practice
		 The Oct. 2005 Report describes injecting activated carbon sorbent during the February 2004 testing (pages 26-27):

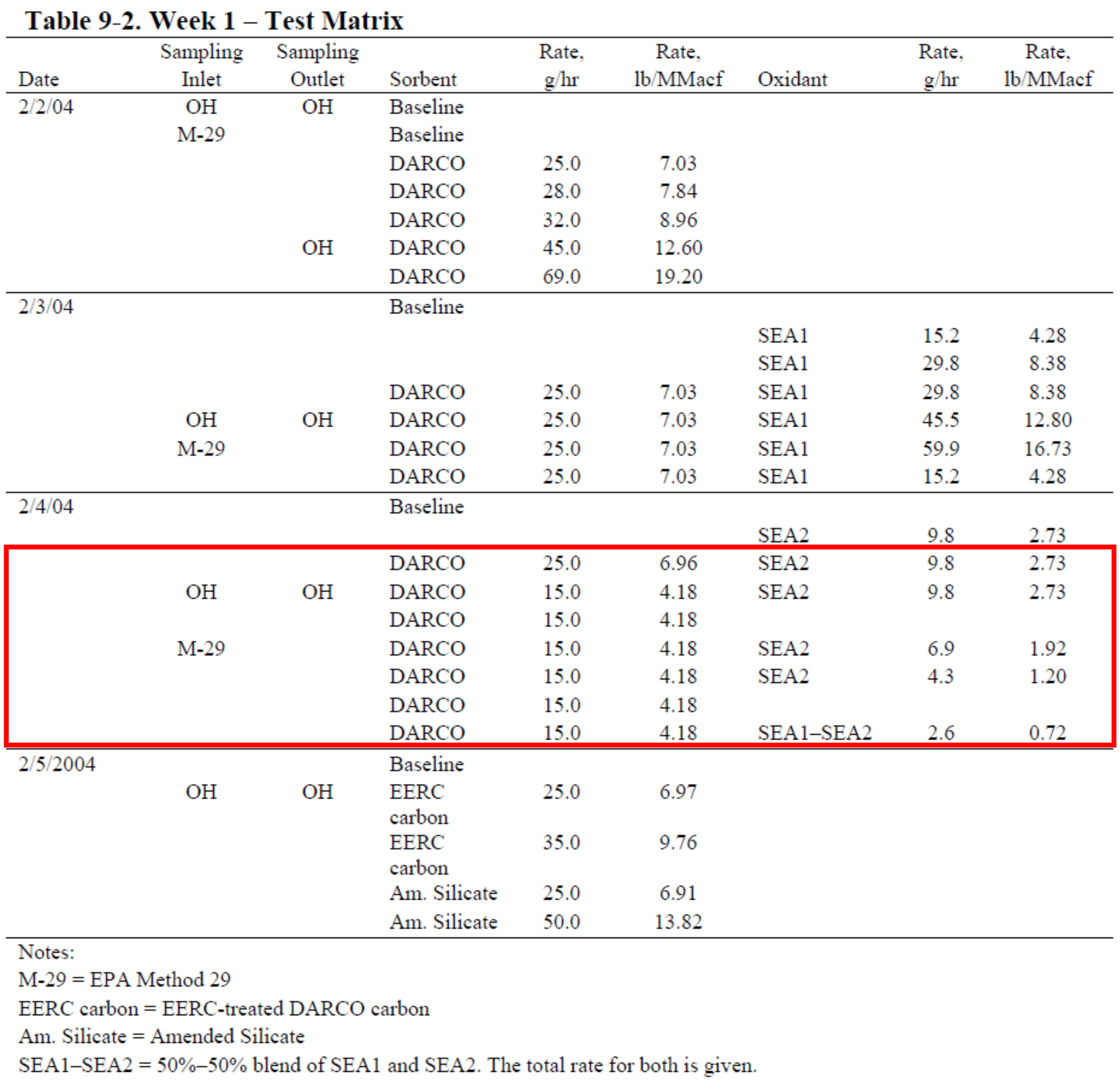


Table 9-2. Week 1 – Test Matrix

Date	Sampling Inlet	Sampling Outlet	Sorbent	Rate, g/hr	Rate, lb/MMacf	Oxidant	Rate, g/hr	Rate, lb/MMacf
2/2/04	OH	OH	Baseline					
	M-29		Baseline					
			DARCO	25.0	7.03			
			DARCO	28.0	7.84			
			DARCO	32.0	8.96			
		OH	DARCO	45.0	12.60			
			DARCO	69.0	19.20			
2/3/04			Baseline					
						SEA1	15.2	4.28
						SEA1	29.8	8.38
			DARCO	25.0	7.03	SEA1	29.8	8.38
	OH	OH	DARCO	25.0	7.03	SEA1	45.5	12.80
	M-29		DARCO	25.0	7.03	SEA1	59.9	16.73
			DARCO	25.0	7.03	SEA1	15.2	4.28
2/4/04			Baseline					
						SEA2	9.8	2.73
			DARCO	25.0	6.96	SEA2	9.8	2.73
	OH	OH	DARCO	15.0	4.18	SEA2	9.8	2.73
			DARCO	15.0	4.18			
	M-29		DARCO	15.0	4.18	SEA2	6.9	1.92
			DARCO	15.0	4.18	SEA2	4.3	1.20
			DARCO	15.0	4.18			
			DARCO	15.0	4.18	SEA1–SEA2	2.6	0.72
2/5/2004			Baseline					
	OH	OH	EERC carbon	25.0	6.97			
			EERC carbon	35.0	9.76			
			Am. Silicate	25.0	6.91			
			Am. Silicate	50.0	13.82			

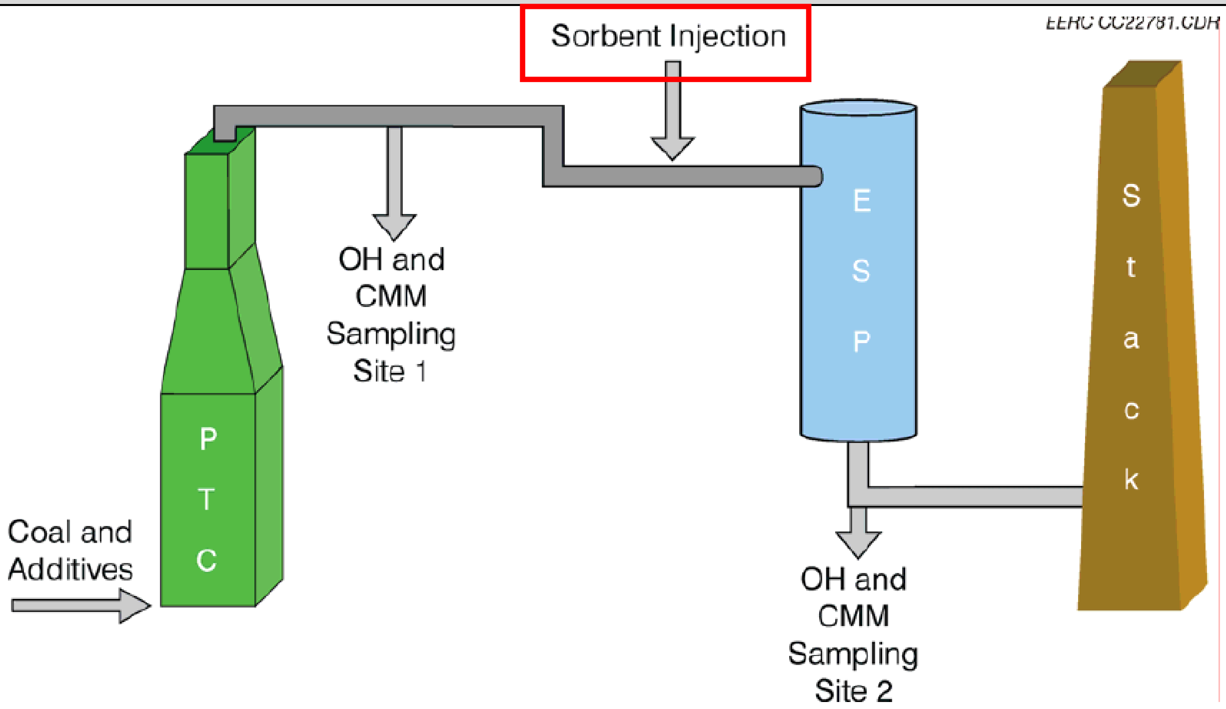
Notes:

M-29 = EPA Method 29

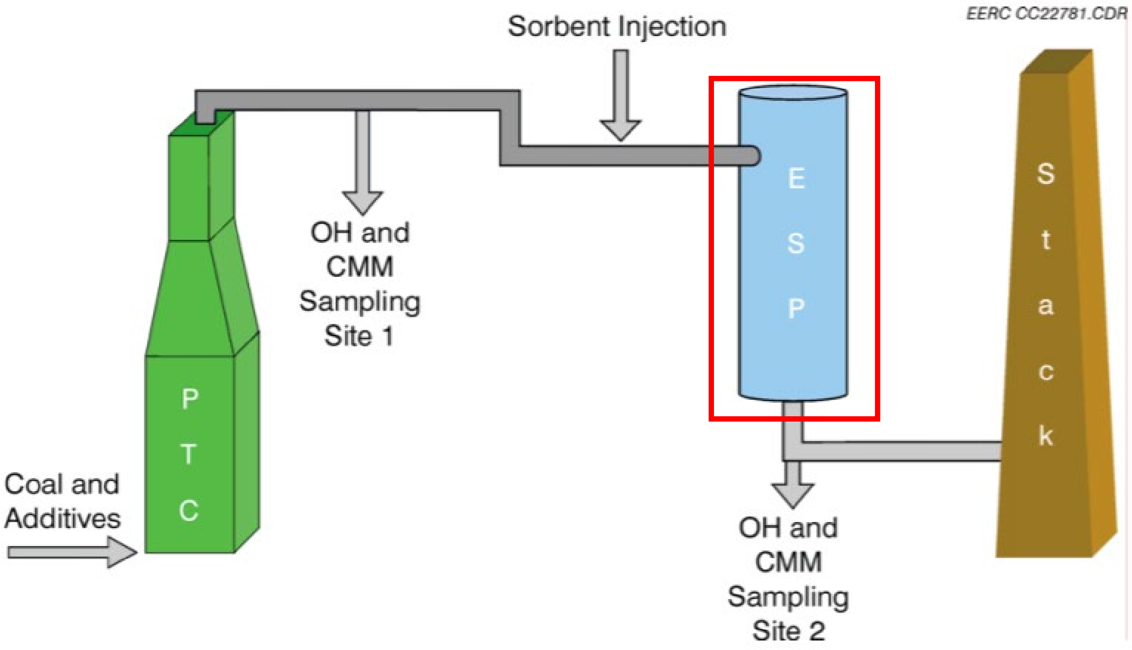
EERC carbon = EERC-treated DARCO carbon

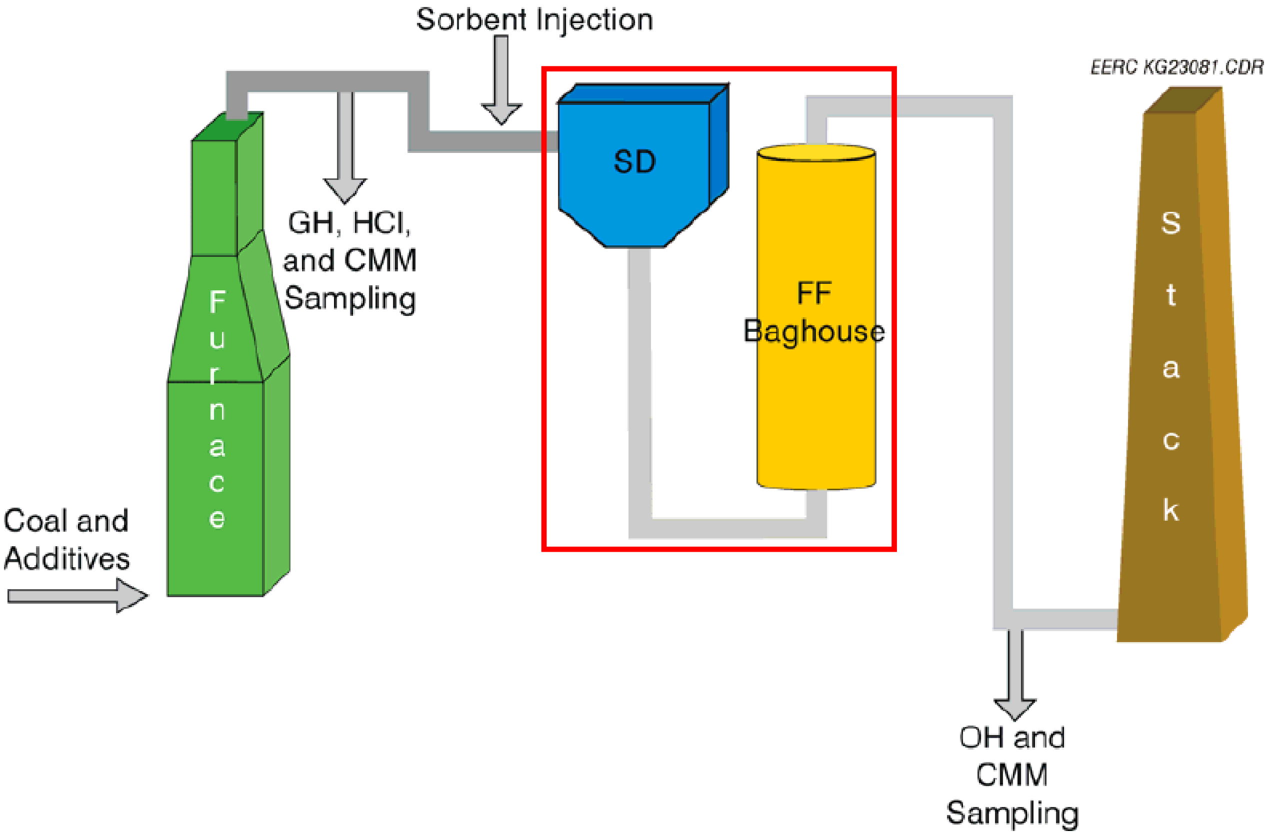
Am. Silicate = Amended Silicate

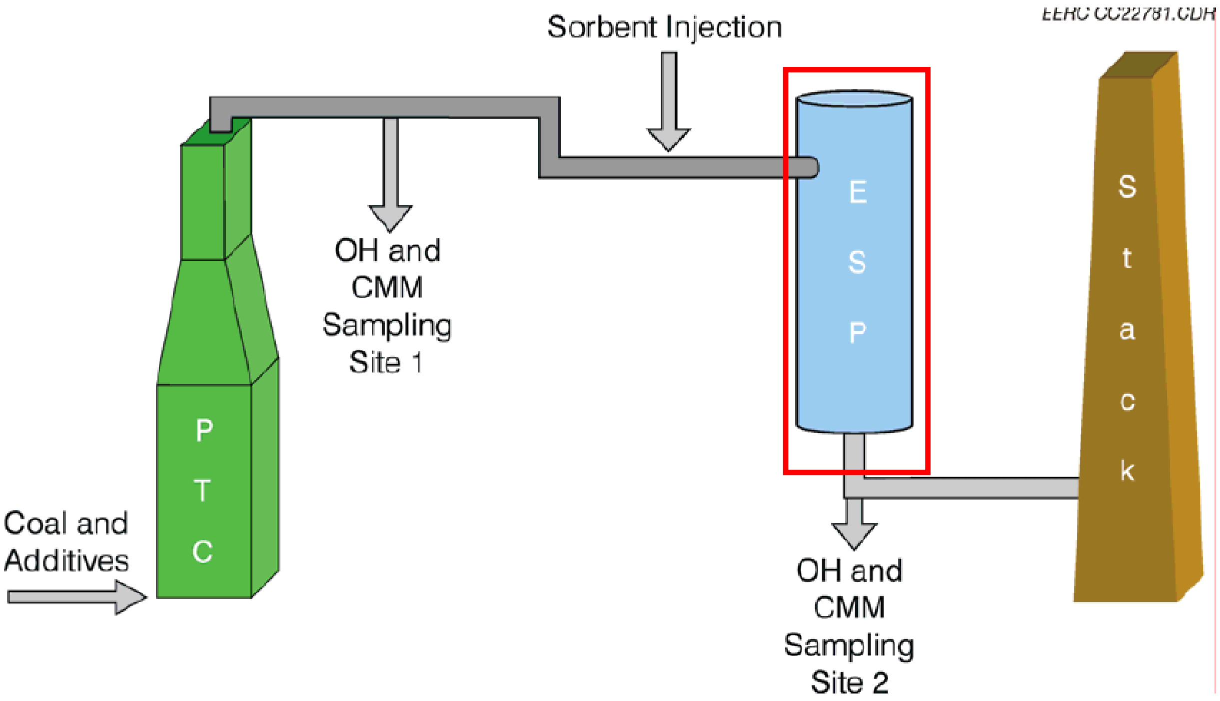
SEA1–SEA2 = 50%–50% blend of SEA1 and SEA2. The total rate for both is given.

No.	’430 Claim Element	Evidence of Reduction to Practice
		
1e	contacting mercury in the mercury-containing gas	Because the coal and sodium bromide were combusted, and activated carbon was injecting into the emission gas, the sorbent and mercury formed a mercury/sorbent composition. *See, e.g.*, Ex. 2012, Feb. 2004 Report at 2 (“Sorbent injection for removing Hg involves adsorption of Hg species by a solid sorbent injected upstream of a particulate control device such as an FF (baghouse) or ESP.”); *see also* Ex. 2013,

No.	’430 Claim Element	Evidence of Reduction to Practice
	with the sorbent; and	Feb. 2005 Report at 18 (“The significant improvement by DARCO® FGD–SEA2 is not merely an additive effect but more a synergistic response. The SEA2 addition in the combustion zone not only enhances gaseous mercury conversion to particulate-associated mercury, but also improves DARCO® FGD carbon reactivity with mercury species.”).
1f	separating the sorbent contacted with the mercury from the mercury-containing gas.	The mercury/sorbent composition was separated using an electrostatic precipitator during the September 2003 testing. Feb. 2004 Report at 10-11 (“Fourteen tests were completed to evaluate various sorbent and mercury oxidant performance on mercury removal across the ESP as functions of feed rate.”):

No.	’430 Claim Element	Evidence of Reduction to Practice
		 Figure 4. Injection and sampling schematic of the PTC with an ESP. The mercury/sorbent composition was separated using a scrubbed baghouse system during the December 2003 testing. Feb. 2004 Report at 14 (“One week of short-term sorbent (Task 2.2) and furnace additive testing was accomplished in December 2003 to demonstrate mercury removal by sorbent injection combined with various

No.	’430 Claim Element	Evidence of Reduction to Practice
		oxidizing additives to simulate a scrubbed baghouse system.”); *see also* Feb. 2005 Report at 25: 

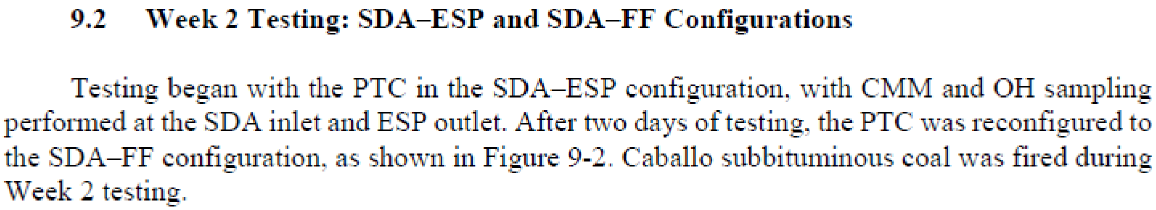
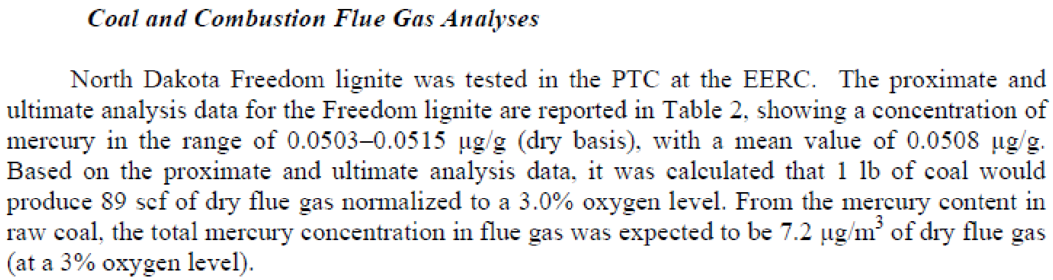
No.	’430 Claim Element	Evidence of Reduction to Practice
		The mercury/sorbent composition was separated using an electrostatic precipitator during the February 2004 testing. Oct. 2005 Report at 26 (“ESP Hg removal testing was performed with the PTC firing Caballo subbituminous coal.”): 

No.	’430 Claim Element	Evidence of Reduction to Practice
2	The method of claim 1, wherein the coal comprises the additive comprising the Br_2, HBr, the bromide compound, or a combination thereof, wherein the additive is added to the coal before the coal enters the combustion chamber.	*See* claim 1.
3	The method of claim 1,	*See* claim 1.

