

**IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF DELAWARE**

MIDWEST ENERGY EMISSIONS CORP. and
MES INC.,

Plaintiffs,

v.

ARTHUR J. GALLAGHER & CO., ET AL.,

Defendants.

CIV. NO. 1:19-01334- CJB

**REBUTTAL EXPERT REPORT OF PHILIP J. O'KEEFE, PE
REGARDING PATENT VALIDITY**



1. BACKGROUND

1.1 Summary of Opinions

1. This rebuttal expert report provides my opinions and the bases therefore in rebuttal to the opinions provided in the October 25, 2022 Opening Report of Dr. Stephen Niksa. This report incorporates by reference my October 25, 2022 Opening Report. In my opinion, Dr. Niksa has failed to demonstrate that the patents-in-suit are invalid. In this report I explain how I arrived at this opinion as well as other opinions and findings.

1.2 Personal Background

2. See section 1.2 of my opening report.

1.3 Materials Considered

3. In addition to the information identified in section 1.3 and throughout my opening report, the evidence upon which I have relied to form my opinions is cited in this report.

1.4 Understanding of the Law

4. See section 1.4 of my opening report. In addition, I have been informed by counsel of various principles of patent law relevant to the issues in this case. I have set forth my understanding of those principles in this section.

5. I understand that the first step in determining either validity or infringement is to properly construe the claims. I also understand that claims must be construed the same way in determining validity/invalidity and infringement/non-infringement.

6. **Presumption of Validity.** It is my understanding that the claims of an issued U.S. patent are presumed to be valid and that it is the Defendants' burden to invalidate a patent by presenting evidence that meets a higher burden of proof. Thus, while infringement must be proven by a preponderance of evidence, invalidity (including anticipation, obviousness, lack of written description and lack of enablement) must be proven by clear and convincing evidence.

[REDACTED]

This evidentiary burden is the same, regardless of whether the asserted prior art was previously presented to the USPTO. In granting a patent, an examiner is under no duty to cite every reference he considers. For example, the examiner may have considered every reference and combination on which Dr. Niksa's Report relies, but the examiner could have opted to cite better art instead.

7. **Statutory Bases for Invalidity Over Prior Art.** I understand that a patent may be found invalid based on prior art if the Defendant demonstrates one of the statutory bases for invalidity based on 35 U.S.C. § 102 or 103. The relevant statutory provisions are provided below:

35 U.S.C. 102 (PRE-AIA) CONDITIONS FOR PATENTABILITY; NOVELTY AND LOSS OF RIGHT TO PATENT.

A person shall be entitled to a patent unless —

- (a) the invention was known or used by others in this country, or patented or described in a printed publication in this or a foreign country, before the invention thereof by the applicant for patent, or*
- (b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of the application for patent in the United States, or*
- (c) he has abandoned the invention, or*
- (d) the invention was first patented or caused to be patented, or was the subject of an inventor's certificate, by the applicant or his legal representatives or assigns in a foreign country prior to the date of the application for patent in this country on an application for patent or inventor's certificate filed more than twelve months before the filing of the application in the United States, or*
- (e) the invention was described in — (1) an application for patent, published under section 122(b), by another filed in the United States before the invention by the applicant for patent or (2) a patent granted on an application for patent by another filed in the United States before the invention by the applicant for patent, except that an international application filed under the treaty defined in section 351(a) shall have the effects for the purposes of this subsection of an application filed in the United States only if the international application designated the United States and was published under Article 21(2) of such treaty in the English language; or*
- (f) he did not himself invent the subject matter sought to be patented, or*
- (g) (1) during the course of an interference conducted under section 135 or section 291, another inventor involved therein establishes, to the extent permitted in section 104, that before such person's invention thereof the invention was made*

[REDACTED]

by such other inventor and not abandoned, suppressed, or concealed, or (2) before such person's invention thereof, the invention was made in this country by another inventor who had not abandoned, suppressed, or concealed it. In determining priority of invention under this subsection, there shall be considered not only the respective dates of conception and reduction to practice of the invention, but also the reasonable diligence of one who was first to conceive and last to reduce to practice, from a time prior to conception by the other.

35 U.S.C. 103 CONDITIONS FOR PATENTABILITY; NON-OBVIOUS SUBJECT MATTER.

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 , if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

8. **Critical Date and Priority Date.** I understand that the “critical date” for a patent is one year prior to its filing date. A claim must be found invalid if a prior art reference dated before the critical date discloses each and every limitation of the claims regardless of when the inventor conceived of the invention. I also understand that the “priority date” of a patent is the date on which the application from which it matured is filed, or the date on which such application was effectively filed (e.g., the filing date of an application from which priority is claimed).

9. I understand that for a patent to be entitled to the priority date of an earlier filed application, the prior application must describe the claimed invention in sufficient detail to comply with the written description and enablement requirements discussed below. It is not enough that the claim would have been obvious from the earlier application, that application itself must describe the claimed invention. A priority date analysis is conducted on a claim by claim basis. Moreover, each application in a chain of applications must meet this requirement.

[REDACTED]

An application may incorporate by reference information from an earlier provisional or non-provisional application to meet this requirement.

10. **Earlier Conception/Reduction to Practice.** I understand that a patent may be valid over prior art that was published or was publicly available before the priority date (but after the critical date) if the inventors conceived of the claimed invention before the prior art, and were diligent in reducing the claimed invention to practice.

11. I understand that the patentee must come forward with evidence corroborating an earlier conception date. I understand that a “rule of reason” analysis is applied to determine whether an inventor’s prior conception or reduction to practice testimony has been corroborated. I understand that there is no single formula that must be followed in proving corroboration. I understand that an evaluation of all pertinent evidence must be made so that a sound determination of the credibility of an inventor’s story may be reached. I understand that factors bearing on the inventor’s credibility and on whether the inventor’s testimony has been adequately corroborated include: delay between the event and the trial; interest of corroborating witnesses; contradiction or impeachment; corroborating witnesses’ familiarity with details of alleged prior structure; improbability of prior use considering state of the art; impact of the invention on the industry; and relationship between witness and alleged prior user. I understand that all of the evidence put forth by the patentee, including any of the inventor’s corroborated testimony, must be considered as a whole, not individually, in determining earlier conception. In other words, an inventor can conceivably prove prior conception although no one piece of evidence in and of itself establishes the prior conception. It is sufficient if the picture painted by all of the evidence taken collectively gives “an abiding conviction” that the inventor’s assertion of prior conception is “highly probable.” For example, I understand that the analysis can consider

[REDACTED]

whether the inventor made disclosure to others or an embodiment of the invention in some clearly perceptible form, such as drawings or model, with sufficient proof of identify in point of time. I understand that only the inventor's testimony requires corroboration, and that physical or documentary evidence proffered to corroborate that testimony need itself not be supported by corroborating evidence as to what it discloses.

12. **Qualifying a Reference as Prior Art.** It is my understanding that in order to serve as a "printed publication," a document must be publicly accessible. This depends on a satisfactory showing that the document has been disseminated or otherwise made available to the extent that POSITA, exercising reasonable diligence, can locate it. I understand that public accessibility requires more than technical accessibility where someone could theoretically find a reference on the Internet.

13. For example, a reference may qualify as a printed publication if it is indexed and located in a publicly accessible library and a POSITA could locate the document through reasonably diligent searching. Such a document would not be considered a printed publication if the person searching for the document would need to already be aware of its existence.

14. A reference may also be publicly accessible if it was distributed to the public without restriction. For example, a reference may qualify as a printed publication if based on presentation at a public conference. In determining whether a reference qualifies as a printed publication based on public display, it is appropriate to consider: (1) the length of time the reference was displayed, (2) expertise of the intended audience and how easily those who viewed it could retain the displayed material, and (3) whether professional and behavioral norms entitle a party to a reasonable expectation that the information displayed will not be copied.

[REDACTED]

15. I understand that a patent cannot be invalidated based on one person's testimony without corroborating evidence, particularly documentary evidence. Moreover, I understand that corroboration is required of any witness whose testimony alone is asserted to invalidate a patent, regardless of his or her level of interest in relation to that patent. Accordingly, even if the testifying individual has no interest in the litigation, it is my understanding that corroboration is still required.

16. **Anticipation.** It is my understanding that a prior art reference is anticipatory only if it expressly or inherently discloses each and every limitation of the claim (as properly construed) at issue. In other words, every limitation of a claim must appear in a single prior art reference for it to anticipate a claim. A prior art reference inherently discloses a claimed limitation if that missing characteristic is necessarily present, or inherent, in the single anticipating reference. A claim must be found invalid if a single prior art reference dated before the critical date discloses each and every limitation of the claims regardless of when the inventor conceived of the invention.

17. I understand to qualify as anticipatory prior art, a reference must contain an enabling disclosure that would allow a person of ordinary skill in the art to practice the claims without undue experimentation.

18. **Obviousness.** It is my further understanding that a claimed invention is unpatentable if the differences between the invention and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which the subject matter pertains. Obviousness, as I understand it, is based on the scope and content of the prior art, the differences between the prior art and the claim, and the level of ordinary skill in the art.

[REDACTED]

19. I also understand that when considering the obviousness of a patent claim, one should consider whether a teaching, suggestion or motivation to combine the references exists so as to avoid impermissibly applying hindsight when considering the prior art. I understand this test should not be rigidly applied, but that the test can be important to avoiding such hindsight.

20. In addition, it is my understanding that one must consider whether or not there is objective evidence of non-obviousness, which is also referred to as “secondary considerations of non-obviousness.” These secondary considerations include: (1) a long felt but unmet need in the prior art that was satisfied by the claimed invention; (2) commercial success or lack of commercial success of products or processes covered by the claimed invention; (3) unexpected results achieved by the claimed invention; (4) praise of the claimed invention by others skilled in the art; (5) the taking of licenses under the patent by others; (6) deliberate copying of the claimed invention; and (7) failure of others to achieve the results of the claimed invention. I further understand that contemporaneous and independent invention by others is a secondary consideration supporting an obviousness determination.

21. I also understand that evidence of secondary considerations must be relevant to the subject matter as claimed, and thus one must determine whether there is a nexus between the merits of the claimed invention and the evidence of secondary considerations. The term “nexus” designates a factually and legally sufficient connection between the objective evidence of non-obviousness and the claimed invention so that the evidence is of probative value in the determination of non-obviousness.

22. **Written Description.** I understand that a patent must satisfy a written description requirement, and that to satisfy the written description requirement, I understand that the patent’s description must clearly allow persons of ordinary skill in the art to recognize that the inventor

[REDACTED]

invented what is claimed. In other words, I understand that the test is whether the disclosure of the application reasonably conveys to those skilled in the art that the inventor had possession of the claimed subject matter as of the filing date. I understand that the written description requirement can be satisfied with any one or any combination of text/words, structures, figures, diagrams, formulas, etc. that are disclosed in the application. An application may also incorporate by reference information from an earlier non-provisional application to meet this requirement. I also understand that the full scope of a claim or a particular claim limitation need not be disclosed verbatim or expressly in the application as long as someone having ordinary skill in the art would have understood that the full scope of the claim or claim limitation is in the application.

23. I understand that the patent applicant is not required to describe in the specification every conceivable and possible future embodiment of their invention.

24. I understand that the specification need not show examples or actual reduction to practice of the invention. Instead, a constructive reduction to practice is sufficient.

25. I understand that when an invention is to a claimed combination and not the discovery of a property of a specific material, an application need not disclose all possible materials with that property.

26. I understand that there is no categorical rule that a description in the specification of a species cannot suffice to support or claim a genus. So long as disclosure of the species is sufficient to convey to one skilled in the art that the inventor possessed the subject matter of the genus, the genus will be supported by an adequate written description.

27. I understand that one way to sufficiently describe a genus is to disclose a representative number of species falling within the scope of the genus.

[REDACTED]

28. **Enablement.** I understand that a claimed invention must enable those of ordinary skill in the art to make and use the invention as it is claimed without undue experimentation. Undue experimentation is based on the level of skill in the art as of the effective filing date of the patent. I understand that a patent must enable the full scope of the claimed invention to be enabled.

29. I also understand, however, that a patent is not invalid for lack of enablement when there are alternative modes for making and using the invention and only one mode is enabled by the patent's specification. I understand that a patent application need not enable the most optimized configuration of any invention unless that is an explicit part of the claims.

30. I understand that the determination of whether any experimentation regarding the making and using of the claimed invention is governed by a non-exclusive set of factors, known as the *Wands* factors. These factors include: (1) the quantity of experimentation necessary; (2) the amount of direction or guidance presented; (3) the presence or absence of working examples; (4) the nature of the invention; (5) the state of the prior art; (6) the relative skill of those in the art; (7) the predictability or unpredictability of the art; and (8) the breadth of the claims.

31. I understand that these factors are only relevant if the patent challenger comes forward with evidence the experimentation is required to practice the claim.

1.5 The Organization of Patents

32. Patents are organized into different sections. Notable sections of patents are the drawings, which are sometimes referred to as figures; the background of the invention, which discusses the state of the art before the invention; the summary of the invention; the detailed description of the invention, which discusses various preferred embodiments; and the claims, which define and set out the patent property right given to the patentee by the United States. The term "preferred embodiment" refers to a specific, particular way to practice or implement the

ideas of the patent, but patents typically are not limited to their preferred embodiments. Patents also have a title; a list of prior art, which is all deemed to have been considered by the USPTO; the filing date of the patent; related applications and their filing dates; a list of the inventors; the date the patent was issued; and the assignee, which is the person or company who owns the patent.

1.6 The Level of Ordinary Skill in the Art

33. A person of ordinary skill in the art of the patent-in-suit at the time of the invention would have a bachelor's degree in mechanical engineering, chemical engineering, chemistry, or a related field of technology and at least two years of experience dealing with power plant operation, and/or pollution control equipment. Additional work experience in relevant industries could compensate for less education, or education in a different field. Similarly, advanced education and degrees could compensate for less work experience.

34. I base this opinion on the background of the inventors—including their experience level—and the subject matter of the patent-in-suit. I have also considered the engineers and power plant employees with whom I had experience in the timeframe of the filing dates of the patent-in-suit, specifically: (i) the education level and background needed for them to begin to grasp this material; and (ii) the practical experience needed to allow them to understand the patent in making effective use of the material laid out in this patent.

35. This description of the level of skill in the art is consistent with Dr. Niksa's testimony from the IPR proceedings related to the '114 and '147 patents. In those proceedings, Dr. Niksa opined:¹

¹ Ref. 238, Pg. 58.

64. As of the Challenged Patent's earliest claimed priority date (August 2004), a POSITA would have had at least a Bachelor's Degree in chemical engineering, mechanical engineering, or a related field of study. A POSITA would also have at least two years' experience with implementing pollution control in power generation plants for natural gas, coal, and/or industrial waste incineration. Among other areas, the POSITA would have been familiar with each of the topics discussed below in the State of the Art section.

36. However, Dr. Niksa offers a different description of the level of skill in the art in his report in this case, stating:

67. As of the Asserted Patents' earliest claimed priority date (August 2004), a POSITA would have had at least a Master's Degree in chemical engineering, chemistry, or a related field of study, as well as knowledge of mercury chemistry—including knowledge of gas phase and heterogeneous reactions of mercury and halogen species at the temperatures and under the conditions found in coal-fired power plants. A POSITA would also have at least two years' experience with research and development or implementing pollution control in power generation plants for natural gas, coal, and/or industrial waste incineration. Among other areas, the POSITA would have been familiar with each of the topics discussed below in the State of the Art section.

37. This second description of the level of skill in the art differs from my definition, and Dr. Niksa's prior definition in that he now opines that a POSITA would have a Master's

[REDACTED]

Degree in chemical engineering, chemistry, or a related field, and a knowledge of mercury chemistry including knowledge of gas phase and heterogeneous reactions of mercury and halogen species. Dr. Niksa provides no explanation for this change of opinion, or the basis for his new opinion.

38. I disagree with Dr. Niksa's proposed heightened level of skill in the art. Based on my experience working at power plants, POSITA typically do not have advanced degrees in chemistry or detailed knowledge of organic chemistry theory, and it would have been common for these individuals to "learn on the job," given that the study of mercury capture was still fairly new in 2004.

39. Regardless, even assuming a POSITA had the additional education called for by Dr. Niksa, Dr. Niksa has failed to present clear and convincing evidence of invalidity, as explained below.

2. Response to Dr. Niksa's Description of the State of the Art

40. Dr. Niksa's opening report contains a description of background information which he claims describes information that would have been known by a POSITA around the time the patents-in-suit were filed with the patent office. This section contains a number of errors. Notably, Dr. Niksa describes information contained in various references and then draws conclusions as to information a POSITA would draw from those references. However, I understand that a proper anticipation or obviousness analysis requires comparison of specific prior art references to specific claims. Moreover, an obviousness analysis requires consideration of, for example, motivations to combine references. While consideration of motivation to combine is not meant to be a rigid test, that sort of consideration is important for avoiding hindsight bias.

[REDACTED]

41. Dr. Niksa's report demonstrates hindsight bias. For example, he states: *"By 2002, it was known that the catalysts in SCR units could also oxidize elemental mercury (Hg_0) while they eliminated NO_x from the flue gas. Field tests across several SCRs at commercial power plants indicated that SCR systems "may also promote Hg_0 oxidation to Hg_{2+} , and this effect appeared to be coal-specific and possibly catalyst-specific. The coal-specific aspect was attributed to a coal's native chlorine content, as researchers interpreting the full-scale SCR field test data noted that significant increases in mercury oxidation (to Hg_{2+}) across the SCR that "correlate[s] with the amount of chloride in the coal. Thus, a POSITA would have readily realized that adding chlorine compounds to the coal or furnace to produce HCl in flue gas would promote oxidation of elemental mercury across an SCR. It would have been a very simple extension to recognize that other halogens, particularly Br , would promote mercury oxidation on SCR catalysts as well as, or better than, chlorine."*

42. In the preceding example from Dr. Niksa's report, he identifies a study related to SCR performance which noted a correlation between chlorine content in coal and SCR performance. However, this is merely an observation about test data, not a teaching in the art to add chlorine to coal. Similarly, Dr. Niksa concludes that this study would lead a POSITA to expect bromine added to coal to be beneficial. However, again, he identifies no such teaching in the reference. Rather, Dr. Niksa is relying on the patents-in-suit as a roadmap to supply the idea of adding bromine to coal and then identifying that as a reason to modify the test approach actually described in the reference. This is hindsight, and it is an unreliable approach to the inquiry of obviousness as it will always lead to a conclusion of obviousness. A correct obviousness analysis, i.e., one that does not rely on impermissible hindsight, would not focus on the missing limitation but would instead consider a system without reference to the missing

[REDACTED]

limitation and contemplate how that system would be put into practice by a person of ordinary skill in the art.

43. Dr. Niksa's report also references documents without regard to their status as prior art or as part of a proposed obviousness or anticipation theory. For example, he states:²

"By 2004, a POSITA would have known that chlorine in coal would be released into flue gas as HCl, which is spontaneously bound to inherent unburned carbon and injected carbon sorbents. The POSITA would also know that the chlorinated sites on the carbon would oxidize elemental Hg at economizer temperatures, and irreversibly capture the elemental and oxidized Hg on the carbon at air preheater temperatures and cooler."

For support, he cites Exhibit 1044 which is an article written by Dr. Niksa. However, the document is undated and Dr. Niksa provides no evidence that it would qualify as prior art to the patents-in-suit. Thus, his conclusion that a POSITA would have been aware of the content of the article are erroneous.

44. Dr. Niksa also identifies statements in various references and characterizes them as being well known in the art. However, even if the reference cited by Dr. Niksa qualifies as prior art—and he does not demonstrate this for all references—the mere existence of a statement in a document does not mean that it was well known at the time. For example, Dr. Niksa cites Granite as providing evidence of well known facts about alkali and halogen interactions with sorbents, despite Granite stating, for example, that he "speculated that lime aids in the removal of mercury by reacting with acid gases such as SO₂ that compete for adsorption with mercury on coal ash, unburned carbon particles, and activated-carbon sorbents." I understand that it is

² Ref. 239, Pg. 78.

[REDACTED]

incorrect to sidestep a proper obviousness analysis by characterizing past speculation as facts well known during the relevant time frame.³

45. Dr. Niksa's report also describes principles of chemistry that he claims would have been known to a POSITA. However, as explained above, he has not demonstrated that a POSITA would have such an advanced background in chemistry. Moreover, Dr. Niksa assumes that theoretical principles would apply in the context of coal combustion. For example, Dr. Niksa states:⁴ *"It was known that the dissociation energies are 428 kJ/mol for HCl, 363 for HBr, and 294 for HI. Based on these values a POSITA would expect Br and I to have an even greater affinity for PAC than Cl, because it takes less energy to form the ions of Br and I than those of Cl."* While a chemist may be able to calculate those values, that is not necessarily an indication as to how bromine would react in a combustion gas or flue gas given the temperatures, other constituents, and short contact time as the gas passes through various equipment. In short, the fact that Dr. Niksa can perform various calculations based on principles of chemistry is not an indication as to what was known in the art during the 2003-2004 timeframe.

46. Dr. Niksa's report also compares various references without providing an actual anticipation or obviousness analysis. Dr. Niksa identifies distinct grounds of invalidity labelled as grounds A – AC. I am able to consider this analysis and respond. Dr. Niksa also compares statements in various references such as Nelson and Vosteen.⁵ However, despite making conclusory statements about these references, he does not offer a claim by claim analysis or a proper obviousness analysis, by, for example, considering whether and how a POSITA would combine these references. I understand that this is insufficient to demonstrate obviousness.

³ Ref. 239, Pgs. 86 – 88.

⁴ Ref. 239, Pg. 94.

⁵ Ref. 239, Pgs. 94 – 97.

[REDACTED]

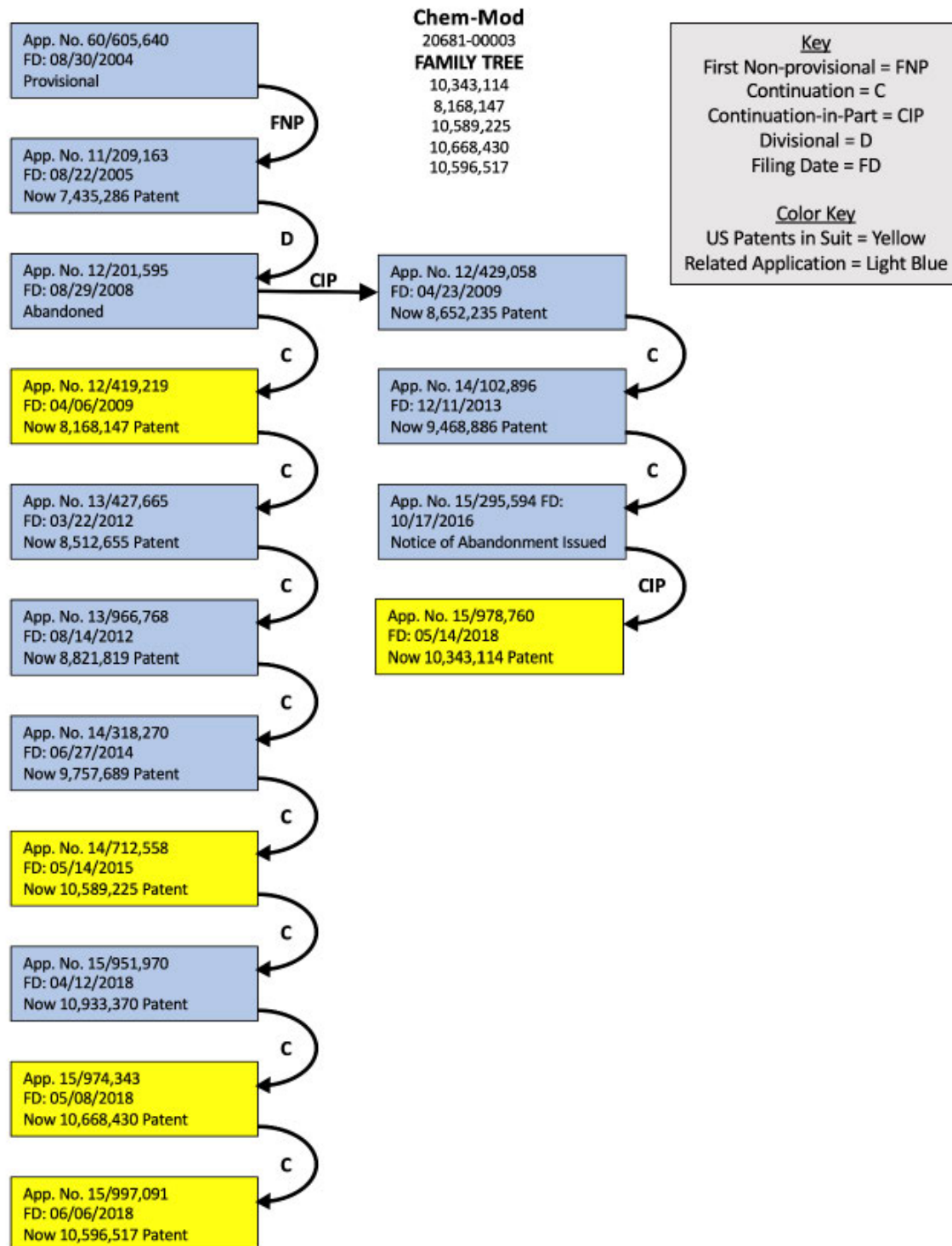
47. Dr. Niksa's report also contains opinions regarding halogen and activated carbon interactions based on references such as Granite, Bustard, Puri, etc. without identifying any particular anticipation or obviousness theory and without relating this discussion to the actual claim language. This discussion combines the various errors discussed above, i.e., Dr. Niksa relies on his knowledge of the patents-in-suit to pull elements from various references in an effort to arrive at a method similar to the patents-in-suit. This approach fails to demonstrate obviousness, and fails to address various elements of the claims, for example, providing bromine additive upstream of the combustion chamber and providing activated carbon downstream of the combustion chamber. It also fails to consider the secondary considerations discussed below.