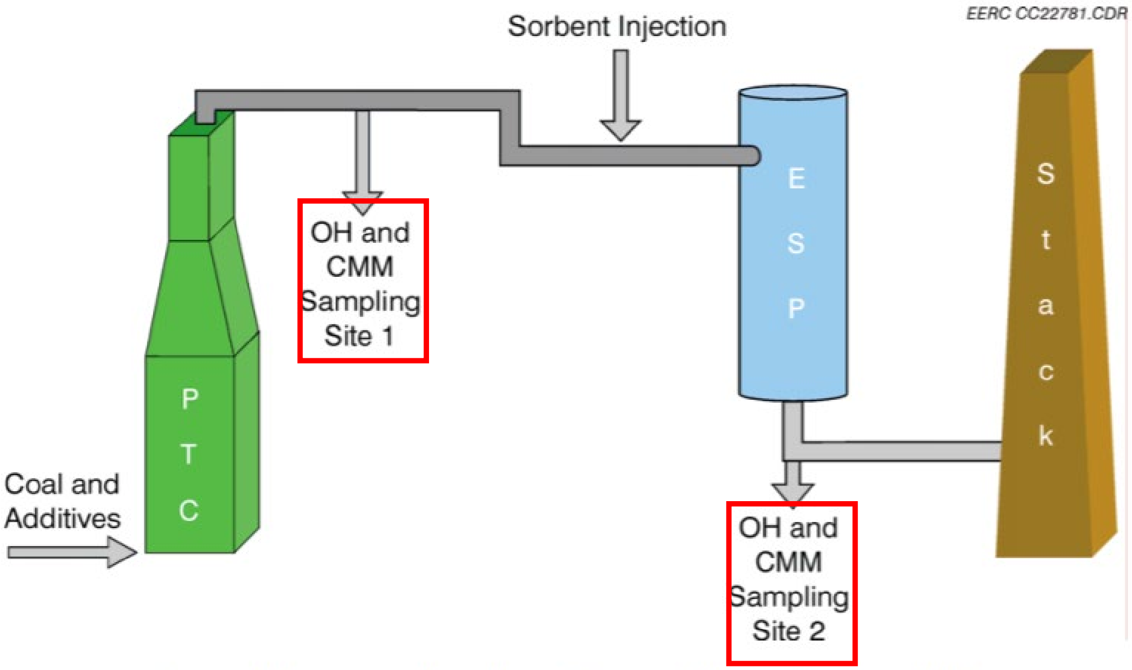
No.	’430 Claim Element	Evidence of Reduction to Practice
	wherein the combustion chamber comprises the additive comprising the Br_2, HBr, the bromide compound, or a combination thereof.	
4	The method of claim 1, wherein the coal is combusted in the combustion chamber at a coal-combustion facility, wherein	*See* claim 1.

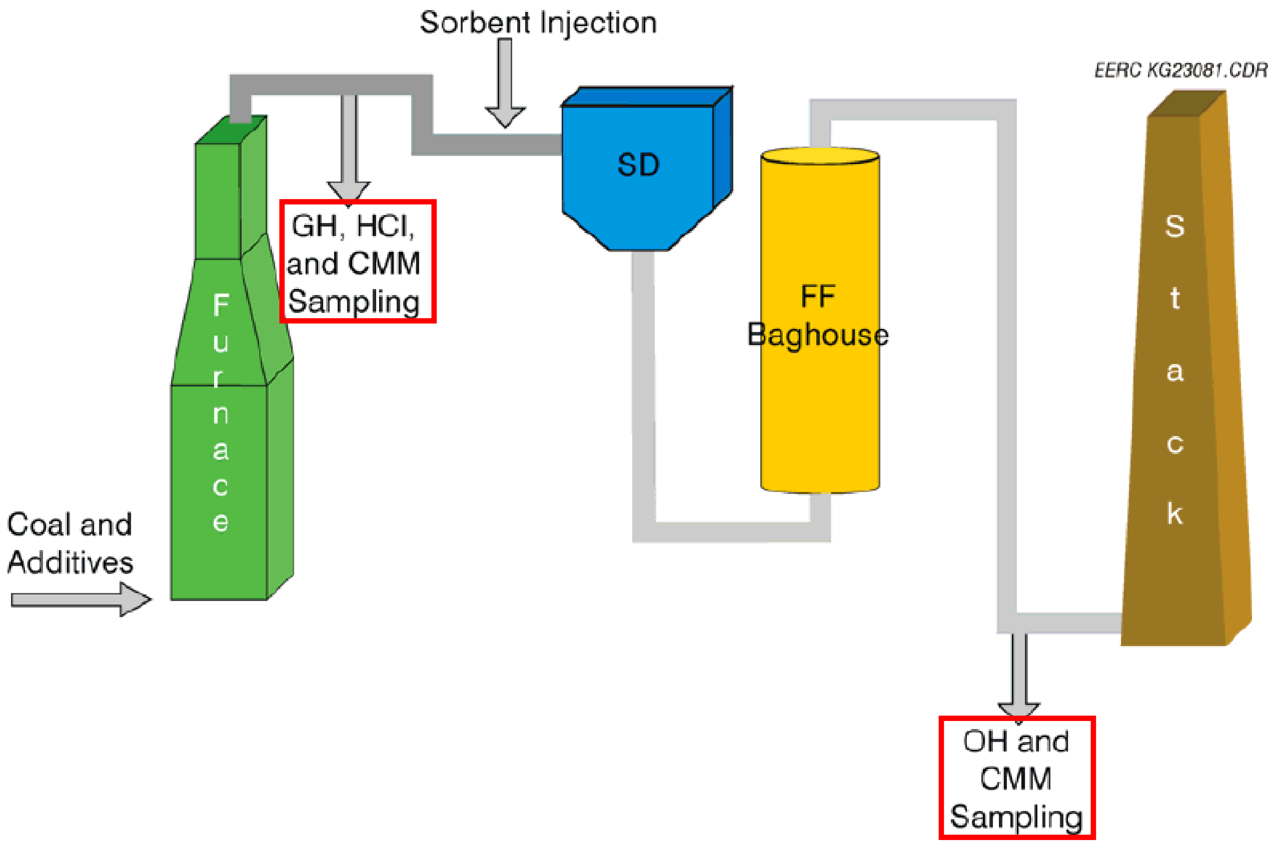
No.	’430 Claim Element	Evidence of Reduction to Practice
	the additive comprising the Br_2, HBr, bromide compound, or combination thereof, is added to the coal before the coal enters the combustion chamber, wherein the addition of the additive comprising the Br_2, HBr, bromide compound, or combination thereof, to the coal is performed	

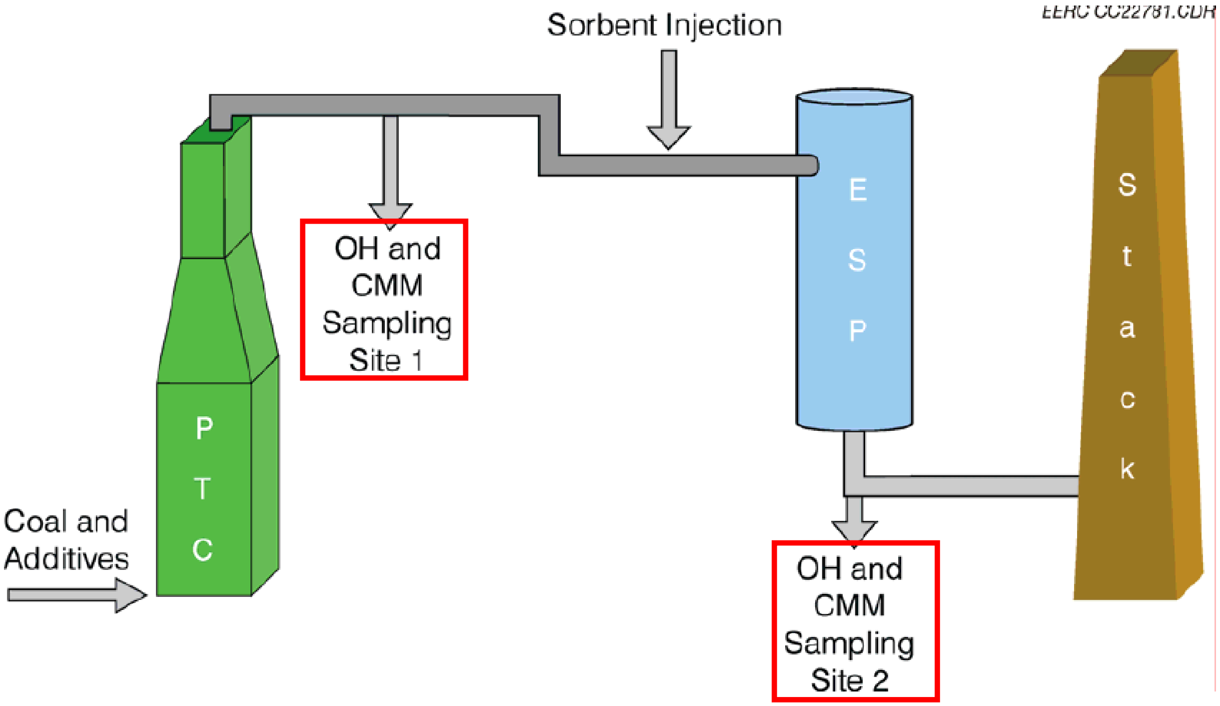
No.	**’430 Claim Element**	**Evidence of Reduction to Practice**
	at the coal-combustion facility.	
6	The method of claim 1, wherein the combustion chamber is an electric utility coal combustion chamber.	*See* 1a-c.
7	The method of claim 1, wherein the combustion chamber is a coal combustion furnace.	*See* 1a-c.

No.	’430 Claim Element	Evidence of Reduction to Practice
8	The method of claim 1, wherein the coal comprises a subbituminous coal.	Our testing included tests with subbituminous coal. *See* Ex. 2014, Oct. 2005 Report at 28:  **9.2 Week 2 Testing: SDA–ESP and SDA–FF Configurations** Testing began with the PTC in the SDA–ESP configuration, with CMM and OH sampling performed at the SDA inlet and ESP outlet. After two days of testing, the PTC was reconfigured to the SDA–FF configuration, as shown in Figure 9-2. Caballo subbituminous coal was fired during Week 2 testing.
9	The method of claim 1, wherein the coal comprises a lignite coal.	Our testing included tests with lignite coal. *See* Ex. 2012 Feb. 2004 Report at 10:  ***Coal and Combustion Flue Gas Analyses*** North Dakota Freedom lignite was tested in the PTC at the EERC. The proximate and ultimate analysis data for the Freedom lignite are reported in Table 2, showing a concentration of mercury in the range of 0.0503–0.0515 µg/g (dry basis), with a mean value of 0.0508 µg/g. Based on the proximate and ultimate analysis data, it was calculated that 1 lb of coal would produce 89 scf of dry flue gas normalized to a 3.0% oxygen level. From the mercury content in raw coal, the total mercury concentration in flue gas was expected to be 7.2 µg/m^3 of dry flue gas (at a 3% oxygen level).
10a	The method of claim 1,	*See* Claim 1.

No.	’430 Claim Element	Evidence of Reduction to Practice
	further comprising	
10b	measuring the mercury content of the mercury-containing gas; and	The Feb. 2004 Report describes the use of “Continuous Mercury Monitors” during the September 2003 testing and December 2003 testing. Feb. 2004 Report at 8 (“Hg^0 and total Hg levels will be measured on a nearly continuous basis using a continuous mercury monitor (CMM)”); at 10:

No.	’430 Claim Element	Evidence of Reduction to Practice
		 Figure 4. Injection and sampling schematic of the PTC with an ESP. *See also* Feb. 2005 Report at 25:

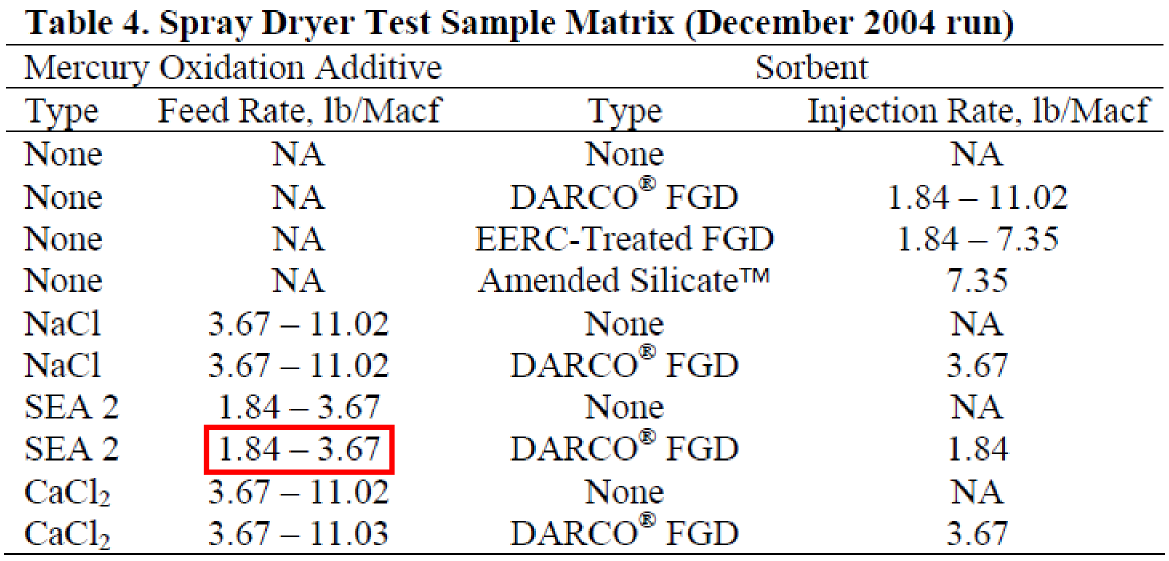
No.	’430 Claim Element	Evidence of Reduction to Practice
		 *See also* Oct. 2005 Report at 26:

No.	’430 Claim Element	Evidence of Reduction to Practice
		
10c	modifying, in response to the measured mercury content	The Feb. 2004 Report describes adjusting the additive and sorbent injection rate. Both options result in changes to the sorbent composition. Feb. 2004 Report at 9 (“Specific sorbent injection rates will be determined based on the measured Hg concentration in the flue gas.”). Feb. 2004 Report at 10 (“For continuous injection, the feed rate will be varied from 2500–12,000 lb sorbent/lb Hg”). Feb. 2004 Report

No.	’430 Claim Element	Evidence of Reduction to Practice
	of the mercury-containing gas, an injection rate of injecting the sorbent into the mercury-containing gas, an amount of the Br_2, HBr, the bromide compound, or a combination thereof, added to the coal or the	at 10 (“Fourteen tests were completed to evaluate various sorbent and mercury oxidant performance on mercury removal across the ESP as functions of feed rate”). *See also* Feb. 2005 Report at 15:[26]

---

[26] This table refers to a “December 2004 run,” which is a typo. It should refer to a December 2003 run as noted in the preceding paragraph. Final Report at 14 (“One week of short-term sorbent (Task 2.2) and furnace additive testing was accomplished in December 2003 to demonstrate mercury removal by sorbent injection combined with various oxidizing additives to simulate a scrubbed baghouse system.”). This is also evidence based on the fact that the Final Report was prepared in February 2004.

<table>
<tr><th>No.</th><th>’430 Claim Element</th><th>Evidence of Reduction to Practice</th></tr>
<tr><td></td><td>combustion chamber, or a combination thereof.</td><td>
Table 4. Spray Dryer Test Sample Matrix (December 2004 run)
<table>
<tr><th colspan="2">Mercury Oxidation Additive</th><th colspan="2">Sorbent</th></tr>
<tr><th>Type</th><th>Feed Rate, lb/Macf</th><th>Type</th><th>Injection Rate, lb/Macf</th></tr>
<tr><td>None</td><td>NA</td><td>None</td><td>NA</td></tr>
<tr><td>None</td><td>NA</td><td>DARCO® FGD</td><td>1.84 – 11.02</td></tr>
<tr><td>None</td><td>NA</td><td>EERC-Treated FGD</td><td>1.84 – 7.35</td></tr>
<tr><td>None</td><td>NA</td><td>Amended Silicate™</td><td>7.35</td></tr>
<tr><td>NaCl</td><td>3.67 – 11.02</td><td>None</td><td>NA</td></tr>
<tr><td>NaCl</td><td>3.67 – 11.02</td><td>DARCO® FGD</td><td>3.67</td></tr>
<tr><td>SEA 2</td><td>1.84 – 3.67</td><td>None</td><td>NA</td></tr>
<tr><td>SEA 2</td><td>1.84 – 3.67</td><td>DARCO® FGD</td><td>1.84</td></tr>
<tr><td>$CaCl_2$</td><td>3.67 – 11.02</td><td>None</td><td>NA</td></tr>
<tr><td>$CaCl_2$</td><td>3.67 – 11.03</td><td>DARCO® FGD</td><td>3.67</td></tr>
</table>
See also Oct. 2005 Report at 27:</td></tr>
<tr><td>*11*</td><td>The method of claim 10, wherein the measuring of the mercury content comprises</td><td>*See* claim 10.</td></tr>
</table>

No.	’430 Claim Element	Evidence of Reduction to Practice
	continuous measurement.	
12a	The method of claim 1, further comprising:	*See* Claim 1
12b	modifying, in response to a measured mercury content,	*See* Claim 10.
12c	an injection rate of injecting the sorbent into the mercury-containing gas,	*See* Claim 10.
12d	an amount of the Br_2, HBr, the bromide	*See* Claim 10.