48. Dr. Niksa's report also fails to consider the extent to which the cited references conflict or otherwise indicate that further study is needed. For example, he cites to Granite as stating: *"Activated carbons are often promoted with halogens or sulfur to improve their ability to sorb elemental mercury. This improvement comes at a price; promoted activated carbons are three times more costly than unpromoted carbons."* However, he also cites Granite as stating: *"It is speculated that lime aids in the removal of mercury by reacting with acid gases such as SO₂ that compete for adsorption with mercury on coal ash, unburned carbon particles, and activated-carbon sorbents."*⁶ Dr. Niksa fails to address whether this would encourage a POSITA to seek increased sulfur or decreased sulfur, use alkali or not, etc. He also fails to consider whether cost considerations would discourage sorbent promotion. Indeed, these references merely confirm that the industry had not yet attained a clear understanding of how mercury interacts in flue gas.

3. Response to Dr. Niksa's Description of the Patent Family

⁶ Compare Ref. 239, Pgs. 87 – 88 to Ref. 239, Pg. 92.

49. Exhibit 2015 to Dr. Niksa's report contains a family tree for the patents-in-suit.



[REDACTED]

50. I understand that this family tree is accurate.

51. Each application identified above incorporates by reference the preceding applications.

4. The Court's Constructions

52. See section 4 of my opening report.

5. Priority Date and Invention Date of the Patents-in-Suit

5.1. Priority Date Analysis

53. Each of the patents-in-suit claim priority to the same provisional patent application. For a claim of a patent to be entitled to the filing date of a provisional application, the provisional application and all subsequent applications in the chain leading to the patent at issue must provide written description and enable a POSITA to practice the claim. I have been asked to consider whether the claims at issue in this case are entitled to the priority date of the provisional application. In my opinion, the claims of each of the patents-in-suit are entitled to claim the priority date of the earliest filed provisional application.

5.1.1. Analysis Related to the Provisional Application

54. Each of the patents-in-suit and the intervening applications incorporate by reference the provisional application as shown below:

US Patent No. 7,435,286:

(10) **Patent No.:** **US 7,435,286 B2**
(45) **Date of Patent:** **Oct. 14, 2008**

Related U.S. Application Data

(60) Provisional application No. 60/605,640, filed on Aug. 30, 2004.

[REDACTED]

This application claims the benefit under 35 U.S.C. § 119 (e) of U.S. Provisional Patent Application No. 60/605,640 filed Aug. 30, 2004, the disclosure of which is hereby incorporated by reference in its entirety.

US Patent Application No. 12/201,595:

(10) **Pub. No.: US 2009/0062119 A1**
(43) **Pub. Date: Mar. 5, 2009**

Related U.S. Application Data

- (62) Division of application No. 11/209,163, filed on Aug. 22, 2005, now Pat. No. 7,435,286.
- (60) Provisional application No. 60/605,640, filed on Aug. 30, 2004.

[0001] This application is a divisional of U.S. patent application Ser. No. 11/209,163 filed Aug. 22, 2005, entitled "Sorbents for the Oxidation and Removal of Mercury", which claims the benefit of U.S. Provisional Application Ser. No. 60/605,640, filed Aug. 30, 2004, both applications are hereby incorporated herein by reference in their entirety for all purposes.

US Patent No. 8,168,147:

(10) **Patent No.: US 8,168,147 B2**
(45) **Date of Patent: May 1, 2012**

Related U.S. Application Data

- (60) Continuation of application No. 12/201,595, filed on Aug. 29, 2008, which is a division of application No. 11/209,163, filed on Aug. 22, 2005, now Pat. No. 7,435,286.
- (60) Provisional application No. 60/605,640, filed on Aug. 30, 2004.

This application is a continuation of U.S. patent application Ser. No. 12/201,595 filed on Aug. 29, 2008, which is a division of U.S. patent application Ser. No. 11/209,163, filed on Aug. 22, 2005 (now U.S. Pat. No. 7,435,286), which claims priority to the extent appropriate from provisional application 60/605,640, filed on Aug. 30, 2004. Application Ser. Nos. 12/201,595; 11/209,163; and 60/605,640 are incorporated herein by reference.

US Patent No. 8,512,655:

(10) **Patent No.:** **US 8,512,655 B2**
(45) **Date of Patent:** ***Aug. 20, 2013**

Related U.S. Application Data

- (60) Continuation of application No. 12/419,219, filed on Apr. 6, 2009, now Pat. No. 8,168,147, which is a continuation of application No. 12/201,595, filed on Aug. 29, 2008, now abandoned, which is a division of application No. 11/209,163, filed on Aug. 22, 2005, now Pat. No. 7,435,286.
- (60) Provisional application No. 60/605,640, filed on Aug. 30, 2004.

This application is a continuation of U.S. patent application Ser. No. 12/419, 219 filed on Apr. 6, 2009, which is a continuation of U.S. patent application Ser. No. 12/201,595 filed on Aug. 29, 2008, which is a division of U.S. patent application Ser. No. 11/209,163, filed on Aug. 22, 2005 (now U.S. Pat. No. 7,435,286), which claims priority to the extent appropriate from provisional application 60/605,640, filed on Aug. 30, 2004. Application Ser. Nos. 12/419,219; 12/201, 595; 11/209,163; and 60/605,640 are incorporated herein by reference.

US Patent No. 8,821,819:

(10) **Patent No.:** **US 8,821,819 B2**
(45) **Date of Patent:** ***Sep. 2, 2014**

Related U.S. Application Data

- (60) Continuation of application No. 13/427,665, filed on Mar. 22, 2012, now Pat. No. 8,512,655, which is a continuation of application No. 12/419,219, filed on Apr. 6, 2009, now Pat. No. 8,168,147, which is a continuation of application No. 12/201,595, filed on Aug. 29, 2008, now abandoned, which is a division of application No. 11/209,163, filed on Aug. 22, 2005, now Pat. No. 7,435,286.
- (60) Provisional application No. 60/605,640, filed on Aug. 30, 2004.

[REDACTED]

This application is a continuation of U.S. patent application Ser. No. 13/427,665, filed on Mar. 22, 2012, which is a continuation of U.S. patent application Ser. No. 12/419,219 filed on Apr. 6, 2009, which is a continuation of U.S. patent application Ser. No. 12/201,595 filed on Aug. 29, 2008, which is a division of U.S. patent application Ser. No. 11/209,163, filed on Aug. 22, 2005 (now U.S. Pat. No. 7,435,286), which claims priority to the extent appropriate from provisional application 60/605,640, filed on Aug. 30, 2004. application Ser. Nos. 13/427,665; 12/419,219; 12/201,595; 11/209,163; and 60/605,640 are incorporated herein by reference.

US Patent No. 9,757,689:

(10) **Patent No.:** **US 9,757,689 B2**
(45) **Date of Patent:** **Sep. 12, 2017**

Related U.S. Application Data

- (60) Continuation of application No. 13/966,768, filed on Aug. 14, 2013, now Pat. No. 8,821,819, which is a continuation of application No. 13/427,665, filed on Mar. 22, 2012, now Pat. No. 8,512,655, which is a continuation of application No. 12/419,219, filed on Apr. 6, 2009, now Pat. No. 8,168,147, which is a continuation of application No. 12/201,595, filed on Aug. 29, 2008, now abandoned, which is a division of application No. 11/209,163, filed on Aug. 22, 2005, now Pat. No. 7,435,286.
- (60) Provisional application No. 60/605,640, filed on Aug. 30, 2004.

This application is a continuation of U.S. patent application Ser. No. 13/966,768, filed on Aug. 14, 2013, which, is a continuation of U.S. patent application Ser. No. 13/427,665, filed on Mar. 22, 2012, which is a continuation of U.S. patent application Ser. No. 12/419,219 filed on Apr. 6, 2009, which is a continuation of U.S. patent application Ser. No. 12/201,595 filed on Aug. 29, 2008, which is a division of U.S. patent application Ser. No. 11/209,163, filed on Aug. 22, 2005 (now Pat. No. 7,435,286), which claims priority to the extent appropriate from provisional application 60/605,640, filed on Aug. 30, 2004. Application Ser. Nos. 13/966,768; 13/427,665; 12/419,219; 12/201,595; 11/209,163; and 60/605,640 are incorporated herein by reference.

US Patent No. 10,589,225:

(10) Patent No.: US 10,589,225 B2
(45) Date of Patent: *Mar. 17, 2020

Related U.S. Application Data

- (60) Continuation of application No. 14/318,270, filed on Jun. 27, 2014, now Pat. No. 9,757,689, which is a continuation of application No. 13/966,768, filed on Aug. 14, 2013, now Pat. No. 8,821,819, which is a continuation of application No. 13/427,665, filed on Mar. 22, 2012, now Pat. No. 8,512,655, which is a continuation of application No. 12/419,219, filed on Apr. 6, 2009, now Pat. No. 8,168,147, which is a continuation of application No. 12/201,595, filed on Aug. 29, 2008, now abandoned, which is a division of application No. 11/209,163, filed on Aug. 22, 2005, now Pat. No. 7,435,286.
- (60) Provisional application No. 60/605,640, filed on Aug. 30, 2004.

This application is a divisional of U.S. patent application Ser. No. 11/209,163 filed Aug. 22, 2005, entitled "Sorbents for the Oxidation and Removal of Mercury", which claims the benefit of U.S. Provisional Application Ser. No. 60/605,640, filed Aug. 30, 2004, both applications are hereby incorporated herein by reference in their entirety for all purposes.

US Patent No. 10,933,370:

(10) Patent No.: US 10,933,370 B2
(45) Date of Patent: Mar. 2, 2021

Related U.S. Application Data

- (60) Continuation of application No. 14/712,558, filed on May 14, 2015, now Pat. No. 10,589,225, which is a

continuation of application No. 14/318,270, filed on Jun. 27, 2014, now Pat. No. 9,757,689, which is a continuation of application No. 13/966,768, filed on Aug. 14, 2013, now Pat. No. 8,821,819, which is a continuation of application No. 13/427,665, filed on Mar. 22, 2012, now Pat. No. 8,512,655, which is a continuation of application No. 12/419,219, filed on Apr. 6, 2009, now Pat. No. 8,168,147, which is a continuation of application No. 12/201,595, filed on Aug. 29, 2008, now abandoned, which is a division of application No. 11/209,163, filed on Aug. 22, 2005, now Pat. No. 7,435,286.

- (60) Provisional application No. 60/605,640, filed on Aug. 30, 2004.

This application is a continuation of U.S. patent application Ser. No. 14/318,270, filed Jun. 27, 2014, which is a continuation of U.S. patent application Ser. No. 13/966,768, filed Aug. 14, 2013, issued as U.S. Pat. No. 8,821,819, which is a continuation of U.S. patent application Ser. No. 13/427,665, filed Mar. 22, 2012, issued as U.S. Pat. No. 8,512,655, which is a continuation of U.S. patent application Ser. No. 12/419,219, filed Apr. 6, 2009, issued as U.S. Pat. No. 8,168,147, which is a continuation of U.S. patent application Ser. No. 12/201,595, filed Aug. 29, 2008, which is a division of U.S. patent application Ser. No. 11/209,163, filed Aug. 22, 2005, issued as U.S. Pat. No. 7,435,286, which application claims the benefit under 35 U.S.C. § 119 (e) of U.S. Provisional Patent Application No. 60/605,640 filed Aug. 30, 2004, the disclosure of which is hereby incorporated by reference in its entirety.

US Patent No. 10,668,430:

- (10) **Patent No.:** **US 10,668,430 B2**
(45) **Date of Patent:** ***Jun. 2, 2020**

Related U.S. Application Data

- (60) Continuation of application No. 15/951,970, filed on Apr. 12, 2018, which is a continuation of application

No. 14/712,558, filed on May 14, 2015, now Pat. No. 10,589,225, which is a continuation of application No. 14/318,270, filed on Jun. 27, 2014, now Pat. No. 9,757,689, which is a continuation of application No. 13/966,768, filed on Aug. 14, 2013, now Pat. No. 8,821,819, which is a continuation of application No. 13/427,665, filed on Mar. 22, 2012, now Pat. No. 8,512,655, which is a continuation of application No. 12/419,219, filed on Apr. 6, 2009, now Pat. No. 8,168,147, which is a continuation of application No. 12/201,595, filed on Aug. 29, 2008, now abandoned, which is a division of application No. 11/209,163, filed on Aug. 22, 2005, now Pat. No. 7,435,286.

- (60) Provisional application No. 60/605,640, filed on Aug. 30, 2004.

This application is a continuation of U.S. patent application Ser. No. 15/951,970, filed Apr. 12, 2018, which is a continuation of U.S. patent application Ser. No. 14/318,270, filed Jun. 27, 2014, which is a continuation of U.S. patent application Ser. No. 13/966,768, filed Aug. 14, 2013, issued as U.S. Pat. No. 8,821,819, which is a continuation of U.S. patent application Ser. No. 13/427,665, filed Mar. 22, 2012, issued as U.S. Pat. No. 8,512,655, which is a continuation of U.S. patent application Ser. No. 12/419,219, filed Apr. 6, 2009, issued as U.S. Pat. No. 8,168,147, which is a continuation of U.S. patent application Ser. No. 12/201,595, filed Aug. 29, 2008, which is a division of U.S. patent application Ser. No. 11/209,163, filed Aug. 22, 2005, issued as U.S. Pat. No. 7,435,286, which application claims the benefit under 35 U.S.C. § 119 (e) of U.S. Provisional Patent Application No. 60/605,640 filed Aug. 30, 2004, the disclosure of which is hereby incorporated by reference in its entirety.

US Patent No. 10,596,517:

- (10) **Patent No.:** **US 10,596,517 B2**
(45) **Date of Patent:** ***Mar. 24, 2020**

Related U.S. Application Data

- (63) Continuation of application No. 15/974,343, filed on May 8, 2018, which is a continuation of application

No. 15/951,970, filed on Apr. 12, 2018, which is a continuation of application No. 14/712,558, filed on May 14, 2015, which is a continuation of application No. 14/318,270, filed on Jun. 27, 2014, now Pat. No. 9,757,689, which is a continuation of application No. 13/966,768, filed on Aug. 14, 2013, now Pat. No. 8,821,819, which is a continuation of application No. 13/427,665, filed on Mar. 22, 2012, now Pat. No. 8,512,655, which is a continuation of application No. 12/419,219, filed on Apr. 6, 2009, now Pat. No. 8,168,147, which is a continuation of application No. 12/201,595, filed on Aug. 29, 2008, which is a continuation of application No. 11/209,163, filed on Aug. 22, 2005, now Pat. No. 7,435,286.

- (60) Provisional application No. 60/605,640, filed on Aug. 30, 2004.

This application is a continuation of U.S. patent application Ser. No. 15/974,343, filed May 8, 2018, which is a continuation of U.S. patent application Ser. No. 15/951,970, filed Apr. 12, 2018, which is a continuation of U.S. patent application Ser. No. 14/712,558, filed May 14, 2015, which is a continuation of U.S. patent application Ser. No. 14/318,270, filed Jun. 27, 2014, which is a continuation of U.S. patent application Ser. No. 13/966,768, filed Aug. 14, 2013, issued as U.S. Pat. No. 8,821,819, which is a continuation of U.S. patent application Ser. No. 13/427,665, filed Mar. 22, 2012, issued as U.S. Pat. No. 8,512,655, which is a continuation of U.S. patent application Ser. No. 12/419,219, filed Apr. 6, 2009, issued as U.S. Pat. No. 8,168,147, which is a continuation of U.S. patent application Ser. No. 12/201,595, filed Aug. 29, 2008, which is a division of U.S. patent application Ser. No. 11/209,163, filed Aug. 22, 2005, issued as U.S. Pat. No. 7,435,286, which application claims the benefit under 35 U.S.C. § 119 (e) of U.S. Provisional Patent Application No. 60/605,640 filed Aug. 30, 2004, the disclosure of which is hereby incorporated by reference in its entirety.

US Patent No. 8,652,235:

- (10) **Patent No.:** **US 8,652,235 B2**
(45) **Date of Patent:** **Feb. 18, 2014**

Related U.S. Application Data

- (60) Continuation-in-part of application No. 12/201,595, filed on Aug. 29, 2008, now abandoned, which is a division of application No. 11/209,163, filed on Aug. 22, 2005, now Pat. No. 7,435,286.
(60) Provisional application No. 60/605,640, filed on Aug. 30, 2004.

[REDACTED]

This application is a continuation-in-part of U.S. patent application Ser. No. 12/201,595 filed on Aug. 29, 2008, which is a division of U.S. patent application Ser. No. 11/209,163, filed on Aug. 22, 2005 (now U.S. Pat. No. 7,435,286), which claims priority from provisional application 60/605,640, filed on Aug. 30, 2004. The disclosures of U.S. patent application Ser. Nos. 12/201,595; 11/209,163; and 60/604,640 are hereby incorporated herein by reference to the extent appropriate.

US Patent No. 9,468,886:

(10) **Patent No.:** **US 9,468,886 B2**
(45) **Date of Patent:** ***Oct. 18, 2016**

Related U.S. Application Data

- (60) Continuation of application No. 12/429,058, filed on Apr. 23, 2009, now Pat. No. 8,652,235, which is a continuation-in-part of application No. 12/201,595, filed on Aug. 29, 2008, now abandoned, which is a division of application No. 11/209,163, filed on Aug. 22, 2005, now Pat. No. 7,435,286.
- (60) Provisional application No. 60/605,640, filed on Aug. 30, 2004.

This application is a continuation of U.S. patent application Ser. No. 12/429,058 filed on Apr. 23, 2009, which is a continuation-in-part of U.S. patent application Ser. No. 12/201,595 filed on Aug. 29, 2008 (abandoned), which is a divisional of U.S. patent application Ser. No. 11/209,163 filed on Aug. 22, 2005 (now U.S. Pat. No. 7,435,286), which claims priority from provisional application Ser. No. 60/605,640 filed on Aug. 30, 2004. The disclosures of U.S. patent application Ser. Nos. 12/429,058; 12/201,595; 11/209,163; and 60/605,640 are hereby incorporated herein by reference to the extent appropriate.

US Patent Application No. 15/295,594:

(10) **Pub. No.:** **US 2017/0128908 A1**
(43) **Pub. Date:** **May 11, 2017**

Related U.S. Application Data

- (60) Continuation of application No. 14/102,896, filed on Dec. 11, 2013, now Pat. No. 9,468,886, which is a continuation of application No. 12/429,058, filed on Apr. 23, 2009, now Pat. No. 8,652,235, which is a continuation-in-part of application No. 12/201,595, filed on Aug. 29, 2008, now abandoned, which is a division of application No. 11/209,163, filed on Aug. 22, 2005, now Pat. No. 7,435,286.
- (60) Provisional application No. 60/605,640, filed on Aug. 30, 2004.

[0001] This application is a continuation of U.S. patent application Ser. No. 14/102,896 filed on Dec. 11, 2013, which is a continuation of U.S. patent application Ser. No. 12/429,058 filed on Apr. 23, 2009 (now U.S. Pat. No. 8,652,235), which is a continuation-in-part of U.S. patent application Ser. No. 12/201,595 filed on Aug. 29, 2008 (abandoned), which is a divisional of U.S. patent application Ser. No. 11/209,163 filed on Aug. 22, 2005 (now U.S. Pat. No. 7,435,286), which claims priority from provisional application Ser. No. 60/605,640 filed on Aug. 30, 2004. The disclosures of U.S. patent application Ser. Nos. 14/102,896; 12/429,058; 12/201,595; 11/209,163; and 60/605,640 are hereby incorporated herein by reference to the extent appropriate.

US Patent No. 10,343,114:

- (10) **Patent No.:** **US 10,343,114 B2**
(45) **Date of Patent:** ***Jul. 9, 2019**

Related U.S. Application Data

- (60) Continuation-in-part of application No. 15/295,594, filed on Oct. 17, 2016, which is a continuation of application No. 14/102,896, filed on Dec. 11, 2013, now Pat. No. 9,468,886, which is a continuation of application No. 12/429,058, filed on Apr. 23, 2009, now Pat. No. 8,652,235, which is a continuation-in-part of application No. 12/201,595, filed on Aug. 29, 2008, which is a division of application No. 11/209,163, filed on Aug. 22, 2005, now Pat. No. 7,435,286.
- (60) Provisional application No. 60/605,640, filed on Aug. 30, 2004.

[REDACTED]

This application is a continuation-in-part of U.S. patent application Ser. No. 15/295,594, filed Oct. 17, 2016, which is a continuation of U.S. patent application Ser. No. 14/102,896 filed on Dec. 11, 2013 (now U.S. Pat. No. 9,468,886), which is a continuation of U.S. patent application Ser. No. 12/429,058 filed on Apr. 23, 2009 (now U.S. Pat. No. 8,652,235), which is a continuation-in-part of U.S. patent application Ser. No. 12/201,595 filed on Aug. 29, 2008 (abandoned), which is a divisional of U.S. patent application Ser. No. 11/209,163 filed on Aug. 22, 2005 (now U.S. Pat. No. 7,435,286), which claims priority from provisional application Ser. No. 60/605,640 filed on Aug. 30, 2004. The disclosures of U.S. patent application Ser. Nos. 14/102,896; 12/429,058; 12/201,595; 11/209,163; and 60/605,640 are hereby incorporated herein by reference to the extent appropriate.

55. Accordingly, if Defendants fail to prove by clear and convincing evidence that claims lack support in the provisional application, then the claims are entitled to the priority date of the provisional application.

5.1.1. Dr. Niksa has Failed to Show that the Provisional Application Lacks Support for the Claims of the '114 Patent

56. With respect to the '114 patent, Dr. Niksa identifies two deficiencies in the provisional application, he opines that the provisional: (a) “fails to clearly disclose that ‘the coal comprises added’ bromine-containing species, as required by each of the independent claims of the '114 Patent;” and (b) “does not demonstrate that the inventors were in possession of the broad class of chemicals of any ‘bromide compound.’” Specifically, he asserts that the following limitations lack support in the provisional application:

- *“the coal comprises added Br₂, HBr, Br-, or a combination thereof, added to the coal of the combustion chamber” (claims 1, 23, 24) and “the coal comprises added Br₂, HBr, a bromide compound, or a combination thereof, added to the coal upstream of the combustion chamber” (claim 25);*
- *“the combustion chamber comprises added Br₂, HBr, Br-, or a combination thereof” (claims 1, 23, 24) and “the combustion chamber comprises added Br₂, HBr, a bromide compound, or a combination thereof” (claim 25);*
- *the coal or combustion chamber comprising “added Br₂, . . . Br-, or a combination thereof” (claims 1, 23, 24), and the coal or combustion chamber comprising “added Br₂, . . . a bromide compound, or a combination thereof” (claim 25).*

57. I disagree with these assertions.

58. First, this issue was already considered by the patent office. Shortly after the filing of the original application for the '114 patent, the applicant added the following independent claim:

2. (New) A method of separating mercury from a mercury-containing gas, the method comprising:

- combusting coal in a combustion chamber, to provide the mercury-containing gas, wherein the mercury-containing gas comprises a halogen or halide promoter comprising Br₂, HBr, Br⁻, or a combination thereof;
- injecting a sorbent material 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;
- reacting mercury in the mercury-containing gas with the promoted sorbent, to form a mercury/sorbent composition;
- separating the mercury/sorbent composition from the mercury-containing gas, to form a cleaned gas;
- monitoring the mercury content of the cleaned gas, and
- controlling, in response to the monitored mercury content of the cleaned gas, an injection rate of injecting the sorbent into the mercury-containing gas, the sorbent composition, or a combination thereof, so that the mercury content of the cleaned gas is maintained at or below a desired level.

59. This claim encompasses all of the features that Dr. Niksa contends are absent from the provisional application. It requires combusting coal to produce a mercury containing gas containing a halogen or halide promoter comprising HBr, Br₂, or Br⁻. It thus encompasses embodiments where bromine or bromide are added to coal, and it encompasses a broad class of bromide compounds.

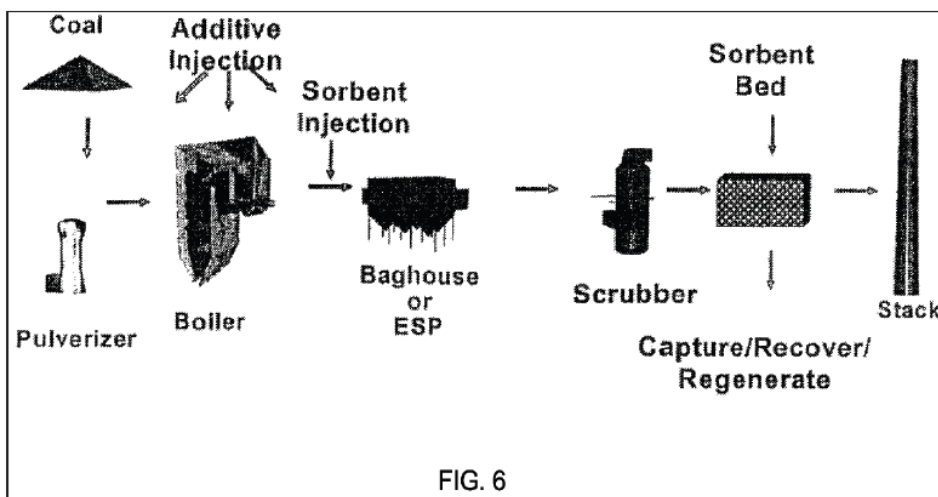
60. Prior to issuing the first office action, the examiner requested an interview to discuss this claim and others. That interview was summarized as follows:

Issues Discussed:

Item(s) under 35 U.S.C. 112:

The examiner asked for clarification where exactly the new claims 2-21 have support within the originally filed application. The applicant pointed to figure 6. The examiner agreed.

61. Ex. 1026 at 1535. Thus, the examiner found that the claim scope now challenged by Petitioners were supported, at least in part, by '114 patent figure 6:



62. Ex. 1001. Figure 6 above is taken directly from the provisional application. Ex. 1020, Provisional application Fig. 2. Thus, the same written description issues identified by Dr. Niksa were considered by the examiner, and the examiner agreed that information contained in the provisional application supported the relevant claim limitations. Indeed, even after the applicant amended the claims to match what issued in the '114 patent, the examiner did not reject the claims for failure to provide written description support.

63. In addition, the provisional application provides further support for these limitations. It explains that the invention provides ways of capturing mercury by taking

advantage of reactions involving bromine, activated carbon, and mercury. For example, it explains:

We now teach that the formation of the new bromide compound with carbon increases the reactivity of the carbon forms toward mercury and other pollutants. The resulting bromide compound is uniquely suited to facilitate oxidation of the mercury. The effectiveness of the oxidation results from the promotion effect of the halide exerted on the developing positive charge on the mercury during the oxidation, known in the chemical art as a specific catalytic effect. Thus, as the mercury electrons are drawn toward the positive carbon, the halide anion

electrons are pushing in from the other side, which stabilizes the positive charge developing on the mercury and lowers the energy requirement for the oxidation process. Bromide is especially reactive, owing to the highly polarizable electrons in the outer 4p orbitals of the ion. Thus, adding HBr or Br₂ to the carbon forms a similar carbon bromide, in which the positive carbon oxidizes the mercury with the assistance of the bromide ion.

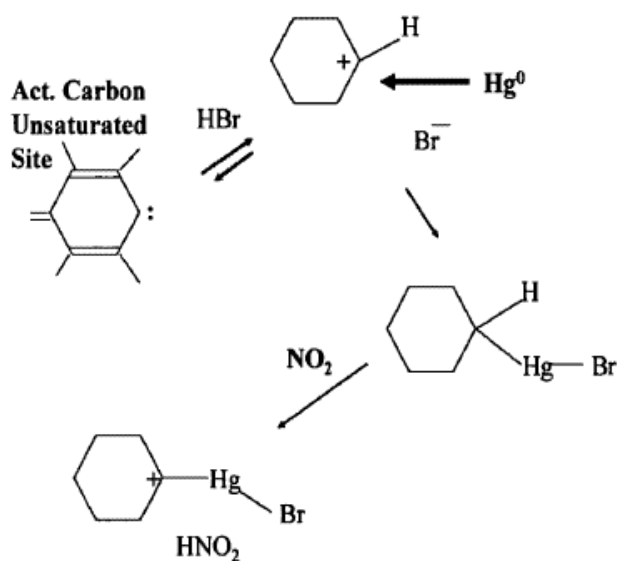


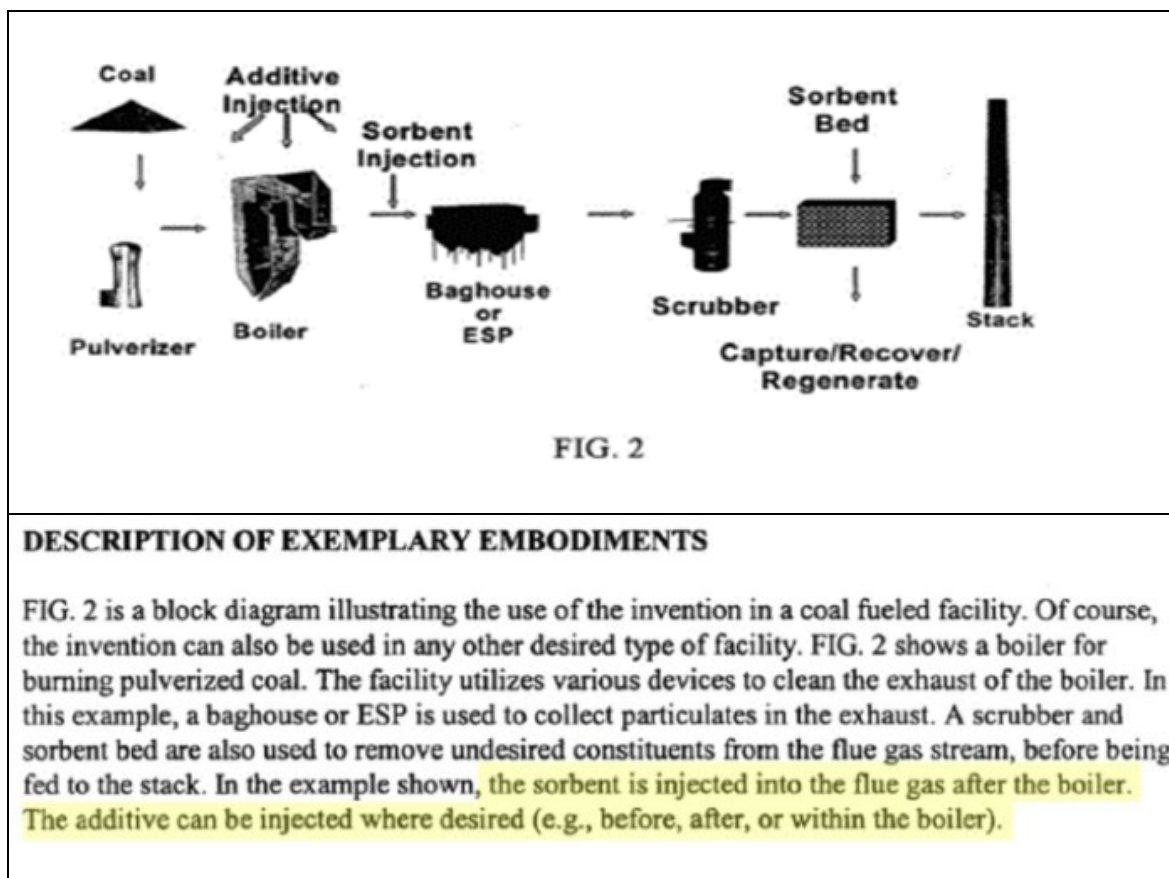
Figure 1. A mechanistic model of the reactions resulting in oxidation and capture of mercury.

64. The provisional application also describes the use of “an optional second component.” This component is a halogen or a compound from a halogen such as HBr. Ex.

1020 at 10. Thus, the inventors describe the use of an activated carbon sorbent with a source of bromine ions, and, optionally, another source of halogen ions, which could also be bromine ions:

It has been demonstrated that addition of an optional second component, in addition to the bromine, results in improved reactivity and capacity for the sorbent, exceeding that of both the untreated carbon and the brominated carbon. The second compound comprises either a second halogen or a compound from a second halogen, such as HBr. Thus, in addition to having a reactive carbon form present, the second component generates a Lewis base with greater ability to stabilize the developing positive charge on the mercury. Thus the second component is an element with more polarized electrons (4p and 5p).

65. Having provided this background, the provisional application goes on to explain ways to implement the invention. It contains the following figure and description:



66. As shown above, the provisional application discloses providing bromine/bromide additive before, into, or after the boiler and injecting activated carbon sorbent downstream of the

[REDACTED]

boiler. For example, bromine/bromide additive can be added to coal either before or after the pulverizer, or into the boiler. The provisional application also describes the benefits of providing bromine/bromide and activated carbon on-site at a power plant, as opposed to pre-treating activated carbon with bromine and then transporting the brominated carbon to a power plant:

Furthermore, we demonstrated that the sorbent can be readily treated with any combination of bromine and the second component in-flight using vapors of the these components contacting the

A unique, nonobvious technique for preparation of the treated carbon is through combining the treatment system with the carbon injection system at the end-use site. With this technique, the halogen is introduced to the carbon-air mixture in the transport line (or other part of the sorbent storage and injection system). Benefits over current concepts to treat sorbents off-site include the following:

- Capital equipment costs at a treatment facility are eliminated.
- Costs to operate the treatment facility are eliminated.
- There are no costs for transporting carbon and additive to a treatment facility.
- This process uses existing hardware and operation procedures.
- This technology ensures that the sorbent is always fresh, and thus, more reactive.
- No new handling concerns are introduced.
- There are no costs for removing carbon from treatment system.
- This process allows rapid on-site tailoring of additive-sorbent ratios in order to match the requirements of flue gas changes, such as needed when changing fuels or reducing loads, thus further optimizing the economics.
- This technology reduces the amount of spent sorbents that are disposed.

67. These descriptions indicate that the bromine/bromide may be added into the combustion chamber, or before the combustion chamber. A POSITA would recognize that adding bromine/bromide before the combustion chamber would include adding it to coal as depicted in figure 2.

68. Dr. Niksa disputes this conclusion, stating: “A POSITA would not necessarily understand that injecting an additive “before . . . the boiler” involves adding the promoter to the coal, as there are a number of systems ahead of the boiler that do not interface with coal—including secondary-air systems and/or low-NOx overfire air systems. Injecting an additive “before . . . the boiler” could also involve a specialized additive injection system leading to the

[REDACTED]

boiler, that does not interact with the coal before being introduced to the combustion chamber.”⁷

These assertions do not match the actual disclosure in the provisional application (which includes arrows pointing to coal and the boiler). Moreover, this opinion is inconsistent with Dr. Niksa’s interpretation of the Sjostrom reference which includes an arrow pointing before the boiler.⁸ For example, Dr. Niksa does not identify secondary-air systems, low-NOx overfire air systems, or specialized additive injection systems in the provisional application. Instead, figure 2 depicts “coal,” and a “pulverizer.” Adding bromine/bromide additive to either of these locations would constitute adding it to coal.

69. In addition, Dr. Niksa opines: “Provisional also fails to disclose adding to the coal or to the combustion chamber the particular bromine-containing species recited in the claims of the ’114 Patent [i.e., Br₂, HBr, Br⁻, a bromide compound].”⁹ I disagree.

70. As shown above, Figure 1 of the provisional application discloses HBr reacting with activated carbon to practice the invention. The provisional application further states:

A body of theory has been developed from scientific evidence to explain the nature of the promotion effect of the bromine compounds. This principle is illustrated in FIG. 1, which in step 1 shows the reaction of the hydrogen bromide with the unsaturated structure of the activated carbon. This may be a carbene species on the edge of the graphene sheets structures of the carbon. Molecular bromine or a bromine compound reacts to form a similar structure, with a positive carbon that is active for oxidizing the mercury.

71. Thus, the provisional discloses that activated carbon may be used with hydrogen bromide (“HBr”), molecular bromine (“Br₂”), or a bromine compound (bromide or Br⁻). Figure 1 also illustrates that these bromine containing forms include Br⁻.

⁷ Ref. 239, Pgs. 180 – 181.

⁸ Ref. 239, Pgs. 243 – 244.

⁹ Ref. 239, Pgs. 181 – 182.

72. In addition, the provisional application discloses the use of an optional second component:

It has been demonstrated that addition of an optional second component, in addition to the bromine, results in improved reactivity and capacity for the sorbent, exceeding that of both the untreated carbon and the brominated carbon. The second compound comprises either a second halogen or a compound from a second halogen, such as HBr. Thus, in addition to having a reactive carbon form present, the second component generates a Lewis base with greater ability to stabilize the developing positive charge on the mercury. Thus the second component is an element with more polarized electrons (4p and 5p).

73. By explaining that the optional second component can include a “halogen or a compound form of a second halogen, such as HBr,” a POSITA would understand that this could include hydrogen bromide (“HBr”), molecular bromine (“Br₂”), and/or a bromine compound (bromide or Br⁻).

74. Accordingly, I disagree that Dr. Niksa has presented clear and convincing evidence that the provisional application provides insufficient support for the claims of the ’114 patent.

5.1.2. Dr. Niksa has Failed to Show that the Provisional Application Lacks Support for the Claims of the ’225, ’430, and ’517 Patents

75. With respect to the ’114 patent, Dr. Niksa identifies two deficiencies in the provisional application, he opines that the provisional: (a) “fails to clearly disclose that “the coal comprises added” bromine-containing species, as required by each of the independent claims of the ’114 Patent;” and (b) “does not demonstrate that the inventors were in possession of the broad class of chemicals of any “bromide compound.” Specifically, he asserts that the following limitations lack support in the provisional application:

- “the coal comprises an additive comprising Br₂, HBr, a bromide compound, or a combination thereof, wherein the additive is added to the coal before the coal enters the combustion chamber” (claims 1, 28, and 29 of the ’430 Patent)
- “the coal comprising an additive comprising Br₂, HBr, a bromide compound, or a combination thereof” (claim 1 of the ’517 Patent)

- “the coal comprises added Br₂, HBr, bromide compound, or a combination thereof, added to the coal before the coal enters the combustion chamber” (claims 29 and 30 of the ’517 Patent).
- “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” (claims 1, 14, and 17 of the ’225 Patent)
- “the coal is combusted in a combustion chamber at a coal combustion facility, wherein the HBr, bromide compound, or combination thereof, is added to the coal before the coal enters the combustion chamber” (claim 20 of the ’225 Patent)

76. I disagree with these assertions. Dr. Niksa’s arguments for these patents are the same as his arguments for the ’114 patent. Just as I disagree with his conclusions with respect to the ’114 patent, Dr. Niksa has failed to present clear and convincing evidence that the claims of the ’225, ’430, and ’517 patents lack support in the provisional application.

77. In addition, Dr. Niksa argues that the provisional application fails to support the claims, because one of the examples in the provisional application uses the word “additive” to refer to something other than a bromine/bromide additive. In particular, Dr. Niksa refers to the highlighted sentence in example 9 listed in the “outline of examples of the invention:”

9. The process of using additives (1-8) in conjunction with sorbents to capture acid gases and other flue gas constituents that block oxidation reactions or consume sorbent sites that would otherwise capture mercury. The additive is a compound comprised of Group I or II elements, such as Ca, Na, and others. These additives of base chemistry may be added to flue gas as a sorbent mixture or co-injected to selectively sorb acid gases or other gas constituents that compete for mercury reactive/sorption sites, thereby improving the effectiveness of activated carbon to capture mercury. In addition, the base additives can augment the treated activated carbon by helping to capture oxidized mercury forms in the flue gas, such as mercuric chloride, or that are produced on the carbon sorbent, such as mercuric bromide, but are released to the gas phase as the sorbent becomes saturated or capacity limited.

78. Because this is just one example, a POSITA would not rely on this portion of the application to disregard the other portions cited above. Moreover, this example refers to situation where an additive is “added to flue gas.” In other words, this example refers to a situation where the additive is added downstream of the combustion chamber, in contrast to the

other descriptions I have cited above where an additive is added upstream of the combustion chamber.

79. Moreover, example 9 refers to the “process of using additives (1-8).” Looking back at examples 1-8, they describe additives such as molecular bromine, hydrogen bromide, and bromide compounds, for example:

2. A modified carbon sorbent was prepared by reacting the carbon with molecular bromine by contacting the carbon with a gas containing molecular bromine. In one example, the amount of bromine taken up by the carbon ranges from <1 to about 30 g per 100g of activated carbon, depending on the proportions used.

4. An activated carbon sorbent was prepared by impregnating hydrogen bromide by passing a gas composition containing hydrogen bromide diluted with nitrogen or air through a fluidized bed or ebullated bed of the carbon. In one example, the amount of bromine taken up by the carbon ranges from <1 to about 30 g per 100g of activated carbon, depending on the proportions used.

7. Treatment of a carbon with a Group V or VI element combined with Group VII element, such as PBr_3 or SCl_2 . In one example, the amount of Group V or VI halide is 1-30 wt % of the carbon. The compound is added in vapor phase or in solution (solvent is hydrocarbon, chlorinated hydrocarbon, or other solvent as described in 1B, but not water, since the compound is destroyed in water solution).

80. Accordingly, a POSITA would recognize that these examples do not exclude the use of bromine and bromide additives.

5.1.3. Dr. Niksa has Failed to Show that the Provisional Application Lacks Support for the Claims of the '147 Patent

81. With respect to the '147 patent, Dr. Niksa claims to have investigated two potential deficiencies in the disclosure of the provisional application. Specifically he states:

“During my review, I specifically looked for any disclosure of: (a) injecting the sorbent material separately from the bromine containing promoter into a mercury-containing gas stream; such that (b) in-flight reaction in the mercury containing gas produces the promoted brominated sorbent, as required by claim 18 of the '147 Patent. In addition, I also looked for any disclosure

[REDACTED]

of the above in which the mercury-containing gas (as per claim 18) is also a transport gas, as required by claim 19 of the '147 Patent." He concludes that these statements are not disclosed in the provisional application. I disagree.

82. As explained above with respect to the '114 patent, the provisional application discloses adding bromine/bromide compounds before, into, or after the boiler, and separately injecting sorbent material. These scenarios include adding bromine/bromide additive to coal, into a transport line containing pulverized coal, or directly into the boiler. In any of these scenarios, the bromine/bromide additive will be injected into a gas stream that includes the mercury contained in the coal. In addition, the provisional application discloses adding bromine/bromide additive after the boiler, e.g., into the flue gas, which again will have mercury resulting from the combustion of the coal. The sorbent material is disclosed as being injected separately, accordingly, the reaction between the bromine/bromide additive will occur in-flight, i.e., in the gas transporting the bromine/bromide additive and sorbent. In all of these scenarios, the gas transporting these components would be a transport gas.

5.2. Analysis Related to Intervening Applications.

83. I understand that Dr. Niksa also contends that the provisional application was not properly incorporated by reference into subsequent applications. He has further opined that those subsequent applications fail to support the claims of the patents-in-suit. Below is my response to those opinions.

5.2.1. Dr. Niksa Failed to Show that the '595 Application (Filed Aug. 29, 2008) Lacks Support for the '114 Claims

84. Dr. Niksa opines that the '595 Application fails to provide support for the claims of the '114 patent. Specifically, he states:¹⁰ *"nothing in the '595 Application discloses adding a*

¹⁰ Ref. 239, Pgs. 184 – 185.

[REDACTED]

bromine-containing species in the combustion chamber or to the coal, let alone the specific types of bromine-containing species recited in the '114 Patent claims. This is because the '595 Application is directed to preparing a brominated activated carbon outside of the mercury-containing flue gas, and then injecting the brominated sorbent into the mercury-containing flue gas downstream from the combustion chamber. Nothing in the '595 Application describes adding the bromine promoter independently from the mercury sorbent, let alone to the coal or combustion chamber.” I disagree with these assertions.

85. The '595 application incorporates by reference the provisional application, thus for the same reasons the provisional application supports the '114 claims, the '595 Application does so as well.

86. In addition, the '595 application discloses the chemical model described in the provisional application (fig. 2; ¶¶ 52-55), the use of a “promoter” that supplies Br- such as HBr or Br₂ (¶¶ 46, 52-56, 64, original claim 8), and the practice of adding the promoter and sorbent at one or multiple locations (¶ 58).

[0054] Referring now to FIG. 2, there is illustrated a theory developed from scientific evidence to explain the nature of the promoting compounds. For example, as illustrated in FIG. 2, hydrogen bromide reacts with the unsaturated structure of the activated carbon. This may be, by way of illustration only, a carbene species on the edge of the graphene sheet structures of the carbon. Molecular bromine or a bromine compound reacts to form a similar structure, with a positive carbon that is active for oxidizing the mercury with subsequent capture by the sorbent.

[0058] For clarity, single injection points 116 or 119 are shown in FIG. 3, although one skilled in the art will understand that multiple injection points are within the scope of the present invention. Optical density measuring device (s) 204 is connected to transport line 115 and/or 118 to provide signals representative of the optical density inside transport line 115 and/or 118 as a function of time.

87. The '595 Application also describes an embodiment where bromine and sorbent were used at an actual power plant. In that example, brominated sorbent was injected downstream of the boiler. However, the application explains that bromine and sorbent can be injected before and/or into the boiler as well:

Example 10
Full-Scale Testing

[0118] In this example, a baghouse (fabric filter) or ESP was used to collect particulates in the exhaust of a full-scale commercial pulverized coal-burning facility. A scrubber and sorbent bed were also used to remove undesired constituents from the flue gas stream, before being fed to the stack. In this example, the halogen/halide promoted carbon sorbent was injected into the flue gas after the boiler. In general however, the inventive sorbent can be injected where desired (e.g., before, after, or within the boiler).

88. While this passage refers to the “inventive sorbent” being injected before, after, or within the boiler, a POSITA would recognize that brominated sorbent inherently contains bromine/bromide. Thus, a POSITA would understand that the invention encompassed the use of Br_2 , HBr , and Br^- that is provided upstream or into a boiler along with activated carbon sorbent injected downstream of the boiler.

5.2.2. Dr. Niksa Failed to Show that the '594, '896, and '058 Applications Lack Support for the '114 Claims

[REDACTED]

89. Dr. Niksa opines that the '594, '896, and '058 applications lack support for the '114 claims. Specifically, he states: "The '594, '896, and '058 Application do include new Figures 5A and 5B (not present in the '595 Application filed Aug. 29, 2008) . . . Figures 5A and 5B and their newly added descriptions in the specification provide the first arguable support for any embodiment where the bromide promoter is introduced independently from the sorbent into the combustion chamber or the flue gases . . . However, as previously described, where the arrows 401/401' and 501/501' of Figures 5A and 5B illustrate "streams" that originate outside of the boiler, this again does not necessarily describe to a POSITA that "the coal comprises added" bromine promoter. For example, in Figures 5A and 5B, the promoter could be added to the combustion chamber by first introducing the promoter into any one of the multitude of auxiliary systems located upstream of the combustion chamber (e.g., secondary air systems, low NO_x overfire air systems, or a specialized promoter injection system), which do not necessarily add the promoter to the coal."