No.	’430 Claim Element	Evidence of Reduction to Practice
	compound, or a combination thereof, added to the coal or the combustion chamber, or	
12e	a combination thereof.	*See* Claim 10.
13	The method of claim 1, wherein the mercury-containing gas comprises about 1 g to about 30 g of the element bromine per 100 g of the sorbent.	The February 2004 testing used bromine injection rates within this range. See Ex. 2014, Oct. 2005 Report at 27:

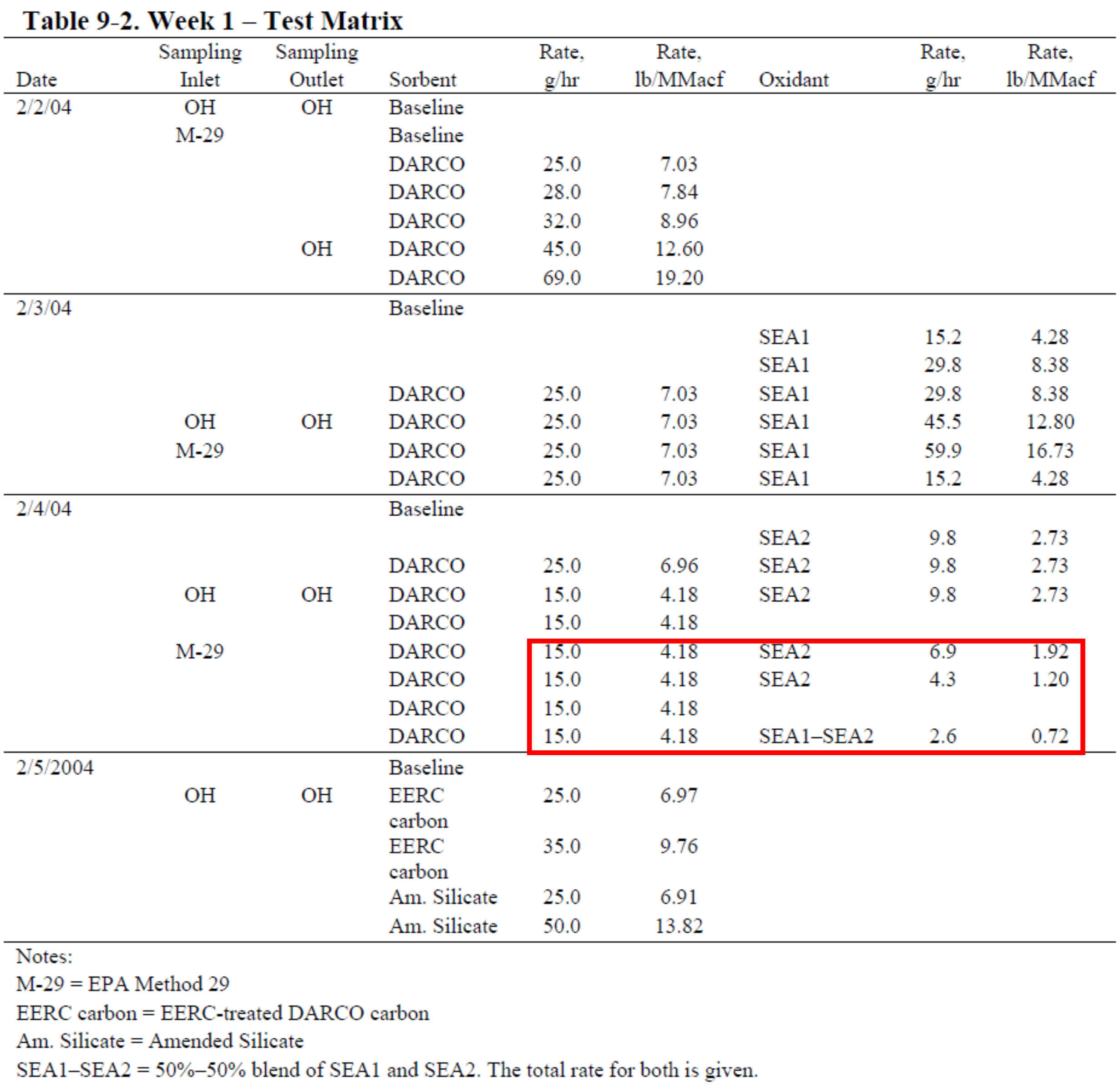


Table 9-2. Week 1 – Test Matrix

Date	Sampling Inlet	Sampling Outlet	Sorbent	Rate, g/hr	Rate, lb/MMacf	Oxidant	Rate, g/hr	Rate, lb/MMacf
2/2/04	OH	OH	Baseline					
	M-29		Baseline					
			DARCO	25.0	7.03			
			DARCO	28.0	7.84			
			DARCO	32.0	8.96			
		OH	DARCO	45.0	12.60			
			DARCO	69.0	19.20			
2/3/04			Baseline					
						SEA1	15.2	4.28
						SEA1	29.8	8.38
			DARCO	25.0	7.03	SEA1	29.8	8.38
	OH	OH	DARCO	25.0	7.03	SEA1	45.5	12.80
	M-29		DARCO	25.0	7.03	SEA1	59.9	16.73
			DARCO	25.0	7.03	SEA1	15.2	4.28
2/4/04			Baseline					
						SEA2	9.8	2.73
			DARCO	25.0	6.96	SEA2	9.8	2.73
	OH	OH	DARCO	15.0	4.18	SEA2	9.8	2.73
			DARCO	15.0	4.18			
	M-29		DARCO	15.0	4.18	SEA2	6.9	1.92
			DARCO	15.0	4.18	SEA2	4.3	1.20
			DARCO	15.0	4.18			
			DARCO	15.0	4.18	SEA1–SEA2	2.6	0.72
2/5/2004			Baseline					
	OH	OH	EERC carbon	25.0	6.97			
			EERC carbon	35.0	9.76			
			Am. Silicate	25.0	6.91			
			Am. Silicate	50.0	13.82			

Notes:
M-29 = EPA Method 29
EERC carbon = EERC-treated DARCO carbon
Am. Silicate = Amended Silicate
SEA1–SEA2 = 50%–50% blend of SEA1 and SEA2. The total rate for both is given.

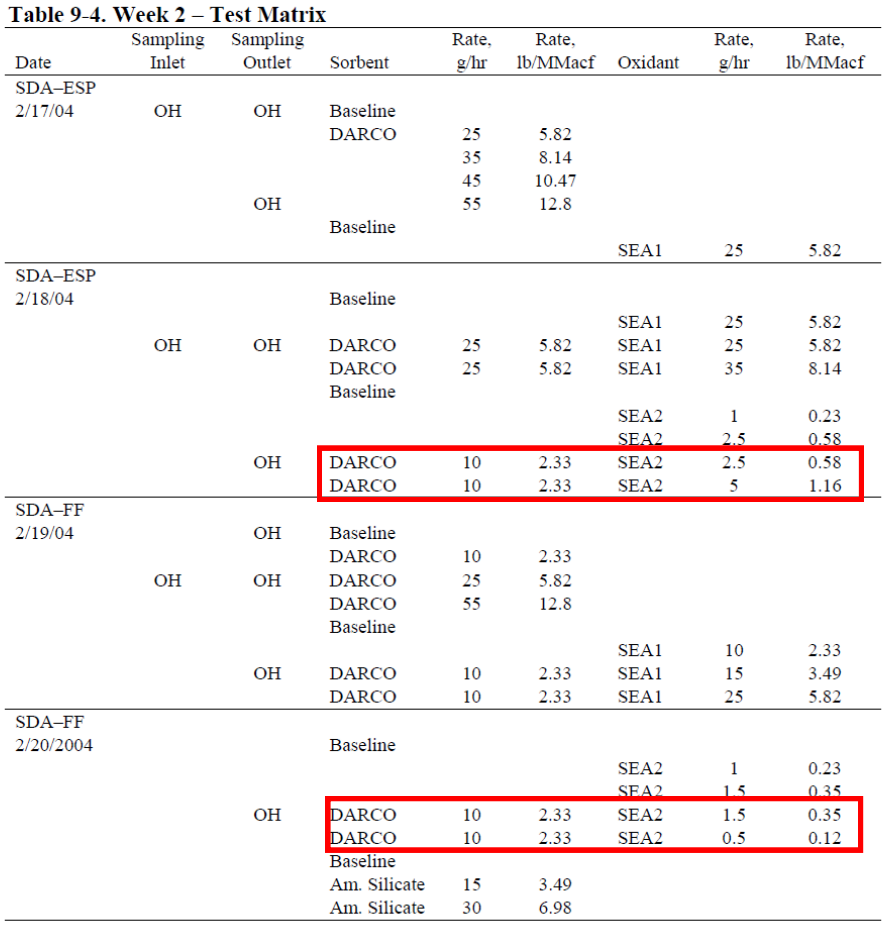
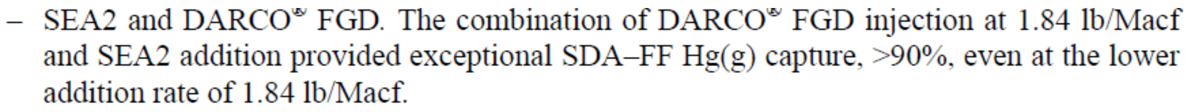
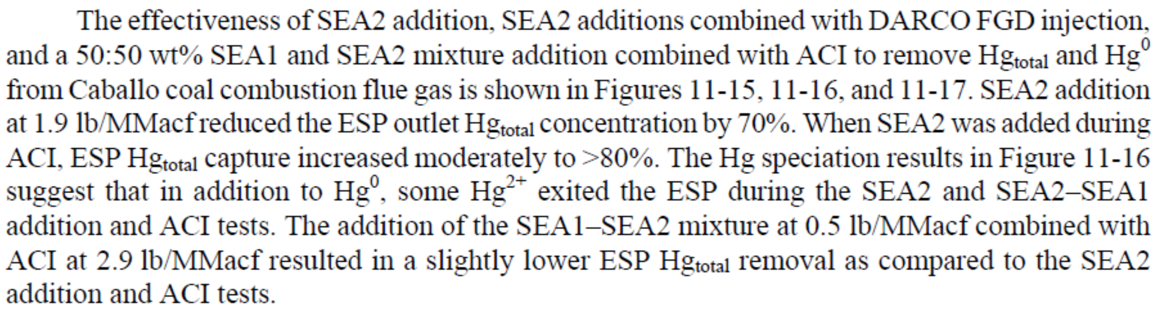
No.	’430 Claim Element	Evidence of Reduction to Practice
		See Ex. 2014 Oct. 2005 Report at 30: 

Table 9-4. Week 2 – Test Matrix

Date	Sampling Inlet	Sampling Outlet	Sorbent	Rate, g/hr	Rate, lb/MMacf	Oxidant	Rate, g/hr	Rate, lb/MMacf
SDA–ESP								
2/17/04	OH	OH	Baseline					
			DARCO	25	5.82			
				35	8.14			
				45	10.47			
		OH		55	12.8			
			Baseline					
						SEA1	25	5.82
SDA–ESP								
2/18/04			Baseline					
						SEA1	25	5.82
	OH	OH	DARCO	25	5.82	SEA1	25	5.82
			DARCO	25	5.82	SEA1	35	8.14
			Baseline					
						SEA2	1	0.23
						SEA2	2.5	0.58
		OH	DARCO	10	2.33	SEA2	2.5	0.58
			DARCO	10	2.33	SEA2	5	1.16
SDA–FF								
2/19/04		OH	Baseline					
			DARCO	10	2.33			
	OH	OH	DARCO	25	5.82			
			DARCO	55	12.8			
			Baseline					
						SEA1	10	2.33
		OH	DARCO	10	2.33	SEA1	15	3.49
			DARCO	10	2.33	SEA1	25	5.82
SDA–FF								
2/20/2004			Baseline					
						SEA2	1	0.23
						SEA2	1.5	0.35
		OH	DARCO	10	2.33	SEA2	1.5	0.35
			DARCO	10	2.33	SEA2	0.5	0.12
			Baseline					
			Am. Silicate	15	3.49			
			Am. Silicate	30	6.98			

No.	’430 Claim Element	Evidence of Reduction to Practice
14	The method of claim 1, wherein the sorbent contacted with the mercury comprises the element bromine and mercury.	*See* Claim 1.
15	The method of claim 1, comprising removing greater than 70 wt % of the mercury in the mercury-containing gas.	This level of mercury capture was achieved during the September 2003, December 2003, and February 2004 testing. *See* Ex. 2013, Feb. 2005 Report at 73:  – SEA2 and DARCO® FGD. The combination of DARCO® FGD injection at 1.84 lb/Macf and SEA2 addition provided exceptional SDA–FF Hg(g) capture, >90%, even at the lower addition rate of 1.84 lb/Macf. *See* Ex. 2014, Oct. 2005 Report at 49:

No.	’430 Claim Element	Evidence of Reduction to Practice
		 The effectiveness of SEA2 addition, SEA2 additions combined with DARCO FGD injection, and a 50:50 wt% SEA1 and SEA2 mixture addition combined with ACI to remove Hg_{total} and Hg^0 from Caballo coal combustion flue gas is shown in Figures 11-15, 11-16, and 11-17. SEA2 addition at 1.9 lb/MMacf reduced the ESP outlet Hg_{total} concentration by 70%. When SEA2 was added during ACI, ESP Hg_{total} capture increased moderately to >80%. The Hg speciation results in Figure 11-16 suggest that in addition to Hg^0, some Hg^{2+} exited the ESP during the SEA2 and SEA2–SEA1 addition and ACI tests. The addition of the SEA1–SEA2 mixture at 0.5 lb/MMacf combined with ACI at 2.9 lb/MMacf resulted in a slightly lower ESP Hg_{total} removal as compared to the SEA2 addition and ACI tests.
16	The method of claim 1, comprising removing greater than 70 wt % of the mercury in the mercury-containing gas with the sorbent.	*See* Claim 15
17	The method of claim 1, wherein the	*See* Claim 13.

No.	**’430 Claim Element**	**Evidence of Reduction to Practice**
	sorbent in the mercury-containing gas comprises about 1 g to about 30 g of the added Br_2, HBr, the bromide compound, or a combination thereof, per 100 g of the sorbent.	
18	The method of claim 1, wherein the Br_2, HBr, or the bromide compound is contacted with the sorbent in	Given the temperatures of coal combustion, the halide additive (NaBr) provides the promoter (Br^2, HBr, Br^-)) in gaseous form.

No.	'430 Claim Element	Evidence of Reduction to Practice
	vapor form, gaseous form, liquid form, or in an organic solvent.	
19	The method of claim 1, wherein the activated carbon comprises powdered activated carbon, granular activated carbon, or a combination thereof.	*See* 1d.
21	The method of claim 1, wherein the	*See* 1d.

No.	’430 Claim Element	Evidence of Reduction to Practice
	sorbent injected into the mercury-containing gas is free of contact with a halogen or halide promoter prior to injection of the sorbent into the mercury-containing gas.	
22	The method of claim 1, wherein the combustion chamber comprises a boiler.	*See* 1a-b.

No.	’430 Claim Element	Evidence of Reduction to Practice
23	The method of claim 1, wherein the mercury-containing gas is a flue gas.	The combustion gases exiting the combustion chamber is a flue gas. Thus mercury-containing gas is a flue gas.
24	The method of claim 1, wherein the injection of the sorbent into the mercury-containing gas occurs upstream of a particulate separator, a scrubber, or a combination thereof.	*See* 1d.

No.	**’430 Claim Element**	**Evidence of Reduction to Practice**
25	The method of claim 24, wherein the particulate separator comprises a baghouse, an electrostatic precipitator, a fabric filter, or a combination thereof.	*See* 1d.
28a	A method of separating mercury from a mercury-containing as, the method comprising:	*See* 1a.

No.	’430 Claim Element	Evidence of Reduction to Practice
28b	combusting coal in a combustion chamber, to provide the mercury-containing gas, wherein the mercury-containing gas comprises a halogen or halide promoter comprising HBr, Br^-, or a combination thereof, wherein	*See* 1b.
28c	the coal comprises an additive	*See* 1c.

No.	’430 Claim Element	Evidence of Reduction to Practice
	comprising Br_2, HBr, a bromide compound, or a combination thereof, wherein the additive is added to the coal before the coal enters the combustion chamber, or	
28d	the combustion chamber comprises an additive comprising Br_2, HBr, a bromide compound, or a	*See* 1c.

No.	**’430 Claim Element**	**Evidence of Reduction to Practice**
	combination thereof, or	
28e	a combination thereof,	*See* 1c.
28f	injecting a sorbent comprising activated carbon into the mercury-containing gas downstream of the combustion chamber;	*See* 1d.
28g	contacting mercury in the mercury-containing gas	*See* 1e.

No.	**’430 Claim Element**	**Evidence of Reduction to Practice**
	with the sorbent; and	
28h	separating the sorbent contacted with the mercury from the mercury-containing gas.	*See* 1f.
29a	A method of separating mercury from a mercury-containing gas, the method comprising:	*See* 1a.
29b	combusting coal in a combustion chamber, to	*See* 1b-c.

No.	’430 Claim Element	Evidence of Reduction to Practice
	provide the mercury-containing gas, wherein the mercury-containing gas comprises a halogen or halide promoter comprising HBr, Br^-, or a combination thereof, wherein	
29c	the coal comprises an additive comprising Br_2, HBr, a bromide compound, or a	*See* 1c.

No.	’430 Claim Element	Evidence of Reduction to Practice
	combination thereof, wherein the additive is added to the coal before the coal enters the combustion chamber, or	
29d	the combustion chamber comprises an additive comprising Br_2, HBr, a bromide compound, or a combination thereof, or	*See* 1c.
29e	a combination thereof;	*See* 1c.

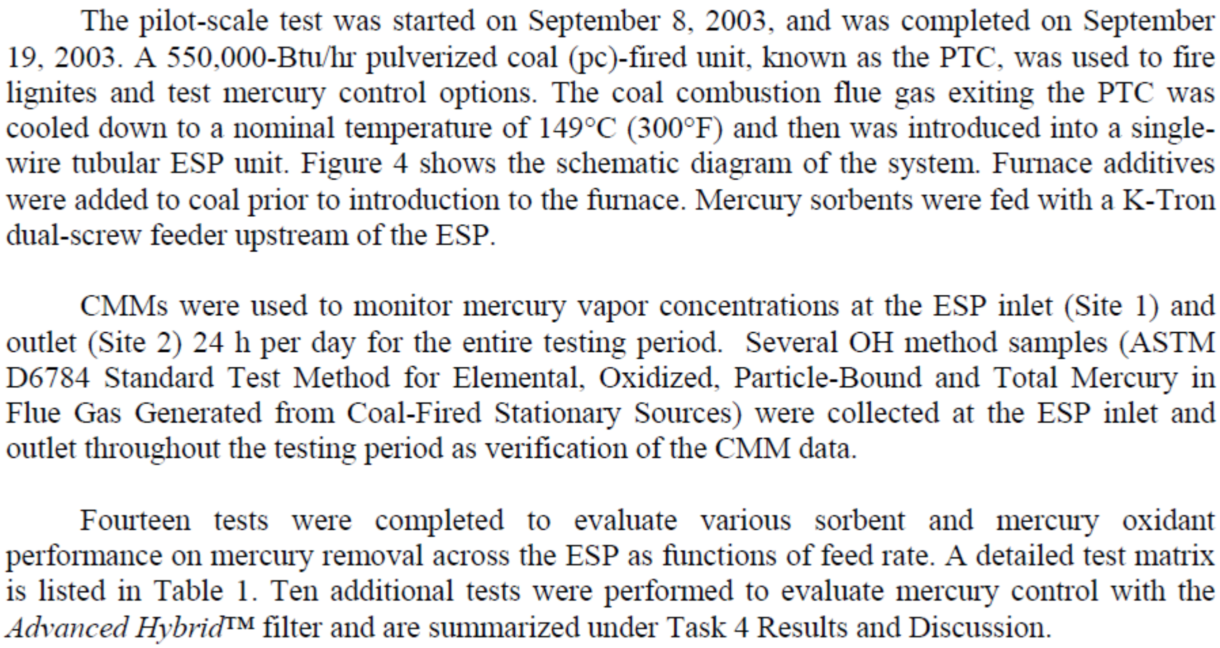
No.	’430 Claim Element	Evidence of Reduction to Practice
29f	injecting a sorbent comprising activated carbon into the mercury-containing gas downstream of the combustion chamber such that the activated carbon reacts with the halogen or halide promoter in the mercury-containing gas to form a promoted sorbent;	*See* 1d.