90. I disagree. The '594, '896, and '058 applications each incorporate by reference the provisional application and the '595 application. Thus, for the same reasons those applications support the claims, the '594, '896, and '058 applications support the claims.

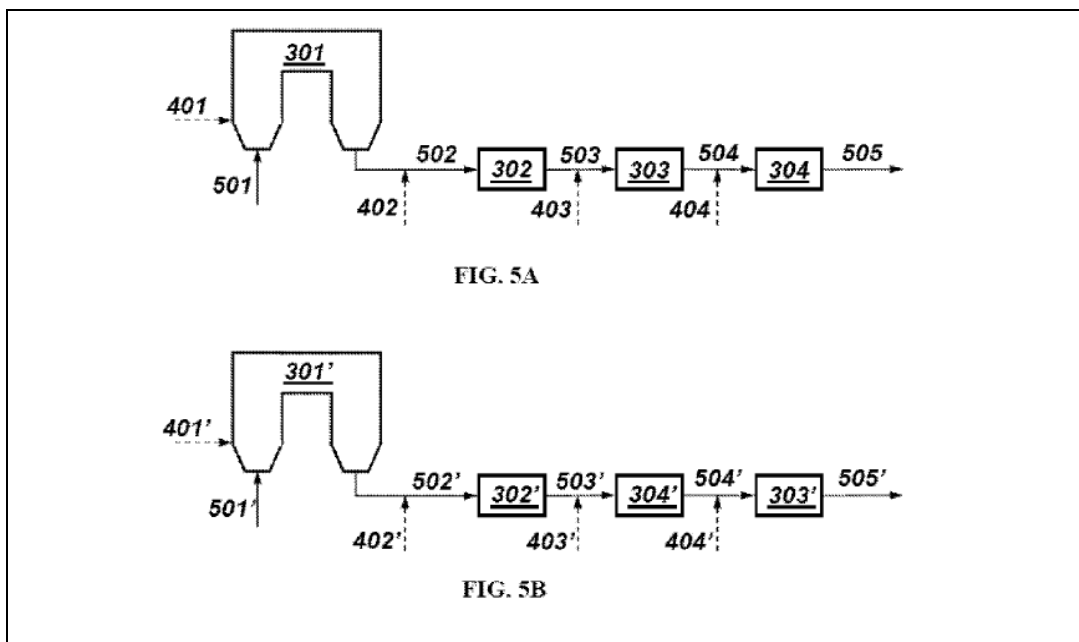
91. In addition, these applications describe the same chemical model and reactions with HBr, BR₂, and Br⁻ described above. See figure 2 and accompanying explanation in specification. And as Dr. Niksa notes, these applications disclose separate introduction of bromine additives and sorbents. For example they state:

[0091] As stated previously, the halogen promoted sorbent can be readily produced in-flight. This is accomplished by, for example, contacting the vapors of any combination of halogens and, optionally, a second component, in-flight, with base sorbent particles. The particles may be dispersed in a stream of transport air (or other gas, such as the flue gas itself), which also conveys the halogen/halide-promoted sorbent particles to the flue gas duct, or other contaminated gas stream, from which mercury is to then be removed. There is no particular temperature requirement for this contact. This technology is obviously very simple to implement, and results in a great cost savings to facilities using this technology for mercury capture.

[0094] At each of the aforementioned injection stream locations 401, 401', 402, 402', 403, 403', 404 and 404', 501,

501' multiple injection points are contemplated so that promoter and base sorbent may be injected as a single injection stream or as separate injection streams, as further illustrated in the following exemplary embodiments.

[0095] In an embodiment, a promoter is introduced to chamber 301 at location 401. A base sorbent (carbon, non-carbon, or their combination) is introduced at location 402 upstream of air heater 302. In a further embodiment, a promoter is introduced to at location 402 upstream of air heater 302. A base sorbent (carbon, non-carbon, or their combination) is also introduced at location 402 either as a separate stream or as a mixed single stream with the promoter. In another embodiment, a promoter is introduced at locations 401 and 402. A base sorbent (carbon, non-carbon, or their combination) is introduced at location 402 either as a separate stream or as a mixed single stream with the promoter.



92. As shown above, bromine/bromide additive is added with the coal at point 401 to the combustion chamber 301. Thus, it is added to the coal or directly into the combustion chamber. Activated carbon sorbent is added at point 402, which is downstream of combustion chamber 301.

5.2.3. Dr. Niksa Failed to Show that the '163 Application and the Intervening Applications Lack Support for the '225 Patent, the '430 Patent, and the '517 Patent

93. Dr. Niksa opines that the '163 Application lacks support for the '225, '430, and '517 patent claims. He opines:¹¹ “none of these applications contain any additional disclosures adding a bromine-containing species to the coal recited in the '225, '430, and '517 Patent claims. This is not surprising considering the '163 Application and the later filed applications in the priority chain, even including the '430 and '517 Patents, discuss preparing a brominated activated carbon outside of the mercury-containing flue gas, and then injecting the brominated sorbent into the mercury-containing flue gas downstream from the combustion chamber. Nothing

¹¹ Ref. 239, Pg. 196.

[REDACTED]

in the '163 Application or any of the intervening applications describes adding the bromine promoter independently from the mercury sorbent, let alone to the coal.”

94. However, the '163 Application incorporates by reference the provisional application, thus for the same reasons the provisional application supports the claims of the '225, '430, and '517 patents, the '163 Application does so as well.

95. In addition, the '163 Application includes the same disclosures as the '595 Application discussed above with respect to the '114 patent. Thus, for the same reasons provided above, the '163 Application supports the claims of the '225, '430, and '517 patents.

96. Specifically, the '163 application discloses the chemical model described in the provisional application (fig. 2; 7:58 – 8:17), the use of a “promoter” that supplies Br- such as HBr or Br₂ (7:41-8:17), and the practice of adding the promoter and sorbent at one or multiple locations (8:50-57).

Referring now to FIG. 2, there is illustrated a theory developed from scientific evidence to explain the nature of the promoting compounds. For example, as illustrated in FIG. 2, hydrogen bromide reacts with the unsaturated structure of the activated carbon. This may be, by way of illustration only, a carbene species on the edge of the graphene sheet structures of the carbon. Molecular bromine or a bromine compound reacts to form a similar structure, with a positive carbon that is active for oxidizing the mercury with subsequent capture by the sorbent.

For clarity, single injection points 116 or 119 are shown in FIG. 3, although one skilled in the art will understand that multiple injection points are within the scope of the present invention. Optical density measuring device(s) 204 is connected to transport line 115 and/or 118 to provide signals representative of the optical density inside transport line 115 and/or 118 as a function of time.

97. The '163 Application also describes an embodiment where bromine and sorbent were used at an actual power plant. In that example, brominated sorbent was injected

downstream of the boiler. However, the application explains that bromine and sorbent can be injected before and/or into the boiler as well:

Example 10

Full-Scale Testing

In this example, a baghouse (fabric filter) or ESP was used to collect particulates in the exhaust of a full-scale commercial pulverized coal-burning facility. A scrubber and sorbent bed were also used to remove undesired constituents from the flue gas stream, before being fed to the stack. In this example, the halogen/halide promoted carbon sorbent was injected into the flue gas after the boiler. In general however, the inventive sorbent can be injected where desired (e.g., before, after, or within the boiler).

98. While this passage refers to the “inventive sorbent” being injected before, after, or within the boiler, a POSITA would recognize that brominated sorbent inherently contains bromine/bromide. Thus, a POSITA would understand that the invention encompassed the use of Br_2 , HBr , and Br^- that is provided upstream or into a boiler along with activated carbon sorbent injected downstream of the boiler.

5.2.4. Dr. Niksa Failed to Show that the '558 Application Lacks Support for the '225 Patent

99. Dr. Niksa contends that the '558 Application lacks support for the claims of the '225 Patent. Dr. Niksa notes that this application contains the same disclosures as earlier applications. In particular, the '558 Application contains the same disclosures as the '163 Application discussed above, and as explained above that application supports the claims of the '225 patent.

100. Dr. Niksa specifically focuses on paragraph 119 of the '558 Application. This paragraph states:

Example 10

Full-Scale Testing

In this example, a baghouse (fabric filter) or ESP was used to collect particulates in the exhaust of a full-scale commercial pulverized coal-burning facility. A scrubber and sorbent bed were also used to remove undesired constituents from the flue gas stream, before being fed to the stack. In this example, the halogen/halide promoted carbon sorbent was injected into the flue gas after the boiler. In general however, the inventive sorbent can be injected where desired (e.g., before, after, or within the boiler).

101. Dr. Niksa notes that this paragraph was cited to the examiner during prosecution as providing support for the '225 claims, and the examiner accepted it as sufficient support. Dr. Niksa has not demonstrated error in that decision. This paragraph, in combination with the other disclosures recited above, describes the use of bromine and sorbent before, after, or within the boiler. This is consistent with the claims of the '225 patent which recite, for example, “[a] method for treating a mercury-containing gas, the method comprising: 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 an embodiment where the “HBr, bromide compound, or combination thereof, is added to the coal before the coal enters the combustion chamber.” This claim language merely covers a subset of the embodiments disclosed in the '558 Application. For example, embodiments where some inventive sorbent (including bromine and pyrolysis char) is combusted with the coal.

5.2.5. Dr. Niksa Failed to Show that the Passages Cited by ME2C During Prosecution of the '430 Patent and the '517 Patent Do Not Support the Claim Limitations of the '430 Patent and the '517 Patent

102. The applications that led to the '430 Patent and '517 patent include figures and text from the provisional application. During prosecution of those patents, some of that information, as well as other disclosures in those applications were identified as providing

[REDACTED]

support for the claims of those patents, and the examiner accepted those assertions. Dr. Niksa opines that this was incorrect. I disagree.

103. As explained above, the disclosures in the provisional application provide support for the claims of the '430 and '517 patents. Because that same information was copied from the provisional application into the applications that led to the '430 and '517 patents, those applications of course also support the claims of those patents.

5.2.6. Dr. Niksa Failed to Show that the '163 and '595 Applications Lack Support for the '147 patent

104. The '163 and '595 Applications provide substantially the same disclosure. For consistency, citations in this section will be to the '595 Application. Dr. Niksa contends that these two applications fail to provide support for the claims of the '147 Patent. In particular, he states: *“The '163 Application and the '595 Application, which are parents to the '147 Patent, do not disclose the subject matter of Claims 17-20. The '163 and '595 Applications repeatedly describe treating a base activated-carbon sorbent with a bromine promoter prior to injecting the prepared promoted sorbent into a mercury containing flue gas, such that: (a) the sorbent material and bromine containing promoter are not injected “separately” into the mercury-containing gas (they are injected together); and (b) an in-flight reaction between sorbent and promoter occurs prior to injection into the mercury-containing gas, and not in the “gas stream [that] is a mercury-containing gas.”* I disagree with these assertions.

105. The '595 application incorporates by reference the provisional application, thus for the same reasons the provisional application supports the '147 claims, the '595 Application does so as well.

106. In addition, the '595 application discloses the chemical model described in the provisional application (fig. 2; ¶¶ 52-55), the use of a “promoter” that supplies Br- such as HBr

or Br₂ (¶¶ 46, 52-56, 64, original claim 8), and the practice of adding the promoter and sorbent at one or multiple locations (¶ 58).

[0054] Referring now to FIG. 2, there is illustrated a theory developed from scientific evidence to explain the nature of the promoting compounds. For example, as illustrated in FIG. 2, hydrogen bromide reacts with the unsaturated structure of the activated carbon. This may be, by way of illustration only, a carbene species on the edge of the graphene sheet structures of the carbon. Molecular bromine or a bromine compound reacts to form a similar structure, with a positive carbon that is active for oxidizing the mercury with subsequent capture by the sorbent.

[0058] For clarity, single injection points 116 or 119 are shown in FIG. 3, although one skilled in the art will understand that multiple injection points are within the scope of the present invention. Optical density measuring device (s) 204 is connected to transport line 115 and/or 118 to provide signals representative of the optical density inside transport line 115 and/or 118 as a function of time.

107. The '595 Application also describes an embodiment where bromine and sorbent were used at an actual power plant. In that example, brominated sorbent was injected downstream of the boiler. However, the application explains that bromine and sorbent can be injected before and/or into the boiler as well:

Example 10

Full-Scale Testing

[0118] In this example, a baghouse (fabric filter) or ESP was used to collect particulates in the exhaust of a full-scale commercial pulverized coal-burning facility. A scrubber and sorbent bed were also used to remove undesired constituents from the flue gas stream, before being fed to the stack. In this example, the halogen/halide promoted carbon sorbent was injected into the flue gas after the boiler. In general however,

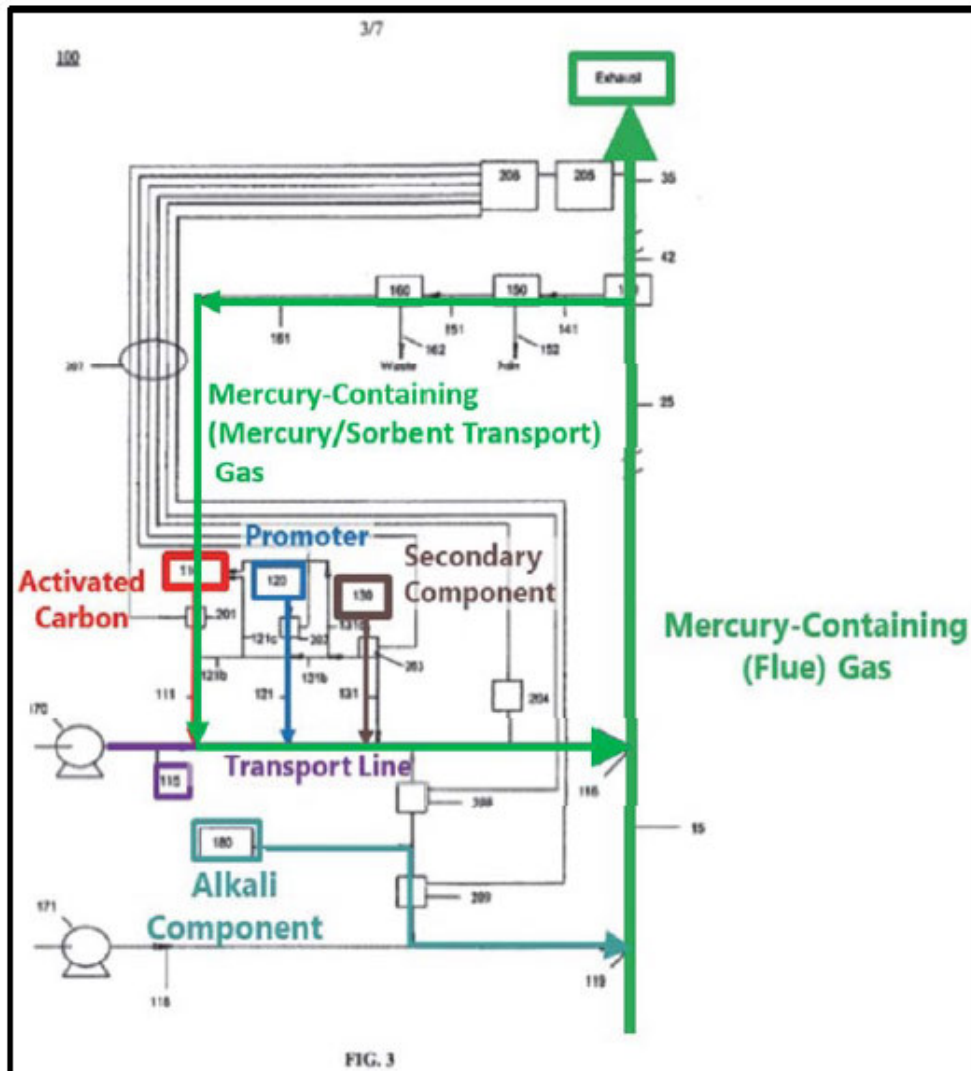
the inventive sorbent can be injected where desired (e.g., before, after, or within the boiler).

[REDACTED]

108. While this passage refers to the “inventive sorbent” being injected before, after, or within the boiler, a POSITA would recognize that brominated sorbent inherently contains bromine/bromide. Thus, a POSITA would understand that the invention encompassed the use of bromine containing promoter that is provided upstream or into a boiler along with activated carbon sorbent injected downstream of the boiler. Moreover, as noted above, the Application states that multiple injection points may be used, thus providing for separate injection of bromine containing promoter and sorbent.¹²

109. In addition, these applications describe a mercury/sorbent recycling system, as shown in figure 3 annotated below:

¹² For example, figure 3 shows activated carbon, promoter, and the secondary component provided to a transport line that then carries those components to the flue gas. But the description of multiple injection points indicates that multiple transport lines could be used, each with activated carbon, promoter, a secondary component, or any combination of those components.



110. In this example, activated carbon sorbent is injected into a transport line that takes the sorbent to mercury containing flue gas. The flue gas then passes through a particle collection device that is able to filter activated carbon sorbent from fly ash. This filtered out activated carbon sorbent is then transported back to the activated carbon reservoir so that it can be injected back into the transport line. See:

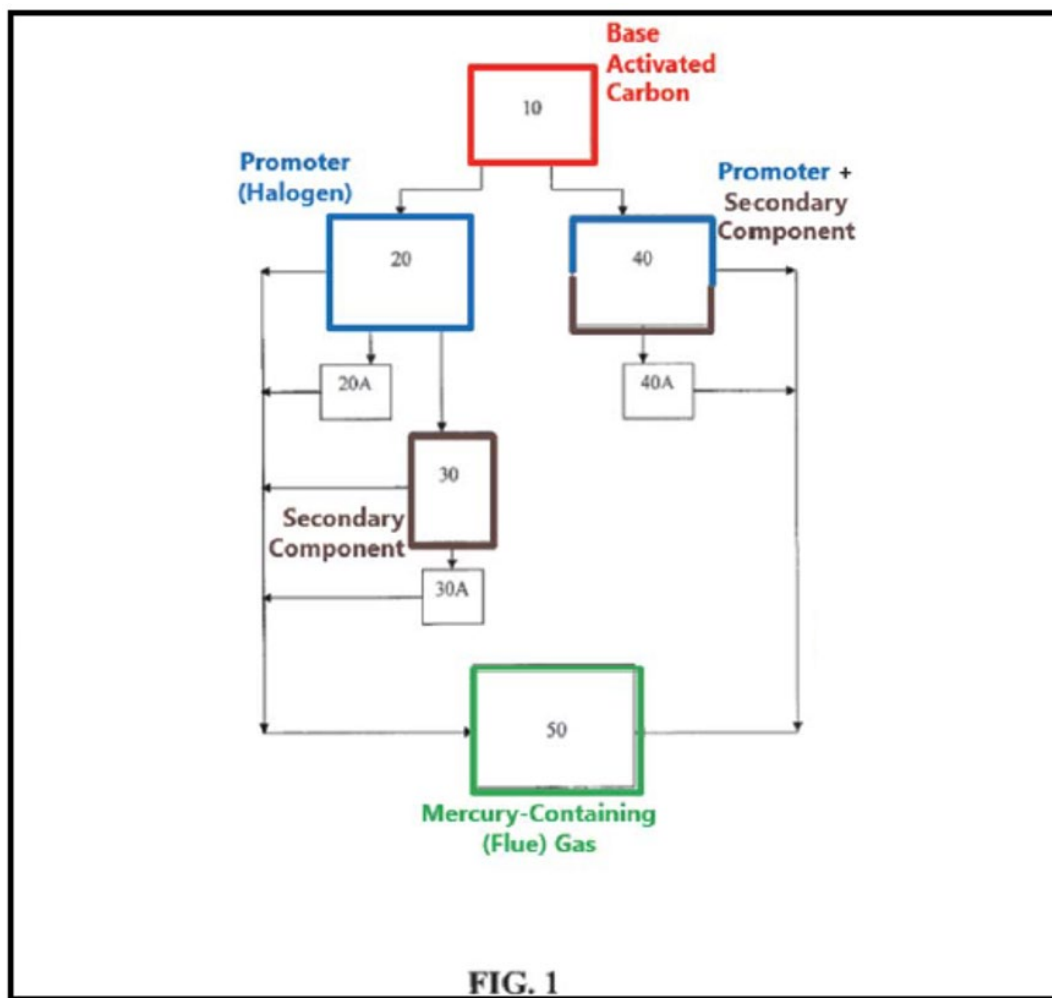
[0059] Downstream from injection point 116 and 119 is provided particulate separator 140. By way of illustration and not limitation, particulate separator 140 may comprise one or more fabric filters, one or more electrostatic precipitators (hereinafter "ESP"), or other particulate removal devices as are known in the art. It should be further noted that more than one particulate separator 140 may exist, sequentially or in parallel, and that injection point 116 and 119 may be at a location upstream and/or downstream of 140 when parallel, sequential, or combinations thereof exist. Particulate separator 140 produces at least a predominantly gaseous ("clean") stream 142, and a stream 141 comprising separated solid materials. A sorbent/ash separator 150 separates stream 141 into a largely ash stream 152, and a largely sorbent stream 151. Stream 151 may then preferably be passed to an optional sorbent regenerator 160, which yields a regenerated sorbent stream 161 and a waste stream 162.

[0028] In an embodiment, a method for reducing the mercury content of a mercury and ash containing gas stream is provided wherein particulate activated carbon sorbent with a mass mean size greater than 40 μm is injected into the gas stream, mercury is removed from the gas by the sorbent particles, the sorbent particles are separated from the ash particles on the basis of size, and the sorbent particles are re-injected to the gas stream. In another embodiment, the

111. Because this used sorbent will have collected some of the mercury, this transport line will contain mercury containing gas. Thus, activated carbon sorbent and promoter are injected separately into a mercury containing gas that is also a transport line and at least some of the sorbent will be promoted either in that transport line or in the flue gas.

112. In addition, figure 1 (annotated below) depicts separate injection of bromine and promoter into a mercury containing flue gas. In this example, activated carbon is sent through

path 20 and/or 40, and thus, the activated carbon along path 20 is mixed with promoter in path 20. However, the activated carbon in path 20 is separate from the promoter in path 40.¹³



113. In contrast to the evidence cited above, Dr. Niksa relies on statements in these applications that do not support his conclusions. For example, Dr. Niksa includes the following annotated section in his report and states that it means that “in flight promotion” must occur on the way to flue gas as opposed to in flue gas:

¹³ Figure 1 of the '147 patent also depicts a third path where activated carbon sorbent is injected separately into the flue gas. This provides further written description support for the claims of the '147 patent, as discussed in the section on 35 USC § 112 below.

"In-Flight" Sorbent Preparation

[0075] Furthermore, we have demonstrated that the halogen promoted carbon sorbent can be readily produced "in-flight". This is accomplished by, for example, contacting the vapors of any combination of halogens and optionally a second component, in-flight, with very fine carbon particles. The particles may be dispersed in a stream of transport air (or other gas), which also conveys the halogen/halide promoted carbon sorbent particles to the flue gas duct, or other contaminated gas stream, from which mercury is to then be removed. There is no particular temperature requirement for this contact. This technology is obviously very simple to implement, and results in a great cost savings to facilities using this technology for mercury capture.

114. However, contrary to Dr. Niksa's assertion, the statements regarding "in flight" promotion do not require contact between sorbent and additive prior to the flue gas. The next sentence (highlighted and underlined by Dr. Niksa) does provide an example where sorbent and additive are mixed together and then conveyed to flue gas, but the specification merely states that this is a way that these components "may" be mixed.

6. Conception/Reduction to Practice

115. During previous *Inter Partes* Review proceedings, I understand that the inventors claimed to have conceived and reduced to practice their invention before the prior art dates of certain asserted prior art references. This information includes declarations and exhibits submitted during the IPR proceedings, and testimony from the inventors and EERC personnel. This information indicates that the inventors conceived and reduced their invention to practice prior to the earliest filing date for the patents-in-suit. Below is an explanation of this evidence,¹⁴ and attached as Appendix A are claim charts matching the asserted claims to evidence of the inventors' actual reduction to practice.

¹⁴ See Ref. 180.

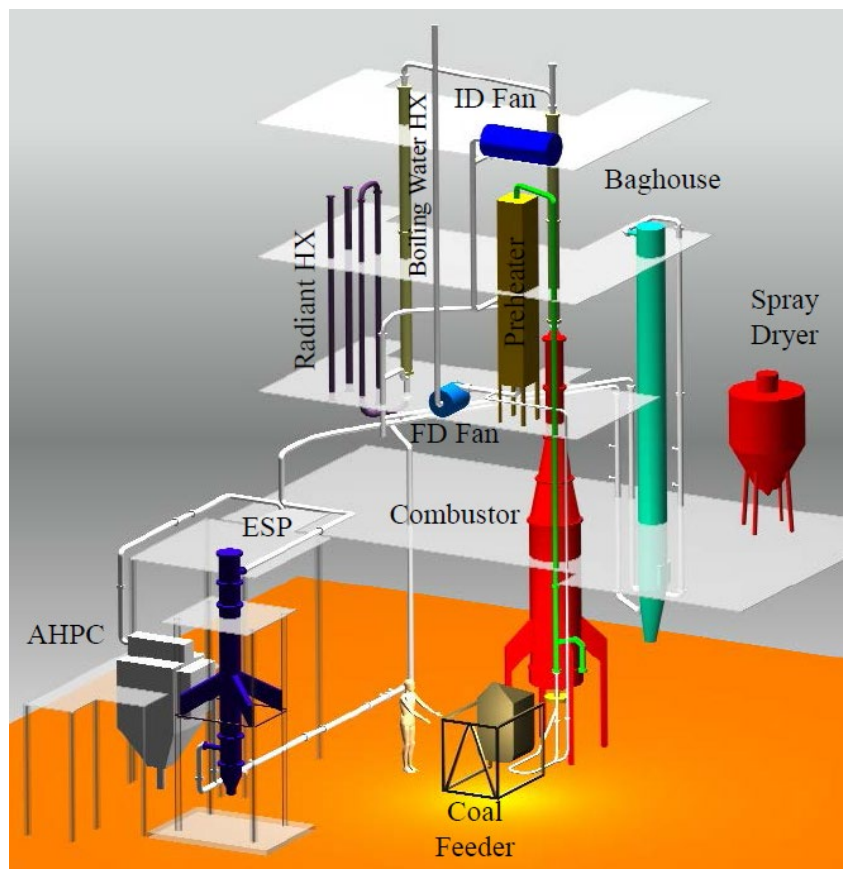
116. By the early 2000s, the inventors (Edwin Olson, John Pavlish, and Michael Holmes) had spent several years studying mercury emissions testing and capture technologies at the EERC. As part of this work, they conducted various tests at the EERC's Pilot Test Combustor ("PTC"). The PTC is a coal combustion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

117. An exemplary image of the PTC is shown below. This is an accurate reflection of at least a portion of the system as it appeared in 2002:¹⁵



¹⁵ Ref. 240.

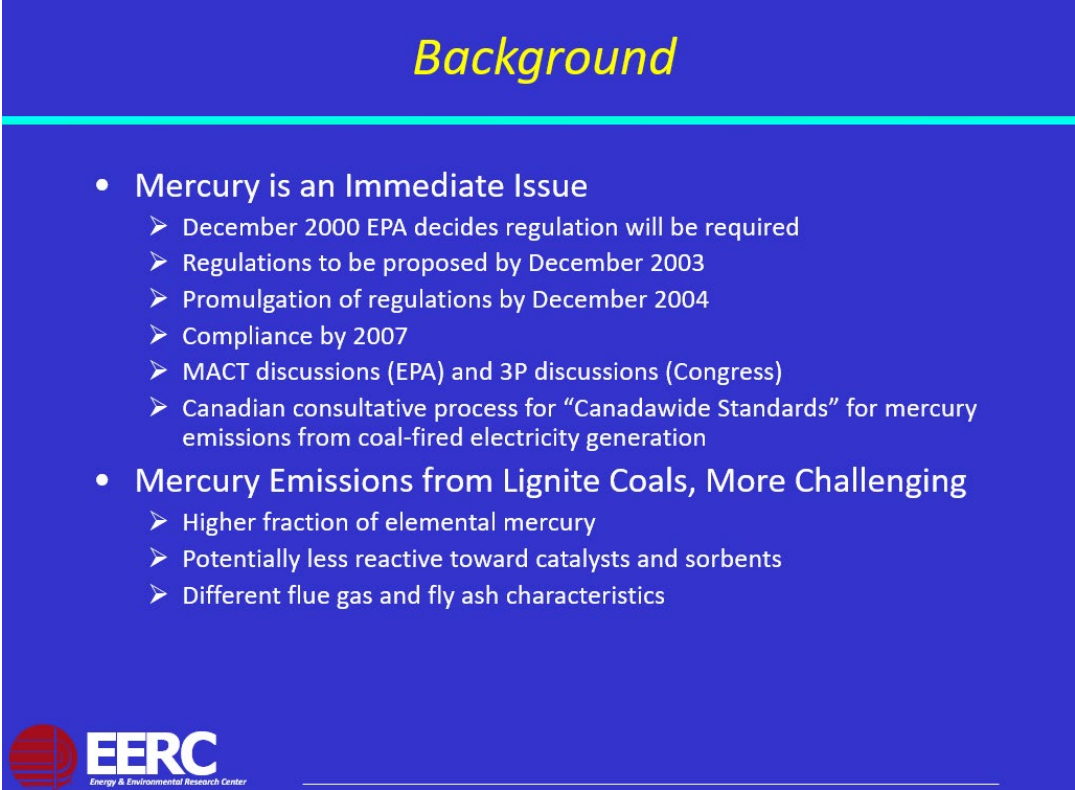
118. The diagram below reflects the PTC layout as of 2002.⁷ A process flow diagram is shown below for the PTC, with additional equipment added such as a dry scrubber:



119. 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.

120. As described below, the inventors developed and tested the patented technology using the PTC.

121. By 2001, the inventors had decided to focus on testing and evaluating various sorbents for use in mercury capture. However, PTC testing was relatively expensive, and thus they needed to obtain funding to perform in depth testing. In December 2001, they 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:¹⁶



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

 **EERC**
Energy & Environmental Research Center

¹⁶ Ref. 241.

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



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.



[REDACTED]

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

123. 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 as the Phase I bench- and pilot-scale testing. The results of the project were later summarized in a report provided to the DOE.¹⁷

124. The EERC held a kickoff meeting to discuss the project on February 28, 2002. During this meeting the inventors discussed the project timeline and overall strategy. As shown below,¹⁸ part of the focus of the project was to identify sorbents and oxidation options. In particular, they had identified a potential reaction between chlorine¹⁹ and activated carbon that they intended to study further.²⁰

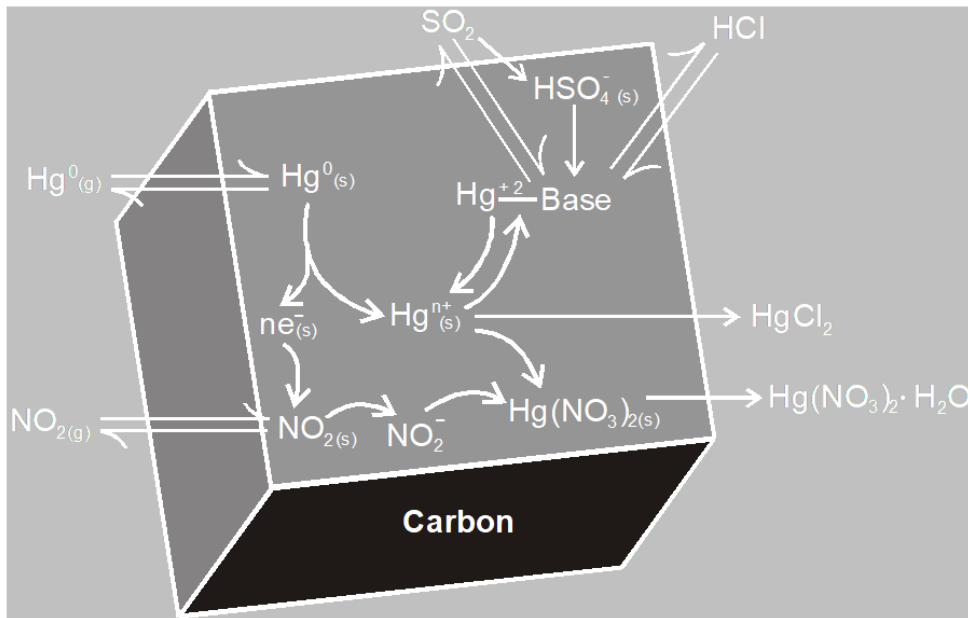
¹⁷ Ref. 242 (the “October 2003 Report”).

¹⁸ Ref. 243

¹⁹ 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.

²⁰ Ref. 244.

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)

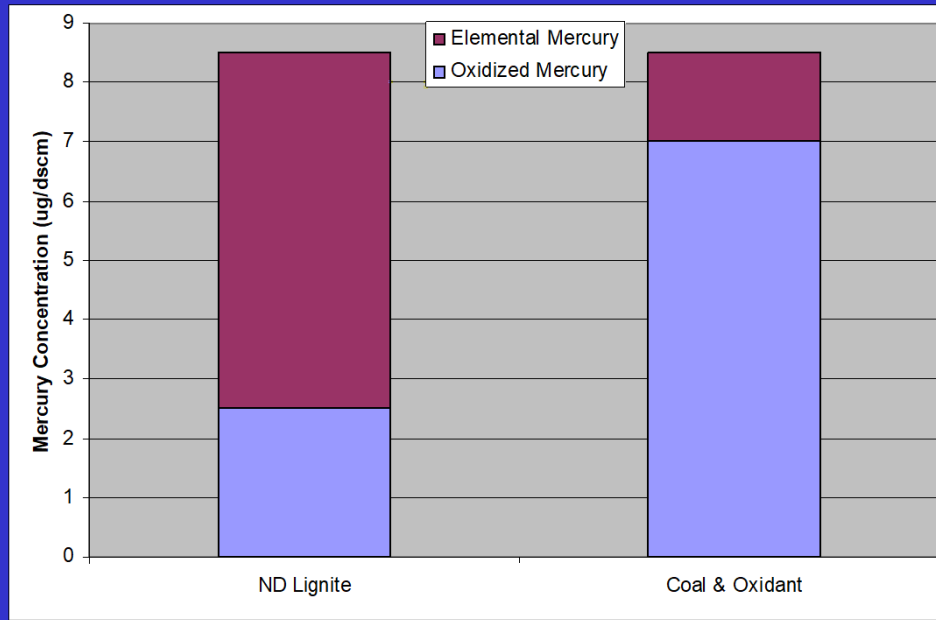


125. Following this kickoff meeting, they tested various sorbents, additives, and other variations at the PTC. Much of this initial work focused on the use of chlorine-based additives and activated carbon sorbents. One of the discoveries consistently demonstrated through that testing was the beneficial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

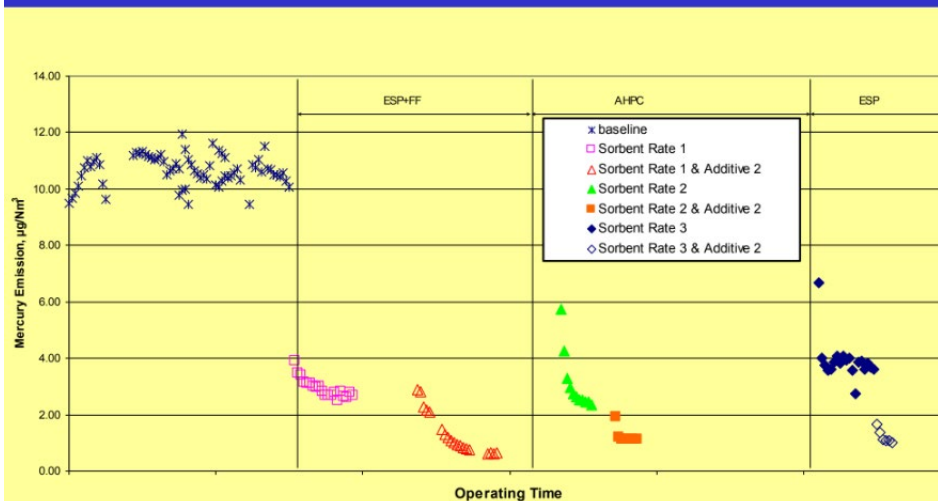
126. These results were memorialized in slides prepared for a post-testing review meeting held on February 3, 2003.²¹ As shown in the slides below, comparative testing of sorbents and additives demonstrated an improvement over merely using sorbents, and a significant improvement over baseline testing:

²¹ Ref. 245.

The Effect of Oxidant Addition on Mercury Speciation – Freedom Coal



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



[REDACTED]

127. The testing described above was conducted during the summer and fall of 2002. The inventors and others at the EERC, compiled and analyzed the results of this work into a report provided to the DOE—The October 2003 Report.²²

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

129. 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-FC26-03NT41897.²³ This round of funding was used for PTC testing conducted in 2003.

130. As described in the October 2003 report, by the time of the 2002 PTC testing, the inventors had conceived of using a pre-boiler additive to boost the performance of post-boiler, injected activated carbon sorbent.²⁴ Testing coal additives was just one portion of the work they were doing for the DOE project. At least initially, their work focused on the use of Chlorine as the additive. This is because the role of Chlorine in combustion 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.

²² Ref. 242.

²³ Ref. 246 (the “February 2004 Report”).

²⁴ Ref. 242, Pg. 51.

[REDACTED]

131. However, on some occasions, after they had completed the required testing, they had some additional time with the PTC when they could experiment with more speculative approaches. It is during one of these “after hours” tests that they first tested the use of a bromine-based additive provided on the coal and injecting activated carbon downstream of the combustor.

132. Inventor John Pavlish attempted to locate documents to pinpoint when the inventors conceived of using bromine as the additive, and when they conducted these after-hours tests with bromine. As part of that search, he located a list of potential research ideas that he 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 he would oversee as Director of the CATM program.²⁵ The metadata for this document indicates that he last edited it on August 30, 2002:²⁶

²⁵ Ref. 247.

See also John Pavlish Deposition at 227:4 – 13:

Q. And so who were the ones who would decide for each of the areas where it said "priority low" or "medium," "medium high," "high," who was the one who -- how was that checked off? How was the right box checked off for that?

A. The PAC members, so five to seven industrial partners would get this document ahead of time and they basically check a box.

²⁶ Ref. 248.

Properties ▾

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

J

jpavlish

Add an author

Last Modified By

JP

John Pavlish

133. This document notes their discovery that chlorine 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.

134. It also identifies the need for studying the use of bromine 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.

135. Thus, at least by August 30, 2002, they had conceived of using bromine as the additive to coal combustion systems. Once they had received funding and were able to conduct the next round of testing at the PTC, they planned to perform at least some tests using a pre-boiler bromine-based additive with post-boiler activated carbon sorbent.

136. The next round of PTC testing began in 2003. From September 8, 2003 to September 19, 2003, they 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.

137. 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 John Pavlish and his co-inventors.²⁷

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

TITLE		Project No. 7-24/750	Book No.	CONFIDENTIAL
from Page No.	1836	STARTED SODIUM BROMIDE FEEDER @ 40 g/hr 375 set		
	1904	3 lbs coal - 48g Sodium Bromide		
	1926	Added <u>204 lbs</u> Coal		
		Added new batch Sodium Bromide Coal to Feeder		
		Same blend 3 lbs C 48g SB @ 40 g/hr		
Witnessed & Understood by me,	Date	Invented by	Date	
	9/18/03	Recorded by		

139. 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:

²⁷ Ref. 249, Ref. 250, Ref. 251.

11:58	Added <u>196.8 grams</u> 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 probe M-26	RL
To Page No. _____		
Witnessed & Understood by me,		Date
		9/18/03
Invented by		Date
Recorded by		

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

0950	START SODIUM Bromide NaBr 5/55 COAL/80 gms ^{Granite} 10 grams/hour Setting 074	BR
1005	BLEW BACK SAMPLE PORT #1	BR/RL
10:28	start Norit FGD carbon 149/hr 20rpm	Ve
1106	DRAINED ice bath condensor	JH
1131	Shut off CARBON Feeder	JH/42
1152	Added COAL <u>1270155</u>	JH/KS
11:57	start EERC HCl pre-treat sorbent 149/hr 20rpm (396.1g 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
		Recorded by

451	Started carbon Injection 109/hr (Br treated)	YQ Jhon
1459	Zero & Spanned SO2 Sample port #1	KJ
15:18	Increase Br treated carbon to 159/hr	Ve
1542	Added COAL <u>122155</u>	JH/KJ
4:59	Started Feeder NaBr, 10g/hr, $\rightarrow$ 10 gr per hour Sodium Bromide	ke
To Page No. _____		
Witnessed & Understood by me,	Date 9-19-03	Invented by
		Recorded by

[REDACTED]

E	PTC-FM-639	Book No.	171
CONFIDENTIAL			
Page No.	553	Blew out sample port #1 probe and static lines	JH/KS
	608	DRAINED Ice bath CONDENSOR	JH
	16:22	stop NaBr injection stop br treated carbon injection	.../

140. 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.

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



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



143. 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. As a result, the EERC initially decided to maintain the use of bromine as proprietary intellectual property.

144. 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 EGD Carbon Feeder 10 g/hr HR YZ
 1759 Pulsed BH 10.5" → 2.3" AP MH
 1805 Lowered NA BR feeder to 10 g/hr 112 setting MH
 1816 Pulsed B4 4.7" → 2.8" AP MH

Witnessed & Understood by me,

Date
12-11-03

Invented by

Date

Recorded by

To Page No.

0802

Coal Mix Sorbent Feeder
 5 lbs Coal
 80 grams NA BR

0814 INCREASED ESP CURRENT TO 3.5 mA JCA

0842 Filled Sorbent Feeder (10 lbs Coal, 160 grams NA BR) JR

Witnessed & Understood by me,

Date
2-4-04

Invented by

Date

Recorded by

To Page No.

Project No. _____		Block No. _____
PTC-CA-641		
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) 10 grams NaBr/hour	BR
0945	Note! ** Recalculate $CaCl_2$ injection rate from 02/03/01	DME
0950	VIBRATOR QUIT - GOT IT GOING AGAIN	BR/RL
10TE	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	BYPASS 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 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 <u>178 lbs</u>	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. _____		
Inspected & Understood by me,	Date 2/4/04	Invented by Date
		Reviewed by

Project No. 4884

Book No.

TITLE PTC-CA-641

Page No.

1455	Sorbent feed turned off Done with O-H Sampling T-14	RK
1512	Bypassed flow, Power off Rapped	MH KJ
1515	ESP back on Line dumped Ash <u>10.75 lbs</u> Took sample	MA/KJ
534	Finished Adding coal <u>1500 lbs</u>	KJ/MH
550	Started Sorbent feed Nabr 5 grams per hour <u>78 set pt</u>	KJ/DM
1640	Had problems with O ₂ . Found that when Int was repaired they had changed some of the Input signals Reading right now	RK 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 <u>60 set pt</u> 2.5 g/hr.	MH
1845	Shut off Sorbent feeder <u>Nabr</u>	KJ/DM
1857	Cleaned out Sorbent feeder then put in 1.25 g of Na BR, Ca Cl ₂ lbs/hr Setting on feeder of 110 ~ 285 g/hr of the mix 10 grams Na BR 13.24g Ca Cl ₂ · 2H ₂ O 5 lbs coal	MH KJ

used & Understood by me.

Date
2/4/04

Inspected by.

Date

145. In February 2004 the inventors performed additional testing with greater variation in the ratios of bromine 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.

146. Also in February 2004, the EERC delivered a report to the DOE describing the results of the inventors' September 2003 testing (the "Feb. 2004 Report").²⁸ 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):

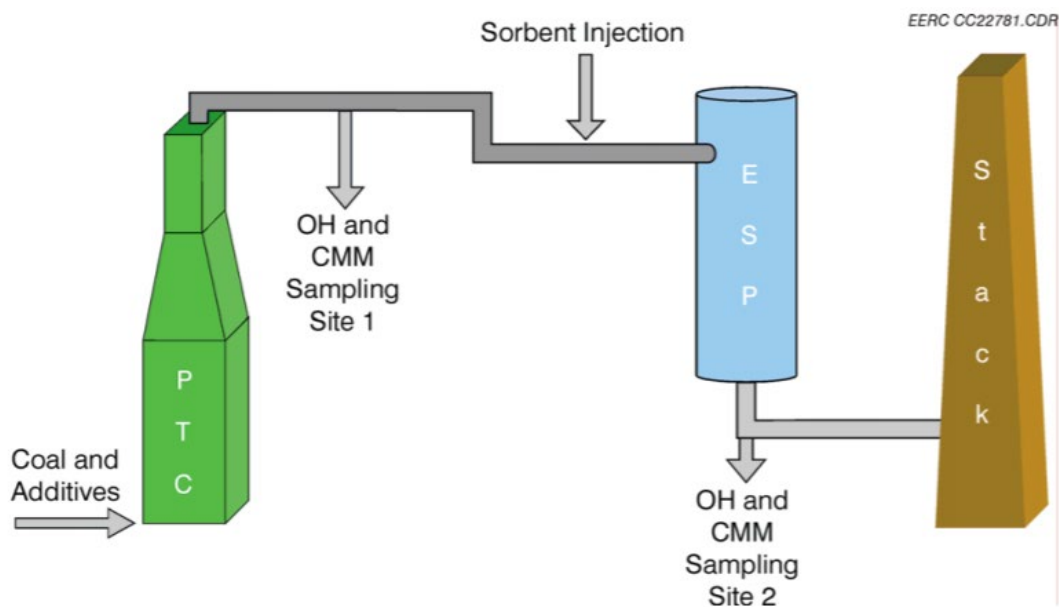


Figure 4. Injection and sampling schematic of the PTC with an ESP.

²⁸ Ref. 246, Pg. 12 (providing coal analysis for "PTC-FM-639," the PTC testing identifier from the logbooks described above); Pg. 17 (explaining that this testing occurred in September 2003).

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

Table 1. Test Matrix for Unscrubbed Systems Equipped with ESPs

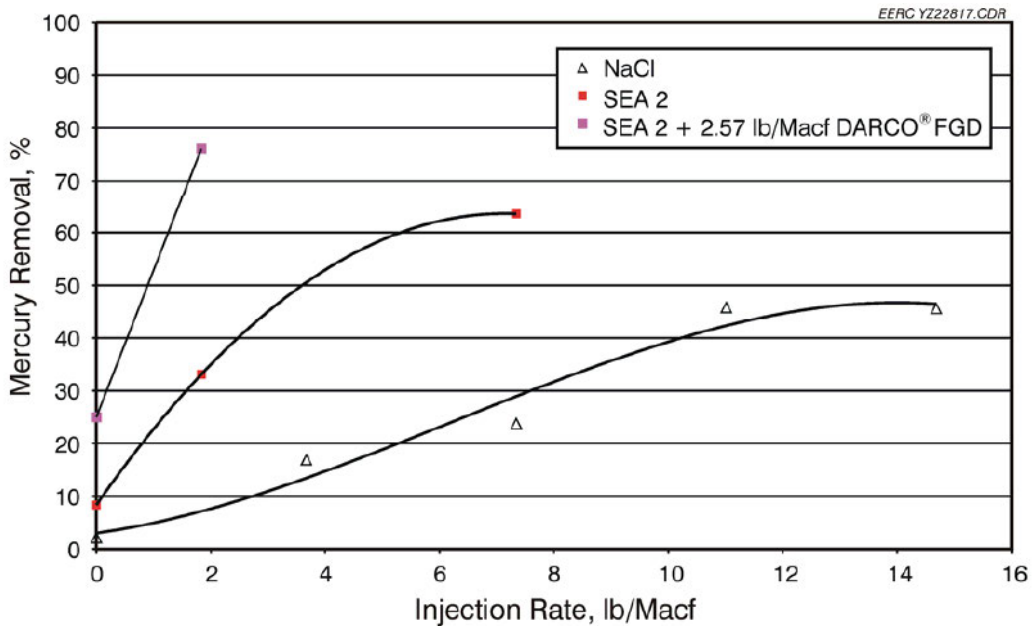
Test No.	Mercury Oxidant Additive		Sorbent	
	Category	Injection Rate, lb/Macf	Category	Injection Rate, lb/Macf
T1-1(Baseline)	None	NA	None	NA
T1-2	None	NA	DARCO® FGD	2.75–18.4
T1-3	NaCl	3.76–14.7	None	NA
T1-4	NaCl	3.76–14.7	DARCO® FGD	2.75–4.59
T1-5	SEA 2	1.84–7.34	None	NA
T1-6	SEA 2	1.84	DARCO® FGD	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 ₂ S 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

148. 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.