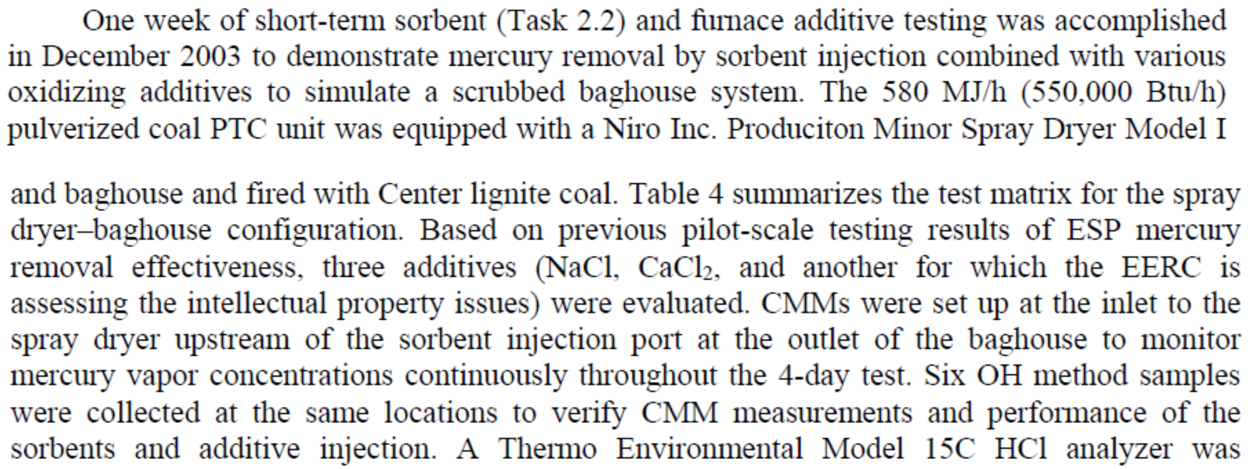
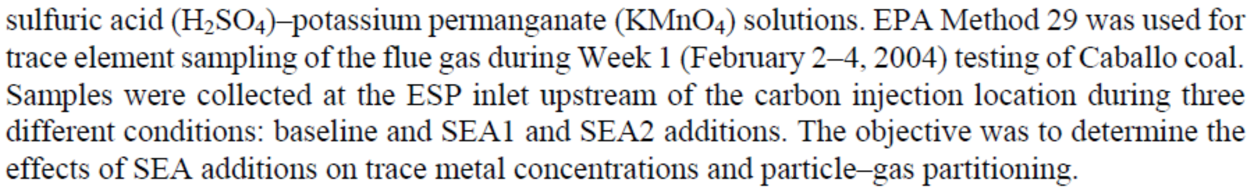
No.	’430 Claim Element	Evidence of Reduction to Practice
29g	contacting mercury in the mercury-containing gas with the promoted sorbent;	*See* 1e.
29h	separating the promoted sorbent contacted with the mercury from the mercury-containing gas;	*See* 1f.
29i	measuring the mercury content of the mercury-containing gas; and	*See* Claim 10.

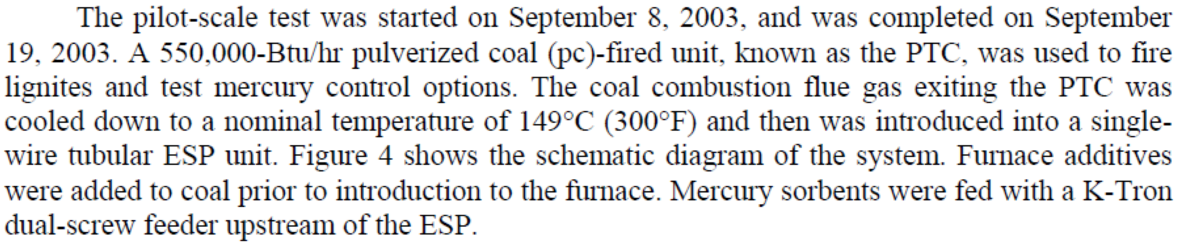
No.	**’430 Claim Element**	**Evidence of Reduction to Practice**
29j	modifying, in response to the measured mercury content,	*See* Claim 10.
29k	an injection rate of injecting the sorbent into the mercury-containing gas,	*See* Claim 10.
29l	an amount of the Br_2, HBr, the bromide compound, or a combination thereof, added to the coal or the combustion chamber, or	*See* Claim 10.

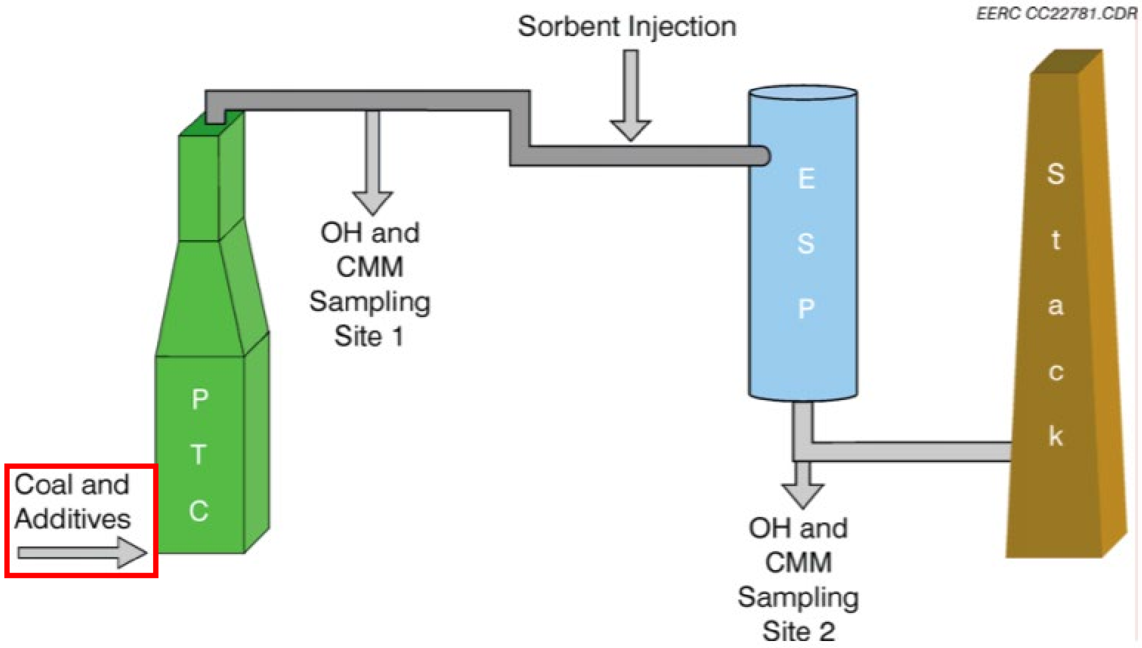
No.	**’430 Claim Element**	**Evidence of Reduction to Practice**
29m	a combination thereof.	*See* Claim 10.

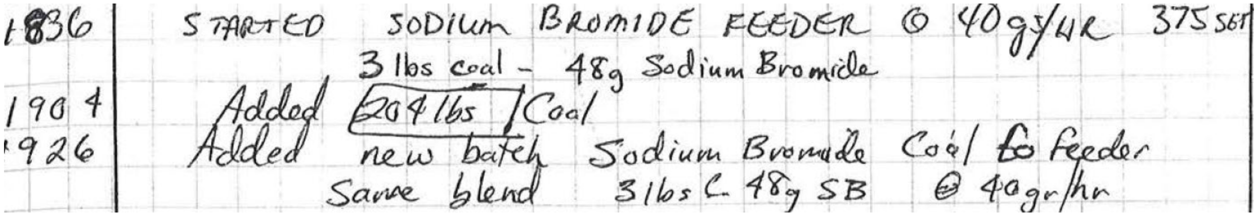
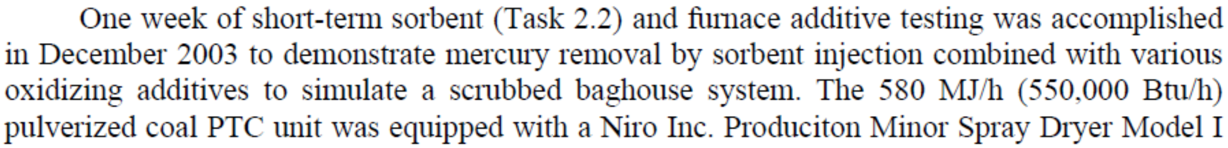
’225 Claim Chart

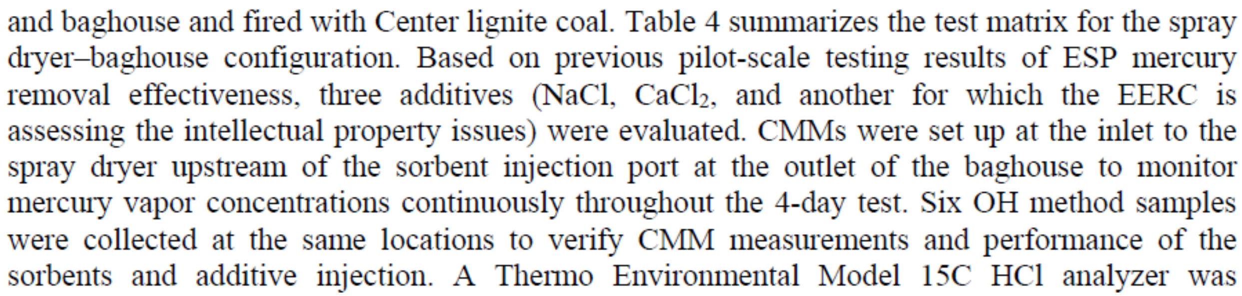
No.	’225 Claim Element	Evidence of Reduction to Practice
1a	A method for treating a mercury-containing gas, the method comprising:	The February 2004 Report describes the September 2003 testing (Ex. 2012 at 10):  The pilot-scale test was started on September 8, 2003, and was completed on September 19, 2003. A 550,000-Btu/hr pulverized coal (pc)-fired unit, known as the PTC, was used to fire lignites and test mercury control options. The coal combustion flue gas exiting the PTC was cooled down to a nominal temperature of 149°C (300°F) and then was introduced into a single-wire tubular ESP unit. Figure 4 shows the schematic diagram of the system. Furnace additives were added to coal prior to introduction to the furnace. Mercury sorbents were fed with a K-Tron dual-screw feeder upstream of the ESP. CMMs were used to monitor mercury vapor concentrations at the ESP inlet (Site 1) and outlet (Site 2) 24 h per day for the entire testing period. Several OH method samples (ASTM D6784 Standard Test Method for Elemental, Oxidized, Particle-Bound and Total Mercury in Flue Gas Generated from Coal-Fired Stationary Sources) were collected at the ESP inlet and outlet throughout the testing period as verification of the CMM data. Fourteen tests were completed to evaluate various sorbent and mercury oxidant performance on mercury removal across the ESP as functions of feed rate. A detailed test matrix is listed in Table 1. Ten additional tests were performed to evaluate mercury control with the *Advanced Hybrid*™ filter and are summarized under Task 4 Results and Discussion. The February 2004 Report also describes additional testing in December 2003 (Ex. 2012 at 14–15):

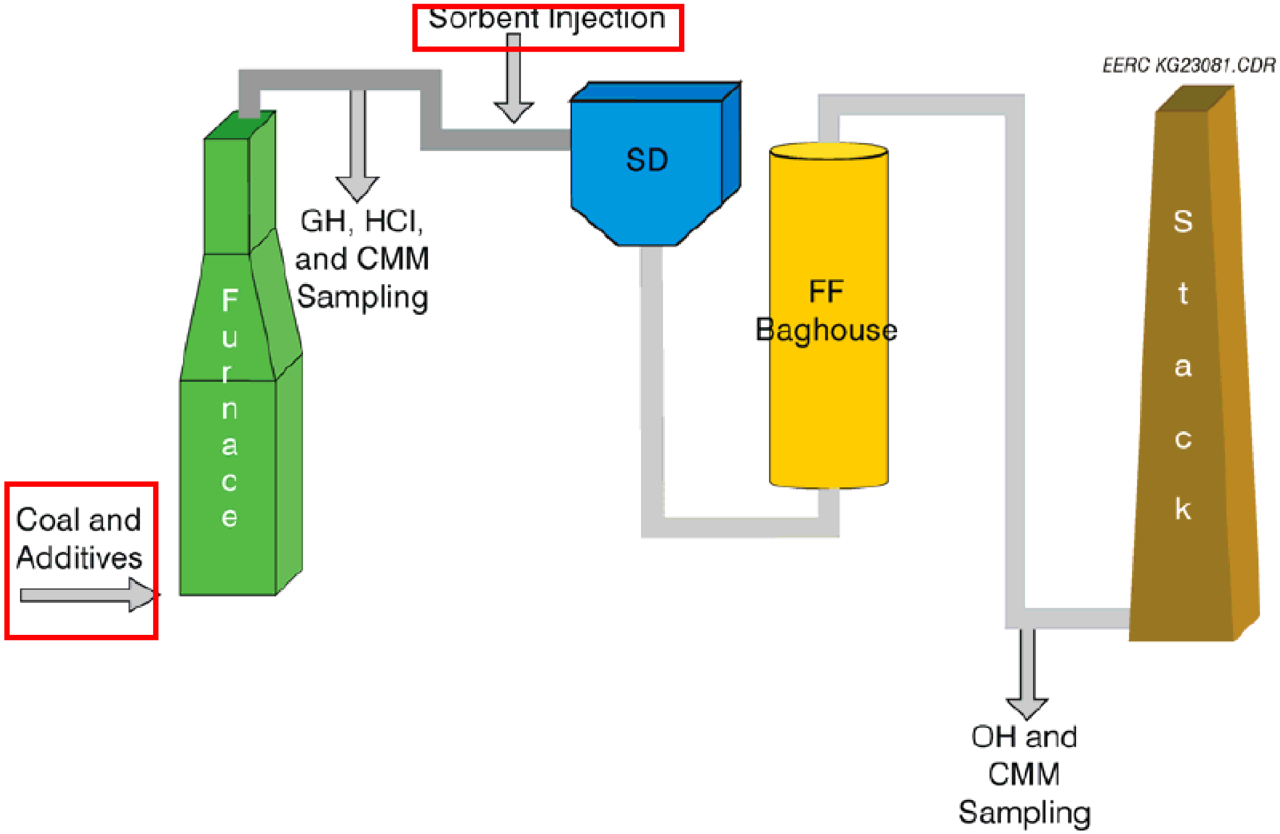
No.	’225 Claim Element	Evidence of Reduction to Practice
		 One week of short-term sorbent (Task 2.2) and furnace additive testing was accomplished in December 2003 to demonstrate mercury removal by sorbent injection combined with various oxidizing additives to simulate a scrubbed baghouse system. The 580 MJ/h (550,000 Btu/h) pulverized coal PTC unit was equipped with a Niro Inc. Produciton Minor Spray Dryer Model I and baghouse and fired with Center lignite coal. Table 4 summarizes the test matrix for the spray dryer–baghouse configuration. Based on previous pilot-scale testing results of ESP mercury removal effectiveness, three additives (NaCl, $CaCl_2$, and another for which the EERC is assessing the intellectual property issues) were evaluated. CMMs were set up at the inlet to the spray dryer upstream of the sorbent injection port at the outlet of the baghouse to monitor mercury vapor concentrations continuously throughout the 4-day test. Six OH method samples were collected at the same locations to verify CMM measurements and performance of the sorbents and additive injection. A Thermo Environmental Model 15C HCl analyzer was The October 2005 Report describes additional testing in February 2004 (page 20):  sulfuric acid (H_2SO_4)–potassium permanganate ($KMnO_4$) solutions. EPA Method 29 was used for trace element sampling of the flue gas during Week 1 (February 2–4, 2004) testing of Caballo coal. Samples were collected at the ESP inlet upstream of the carbon injection location during three different conditions: baseline and SEA1 and SEA2 additions. The objective was to determine the effects of SEA additions on trace metal concentrations and particle–gas partitioning.
1b	combusting a mixture	The February 2004 Report explains that coal was combusted in a 550,000-Btu/hr pc-fire combustor (known as the PTC) (Ex. 2012 at 10):

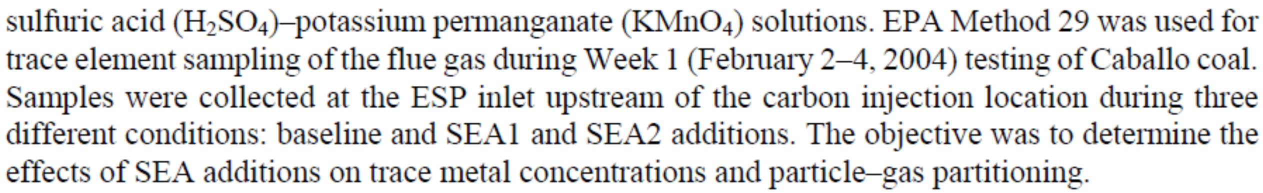
No.	’225 Claim Element	Evidence of Reduction to Practice
	comprising coal, pyrolysis char, and an additive comprising HBr, a bromide compound, or a combination thereof, to form the mercury-containing, gas; and,	 The pilot-scale test was started on September 8, 2003, and was completed on September 19, 2003. A 550,000-Btu/hr pulverized coal (pc)-fired unit, known as the PTC, was used to fire lignites and test mercury control options. The coal combustion flue gas exiting the PTC was cooled down to a nominal temperature of 149°C (300°F) and then was introduced into a single-wire tubular ESP unit. Figure 4 shows the schematic diagram of the system. Furnace additives were added to coal prior to introduction to the furnace. Mercury sorbents were fed with a K-Tron dual-screw feeder upstream of the ESP. This combustion step necessarily includes combustion of coal and pyrolysis char. Pyrolysis char necessarily forms whenever any coal is heated above about 400°C. The February 2004 Report describes adding coal and additives (including SEA 2) to the combustion chamber during the September 2003 testing (page 18):

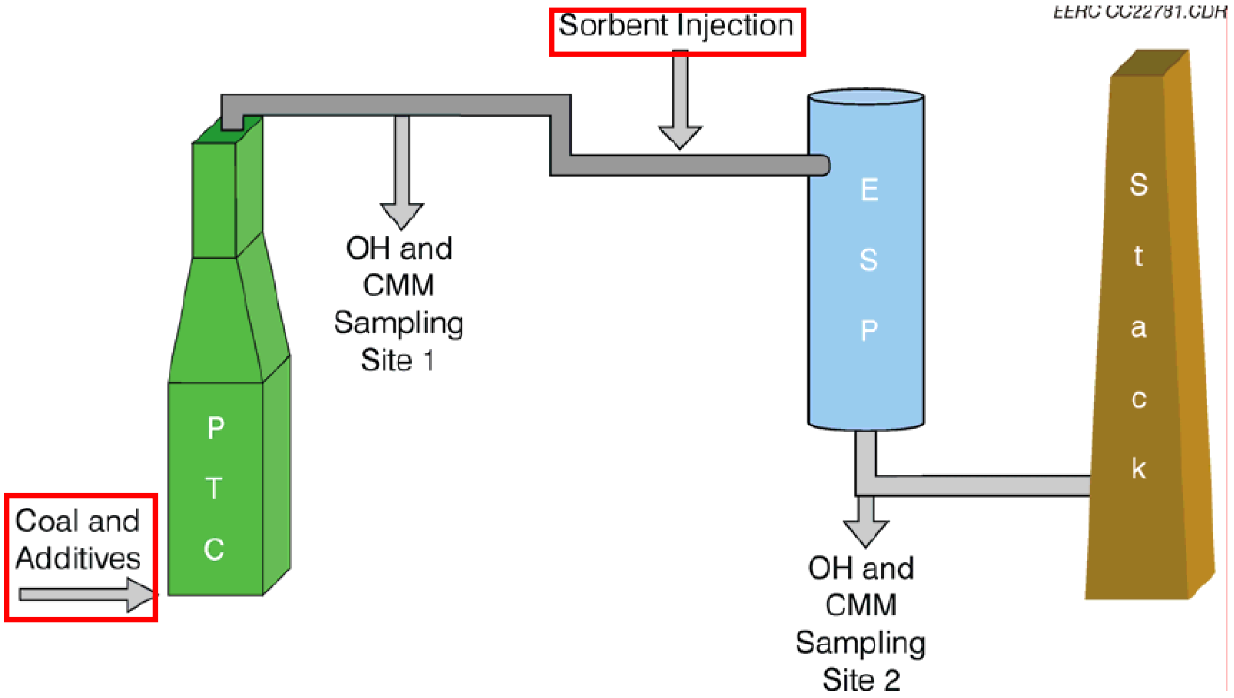
No.	’225 Claim Element	Evidence of Reduction to Practice
		 Figure 4. Injection and sampling schematic of the PTC with an ESP. *See also* Ex. 2012, Feb. 2004 Report at 17 (“[M]ercury oxidants including NaCl, SEA 2, and zinc were examined for their impacts on mercury removal.”); 15 (“Based on previous pilot-scale testing results of ESP mercury removal effectiveness, three additives (NaCl, CaCl2, and another for which the EERC is assessing the intellectual

No.	’225 Claim Element	Evidence of Reduction to Practice
		property issues) were evaluated.”); Final Report at 25 (“SEA2 is a proprietary Hg^0 oxidizing agent effective at addition rates on the order of 1/10 of those for SEA1.”) The Logbook identifies the SEA2 additive used as sodium bromide, which includes Br^-. Thus, the mercury-containing gas, the coal, and the combustion chamber comprised Br^-.  1836 STARTED SODIUM BROMIDE FEEDER @ 40g/HR 375 SET 3 lbs coal - 48g Sodium Bromide 1904 Added 204 lbs Coal 1926 Added new batch Sodium Bromide Coal to feeder Same blend 3 lbs C. 48g SB @ 40gr/hr SEA2 and activated carbon were similarly used during the December 2003 testing. *See* Ex. 2012, Feb. 2004 Report at 15:  One week of short-term sorbent (Task 2.2) and furnace additive testing was accomplished in December 2003 to demonstrate mercury removal by sorbent injection combined with various oxidizing additives to simulate a scrubbed baghouse system. The 580 MJ/h (550,000 Btu/h) pulverized coal PTC unit was equipped with a Niro Inc. Produciton Minor Spray Dryer Model I

No.	’225 Claim Element	Evidence of Reduction to Practice
		 and baghouse and fired with Center lignite coal. Table 4 summarizes the test matrix for the spray dryer–baghouse configuration. Based on previous pilot-scale testing results of ESP mercury removal effectiveness, three additives (NaCl, $CaCl_2$, and another for which the EERC is assessing the intellectual property issues) were evaluated. CMMs were set up at the inlet to the spray dryer upstream of the sorbent injection port at the outlet of the baghouse to monitor mercury vapor concentrations continuously throughout the 4-day test. Six OH method samples were collected at the same locations to verify CMM measurements and performance of the sorbents and additive injection. A Thermo Environmental Model 15C HCl analyzer was *See* Ex. 2013, Feb. 2005 Report at 25 (“Pilot-scale Hg control testing was conducted December 8–11, 2003, using a 580-MJ/hr (550,000-Btu/hr) pc-fired unit equipped with a Niro Inc. Production Minor Spray Dryer Model I and baghouse.”); at 27 (“Nine tests were completed to evaluate the effectiveness of potential Hg sorbents (DARCO® FGD, EERC-treated FGD, and Amended Silicate™) and Hg0 oxidation and sorbent enhancement additives (NaCl, SEA2, and CaCl2) to remove Hg using a SDA and FF.”); at 25:

No.	’225 Claim Element	Evidence of Reduction to Practice
		 SEA2 and activated carbon were also used in the February 2004 testing. Ex. 2014, Oct. 2005 Report at 20:

No.	’225 Claim Element	Evidence of Reduction to Practice
		 sulfuric acid (H_2SO_4)–potassium permanganate ($KMnO_4$) solutions. EPA Method 29 was used for trace element sampling of the flue gas during Week 1 (February 2–4, 2004) testing of Caballo coal. Samples were collected at the ESP inlet upstream of the carbon injection location during three different conditions: baseline and SEA1 and SEA2 additions. The objective was to determine the effects of SEA additions on trace metal concentrations and particle–gas partitioning. Ex. 2014, Oct. 2005 Report at 26:

No.	’225 Claim Element	Evidence of Reduction to Practice
		
1c	adding a particulate sorbent material	The February 2004 Report describes injecting Darco FGD activated carbon into the mercury-containing gas downstream of the combustion chamber during the September 2003 testing (Ex. 2012 at 11):

<table>
<tr><th>No.</th><th>’225 Claim Element</th><th>Evidence of Reduction to Practice</th></tr>
<tr><td></td><td>comprising activated carbon into the mercury-containing gas.</td><td>

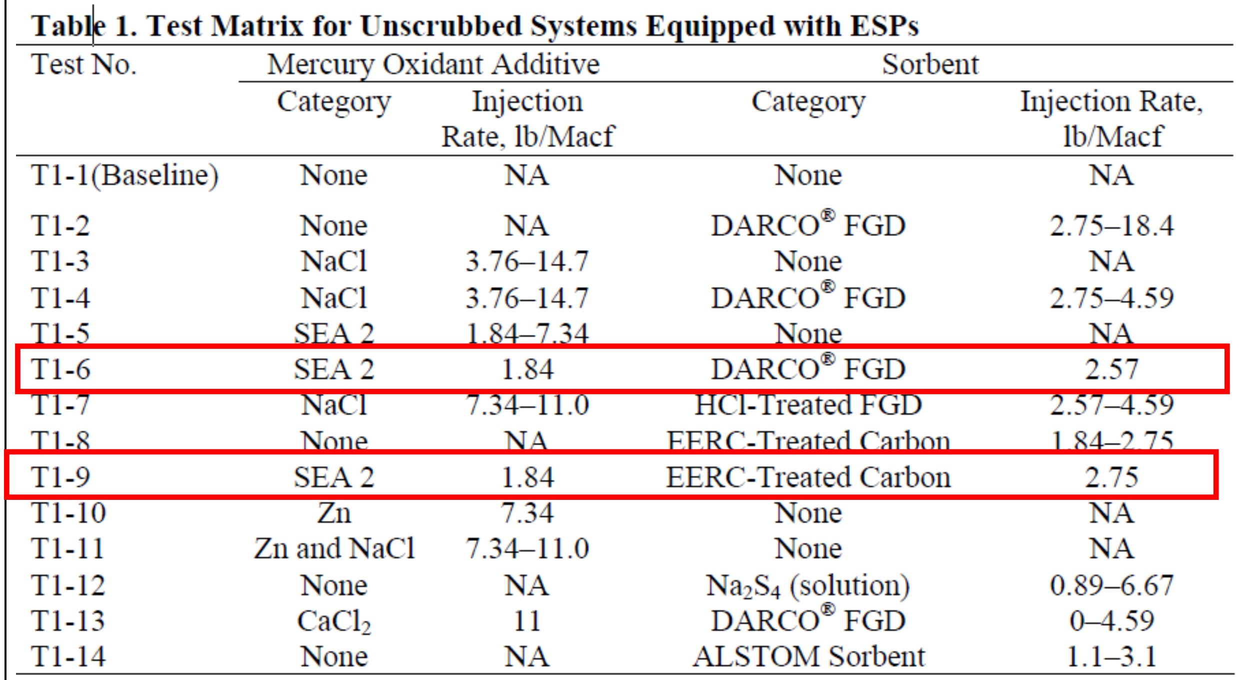
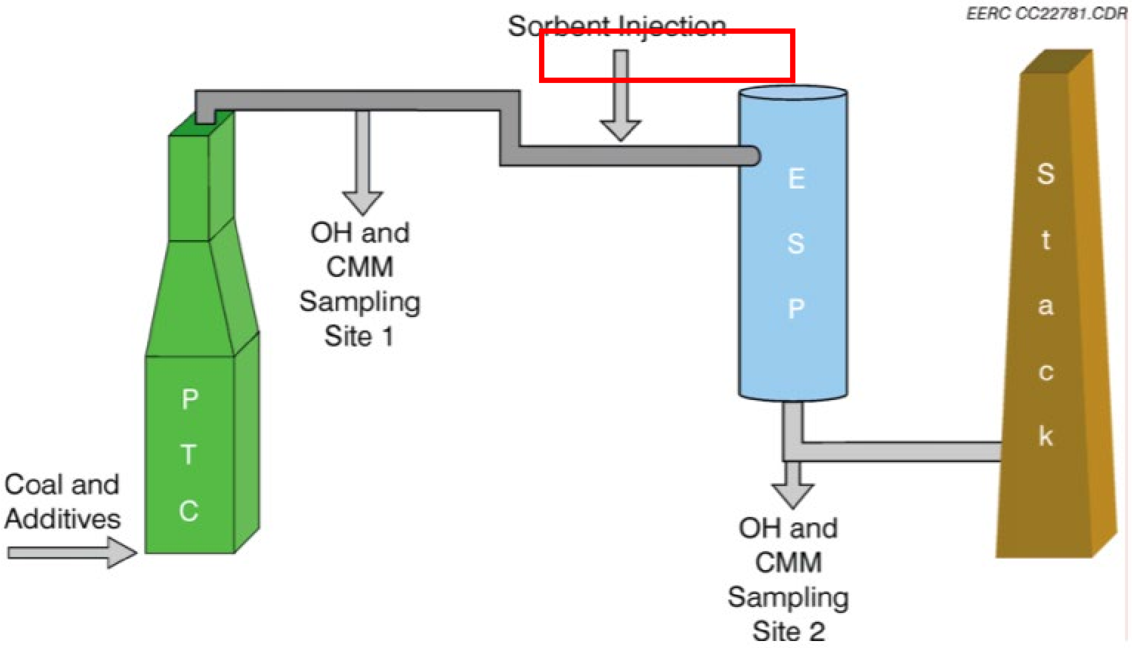



Table 1. Test Matrix for Unscrubbed Systems Equipped with ESPs
<table>
<tr><th>Test No.</th><th>Mercury Oxidant Additive</th><th></th><th>Sorbent</th><th></th></tr>
<tr><th></th><th>Category</th><th>Injection Rate, lb/Macf</th><th>Category</th><th>Injection Rate, lb/Macf</th></tr>
<tr><td>T1-1(Baseline)</td><td>None</td><td>NA</td><td>None</td><td>NA</td></tr>
<tr><td>T1-2</td><td>None</td><td>NA</td><td>DARCO® FGD</td><td>2.75–18.4</td></tr>
<tr><td>T1-3</td><td>NaCl</td><td>3.76–14.7</td><td>None</td><td>NA</td></tr>
<tr><td>T1-4</td><td>NaCl</td><td>3.76–14.7</td><td>DARCO® FGD</td><td>2.75–4.59</td></tr>
<tr><td>T1-5</td><td>SEA 2</td><td>1.84–7.34</td><td>None</td><td>NA</td></tr>
<tr><td>T1-6</td><td>SEA 2</td><td>1.84</td><td>DARCO® FGD</td><td>2.57</td></tr>
<tr><td>T1-7</td><td>NaCl</td><td>7.34–11.0</td><td>HCl-Treated FGD</td><td>2.57–4.59</td></tr>
<tr><td>T1-8</td><td>None</td><td>NA</td><td>EERC-Treated Carbon</td><td>1.84–2.75</td></tr>
<tr><td>T1-9</td><td>SEA 2</td><td>1.84</td><td>EERC-Treated Carbon</td><td>2.75</td></tr>
<tr><td>T1-10</td><td>Zn</td><td>7.34</td><td>None</td><td>NA</td></tr>
<tr><td>T1-11</td><td>Zn and NaCl</td><td>7.34–11.0</td><td>None</td><td>NA</td></tr>
<tr><td>T1-12</td><td>None</td><td>NA</td><td>Na_2S_4 (solution)</td><td>0.89–6.67</td></tr>
<tr><td>T1-13</td><td>$CaCl_2$</td><td>11</td><td>DARCO® FGD</td><td>0–4.59</td></tr>
<tr><td>T1-14</td><td>None</td><td>NA</td><td>ALSTOM Sorbent</td><td>1.1–3.1</td></tr>
</table>
<i>See also</i> Ex. 2012 at 15 (describing “DARCO® FGD activated carbon, supplied by NORIT Americas, Inc.; an EERC-treated activated carbon”).
</td></tr>
</table>

No.	’225 Claim Element	Evidence of Reduction to Practice
		 Figure 4. Injection and sampling schematic of the PTC with an ESP. The February 2004 Report also describes injecting activated carbon sorbent during the December 2003 testing:[27]

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[27] This table refers to a “December 2004 run,” which is a typo. It should refer to a December 2003 run as noted in the preceding paragraph. Final Report at 14 (“One week of short-term sorbent (Task 2.2) and furnace additive testing

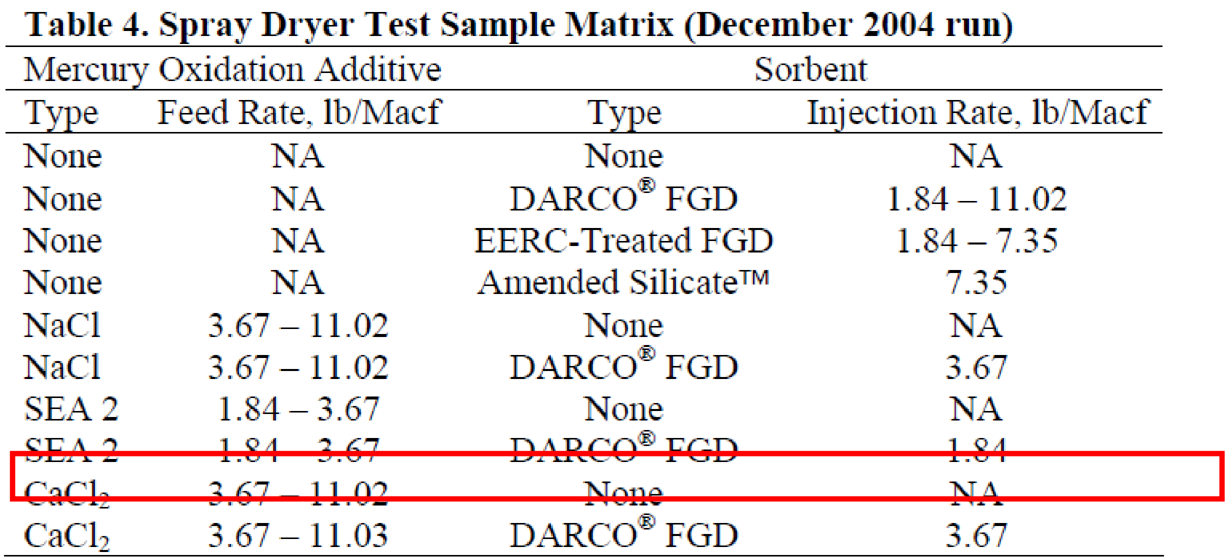
<table>
<tr><th>No.</th><th>’225 Claim Element</th><th>Evidence of Reduction to Practice</th></tr>
<tr><td></td><td></td><td>


Table 4. Spray Dryer Test Sample Matrix (December 2004 run)

<table>
<tr><th colspan="2">Mercury Oxidation Additive</th><th colspan="2">Sorbent</th></tr>
<tr><th>Type</th><th>Feed Rate, lb/Macf</th><th>Type</th><th>Injection Rate, lb/Macf</th></tr>
<tr><td>None</td><td>NA</td><td>None</td><td>NA</td></tr>
<tr><td>None</td><td>NA</td><td>DARCO® FGD</td><td>1.84 – 11.02</td></tr>
<tr><td>None</td><td>NA</td><td>EERC-Treated FGD</td><td>1.84 – 7.35</td></tr>
<tr><td>None</td><td>NA</td><td>Amended Silicate™</td><td>7.35</td></tr>
<tr><td>NaCl</td><td>3.67 – 11.02</td><td>None</td><td>NA</td></tr>
<tr><td>NaCl</td><td>3.67 – 11.02</td><td>DARCO® FGD</td><td>3.67</td></tr>
<tr><td>SEA 2</td><td>1.84 – 3.67</td><td>None</td><td>NA</td></tr>
<tr><td>SEA 2</td><td>1.84 – 3.67</td><td>DARCO® FGD</td><td>1.84</td></tr>
<tr><td>$CaCl_2$</td><td>3.67 – 11.02</td><td>None</td><td>NA</td></tr>
<tr><td>$CaCl_2$</td><td>3.67 – 11.03</td><td>DARCO® FGD</td><td>3.67</td></tr>
</table>

<i>See also</i> Ex. 2013, Feb. 2005 Report at 25:
</td></tr>
</table>

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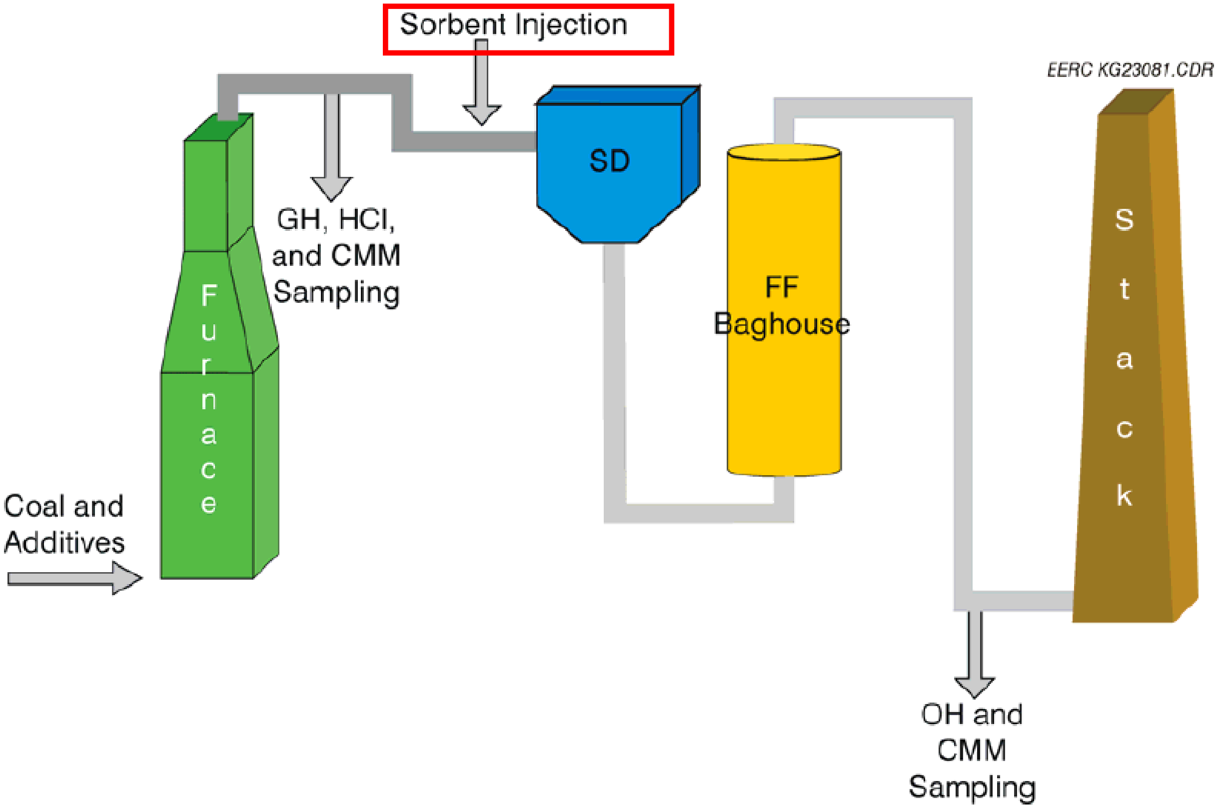
was accomplished in December 2003 to demonstrate mercury removal by sorbent injection combined with various oxidizing additives to simulate a scrubbed baghouse system.”). This is also evidence based on the fact that the Final Report was prepared in February 2004.