149. In February 2005, the EERC provided a further report to the DOE with additional analysis of this testing (the “Feb. 2005 Report”).²⁹ 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

²⁹ See Ref. 252, Pg. 10 (providing coal analysis for “PTC-FM-639,” the PTC testing identifier from the logbooks described above); Pg. 9 (explaining that this testing occurred in September 2003).

mercury species.” It also reported that the combination of SEA2 and activated carbon performed significantly better than alternative approaches:



150. This report also described additional testing performed with SEA2 and activated carbon in December 2003, as noted in the PTC logbook 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 gpm/HR		YZ
1759	Pulsed BH	10.5" → 2.3"	AP	MH
1805	Lowered NA BR feeder to	10 g/hr	112 setting	MH
1816	Pulsed B4	4.7" → 2.8"	AP	MH
To Page No. _____				
Witnessed & Understood by me,		Date	Invented by	Date
		12-11-03		
			Recorded by	

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

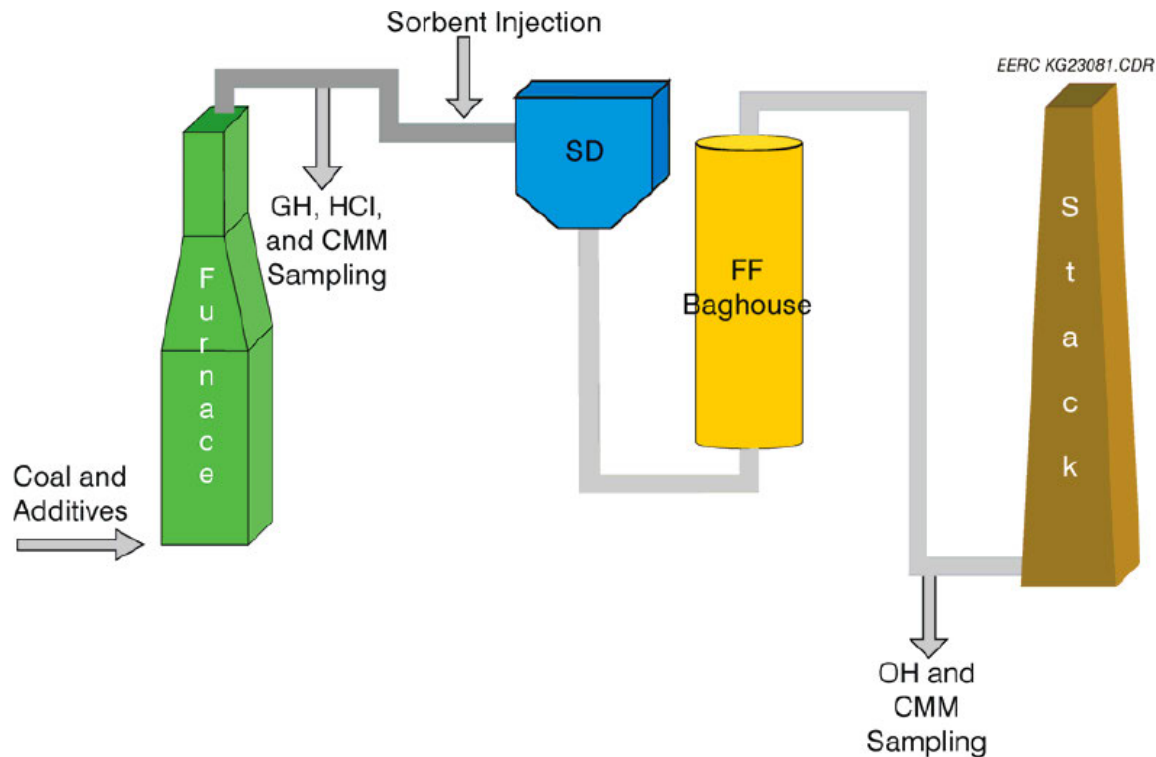


Table 10. Mercury Control Test Matrix

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

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

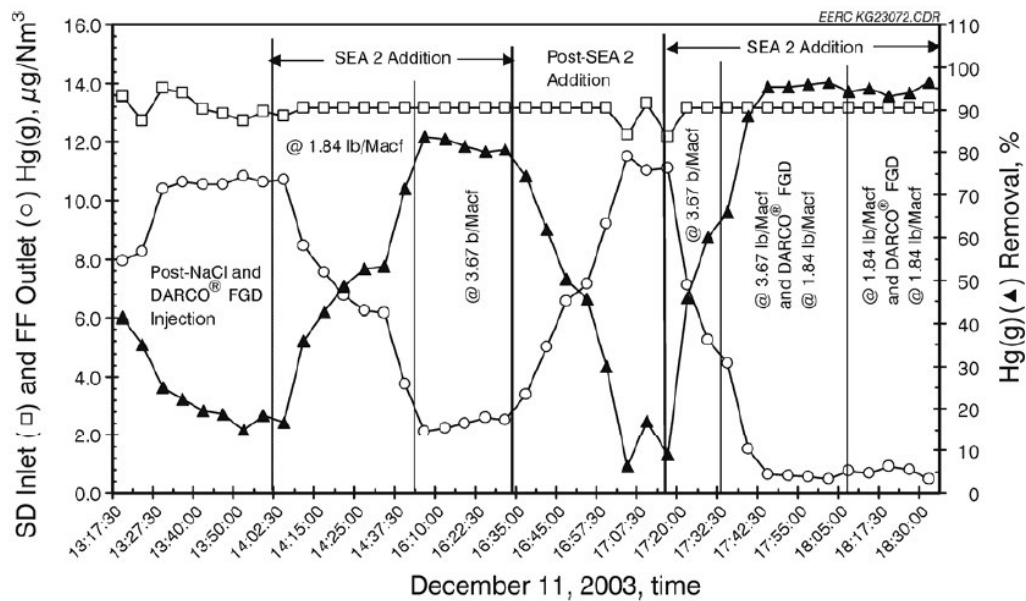


Figure 40. SDA inlet and FF outlet CMM results and SDA–FF Hg(g) removal efficiencies before, during, and after SEA2 additions and DARCO® FGD injection into the Center lignite coal and combustion flue gas, respectively.

153. An October 2005 Report described further testing conducted in February 2004 (the “Oct. 2005 Report”):³⁰

³⁰ Ref. 253, Pg. 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.”); Pg. 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 M-29	OH	Baseline					
			Baseline					
			DARCO	25.0	7.03			
			DARCO	28.0	7.84			
			DARCO	32.0	8.96			
			DARCO	45.0	12.60			
2/3/04			DARCO	69.0	19.20			
			Baseline					
						SEA1	15.2	4.28
						SEA1	29.8	8.38
			DARCO	25.0	7.03	SEA1	29.8	8.38
			DARCO	25.0	7.03	SEA1	45.5	12.80
2/4/04	OH M-29	OH	DARCO	25.0	7.03	SEA1	59.9	16.73
			DARCO	25.0	7.03	SEA1	15.2	4.28
			Baseline					
						SEA2	9.8	2.73
			DARCO	25.0	6.96	SEA2	9.8	2.73
			DARCO	15.0	4.18	SEA2	9.8	2.73
2/5/2004	OH	OH	DARCO	15.0	4.18			
			DARCO	15.0	4.18			
			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	OH	OH	Baseline					
			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.

154. Thus, the inventors reduced their invention to practice at least by September 2003, and again in December 2003, and February 2004 during the PTC testing conducted at those times. Further detail mapping that testing to the claim language is provided in Appendix A.

7. Response to Dr. Niksa's Anticipation/Obviousness Invalidity Theories

7.1. Response to Defendants Sjostrom and Lissianski Presentation Theories

Against All of the Patents-in-Suit

[REDACTED]

155. Dr. Niksa asserts various invalidity theories based on Sjostrom and Lissianski Presentation, for which he attributes a prior art date of January 2005. For each of these theories, Dr. Niksa assumes that the patents-in-suit are only entitled to a priority date of April 2009. However, as explained above, the patents are entitled to the priority date of the provisional application, i.e., August 30, 2004. Thus, Dr. Niksa has failed to show that these theories are based on references that pre-date the patents-in-suit.

156. In addition, even if the patents were not entitled to the priority date of the provisional application, they would be entitled to claim the priority date of the first filed non-provisional application, i.e., the '163 application filed on August 22, 2005. The critical date for this application would be August 22, 2004. Dr. Niksa does not assert that either Sjostrom or Lissianski Presentation qualify as prior art before that critical date. Accordingly, if the inventors reduced the claims to practice before the asserted prior art date of January 2005, then Dr. Niksa has failed to show that these references qualify as prior art. As explained above, the inventors reduced the claims to practice before that date. Thus, for this reason as well, Dr. Niksa has failed to show that the claims are anticipated or obvious based on theories involving Sjostrom or Lissianski Presentation.

7.2. Response to Dr. Niksa's Downs-Boiler Theories Against All of the Patents-in-Suit

157. Dr. Niksa asserts various invalidity theories based on Downs-Boiler, for which he attributes a prior art date of March 22, 2004. However, as explained above, the inventors conceived of, and reduced to, practice the claimed invention before that date. Accordingly, Dr. Niksa fails to show that the claims are anticipated or obvious based on theories involving Downs-Boiler.

7.3. Response to Dr. Niksa's Vosteen Theories Against All of the Patents-in-Suit

158. Dr. Niksa asserts various invalidity theories based on Vosteen, for which he attributes a prior art date of May 6, 2003. However, as explained above, the inventors conceived of the claimed invention prior to that date, and then subsequently diligently reduced to practice. Accordingly, Dr. Niksa fails to show that the claims are anticipated or obvious based on theories involving Vosteen.

159. In addition, Dr. Niksa fails to show that Vosteen, either alone or in combination with other references, discloses all of the limitations of the patents-in-suit.

160. All of the claims of the '114, '225, '517, '430 patents require injecting activated carbon sorbent into flue gas, i.e., downstream of the combustion chamber. All of the claims of the '147 patent require "injecting the particulate sorbent material at a sorbent material injection rate and injecting separately the bromine containing promoter into a gas stream whereby in-flight reaction produces the promoted brominated sorbent." Dr. Niksa cites to portions of Vosteen as disclosing these limitations. He cites to the highlighted portion of claim 1:³¹

1. Process for removing mercury from mercury-containing flue gases of a furnace within which a combustion or incineration is carried out, wherein bromine, a bromine compound, a mixture of bromine compounds or a mixture of bromine and a bromine compound or compounds, is fed to the furnace or to the flue gas of the furnace in a plant section downstream of the furnace, or to both the furnace and the flue gas, the temperature during the first contact of the bromine or of said mixture with the flue gas being at least 500° C., the combustion or incineration is carried out in the presence of a sulphur compound, and then the flue gas is subjected to a cleanup for removing mercury from the flue gas.

³¹ Ref. 239, Pg. 484.

161. However, this claim merely refers to “cleanup for removing mercury from the flue gas. This statement is too vague for a POSITA to interpret it as disclosing activated carbon injection.

162. Dr. Niksa also cites the following portion of Vosteen:

mercury compounds. Such a cleanup can be carried out, for example, by semi-dry desulphurization in a spray-dryer which is impinged with a milk of lime/carbon suspension, or using fixed-bed adsorbers, for example based on granulated activated carbon or oven coke or mixtures of such adsorbers with granular lime, or using pneumatic adsorbers, for example electrostatic precipitators (ESPs), or using cloth filters which are impinged with a blown-in finely pulverulent slaked lime/activated carbon or slaked lime/lignite coal coke mixture. Zeolites are also suitable for removing mercury

163. According to Dr. Niksa, this passage discloses: “injecting a mixture of lime and activated carbon onto fabric filters downstream of the combustion chamber.”³² However, injecting a mixture of lime and activated carbon onto fabric filters is not the same as injecting activated carbon sorbent into a flue gas stream. Indeed, when Dr. Niksa first presented this theory to the patent office during an *Inter Partes* Review proceeding, this difference was explained by ME2C.

164. The term fabric filters refers to a set of filters contained in a baghouse. A baghouse contains cylindrical filters made of a cloth or synthetic materials such as fiber glass or nylon. The baghouse is divided into multiple chambers so that some filters can be brought offline for cleaning and maintenance without shutting down the entire baghouse. When the combustion chamber is in operation, flue gas exits the combustion chamber and eventually enters the online baghouse chambers. The gas is pulled or pushed through the filters to generate a cleaned gas.

³² Ref. 239, Pg. 483.

165. When particulates first come into contact with a baghouse filter, some of the particulates impinge and become trapped on the fabric fibers. These particulates trap additional incoming particulates. Ultimately, the primary filtration mechanism comes from the particles on the filter, known as the “dust cake,” rather than the filter medium itself. This dust cake acts as a sieve and continues to accumulate particulates.

166. POSITA have recognized that the flue gas exiting a coal combustion chamber contains high velocity particles and acid gases. These components can damage fabric filters.³³ Operators can reduce this risk by applying a protective dust layer, known as a “precoat” to the filters before bringing them online.³⁴ In describing general filter bag operation, the EPA has explained that various coatings may be blown onto filter bags before using them in operation.³⁵

³³ Ref. 254, Pgs. 7 – 9:

The baghouse must also be brought on line slowly to avoid permanent damage to the fabric. Clean filters do not have a protective dust cake on them and are sensitive to dust abrasion and penetration by fine particles. Penetration can lead to permanent residual pressure drop. In some applications, bags are precoated with a protective dust layer prior to bringing the unit on-line. The filter velocity should always be kept low until a sufficient dust cake is built up on the bags. This is indicated by a pressure drop of 1 to 2 inches H₂O. The gas flow can then be slowly increased to the designed rate (McKenna and Greiner, 1982).

³⁴ Ref. 255:

After explaining why it's a good idea to precoat new bag and cartridge filters that will handle extremely fine dust particles, this article provides step-by-step instructions on how to do it.

³⁵ Ref. 252, Pgs. 7, 15

[REDACTED]

With this understanding, a POSITA would interpret Vosteen is describing precoated filter bags, not activated carbon sorbent injection.

167. When Dr. Niksa presented this theory to the Patent Office, and ME2C responded with the evidence cited above, the Patent Office found that Dr. Niksa had failed to demonstrate that Vosteen was likely to disclose activated carbon sorbent injection under a preponderance of evidence.³⁶ Similarly, Dr. Niksa has failed to present clear and convincing evidence that Vosteen discloses this requirement of the claims.

Frequently, bag materials are coated with various substances to lengthen their service life and enhance particle collection. Examples are graphite finishes to help reduce static charge buildup and simultaneously to "lubricate" the yarns to reduce abrasion, and Teflon® and silicone treatments to improve resistance to abrasion.

- Injection of limestone to precoat the bags before starting up the system can aid the filtering mechanism before initial dust cake formation.

Ref. 256, Pg. 5:

collected with proper care. The use of selected fibrous or granular filter aids (precoating) permits the high-efficiency collection of submicron smokes and gaseous contaminants. Filter collectors are available in a large number of configurations, resulting in a range of dimensions and inlet and outlet flange locations to suit installation requirements. (AWMA, 1992)

³⁶ Ref. 257:

[REDACTED]

168. Alternatively, Dr. Niksa contends that this limitation would have been obvious in light of Vosteen combined with Granite. However, Dr. Niksa fails to identify a specific teaching in Granite of activated carbon sorbent injection.

169. Granite actually describes experimental testing using packed bed carbon.³⁷ It further cautions against assuming similar results would be achieved using sorbent injection.³⁸ Accordingly, Dr. Niksa has failed to show that a POSITA would rely on Granite to deploy sorbent injection.

Dr. Niksa provides no explanation how Vosteen “also describes injecting a mixture of lime and activated carbon onto fabric filters downstream of the combustion chamber,” as Dr. Niksa states above. Nor does Petitioner provide evidence (other than Dr. Niksa’s testimony) that Vosteen’s arrangement of cloth filters impinged with a mixture would result in the mixture being injected into gas that passes through the cloth filters (e.g., due to release of the mixture from the cloth filters into the gas). Thus, given the lack of support, we are not persuaded that Petitioner’s testimonial evidence regarding whether Vosteen discloses the injection of a sorbent material is entitled to much weight.

Conversely, Patent Owner cites evidence explaining the nature of Vosteen’s cloth filters and how particles would cake upon them. Prelim. Resp. 31–35. Considering the parties’ positions and weighing the evidence before us, we determine, on this record, that Petitioner has not demonstrated a reasonable likelihood that Vosteen discloses the injection of sorbent material comprising activated carbon into a mercury-containing gas, as the challenged claims require.

³⁷ Ref. 258, Pg. 1:

A laboratory-scale packed-bed reactor system is used to screen sorbents for their capability to remove elemental mercury from various carrier gases. When the carrier gas is argon, an on-line atomic fluorescence spectrophotometer (AFS), used in a continuous mode, monitors the elemental mercury concentration in the inlet and outlet streams of the packed-bed reactor. The

³⁸ Ref. 258, Pg. 1026:

The results obtained from the packed-bed unit require judicious interpretation when attempting to extrapolate their relevance to activated carbon sorbent duct injection as a mercury control technique for industrial size combustors. AC-1 was also studied in the NETL 500 lb

[REDACTED]

170. Moreover, Granite tested a variety of untreated and pretreated activated carbon sorbents. Dr. Niksa fails to show that Granite discloses injecting bromine and sorbents into a gas stream at a power plant such that mercury, bromine, and activated carbon react in flight.

171. Granite concludes:³⁹

A packed-bed reactor system was used to screen sorbents for the removal of elemental mercury from a carrier gas. An on-line atomic fluorescence spectrophotometer was used to measure elemental mercury in argon on a continuous basis. For more complex carrier gases, sorbent capacities were determined off-line via CVAAS or ICP-AES. Chemically promoted activated carbons exhibit a far greater capacity for mercury than unpromoted carbons. The activated carbons possess higher capacities at lower temperatures. Chlorine could be a cost-effective chemical promoter for carbon sorbents for the removal of mercury.

172. Thus, Dr. Niksa fails to show that a POSITA reviewing Granite would conclude that bromine and activated carbon sorbent should be injected separately. Rather, Granite reinforces the conventional wisdom that activated carbon sorbents should be pre-treated before being used in flue gas.

173. Dr. Niksa fails to show that a POSITA would combine Granite with Vosteen. Even if Dr. Niksa had made such a showing, he fails to show that the end result would be separate injection of bromine and activated carbon sorbent, let alone adding bromine upstream of the combustion chamber and injecting activated carbon downstream of the combustion chamber. Rather, a POSITA would have believed that a better approach was to use pre-treated sorbents, and/or sorbent beds.

174. When Dr. Niksa previously argued that this limitation would have been obvious over Vosteen, he proposed combining Vosteen with Nelson, another reference that discloses

³⁹ Ref. 258, Pg. 1028.

[REDACTED]

pretreatment of sorbents instead of inflight use of sorbents. In response, ME2C argued that a POSITA would not have arrived at the invention of separate injection of bromine and sorbent. The Patent Office agreed, stating:⁴⁰

Patent Owner, referring to its anticipation-based arguments against Vosteen, argues that Petitioner does not offer any additional analysis in its obviousness grounds explaining how a person of ordinary skill in the art would have been motivated to modify Vosteen to arrive at the sorbent injection limitations of the challenged claims. Prelim. Resp. 29. We agree, because Petitioner's arguments for this ground do not remedy the deficiencies discussed above with regard to Petitioner's anticipation arguments based on Vosteen. Therefore, Petitioner has not demonstrated a reasonable likelihood of prevailing on its assertion that claims 1–9 and 12–30 of the '114 patent would have been unpatentable over Vosteen.

175. Similarly, Dr. Niksa has failed to present clear and convincing evidence that Vosteen in combination with Granite renders the claims obvious.

176. Moreover, throughout Dr. Niksa's analysis of Vosteen and Granite he cites to other references or portions of his report that cite other references.⁴¹ However, he does not propose specific obviousness combinations or otherwise analyze other potential combinations of references. The fact that Dr. Niksa relies on these other references supports my conclusion that Vosteen and Granite do not render the claims obvious.

177. For example, Dr. Niksa cites Crocker to support his opinion that "By 2003, it was well-known that halides "improve[d] Hg capture both by conversion of the Hg₀ to the more easily removed Hg₂₊ forms and by enhancing the reactivity of Hg₀ with activated carbons."⁴² Crocker is a report prepared by individuals at the EERC. Crocker references the work of

⁴⁰ Ref. 257, Pg. 19.

⁴¹ Ref. 239, Pgs. 503, 508–09, for example.

⁴² Ref. 239, Pg. 509.

[REDACTED]

inventors John Pavlish and Mike Holmes, and it is dated November 2003. This is after the inventors reduced their invention to practice at the EERC in September 2003. Thus, Dr. Niksa's reliance on this document confirms that neither Vosteen nor Granite contain sufficient disclosure to render the patents-in-suit invalid.

7.4. Response to Dr. Niksa's Nelson Theories Against the '147 Patent.

178. Dr. Niksa asserts various invalidity theories against claims 17, 19, 20 of the '147 patent based on Nelson alone or in combination with Olson-Paper.⁴³

179. Claim 17 of the '147 patent requires: "injecting the particulate sorbent material at a sorbent material injection rate and injecting separately the bromine containing promoter into a gas stream"

180. Dr. Niksa relies on Nelson to disclose this limitation. However, Dr. Niksa fails to show that Nelson discloses this limitation as opposed to disclosing pretreatment of sorbent with bromine and later injection of the pretreated sorbent into a gas stream. For example, Nelson states that an "essential element" of his invention is mixing bromine and sorbent together *before* injecting the pretreated sorbent into a mercury containing gas stream.⁴⁴

⁴³ In his background discussion of Nelson, Dr. Niksa also refers to another reference the "Stock patent," (Ref. 239, Pgs. 201–02.) as one that is cited by Nelson. However, Dr. Niksa has not provided an obviousness analysis proposing a combination of Nelson and Stock, nor has he attempted to show that the disclosures in Stock are also in Nelson. To the extent he relied on disclosures in Stock to reach his invalidity conclusions based on Nelson, that approach is incorrect.

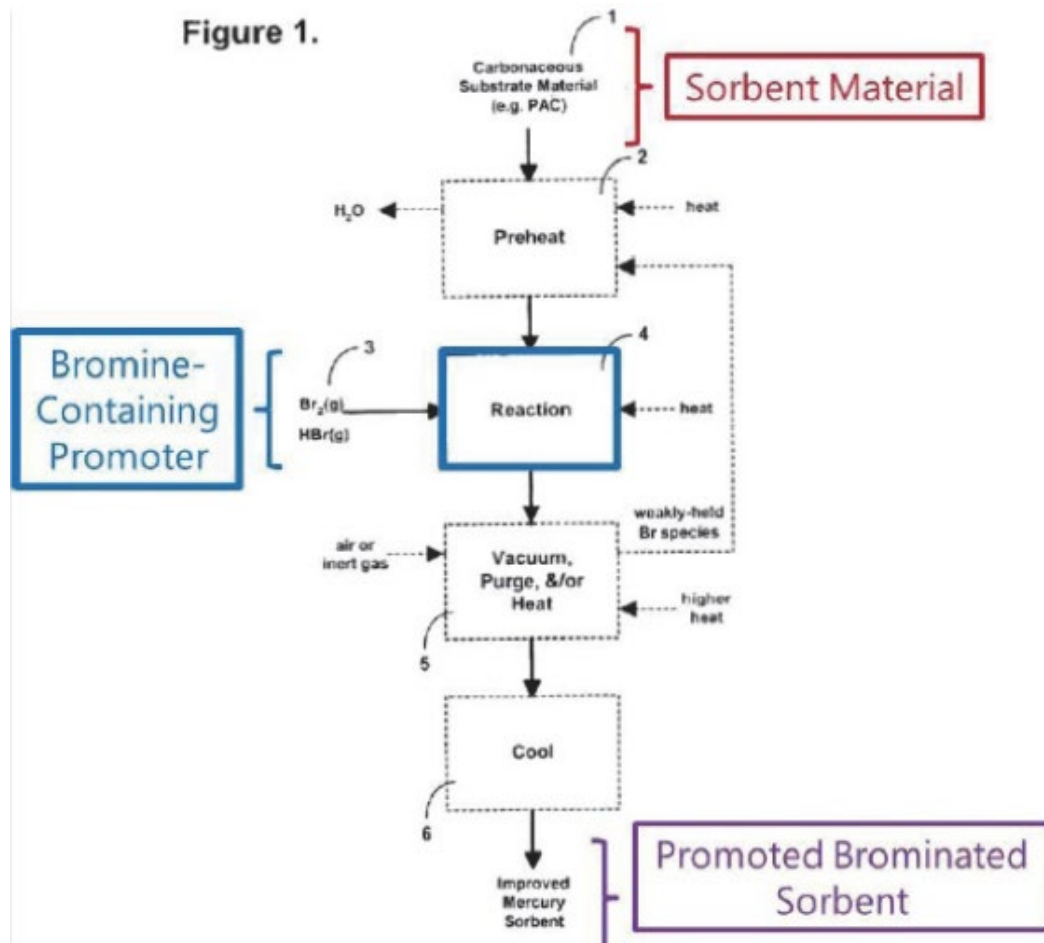
⁴⁴ Ref. 259, Col. 5, Line 63 – Col. 6:, Line 8.