No.	’225 Claim Element	Evidence of Reduction to Practice
		 The October 2005 Report describes injecting activated carbon sorbent during the February 2004 testing (Ex. 2014 at 26–27):

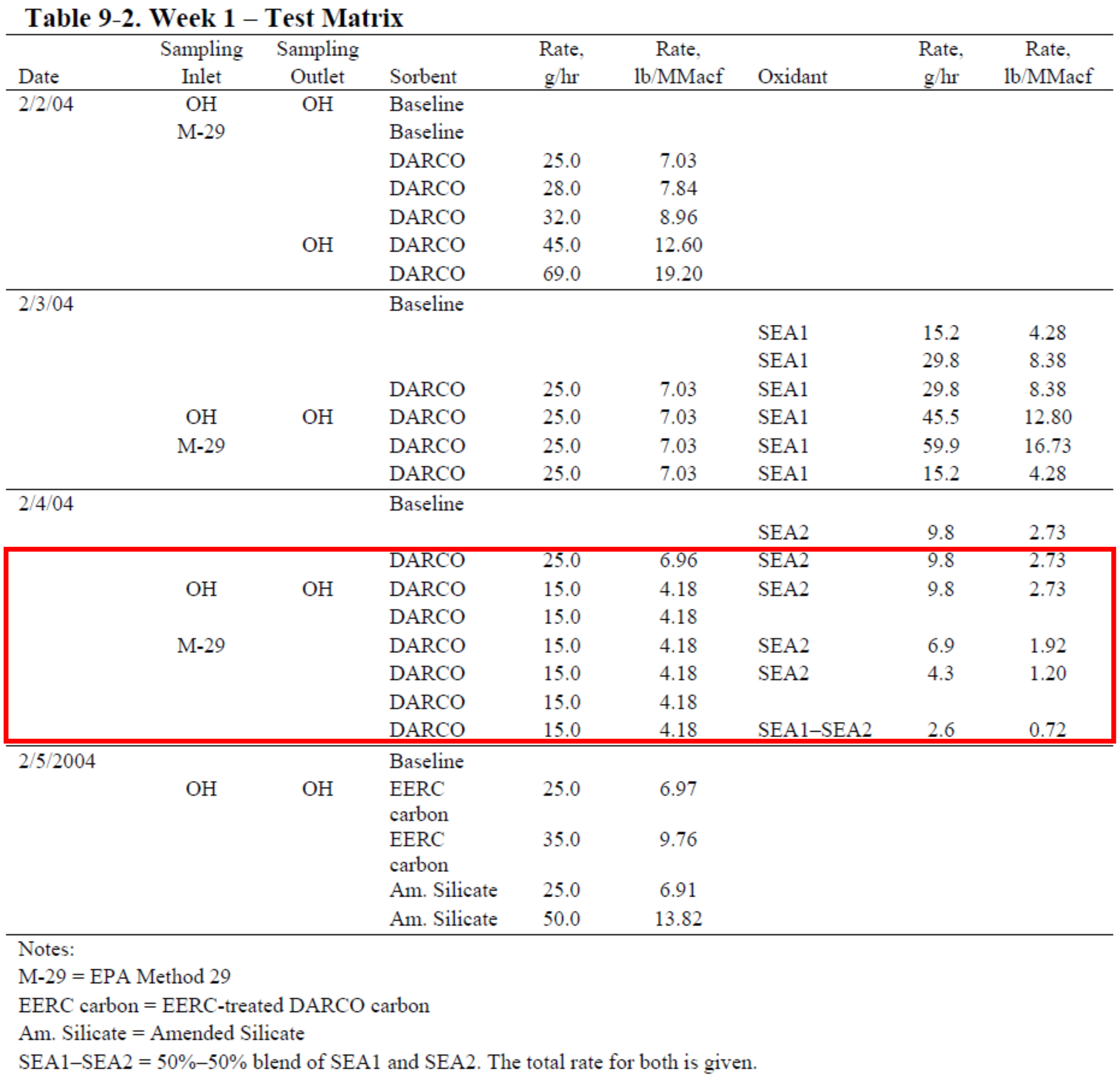
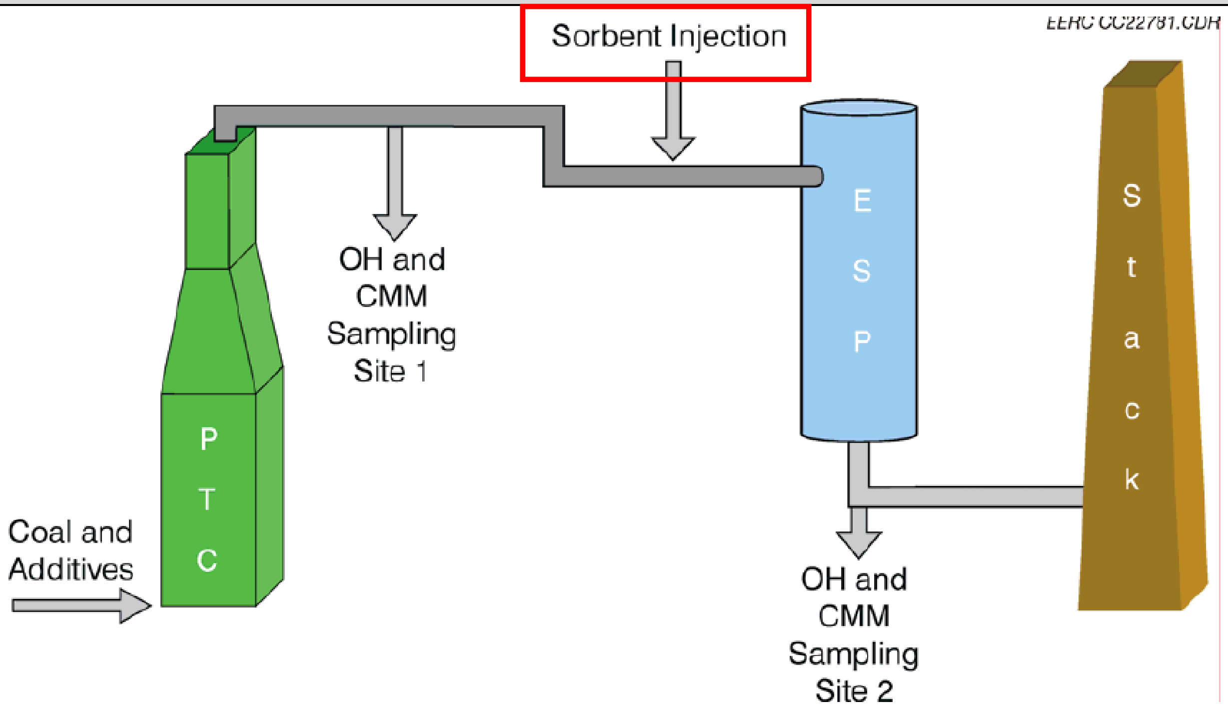
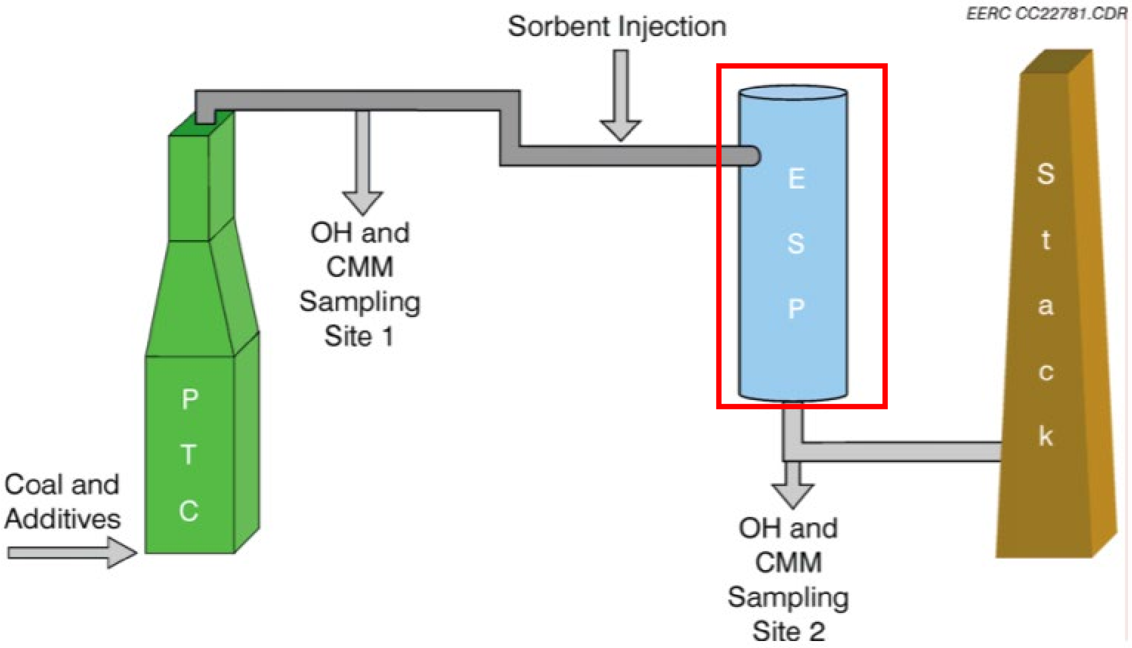


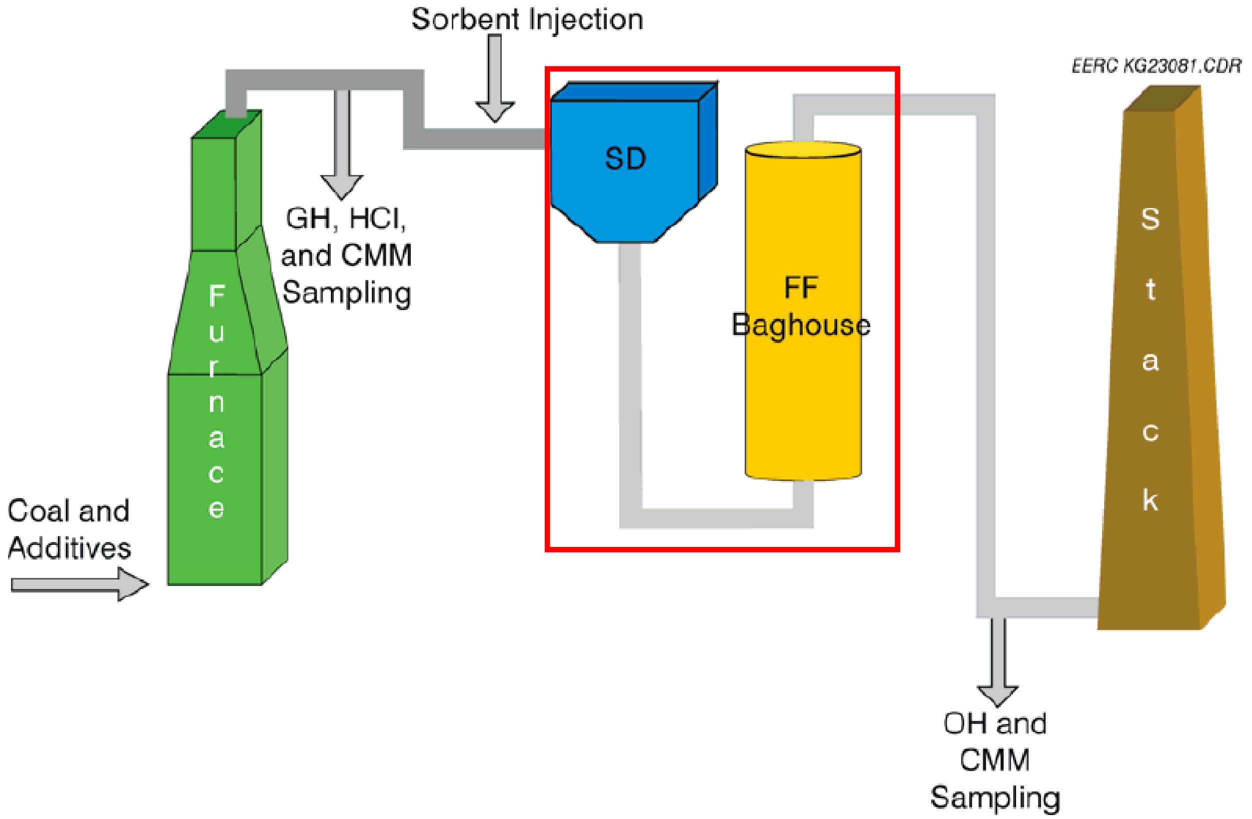
Table 9-2. Week 1 – Test Matrix

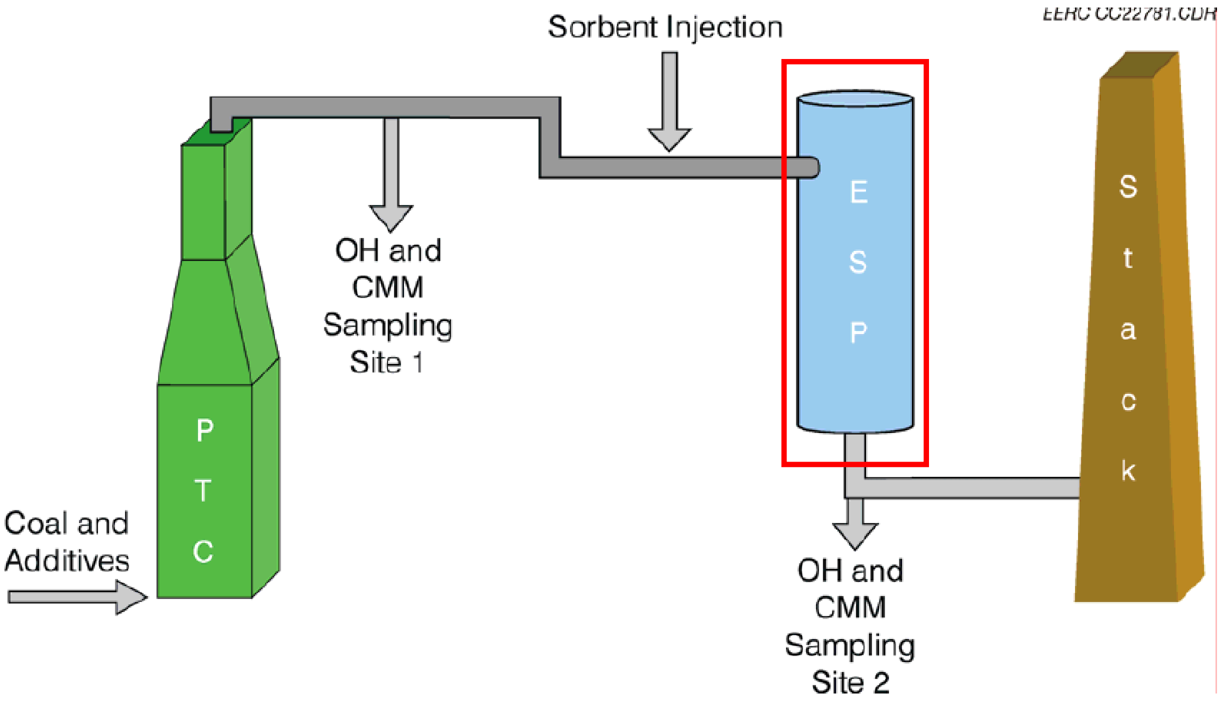
Date	Sampling Inlet	Sampling Outlet	Sorbent	Rate, g/hr	Rate, lb/MMacf	Oxidant	Rate, g/hr	Rate, lb/MMacf
2/2/04	OH	OH	Baseline					
	M-29		Baseline					
			DARCO	25.0	7.03			
			DARCO	28.0	7.84			
			DARCO	32.0	8.96			
		OH	DARCO	45.0	12.60			
			DARCO	69.0	19.20			
2/3/04			Baseline					
						SEA1	15.2	4.28
						SEA1	29.8	8.38
			DARCO	25.0	7.03	SEA1	29.8	8.38
	OH	OH	DARCO	25.0	7.03	SEA1	45.5	12.80
	M-29		DARCO	25.0	7.03	SEA1	59.9	16.73
			DARCO	25.0	7.03	SEA1	15.2	4.28
2/4/04			Baseline					
						SEA2	9.8	2.73
			DARCO	25.0	6.96	SEA2	9.8	2.73
	OH	OH	DARCO	15.0	4.18	SEA2	9.8	2.73
			DARCO	15.0	4.18			
	M-29		DARCO	15.0	4.18	SEA2	6.9	1.92
			DARCO	15.0	4.18	SEA2	4.3	1.20
			DARCO	15.0	4.18			
			DARCO	15.0	4.18	SEA1–SEA2	2.6	0.72
2/5/2004			Baseline					
	OH	OH	EERC carbon	25.0	6.97			
			EERC carbon	35.0	9.76			
			Am. Silicate	25.0	6.91			
			Am. Silicate	50.0	13.82			

Notes:
M-29 = EPA Method 29
EERC carbon = EERC-treated DARCO carbon
Am. Silicate = Amended Silicate
SEA1–SEA2 = 50%–50% blend of SEA1 and SEA2. The total rate for both is given.

No.	’225 Claim Element	Evidence of Reduction to Practice
		 The mercury/sorbent composition was collected using an electrostatic precipitator during the September 2003 testing to form a cleaned gas. Ex. 2012, Feb. 2004 Report at 10–11 (“Fourteen tests were completed to evaluate various sorbent and mercury oxidant performance on mercury removal across the ESP as functions of feed rate.”):

No.	’225 Claim Element	Evidence of Reduction to Practice
		 Figure 4. Injection and sampling schematic of the PTC with an ESP. The mercury/sorbent composition was collected using a scrubbed baghouse system during the December 2003 testing. Ex. 2012, Feb. 2004 Report at 14 (“One week of short-term sorbent (Task 2.2) and furnace additive testing was accomplished in December 2003 to demonstrate mercury removal by sorbent injection combined with

No.	’225 Claim Element	Evidence of Reduction to Practice
		various oxidizing additives to simulate a scrubbed baghouse system.”); *see also* Ex. 2013, Feb. 2005 Report at 25: 

No.	’225 Claim Element	Evidence of Reduction to Practice
		The mercury/sorbent composition was collected using an electrostatic precipitator during the February 2004 testing. Ex. 2014, Oct. 2005 Report at 26 (“ESP Hg removal testing was performed with the PTC firing Caballo subbituminous coal.”): 

No.	’225 Claim Element	Evidence of Reduction to Practice
2	The method of claim 1, wherein the pyrolysis char is a promoted pyrolysis char.	A promoted pyrolysis char will form whenever bromine is added to coal that is then combusted.

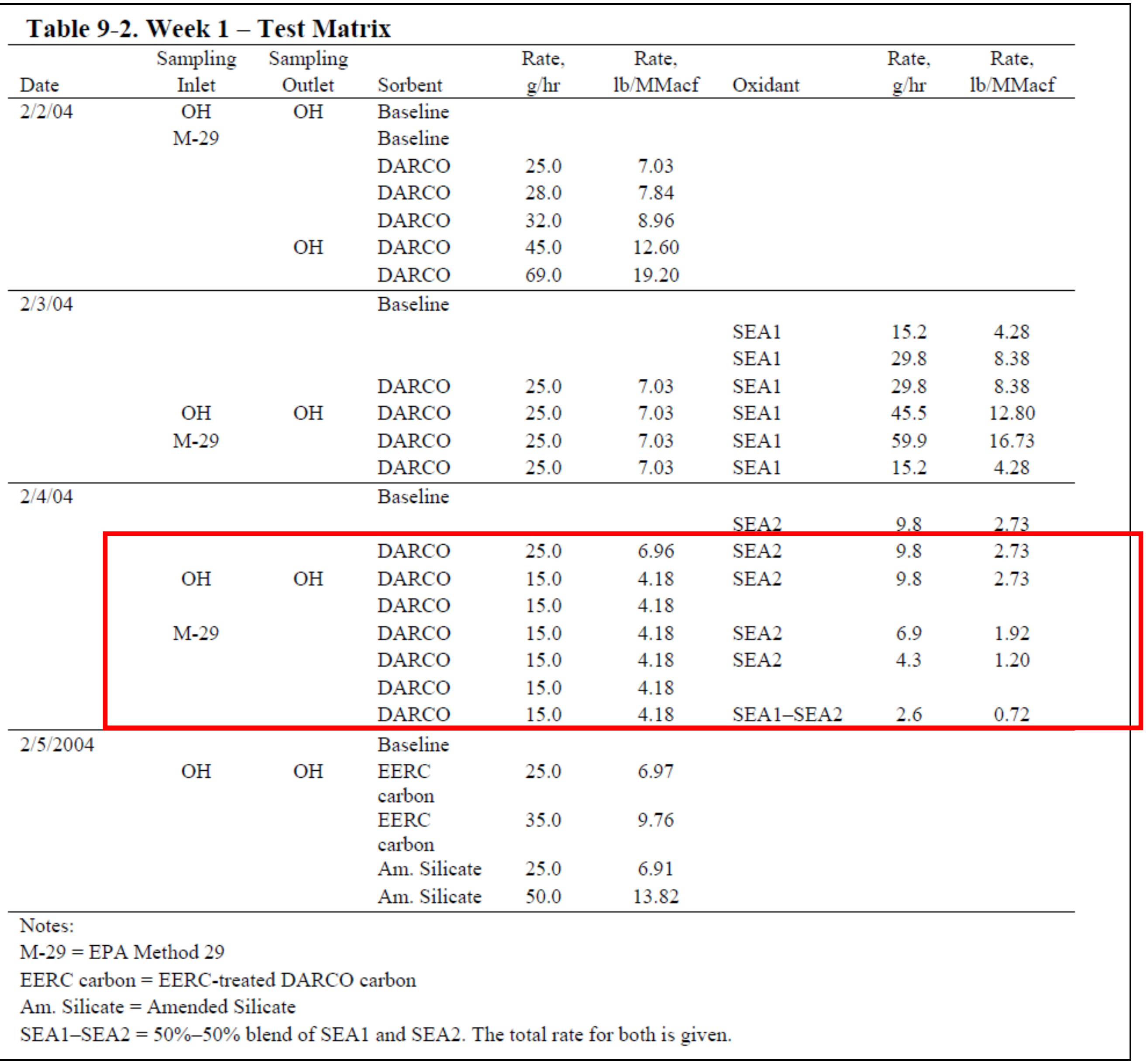


Table 9-2. Week 1 – Test Matrix

Date	Sampling Inlet	Sampling Outlet	Sorbent	Rate, g/hr	Rate, lb/MMacf	Oxidant	Rate, g/hr	Rate, lb/MMacf
2/2/04	OH	OH	Baseline					
	M-29		Baseline					
			DARCO	25.0	7.03			
			DARCO	28.0	7.84			
			DARCO	32.0	8.96			
		OH	DARCO	45.0	12.60			
			DARCO	69.0	19.20			
2/3/04			Baseline					
						SEA1	15.2	4.28
						SEA1	29.8	8.38
			DARCO	25.0	7.03	SEA1	29.8	8.38
	OH	OH	DARCO	25.0	7.03	SEA1	45.5	12.80
	M-29		DARCO	25.0	7.03	SEA1	59.9	16.73
			DARCO	25.0	7.03	SEA1	15.2	4.28
2/4/04			Baseline					
						SEA2	9.8	2.73
			DARCO	25.0	6.96	SEA2	9.8	2.73
	OH	OH	DARCO	15.0	4.18	SEA2	9.8	2.73
			DARCO	15.0	4.18			
	M-29		DARCO	15.0	4.18	SEA2	6.9	1.92
			DARCO	15.0	4.18	SEA2	4.3	1.20
			DARCO	15.0	4.18			
			DARCO	15.0	4.18	SEA1–SEA2	2.6	0.72
2/5/2004			Baseline					
	OH	OH	EERC carbon	25.0	6.97			
			EERC carbon	35.0	9.76			
			Am. Silicate	25.0	6.91			
			Am. Silicate	50.0	13.82			

Notes:
M-29 = EPA Method 29
EERC carbon = EERC-treated DARCO carbon
Am. Silicate = Amended Silicate
SEA1–SEA2 = 50%–50% blend of SEA1 and SEA2. The total rate for both is given.

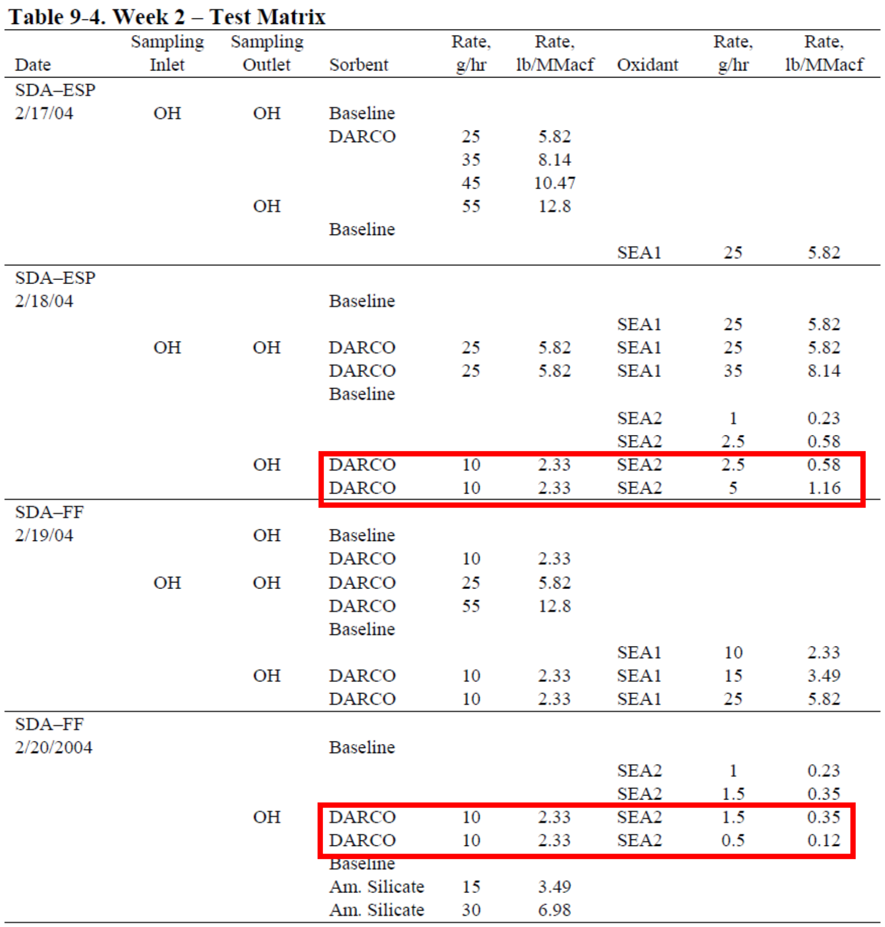
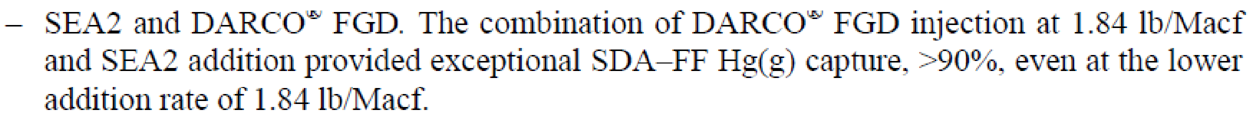
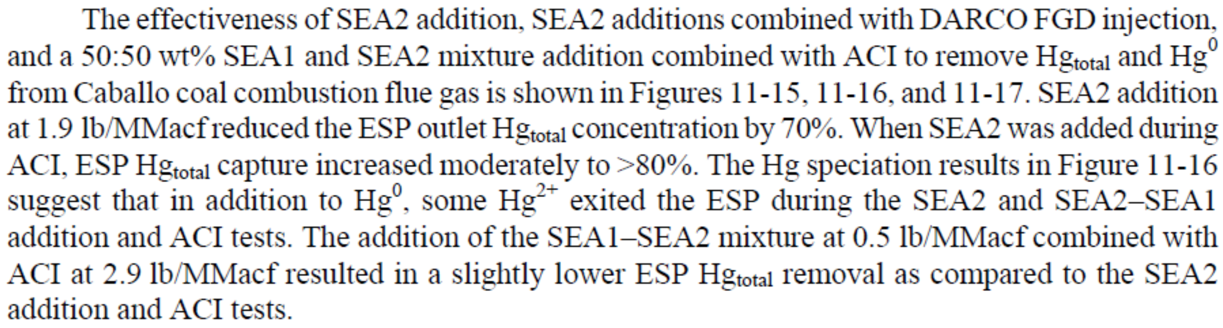
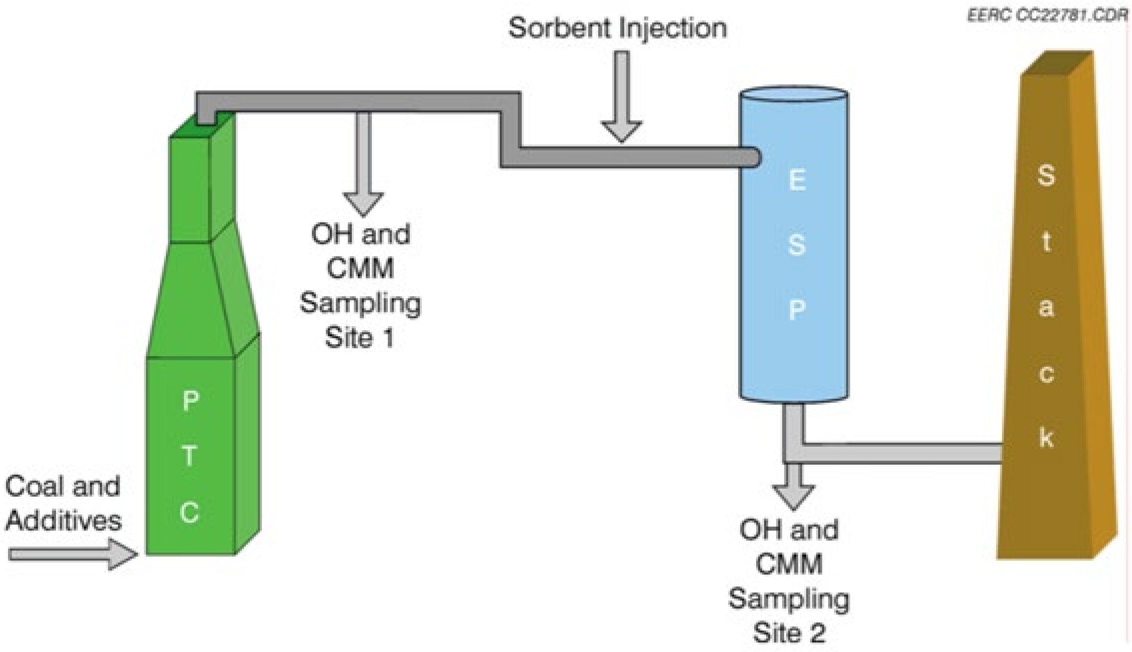
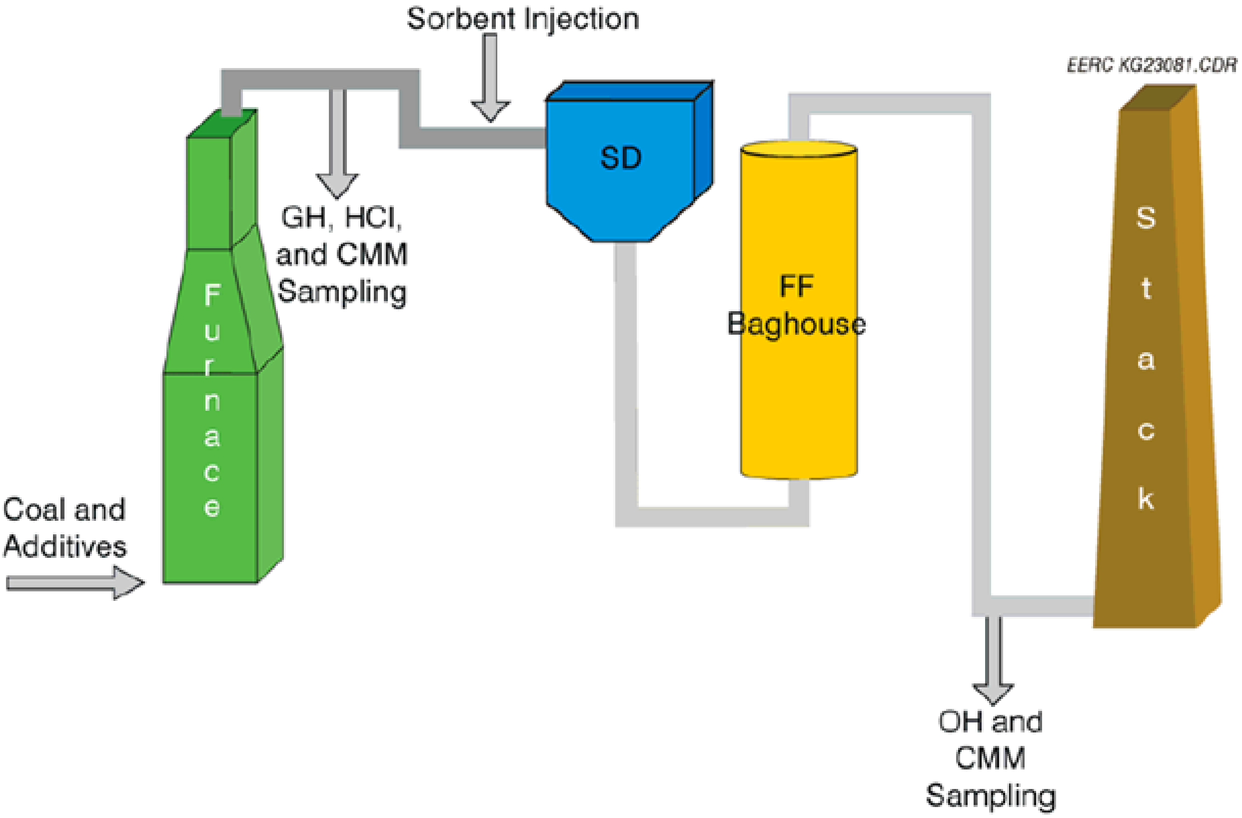
<table>
<tr><th>No.</th><th>’225 Claim Element</th><th>Evidence of Reduction to Practice</th></tr>
<tr><td></td><td></td><td>


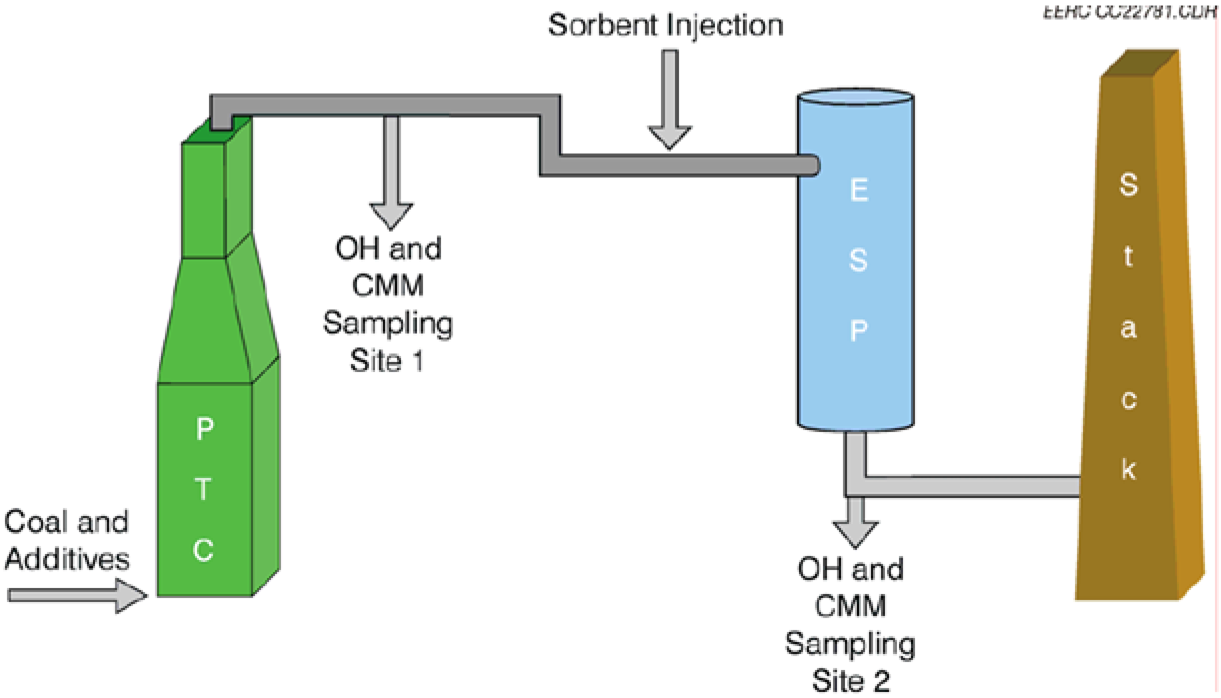
Table 9-4. Week 2 – Test Matrix

<table>
<tr><th>Date</th><th>Sampling Inlet</th><th>Sampling Outlet</th><th>Sorbent</th><th>Rate, g/hr</th><th>Rate, lb/MMacf</th><th>Oxidant</th><th>Rate, g/hr</th><th>Rate, lb/MMacf</th></tr>
<tr><td>SDA–ESP</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>2/17/04</td><td>OH</td><td>OH</td><td>Baseline</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td>DARCO</td><td>25</td><td>5.82</td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td>35</td><td>8.14</td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td>45</td><td>10.47</td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td>OH</td><td></td><td>55</td><td>12.8</td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td>Baseline</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td>SEA1</td><td>25</td><td>5.82</td></tr>
<tr><td>SDA–ESP</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>2/18/04</td><td></td><td></td><td>Baseline</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td>SEA1</td><td>25</td><td>5.82</td></tr>
<tr><td></td><td>OH</td><td>OH</td><td>DARCO</td><td>25</td><td>5.82</td><td>SEA1</td><td>25</td><td>5.82</td></tr>
<tr><td></td><td></td><td></td><td>DARCO</td><td>25</td><td>5.82</td><td>SEA1</td><td>35</td><td>8.14</td></tr>
<tr><td></td><td></td><td></td><td>Baseline</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td>SEA2</td><td>1</td><td>0.23</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td>SEA2</td><td>2.5</td><td>0.58</td></tr>
<tr><td></td><td></td><td>OH</td><td>DARCO</td><td>10</td><td>2.33</td><td>SEA2</td><td>2.5</td><td>0.58</td></tr>
<tr><td></td><td></td><td></td><td>DARCO</td><td>10</td><td>2.33</td><td>SEA2</td><td>5</td><td>1.16</td></tr>
<tr><td>SDA–FF</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>2/19/04</td><td></td><td>OH</td><td>Baseline</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td>DARCO</td><td>10</td><td>2.33</td><td></td><td></td><td></td></tr>
<tr><td></td><td>OH</td><td>OH</td><td>DARCO</td><td>25</td><td>5.82</td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td>DARCO</td><td>55</td><td>12.8</td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td>Baseline</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td>SEA1</td><td>10</td><td>2.33</td></tr>
<tr><td></td><td></td><td>OH</td><td>DARCO</td><td>10</td><td>2.33</td><td>SEA1</td><td>15</td><td>3.49</td></tr>
<tr><td></td><td></td><td></td><td>DARCO</td><td>10</td><td>2.33</td><td>SEA1</td><td>25</td><td>5.82</td></tr>
<tr><td>SDA–FF</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>2/20/2004</td><td></td><td></td><td>Baseline</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td>SEA2</td><td>1</td><td>0.23</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td>SEA2</td><td>1.5</td><td>0.35</td></tr>
<tr><td></td><td></td><td>OH</td><td>DARCO</td><td>10</td><td>2.33</td><td>SEA2</td><td>1.5</td><td>0.35</td></tr>
<tr><td></td><td></td><td></td><td>DARCO</td><td>10</td><td>2.33</td><td>SEA2</td><td>0.5</td><td>0.12</td></tr>
<tr><td></td><td></td><td></td><td>Baseline</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td>Am. Silicate</td><td>15</td><td>3.49</td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td>Am. Silicate</td><td>30</td><td>6.98</td><td></td><td></td><td></td></tr>
</table>
</td></tr>
</table>

No.	**’225 Claim Element**	**Evidence of Reduction to Practice**
5	The method of claim 1, further comprising using a particle separation device to remove mercury from the flue gas and comprising collecting greater than 70 wt % of the mercury in the mercury-containing gas to produce a cleaned gas.	This level of mercury capture was achieved during the September 2003, December 2003, and February 2004 testing. *See* Ex. 2013, Feb. 2005 Report at 73:  – SEA2 and DARCO® FGD. The combination of DARCO® FGD injection at 1.84 lb/Macf and SEA2 addition provided exceptional SDA–FF Hg(g) capture, >90%, even at the lower addition rate of 1.84 lb/Macf. *See* Ex. 2014, Oct. 2005 Report at 49:  The effectiveness of SEA2 addition, SEA2 additions combined with DARCO FGD injection, and a 50:50 wt% SEA1 and SEA2 mixture addition combined with ACI to remove Hg_{total} and Hg^0 from Caballo coal combustion flue gas is shown in Figures 11-15, 11-16, and 11-17. SEA2 addition at 1.9 lb/MMacf reduced the ESP outlet Hg_{total} concentration by 70%. When SEA2 was added during ACI, ESP Hg_{total} capture increased moderately to >80%. The Hg speciation results in Figure 11-16 suggest that in addition to Hg^0, some Hg^{2+} exited the ESP during the SEA2 and SEA2–SEA1 addition and ACI tests. The addition of the SEA1–SEA2 mixture at 0.5 lb/MMacf combined with ACI at 2.9 lb/MMacf resulted in a slightly lower ESP Hg_{total} removal as compared to the SEA2 addition and ACI tests.