There are five essential elements to the mercury sequestration claims of the present invention. The first three are that (1) a carbon-based adsorbent, such as powdered activated carbon (PAC), is used (2) to capture and concentrate vaporous mercury species from (3) a hot, flowing gas stream of combustion products. The fourth requirement is that the adsorbent material be (4) injected into the flowing gas, intimately mix with it, and be separated from the gas in a particulate collector. The fifth and final essential element of the invention is that at some time before it is mixed with the mercury-containing combustion gas, the carbon material must (5) be exposed to a bromine-containing treatment gas, possibly producing surface complexes that are particularly reactive to gaseous mercury species.

181. Given this disclosure, a POSITA would not assume that separately injecting promoter and activated carbon would be an appropriate method for capturing mercury. In flight reaction, as described in the '147 patent, can occur at much higher temperatures, over a much shorter period of time (the time it takes flue gas to travel from the flue to an ESP or baghouse can be mere seconds), and in the presence of many other components in flue gas.

182. Despite this disclosure in Nelson, Dr. Niksa claims that Nelson discloses separate injection of bromine and sorbent based on figure 2 of Nelson. See Dr. Niksa's annotated version of Nelson Figure 1 below:

Figure 1.



183. However, this figure merely illustrates a carbonaceous substrate material reacting with bromine. Dr. Niksa fails to identify any teaching in Nelson that either of these components are separately injected into a gas stream.

184. In light of this deficiency, Dr. Niksa identifies several more passages in Nelson:⁴⁵

⁴⁵ Ref. 259 at Col. 6, Lines 42-52, Col. 7, Lines 64-66, Col. 9, Lines 9-12.

Production of the new mercury sorbent materials is simple and inexpensive. The carbon material and the bromine gas need simply be contacted with each other for the advantageous mercury-reactive surface compounds to quickly form. Elemental bromine is a liquid at ambient temperature, but turns to a gas at only a modestly elevated temperature. Hydrogen bromide is a gas at even ambient temperature. Using a gas-phase carbon reactant considerably simplifies the production of the sorbent and leads to the low costs which are a requirement for a sorbent to be used as a once-through duct injectant. Any common mixing method

In some applications it may be beneficial to utilize a diluting carrier gas to better distribute the $\text{Br}_2(\text{g})$ or $\text{HBr}(\text{g})$ among the carbonaceous substrate particles. However, if the

by a combination of these methods. In one embodiment of the process any bromine species that are desorbed can be transported to unsaturated substrate materials upstream in the process, eliminating the need to dispose of the off-gas stream.

185. However, these passages merely describe mixing gaseous bromine with sorbent. None of these passages disclose separate injection of bromine and activated carbon into a gas stream. Indeed, Nelson's actual description of this mixing process describes the use of mixers, rotating drums, and bed units.⁴⁶ Thus, Dr. Niksa's fails to show that Nelson discloses this injecting limitation rather than disclosing performing mixing in a fixed reactor.

186. Dr. Niksa also identifies various portions of Nelson that use the word "injecting" and "ductwork." For example, figures 14, 15. However, he fails to show that these portions identify separately injecting bromine and activated carbon into a gas stream, as opposed to injecting bromine and activated carbon together as a pre-treated sorbent. As noted above, Nelson

⁴⁶ Ref. 259, Col. 8, Lines 57 – 65:

Note that the bromination step 4 can occur in any number of possible reactors. The particular equipment used to contact the carbonaceous substrates with the bromine-containing gas can be, for example, a stationary mixer, a rotating drum, a structure with a vertically-moving bed, a fluidized-bed unit, a transport reactor, or any other contactor known in the art. The manufacturing process is not limited



states that injecting these components together as a pretreated sorbent is an “essential element” of his invention.

187. Dr. Niksa also compares the disclosure in Nelson to a figure and the specification from the '147 patent. I understand this to be in error. Rather, a proper invalidity analysis requires comparison of the prior art to the claims, not the specification.

188. Dr. Niksa also states: “*In both fluidized-bed reactors and transport reactors, the bromine gas and PAC are injected separately into a gas stream—bromine gas is fed into the bottom through a distributor plate or injected directly into the bed, whereas PAC is fed from a higher elevation to fall into the bubbling or dense bottom bed sections.*” Dr. Niksa provides no support or teaching in the prior art to support this statement. Moreover, Dr. Niksa fails to show that feeding components into a reactor is the same as injecting them into a gas stream.

189. Separately, Dr. Niksa cites to a description of fluidized bed boilers in a document separate from Nelson, see, e.g., below:⁴⁷

⁴⁷ Ref. 260, Pg. 16-1.

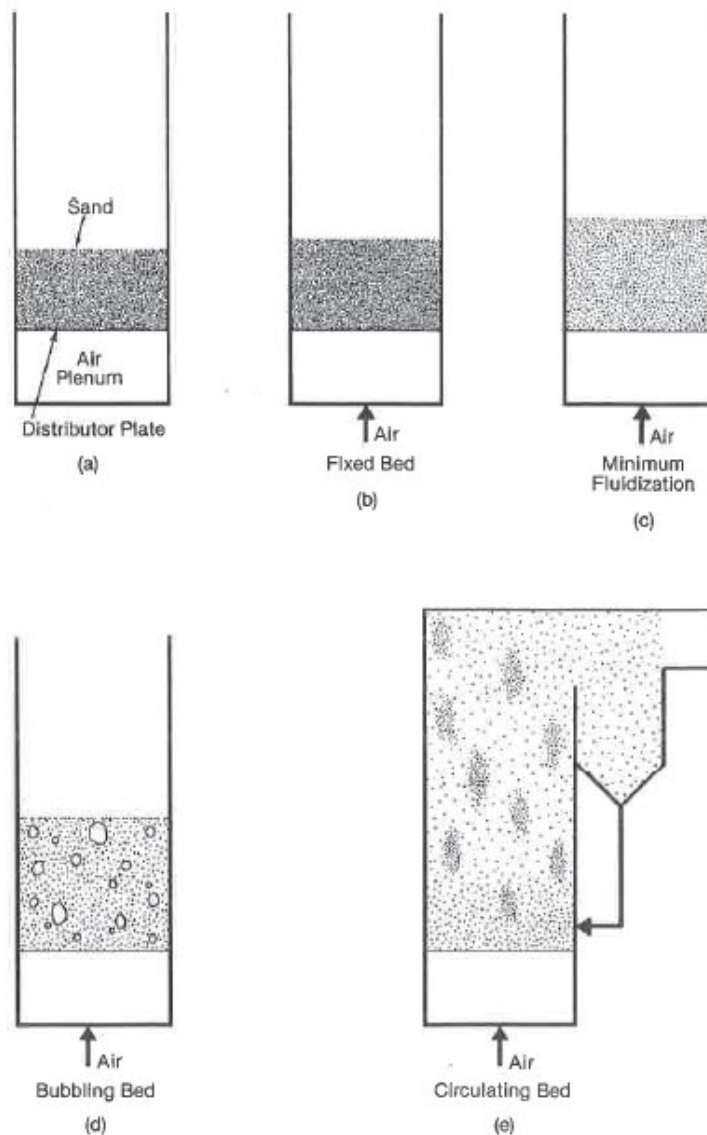


Fig. 1 Typical fluidized-bed conditions.

190. However, this document also fails to disclose that sorbent and bromine are injected into a gas stream.

191. Moreover, during the prosecution of the '114 patent, Nelson was identified as potential prior art. ME2C responded with substantial argumentation and multiple declarations submitted by inventor John Pavlish. The examiner ultimately agreed to issue the claims in response, explaining:

For claims 2-19 and 22-28, as shown within the declarations, in flight promotion with HBr or Br promoters is more effective for mercury removal than treating the sorbent with HBr, Br or Br₂ outside the mercury-containing gas. Further the Nelson reference seems to teach away from in-flight promotion as it states that the bromide is extremely corrosive. Lastly one having ordinary skill in the art would not have looked to in-flight promotion because for the prior art the contact time between the bromine promoter and the activated carbon is about 15 min, while when the promoter is contacted with the activated carbon in-flight, the contact time is generally less than 10 s.

192. This same reasoning applies with respect to claims 17 – 20 of the '147 patent. Those claims all require in-flight promotion which would have presented a POSITA with the same concerns about corrosion and contact time. Thus, the examiner's conclusion further indicates that Dr. Niksa has failed to present clear and convincing evidence of invalidity with respect to the '147 patent.

7.5. Response to Dr. Niksa's Nelson + Lissianski-Patent Theories Against the '147 Patent.

193. Dr. Niksa asserts various invalidity theories against claims 17-20 of the '147 patent based on Nelson in combination with Olson-Paper and/or Lissianski patent. As noted above, Nelson fails to disclose each of the limitations of those claims. Dr. Niksa's reference to Lissianski-patent does not cure those defects.

194. As explained above, the asserted prior art date for Lissianski-patent is January 2004. However, as explained above, the inventors reduced their invention to practice before that date. Accordingly, Dr. Niksa has failed to present evidence that this reference qualifies as prior art.

[REDACTED]

195. Moreover, Dr. Niksa fails to show that a POSITA would have been motivated and able to modify Nelson in light of Lissianski. Both of these references describe their respective systems as complete solutions, not in need of further modification. Moreover, Nelson describes pretreatment of sorbent as an “essential element,” of his invention. Dr. Niksa fails to show that that a POSITA would have been motivated to remove this essential element.

196. Indeed, Dr. Niksa does not identify any motivation to modify Nelson, let alone an explanation as to why a modified Nelson would result in separate injection of promoter and activated carbon. Dr. Niksa states:⁴⁸ *“person of skill in the art would have been motivated to provide additional halogen-containing promoter directly into the flue gas (as disclosed by Lissianski) in conjunction with injecting the improved mercury sorbent of Nelson into the flue gas (as disclosed in Nelson) in order to improve mercury removal (as taught by both Nelson and Lissianski) and also to improve the effectiveness of the NOx removal processes.”* However, this is merely an explanation of what a POSITA would need to change to arrive at the claims of the ’147 patent. Dr. Niksa provides no reason why a POSITA would actually modify either reference or why a POSITA expect that separate injection would provide a benefit as opposed to, for example, pre-treating sorbent with additional bromine. Thus, this is another example of hindsight bias in Dr. Niksa’s analysis.

197. In fact, teaching in the prior art would have led a POSITA away from attempting separate injection of activated carbon and promoter. For example, Nelson notes that “bromine species can be quite corrosive.”⁴⁹ While corrosion would not be a serious problem when treating

⁴⁸ Ref. 239, Pgs. 316–17.

⁴⁹ Ref. 261, ¶ 44.

activated carbon with bromine species in a separate vessel or reactor, corrosion could be a serious problem when it occurs in the equipment on-site at a power plant.

198. Moreover, a POSITA would be aware that Nelson describes contact times between activated carbon and bromine of several minutes. This is much longer than the seconds it takes for flue gas to travel to and through pollution control equipment.

199. A POSITA would also be aware that flue gas contains many other components that are not present when pre-treating sorbent outside the presence of flue gas. While the details of reactions with flue gas were not well understood and under investigation at the time, as Dr. Niksa points out, there was at least some indication that attempting to react activated carbon and bromine in the presence of a mercury containing gas like flue gas would be lead to a sorbent that is less effective compared to a pre-treated sorbent.⁵⁰ Dr. Niksa offers no basis for a POSITA to reject this understanding and engage in a much riskier attempt at in-flight promotion. For all of these reasons a POSITA would not be motivated to, and would not reasonably expect success from, modifying Nelson to incorporate separate injection of promoter and activated carbon, in-flight reaction, as opposed to pre-treatment of sorbent.

200. In addition, as explained above, during the prosecution of the '114 patent, Nelson was identified as potential prior art. ME2C responded with substantial argumentation and

⁵⁰ Ref. 239, Pgs. 87 – 88:

processes.”¹⁸⁶ Researchers noted that “lime has been demonstrated to reduce mercury emissions in coal flue gas, even though lime neither sorbs nor reacts directly with mercury.”¹⁸⁷ The researchers “speculated that lime aids in the removal of mercury by reacting with acid gases such as SO₂ that compete for adsorption with mercury on coal ash, unburned carbon particles, and activated-carbon sorbents.”¹⁸⁸

multiple declarations submitted by inventor John Pavlish. The examiner ultimately agreed to issue the claims in response, explaining:

For claims 2-19 and 22-28, as shown within the declarations, in flight promotion with HBr or Br promoters is more effective for mercury removal than treating the sorbent with HBr, Br or Br₂ outside the mercury-containing gas. Further the Nelson reference seems to teach away from in-flight promotion as it states that the bromide is extremely corrosive. Lastly one having ordinary skill in the art would not have looked to in-flight promotion because for the prior art the contact time between the bromine promoter and the activated carbon is about 15 min, while when the promoter is contacted with the activated carbon in-flight, the contact time is generally less than 10 s.
--

201. This same reasoning applies with respect to claims 17 – 20 of the '147 patent.

Those claims all require in-flight promotion which would have presented a POSITA with the same concerns about corrosion and contact time. Thus, the examiner's conclusion further indicates that Dr. Niksa has failed to present clear and convincing evidence of invalidity with respect to the '147 patent.

7.6. Response to Dr. Niksa's Downs-Halogenation Theories Against the '147 Patent

202. Dr. Niksa asserts various invalidity theories based on Downs-Halogenation, for which he attributes a prior art date of March 22, 2004. However, as explained above, the inventors conceived of, and reduced to practice, the claimed invention before that date. Accordingly, Dr. Niksa fails to show that the claims are anticipated or obvious based on theories involving Downs-Halogenation.

8. Secondary Considerations of Non-Obviousness

203. With respect to Dr. Niksa's obviousness theories, I have also considered whether any objective evidence of non-obviousness indicates that the claims at issue are not invalid.

[REDACTED]

considerations (referred to as objective evidence or secondary considerations) include: (1) a long felt but unmet need in the prior art that was satisfied by the claimed invention; (2) commercial success or lack of commercial success of products or processes covered by the claimed invention; (3) unexpected results achieved by the claimed invention; (4) praise of the claimed invention by others skilled in the art; (5) the taking of licenses under the patent by others; (6) deliberate copying of the claimed invention; and (7) failure of others to achieve the results of the claimed invention. I further understand that contemporaneous and independent invention by others is a secondary consideration supporting an obviousness determination.⁵¹

8.1. Commercial Success

204. The patented technology has experienced commercial success.

205. In 2015, ME2C reported \$12.6 million in revenue,⁵² which increased the next year to \$32.3 million in total revenue.⁵³ As explained in my opening report, this revenue is tied

⁵¹ Evidence regarding secondary considerations was previously submitted to the U.S. Patent & Trademark Office during prosecution of the '114 patent. *See generally* Ref. 64.

⁵² Ref. 262, Pg. 18:

Revenues <i>Sales</i> - We generally achieve revenues from product sales, equipment sales and demonstration and consulting services. We generated revenues of approximately \$12,632,000 and \$2,794,000 for the years ended December 31, 2015 and 2014, respectively. The increase during the year ended December 31, 2015 was primarily due to revenues from equipment sales of \$6,939,000 generated by the completion of nine equipment projects at customer sites. There were no such revenues from equipment sales generated in 2014. Revenues from product sales in the year ended December 31, 2015 increased from 2014 by \$2,577,000. These increases are primarily associated with products used during equipment commissioning activities at six customer sites along with ongoing sales to two plants that began MATS compliance in 2015. Product sales in 2014 were associated with testing and demonstrations as customers prepared to comply with state, provincial and federal regulations. These activities continued at many sites in 2015. We believe the increase in revenues which we achieved in 2015 of more than \$9,800,000 than the revenues realized in 2014 is a strong indication of the growth we expect going forward to meet our already contracted and future business.
--

⁵³ Ref. 263, Pg. 18:

[REDACTED]

to the patented invention; ME2C's revenue streams consist of sales of materials to implement the patented inventions and licensing of the patents themselves.⁵⁴ In addition, the patented technology has also experienced commercial success through Defendants' use of the technology to support its refined coal operations.

Revenues

Sales - We generated revenues of approximately \$32,346,000 and \$12,632,000 for the years ended December 31, 2016 and 2015. Total sorbent product sales for the year ended December 31, 2016 and 2015 were \$28,920,000 and \$5,028,000, respectively. These increases from the prior year were associated with the MATS compliance activities of our customers, which began in April 2016, with our all customers in operation by the end of the year.

Equipment sales for the years ended December 31, 2016 and 2015 were \$2,699,000 and \$6,939,000, respectively. Equipment sales during 2016 are primarily related to the commissioning of one customer project that included both a front end and back end product injection systems. In 2015, equipment sales were related to the completion of nine equipment projects at customer sites, one of which included both a front end and back end product injection system.

Other revenues for the years ended December 31, 2016 and 2015 were \$726,000 and \$664,000, respectively. This increase is primarily associated with increased consulting revenues earned at current and potential customers.

⁵⁴ Ref. 264, ¶¶ 76–77:

76. ME2C has implemented this technology by selling front end additives containing bromine and backend sorbents containing activated carbon. ME2C provides the front-end additives to be applied to pulverized coal⁴⁷ or injected into the boiler,⁴⁸ and it provides backend sorbents to be injected downstream of the boiler.⁴⁹ Each of ME2C's power plant customers also employ at least baghouses or ESPs to capture mercury. While they may adjust application rates from time to time based on mercury emission levels, they rely on daily application of these sorbents and additives to comply with mercury regulations. Those customers are:⁵⁰

77. For the same reasons that the directly infringing power plants in this case infringe by employing calcium bromide to coal and injecting activated carbon, ME2C's US⁵¹ customers have used the patented technology by using ME2C's front-end additives and back-end activated carbon sorbents.⁵²



206. It stands to reason that, if the patented inventions were obvious, they would have been commercialized long before ME2C did so given the pressing need for mercury removal technologies.

207. The fact that the MATS rule only became effective in 2015 (extended to 2016 for most power plants) does not change this conclusion, as several states had already adopted mercury control requirements which imposed similar restrictions upon coal-fired units in those states.⁵⁵

208. Thus, there was already a pre-existing demand for mercury control technology at least in those states, and if the inventions were obvious, it stands to reason that entities providing mercury control solutions to coal-fired power plants would have commercialized the patented inventions in the course of serving those units.

8.2. Long-Felt Need

⁵⁵ Ref. 265, Pg. 49, Lines 16–24:

16	Q	Did ME2C's business prospects improve after
17		the adoption of MATS?
18	A	Possibly.
19		We were growing strong prior to the actual
20		introduction of MATS.
21		Our initial client, for example, was
22		meeting state regulations.
23		But, overall, the industry improved
24		dramatically once MATS took effect.

[REDACTED]

209. In addition, my conclusion is that the patented inventions helped satisfy a long-felt need in the market for mercury control technology, further demonstrating the non-obviousness of the patented inventions.

210. In 1998, before the priority date of the Asserted Patents, the U.S. Environmental Protection Agency (EPA) issued a report to Congress in which the agency stated that it “ha[d] not identified any demonstrated add-on control technologies currently in use in the U.S. that effectively remove mercury from utility emissions.”⁵⁶

211. The report characterized activated carbon injection as a potential technology for mercury control, but noted the need for more research to determine its feasibility.⁵⁷

⁵⁶ Ref. 234:

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. (However, there may be add-on control technologies used in other source categories that effectively reduce mercury emissions.) Based on available data, total mercury removal by existing PM control devices on coal-fired utilities varies considerably, ranging from 0 to 82 percent removal (with a median efficiency of 15 percent removal) for cold-side electrostatic precipitators (ESPs), and from 0 to 73 percent removal (with a median efficiency of 8 percent removal) for fabric filters. Also, hot-side ESPs exhibited no mercury control. Existing flue gas desulfurization (FGD) units exhibit limited mercury control, ranging from 0 to 62 percent removal, with a median removal of 23 percent. The mercury

⁵⁷ Ref. 234, Section 13, Pgs. 40–41:

13.6.2.4 Activated Carbon Injection. Activated carbon (AC) injection is considered a potential control technology for mercury

[REDACTED]

212. These reports led to a significant increase in investment by government and industry organizations alike into researching potential mercury control technologies. These efforts largely focused on retrofit solutions which could be implemented at relatively low cost by the country's existing coal-fired power plants.⁵⁸

213. Among these was the U.S. Department of Energy (DOE), whose Office of Fossil Energy created the Innovations for Existing Plants (IEP) Program. The goal of Phases I & II of

emitted from electric utilities, since a form of this technology has been successfully demonstrated on medical waste incinerators and municipal waste combustors.⁸⁶⁻⁸⁹

The level of mercury control that might be achieved with AC injection into utility flue gas may depend upon flue gas characteristics such as temperature, chloride content (in the fuel), mercury content (in the flue gas), and the volume of flue gas. As shown in Table 13-14, these properties distinctly differ from those in MWC flue gas. In particular, mercury concentrations in MWC flue gas streams may be up to several orders of magnitude greater than those seen in utility flue gas streams.

Due to the differences between the flue gas characteristics at MWCs and utility units, the application of AC injection to utility flue gas has not been directly scaled from the application at MWCs. At utility plants, the small concentrations of mercury are contained in a large volume of flue gas, and large amounts of AC may be needed to provide adequate contact between the carbon particles and mercury. Pilot-scale studies of AC injection on utility flue gas have been conducted, but full-scale testing is needed to determine the feasibility of using AC at utility plants.

⁵⁸ Ref. 64, ¶ 6:

6. In the wake of these reports, various governmental and industry organizations injected millions of dollars into basic scientific research and experimental studies in the search for new mercury removal technologies.⁹ Because increased regulation of mercury emissions was expected to require significant upgrades to the country's fleet of coal-fired plants, much of the research focused on retrofit technologies that could be adopted at relatively low cost, including sorbent injection systems¹⁰.

[REDACTED]

the IEP was to fund the development of mercury control technologies capable of 50–70% mercury capture at well below the then-baseline cost of removal.⁵⁹

214. The inventors of the patented invention received funding through the IEP after presenting initial data showing potential removal efficiency of 50–90%, above and beyond the IEP’s target removal rate.⁶⁰

215. Given the intense search for mercury control technologies with acceptable efficacy rates at an acceptable cost, it stands to reason that, were the patented inventions obvious,

⁵⁹ Ref. 266, Pgs. 4–5:

MERCURY CONTROL TECHNOLOGY

The mercury control technology component of the IEP program is aimed at providing a broad suite of options to respond to future requirements to reduce mercury emissions from power plants. Currently there are 26 active projects, 14 involving field testing and 12 at the bench or pilot stage. Research is being carried out at the bench- and pilot-scale through field testing of promising technologies at operating power plants. The nearer-term objective is to develop mercury control technologies that achieve 50–70% mercury capture at less than three-quarters of the baseline cost estimate of \$50,000–70,000 per pound of mercury removed. The aim is for these technologies to be available for commercial demonstration by 2005 for bituminous coal plants and 2007 for lignite and subbituminous plants. The longer-term goal is to develop advanced mercury control technologies to achieve 90% or greater capture at the same cost reduction target and be available for commercial demonstration by 2010. The following is a brief summary of some of DOE/NETL’s current mercury control technology R&D projects.