No.	'225 Claim Element	Evidence of Reduction to Practice
6	The method of claim 5, further comprising: measuring the mercury content of the mercury-containing gas; and modifying, in response to the measured mercury content: an injection rate of injecting the sorbent into the mercury-containing gas, an amount of the additive in the mixture, or	*See* Claims 1, 5. The Feb. 2004 Report describes the use of "Continuous Mercury Monitors" during the September 2003 testing and December 2003 testing. Feb. 2004 Report at 8 ("Hg^0 and total Hg levels will be measured on a nearly continuous basis using a continuous mercury monitor (CMM)"); *id.* at 10:  Figure 4. Injection and sampling schematic of the PTC with an ESP.

No.	’225 Claim Element	Evidence of Reduction to Practice
	a combination thereof.	*See also* Feb. 2005 Report at 25:  *See also* Oct. 2005 Report at 26:

No.	’225 Claim Element	Evidence of Reduction to Practice
		 The Feb. 2004 Report describes adjusting the additive and sorbent injection rate. Both options result in changes to the sorbent composition. Feb. 2004 Report at 9 (“Specific sorbent injection rates will be determined based on the measured Hg concentration in the flue gas.”). Feb. 2004 Report at 10 (“For continuous injection, the feed rate will be varied from 2500-12,000 lb sorbent/lb Hg”). Feb. 2004 Report at

No.	’225 Claim Element	Evidence of Reduction to Practice
		10 (“Fourteen tests were completed to evaluate various sorbent and mercury injecting the oxidant performance on mercury removal across the ESP as functions of feed rate”). *See also* Feb. 2005 Report at 15:[28]

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[28] This table refers to a “December 2004 nm,” which is a typo. It should refer to a December 2003 nm as noted in the preceding paragraph. Final Report at 14 (“One week of short-term sorbent (Task 2.2) and furnace additive testing was accomplished in December 2003 to demonstrate mercury removal by sorbent injection combined with various oxidizing additives to simulate a scrubbed baghouse system.”). This is also evidence based on the fact that the Final Report was prepared in February 2004.

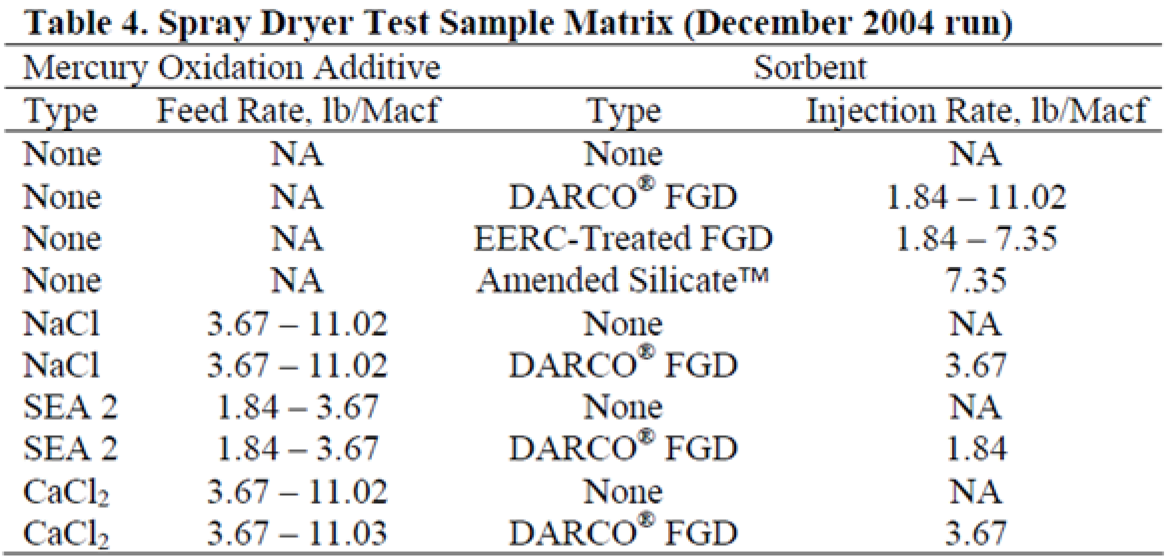
<table>
<tr><th>No.</th><th>’225 Claim Element</th><th>Evidence of Reduction to Practice</th></tr>
<tr><td></td><td></td><td>


Table 4. Spray Dryer Test Sample Matrix (December 2004 run)

<table>
<tr><th colspan="2">Mercury Oxidation Additive</th><th colspan="2">Sorbent</th></tr>
<tr><th>Type</th><th>Feed Rate, lb/Macf</th><th>Type</th><th>Injection Rate, lb/Macf</th></tr>
<tr><td>None</td><td>NA</td><td>None</td><td>NA</td></tr>
<tr><td>None</td><td>NA</td><td>DARCO® FGD</td><td>1.84 – 11.02</td></tr>
<tr><td>None</td><td>NA</td><td>EERC-Treated FGD</td><td>1.84 – 7.35</td></tr>
<tr><td>None</td><td>NA</td><td>Amended Silicate™</td><td>7.35</td></tr>
<tr><td>NaCl</td><td>3.67 – 11.02</td><td>None</td><td>NA</td></tr>
<tr><td>NaCl</td><td>3.67 – 11.02</td><td>DARCO® FGD</td><td>3.67</td></tr>
<tr><td>SEA 2</td><td>1.84 – 3.67</td><td>None</td><td>NA</td></tr>
<tr><td>SEA 2</td><td>1.84 – 3.67</td><td>DARCO® FGD</td><td>1.84</td></tr>
<tr><td>$CaCl_2$</td><td>3.67 – 11.02</td><td>None</td><td>NA</td></tr>
<tr><td>$CaCl_2$</td><td>3.67 – 11.03</td><td>DARCO® FGD</td><td>3.67</td></tr>
</table>

See also Oct. 2005 Report at 27:
</td></tr>
</table>

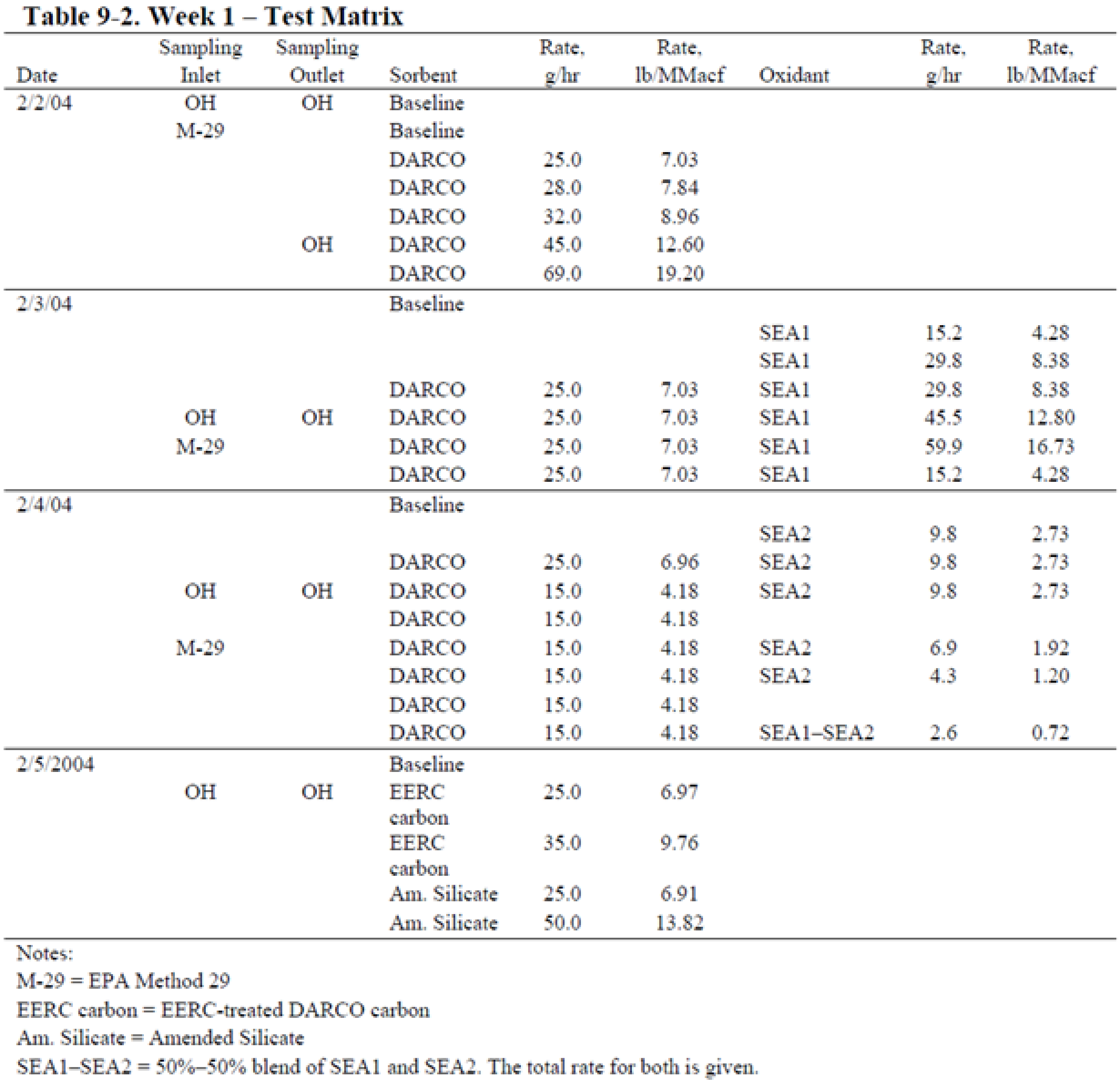
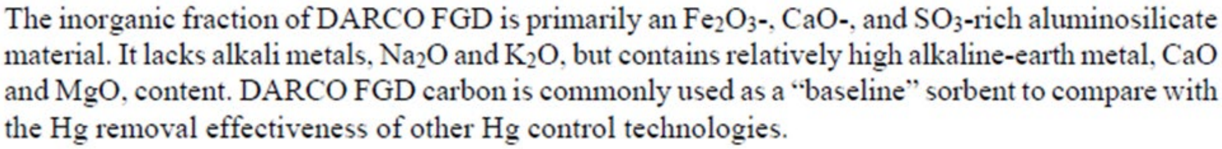


Table 9-2. Week 1 – Test Matrix

Date	Sampling Inlet	Sampling Outlet	Sorbent	Rate, g/hr	Rate, lb/MMacf	Oxidant	Rate, g/hr	Rate, lb/MMacf
2/2/04	OH	OH	Baseline					
	M-29		Baseline					
			DARCO	25.0	7.03			
			DARCO	28.0	7.84			
			DARCO	32.0	8.96			
		OH	DARCO	45.0	12.60			
			DARCO	69.0	19.20			
2/3/04			Baseline					
						SEA1	15.2	4.28
						SEA1	29.8	8.38
			DARCO	25.0	7.03	SEA1	29.8	8.38
	OH	OH	DARCO	25.0	7.03	SEA1	45.5	12.80
	M-29		DARCO	25.0	7.03	SEA1	59.9	16.73
			DARCO	25.0	7.03	SEA1	15.2	4.28
2/4/04			Baseline					
						SEA2	9.8	2.73
			DARCO	25.0	6.96	SEA2	9.8	2.73
	OH	OH	DARCO	15.0	4.18	SEA2	9.8	2.73
			DARCO	15.0	4.18			
	M-29		DARCO	15.0	4.18	SEA2	6.9	1.92
			DARCO	15.0	4.18	SEA2	4.3	1.20
			DARCO	15.0	4.18			
			DARCO	15.0	4.18	SEA1–SEA2	2.6	0.72
2/5/2004			Baseline					
	OH	OH	EERC carbon	25.0	6.97			
			EERC carbon	35.0	9.76			
			Am. Silicate	25.0	6.91			
			Am. Silicate	50.0	13.82			

Notes:
M-29 = EPA Method 29
EERC carbon = EERC-treated DARCO carbon
Am. Silicate = Amended Silicate
SEA1–SEA2 = 50%–50% blend of SEA1 and SEA2. The total rate for both is given.

No.	’225 Claim Element	Evidence of Reduction to Practice
8	The method of claim 1, wherein the sorbent material is chosen from powdered activated carbon, granular activated carbon, carbon black, carbon fiber, aerogel carbon, pyrolysis char, and combinations thereof.	*See* 1c.

No.	’225 Claim Element	Evidence of Reduction to Practice
9	The method of claim 1, further comprising adding an alkaline component to the mercury-containing gas, the alkaline component chosen from alkali elements, alkaline earth elements, alkali salts, alkaline earth salts, and combinations thereof.	As discussed in our DOE reports, DARCO FGD contains high alkaline-earth metal content: *See* Ex. 2014, Oct. 2005 Report at 54:  The inorganic fraction of DARCO FGD is primarily an Fe_2O_3-, CaO-, and SO_3-rich aluminosilicate material. It lacks alkali metals, Na_2O and K_2O, but contains relatively high alkaline-earth metal, CaO and MgO, content. DARCO FGD carbon is commonly used as a “baseline” sorbent to compare with the Hg removal effectiveness of other Hg control technologies.

No.	’225 Claim Element	Evidence of Reduction to Practice
14a	A method for treating a mercury-containing gas, the method comprising:	*See* 1a
14b	combusting coal in a combustor comprising pyrolysis char and an additive comprising HBr, a bromide compound, or a combination thereof, to form the mercury-	*See* 1b

No.	’225 Claim Element	Evidence of Reduction to Practice
	containing gas; and	
14c	adding a particulate sorbent material comprising activated carbon into the mercury-containing gas.	*See* 1c
15	The method of claim 14, wherein the pyrolysis char is a promoted pyrolysis char.	*See* Claim 2.
17a	A method for treating a	*See* 1a

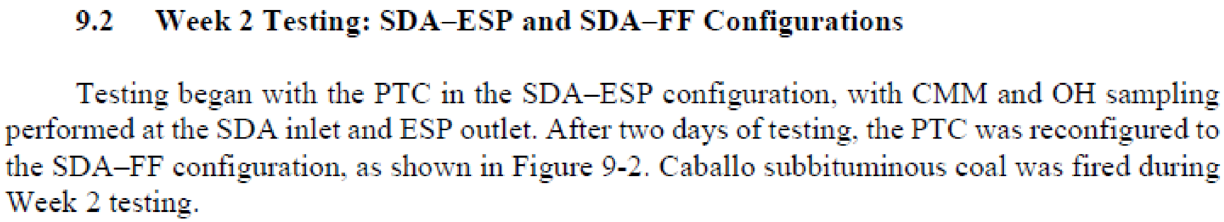
No.	’225 Claim Element	Evidence of Reduction to Practice
	mercury-containing gas, the method comprising:	
17b	combusting a mixture comprising coal, pyrolysis char, and an additive comprising HBr, a bromide compound, or a combination thereof, to form the mercury-containing gas; and	*See* 1b.

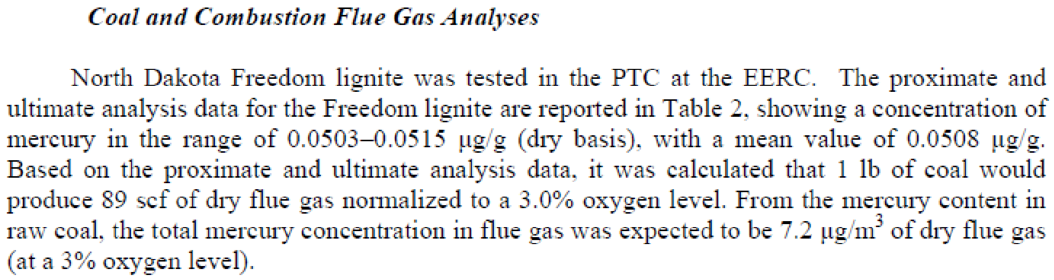
No.	**’225 Claim Element**	**Evidence of Reduction to Practice**
17c	adding a sorbent material comprising activated carbon into the mercury-containing gas.	*See* 1c.
18a	The method of claim 1, further comprising	*See* Claim 1.
18b	modifying, in response to a measured mercury content,	*See* Claim 6.
18c	an injection rate of injecting the	*See* Claim 6.

No.	’225 Claim Element	Evidence of Reduction to Practice
	sorbent into the mercury-containing gas,	
18d	an amount of the additive in the mixture, or	*See* Claim 6.
18e	a combination thereof.	*See* Claim 6.
20	The method of claim 1, wherein the coal is combusted in a combustion chamber at a coal-combustion	*See* 1c.

No.	’225 Claim Element	Evidence of Reduction to Practice
	facility, wherein the HBr, bromide compound, or combination thereof, is added to the coal before the coal enters the combustion chamber, wherein the addition of the HBr, bromide compound, or combination thereof, to the coal is performed at the coal-	

No.	’225 Claim Element	Evidence of Reduction to Practice
	combustion facility.	
23	The method of claim 1, wherein the sorbent is free of contact with a halogen or halide promoter prior to the addition of the sorbent to the mercury-containing gas.	*See* 1c.
24	The method of claim 6, wherein the measurement of the mercury	*See* Claim 6.

No.	’225 Claim Element	Evidence of Reduction to Practice
	content of the mercury-containing gas comprises continuous measurement.	
25	The method of claim 1, wherein the coal comprises subbituminous coal.	Our testing included tests with subbituminous coal. *See* Ex. 2014 Oct. 2005 Report at 28:  **9.2 Week 2 Testing: SDA–ESP and SDA–FF Configurations** Testing began with the PTC in the SDA–ESP configuration, with CMM and OH sampling performed at the SDA inlet and ESP outlet. After two days of testing, the PTC was reconfigured to the SDA–FF configuration, as shown in Figure 9-2. Caballo subbituminous coal was fired during Week 2 testing.
26	The method of claim 1, wherein the	Our testing included tests with lignite coal. *See* Ex. 2012 Feb. 2004 Report at 10:

No.	’225 Claim Element	Evidence of Reduction to Practice
	coal comprises lignite coal.	 ***Coal and Combustion Flue Gas Analyses*** North Dakota Freedom lignite was tested in the PTC at the EERC. The proximate and ultimate analysis data for the Freedom lignite are reported in Table 2, showing a concentration of mercury in the range of 0.0503–0.0515 µg/g (dry basis), with a mean value of 0.0508 µg/g. Based on the proximate and ultimate analysis data, it was calculated that 1 lb of coal would produce 89 scf of dry flue gas normalized to a 3.0% oxygen level. From the mercury content in raw coal, the total mercury concentration in flue gas was expected to be 7.2 µg/m^3 of dry flue gas (at a 3% oxygen level).
27	The method of claim 1, wherein the mixture is combusted in a combustion chamber of a coal-combustion facility upstream of a	These claims are reflected in our testing for the same reasons described above and also with respect to claim 1 of the ’225 Patent.

No.	’225 Claim Element	Evidence of Reduction to Practice
	scrubber, a particulate control system, or a combination thereof, wherein the particulate sorbent is added to the mercury-containing gas before the mercury-containing gas encounters the scrubber, the particulate control system, or the	

No.	’225 Claim Element	Evidence of Reduction to Practice
	combination thereof.	
28	The method of claim 26, wherein the particulate control system comprises an electrostatic precipitator, a baghouse, a fabric filter, or a combination thereof.	These claims are reflected in our testing for the same reasons described above and also with respect to claim 1 of the ’225 Patent.
29	The method of claim 19, wherein the combustion	These claims are reflected in our testing for the same reasons described above and also with respect to claim 1 of the ’225 Patent.

No.	’225 Claim Element	Evidence of Reduction to Practice
	chamber is a coal combustion furnace.	