⁶⁰ Ref. 64, ¶ 15:

15. The EERC obtained funding to test this theory in 2003 from the U.S. Department of Energy’s National Energy Technology Laboratory (DOE/NETL) under the Office of Fossil Energy’s Innovations for Existing Plants (IEP) Program.³⁰ The goal of Phases I and II of the program was development of Hg control technologies that could achieve 50 to 70% Hg capture at costs 25 to 50% less than the baseline 1999 estimate.³¹ Our initial pilot-scale tests suggested that our approach could achieve mercury removal efficiencies ranging from 50-90%. As a result, the EERC successfully obtained several multi-million-dollar awards under the program.³²

[REDACTED]

the U.S. government would not have invested in their development. Likewise, if the patented inventions were obvious, it stands to reason that the U.S. government would not have set its target efficacy rate at *below* the maximum rate already achieved in preliminary tests by the inventors.

216. Another long-running problem solved by the patented inventions concerns fly ash, one of the main byproducts of coal combustion by power plants. This ash is often sold by power plants to cement manufacturers. However, power plants which use activated carbon injection may be unable to sell their fly ash due to the effects of activated carbon injection on the ash, which often renders it unsuitable for use in cement manufacturing.⁶¹ This diminishes the financial viability of this important form of emissions control.

⁶¹ Ref. 204, Pg. 219, Lines 20–21, Pg. 220, Lines 2–14:

20	Q. How does activated carbon
21	affect the saleability of fly ash?

[REDACTED]

217. The patented inventions, however, reduce fly ash contamination by reducing the amount of activated carbon necessary to comply with mercury regulations, allowing power plants making use of the patented inventions to sell fly ash to cement manufacturers. This solves an additional long-felt need on the part of power plant operators who inject activated carbon for mercury control.

8.3 Teaching Away and Skepticism

218. In addition, my conclusion is that the patented inventions teach away from the conventional wisdom as of the priority date, further evincing their non-obviousness.

219. In 2002, the EPA surveyed, and published a report on, the state of mercury control technologies.⁶² While this report made note of then-recent findings regarding the use of

2	A. It has something to do with the
3	-- the activated carbon changes the
4	characteristic of the fly ash in the
5	cement, because that's generally flashes
6	used as a significant percentage, I guess,
7	of cement. So it's added to cement dust or
8	cement -- Portland cement to make your
9	concrete or whatever for your roads. And
10	there's a -- I think there's a spec that
11	each state has on like the tensile strength
12	of the concrete. And I think that's where
13	it gets into why it can't be sold, it won't
14	meet that spec.

⁶² Ref. 267.

halogen-treated sorbents,⁶³ the report primarily explored research into methods of pre-treating sorbents with halogens such as sulfur, iodine, or chlorine, before injecting the treated sorbents downstream from the boiler.⁶⁴ Doing so ensures that the sorbent additives are able to actually react with the sorbents—as opposed to being absorbed by other chemicals that might be present in the boiler—as well as to ensure that the reaction occurs quickly enough that the sorbent, upon

⁶³ Ref. 267, Pg. ES-8:

Chemical adsorption (chemisorption) involves the establishment of a chemical bond (as the result of a chemical reaction, electron transfer). Chemisorption results in stronger bonds than physisorption and is not necessarily reversible. Chemical adsorption is also dependent on the presence of chemically active sites where the sorbate is chemically bound. Some of the chemical constituents of activated carbons influencing Hg capture include: sulfur content, iodine content, and chlorine content. Impregnation of carbons with sulfur, iodine, or chlorine can increase the reactivity and capacity of sorbents. Hg⁰ is likely oxidized and sorbed in a rapid two step reaction, either chemically by reaction with strong ionic groups such as Cl⁻, I⁻, or S⁼ or physically through interaction with functional groups in sorbent pores.

⁶⁴ Ref. 267, Section 5, Pgs. 33–34:

Activated carbon duct injection seems to be the most promising Hg control technology for coal-fired electric utility boilers equipped with ESPs. In this technology, the injected activated carbon removes Hg only while contacting the flue gas during very limited sorbent/gas contact time (<3 seconds). Prior investigations have shown that very high, and rather costly, carbon-to-Hg weight ratios (>50,000) are needed to achieve adequate Hg removal. In order to reduce the operating cost of the carbon injection process, either a more efficient sorbent that can operate at a lower carbon-to-Hg weight ratio or a lower-cost activated carbon (or possibly both) are required. In this study³³, a cost-effective Cl-impregnation process was successfully implemented on an inexpensive virgin activated carbon. The Cl-impregnated carbon was produced in a 5 pound large batch, and its in-flight Hg⁰ removal efficiency was evaluated in a flow reactor (as previously discussed in Section 5.4.2.1) with gas/solid contact times of 3 to 4 seconds. The Hg⁰ removal efficiency of more than 80 percent was obtained in a flue gas containing the effluent of natural gas combustion doped with coal combustion levels of NO_x and SO₂ at carbon-to-Hg weight ratios of about 3000. Hg⁰ removal was rather insensitive to the adsorption temperature in the range of 100-200 °C. Cost analysis showed that this Cl-impregnation process can produce a very active and cost-effective activated carbon that can be used as a practical sorbent in a duct injection control technology in ESP-equipped coal-fired electric utility boilers. Preliminary cost estimates indicated that approximately 53 percent reduction of the total annual cost of Hg control could be possible when using Cl-impregnated FGD in lieu of virgin activated carbon. Future investigations would be focused on evaluating the Cl-impregnated activated carbon in a pilot-scale, 21-kW (90,000-Btu/hr) refractory-lined, furnace fired with pulverized coal.³³

[REDACTED]

injection, is quickly able to react with the mercury it is being used to absorb (given that the sorbent only spends a few seconds in contact with the gas).⁶⁵

220. Thus, the EPA's report reflected the general understanding that halogens used as sorbent additives should be mixed with the sorbents before they are brought into contact with mercury-containing flue gas.

221. The EPA issued yet another report in 2005 which recognized the benefits of brominated sorbent use⁶⁶ and which noted that halogenated sorbent additives had been added to

⁶⁵ Ref. 64, ¶ 8:

8. Notably, the EPA did not recommend in-flight sorbent enhancement in the flue gas by spraying additives on coal or injecting halogens into the boiler. Rather, it described research into methods for *pre-treating* sorbents with various additives, including chlorine, and then injecting those pre-treated sorbents downstream from the boiler.¹⁵ This approach ensured that, e.g., chlorinating agents could react with the sorbent material without being "scavenged" by other chemicals present in the boiler. 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.¹⁶ This is consistent with the general understanding in the industry that sorbent additives such as halogens or halides should be mixed with sorbents *before* coming in contact with mercury-containing flue gas.

⁶⁶ Ref. 268, Pgs. 18–21 (2005):

coal in conjunction with the injection of activated carbon sorbents into the flue gas to remove mercury.⁶⁷ Despite this, the report primarily emphasized injection of pre-treated halogenated activated carbon.

8.4 Copying

222. In addition, copying of the patented inventions speaks to the non-obviousness of the patented inventions and their inventive features.

Some situations, described above, may not have adequate chlorine present in the flue gas for good mercury capture by standard PAC. Accordingly, halogenated PAC sorbents have been developed to overcome some of the limitations associated with PAC injection for mercury control in power plant applications.^{27, 28} Two different halogenated PAC sorbents have been tested in field tests. They are Sorbent Technologies Corp. brominated-PAC (B-PAC) and Norit America's halogenated PAC (E-3).

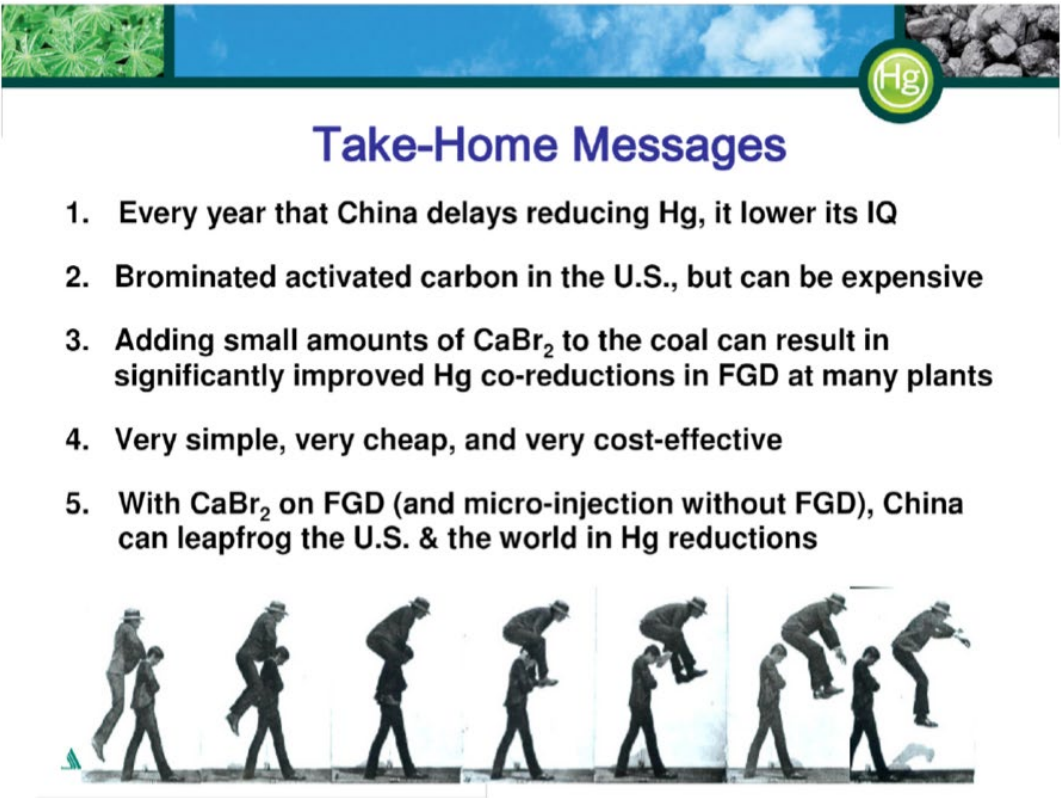
Halogenated PACs offer several potential benefits. Relative to standard PAC, halogenated PAC use: (1) may expand the usefulness of sorbent injection to many situations where standard PAC may not be as effective; (2) may avoid installation of downstream FF, thereby improving cost-effectiveness of mercury capture; (3) would, in general, be at lower injection rates, which potentially will lead to fewer plant impacts and a lower carbon content in the captured fly ash; (4) may result in somewhat better performance with low-sulfur (including low-rank) coals because of less competition from SO₃; and (5) may be a relatively inexpensive and attractive control technology option for developing countries as it does not involve the capital intensive FF installation.

⁶⁷ Ref. 268, Pg. 22:

As discussed in the previous sections, chlorine plays an important role in facilitating the capture of Hg⁰ on sorbent. For low-rank fuels in particular, there may not be adequate chlorine to achieve high Hg⁰ capture efficiency with PAC. Use of halogenated PAC sorbents comprises one approach. Another is to inject a chemical into the fuel, or into the gas stream, to provide the halogens needed for high sorbent capacity. At the 220 MW Leland Olds plant firing lignite coal and equipped with CS-ESPs, a Sorbent Enhancement Additive (SEA) has been tested. SEA, a fuel additive, was added between the feeders and pulverizers. For the field tests, average baseline mercury removal was 18% and the objective was to determine the treatment regimen to reach 55% removal. A one month test with SEA and PAC showed that a 63% mercury removal rate was achieved over the period.³⁸ Therefore, as an alternative to more expensive sorbents, it may be possible to use standard PAC, or even less expensive sorbents, along with an additive, when such additives are broadly available.

223. Sidney Nelson, author of the Nelson reference relied upon by Dr. Niksa, himself evinced this during a presentation titled “How China Can Leapfrog the World in Mercury Emission Reduction.” During this presentation, he stated that, while pre-treated sorbents were accepted in the U.S., he recommended the use of in-flight sorbent enhancement in the flue gas by Chinese operators,⁶⁸ basing this recommendation on data collected by the EERC in 2006.⁶⁹

⁶⁸ Ref. 269, Slide 24:



Take-Home Messages

1. Every year that China delays reducing Hg, it lower its IQ
2. Brominated activated carbon in the U.S., but can be expensive
3. Adding small amounts of CaBr_2 to the coal can result in significantly improved Hg co-reductions in FGD at many plants
4. Very simple, very cheap, and very cost-effective
5. With CaBr_2 on FGD (and micro-injection without FGD), China can leapfrog the U.S. & the world in Hg reductions



⁶⁹ Ref. 269, Slide 20:

224. The company which acquired Nelson's company and patent, Albemarle, one of the world's largest bromine suppliers, not only sells brominated carbon sorbents but also materials and systems for in-flight sorbent enhancement in the flue gas.⁷⁰



Luminant Monticello Station

TX Lignite/PRB & LSFO + KNX™ CaBr₂
- CaCl₂ not work, but CaBr₂ did:



- Results of long-term test (FGD outlet vs. average coal Hg)
 - Baseline: 10%–40% removal
 - 55 ppm Br in coal: 65% removal
 - 113 ppm Br in coal: 86% removal
 - 330 ppm Br in coal: 92% removal

30% → 85% with ~100 ppm

Benson, EERC, Richardson, URS, et al., "Large-Scale Mercury Control Technology Testing for Lignite-Fired Utilities – Oxidation Systems for Wet FGD," DOE NETL Hg Control R&D Program Review, 2006.

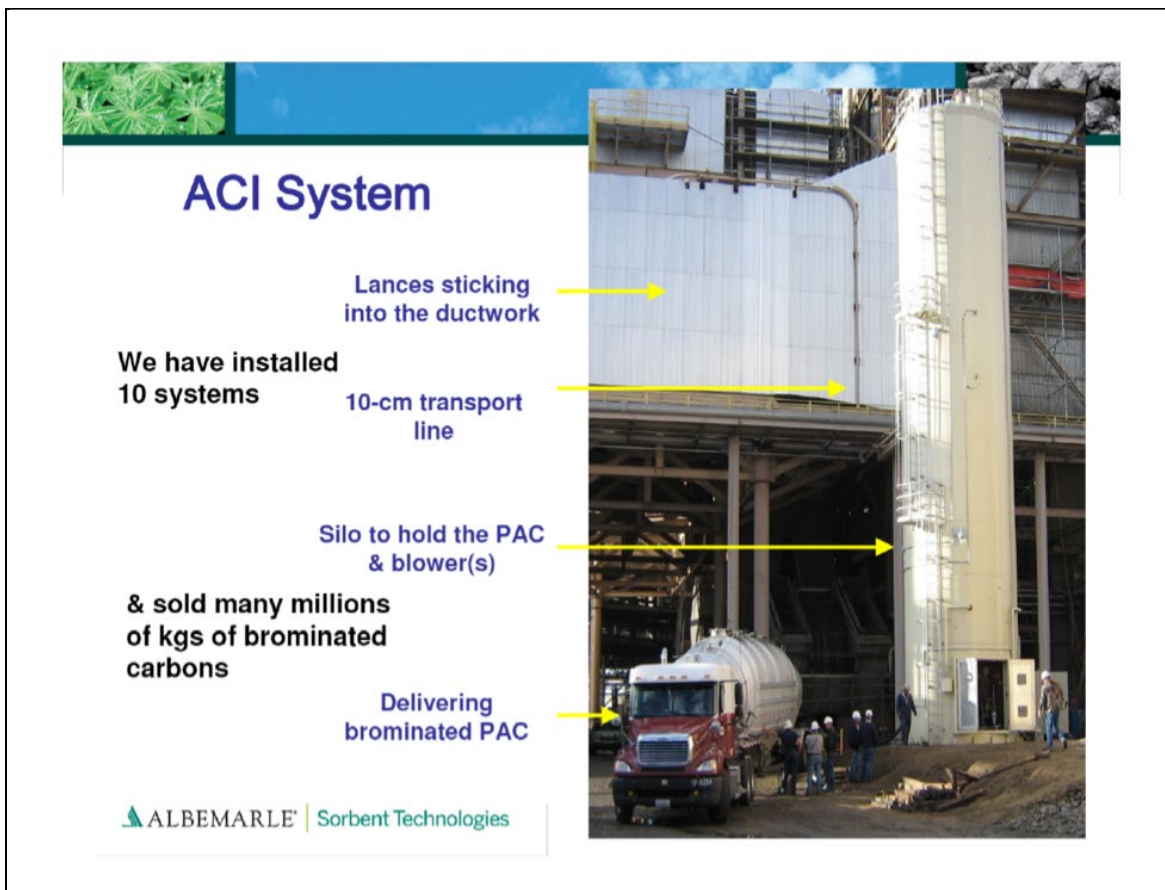
⁷⁰ Ref. 269, Slide 11:

8.5 Recognition of the Patented Inventions as a Critical Advance

225. In addition, the recognition of the patented inventions' success as a critical advance in the field of emissions control further evinces the inventions' nonobviousness.

226. In addition to Nelson, others in the field have recognized the patented inventions' importance. In 2008, the DOE published a report entitled "Success: Sorbent Additive Technology for Mercury Control," which discussed the patented inventions' advantages over conventional approaches to mercury control technology.

227. This 2008 report specifically highlighted several advantages of the patented inventions, including the inventions' ability to achieve up to mercury capture efficiency of up to



90%—versus standard activated carbons which are limited to around 60% efficiency—doing so while using smaller quantities of, and more abundantly available forms of, activated carbon.⁷¹

9. Response to Dr. Niksa's § 112 Theories

9.1. Dr. Niksa Has Failed to Show that '147 Claim 17 Lacks Written Description

228. According to Dr. Niksa:⁷² “Claim 17 of the '147 patent requires the step of “injecting separately the bromine containing promoter into a gas stream.” I understand that under the Plaintiff's theory of infringement, that step is met by combusting a mixture of coal and a bromine additive. I have reviewed the specification of the '147 patent, and there is no description of combusting a mixture of coal that has been pretreated with a bromine additive.”

⁷¹ Ref. 270, Pg. 2:

To overcome this limitation, the EERC developed a sorbent enhancement additive (SEA) technology that significantly improves the reactivity of AC, thereby making it much more effective at capturing both elemental and oxidized forms of mercury. The technology can also improve native capture by existing fly ash and can improve oxidation for subsequent removal by downstream SO₂ control systems.

The following are some key advantages that EERC-developed SEA technology offers:

- Improves native mercury removal by fly ash.
- Improves mercury oxidation, which can improve capture in downstream equipment.
- Allows use of more abundantly available supplies of AC (treated ACs have limited supply).
- Improves mercury capture while using far less AC.
- Improves mercury capture efficiencies, in some instances, to greater than 90 percent (standard ACs can be limited to around 60 percent).
- Allows for performance and cost optimization of SEA and AC at each site.
- Minimizes ESP particulate and opacity problems by using lesser amounts of AC.
- Minimizes fabric filter particulate emissions and pressure drop, while allowing the unit to operate at maximum load, by using lesser amounts of AC.

Through significant testing at many power plant test sites, the SEA technology has consistently shown that significantly less AC can be used when combined with SEAs, providing better economics and fewer potential balance-of-plant impacts. In most cases, the amount of AC can be decreased by a factor of 2–4, yet provide higher levels of mercury capture. The SEAs are abundant and affordable, resulting in improved economics as compared to using high injection rates of AC or commercially available treated carbons.

⁷² Ref. 239, Pg. 323.

[REDACTED]

229. I understand that when conducting a written description analysis, the proper approach is to compare the claims to the patent's specification and figures, not to compare the claims to the accused conduct. Accordingly, Dr. Niksa's analysis is in error.

230. The specification of the '147 patent does disclose this limitation. For example, Figure 3 depicts activated carbon reservoir 110, halogen reservoirs 120 and 130, and injection point 116 where these materials are injected into a gas stream. See figure 3:



of the present invention.”). This multiple injection point embodiment satisfies the requirement of “injecting separately the bromine containing promoter into a gas stream.”

232. Figure 1 also discloses activated carbon 10 can be injected through multiple different pathways into flue gas 50, and also that promoter located at 20 or 40 can be provided to the flue gas through multiple pathways:

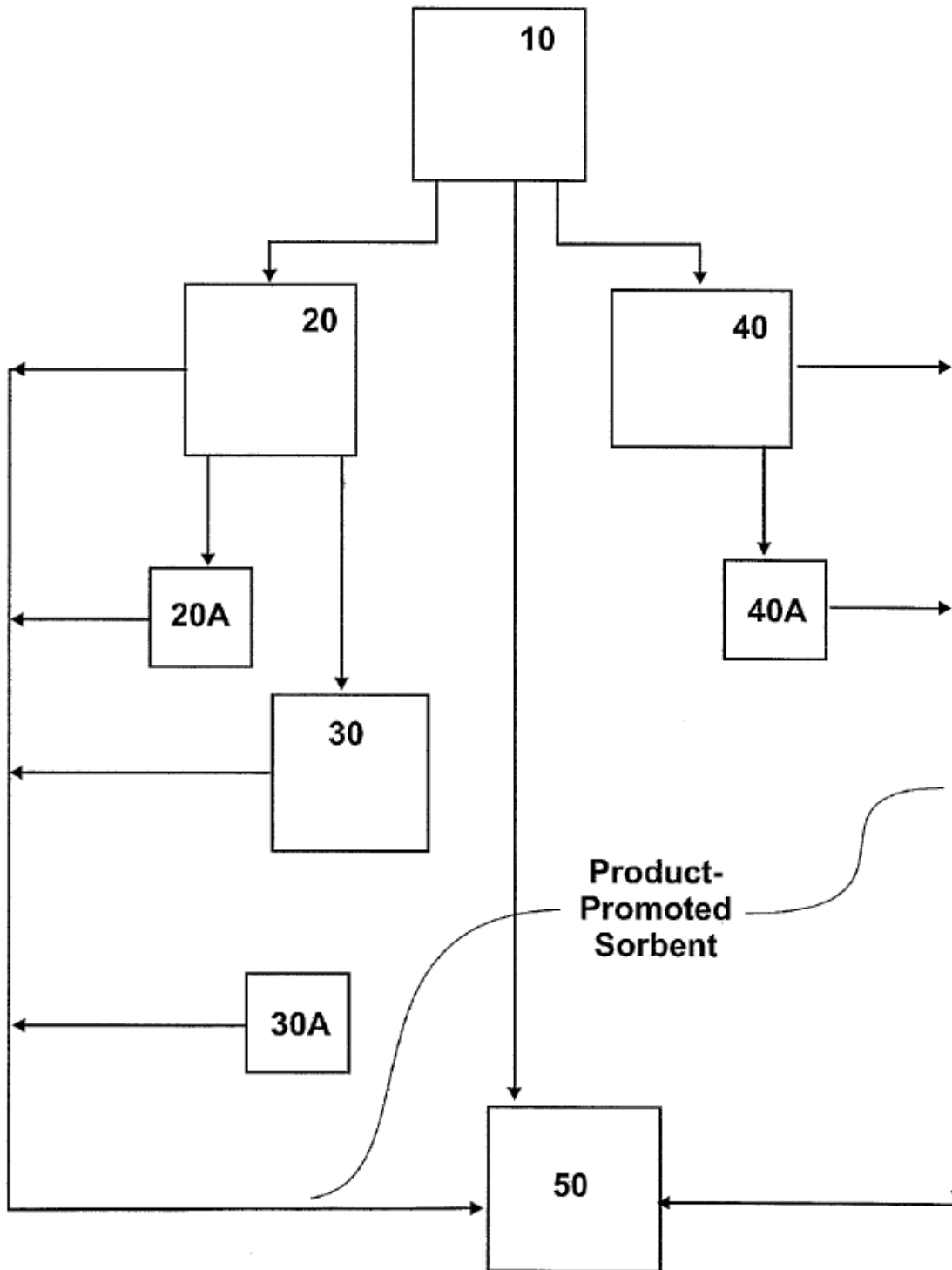


FIG. 1

[REDACTED]

233. Dr. Niksa states that the middle line in this figure depicts promoted activated carbon sorbent being injected from 10 to flue gas 50.⁷³ However, this is incorrect, box 10 refers to un-promoted (“base”) activated carbon sorbent.⁷⁴ Dr. Niksa also states that a POSITA would assume that when activated carbon passes from box 10 to flue gas 50, no other promoter would be added to the flue gas. However, he identifies no statement in the specification that would limit the embodiment in such a way. Rather, a POSITA would understand that the activated carbon could still be promoted using a promoter as described throughout the specification.

9.2. Dr. Niksa Has Failed to Show that ’147 Claim 17 Is Not Enabled.

234. According to Dr. Niksa, the ’147 patent fails to enable a POSITA to practice the following limitation:

(a) promoting at least a portion of a particulate sorbent material comprising activated carbon by chemically reacting the sorbent material with a bromine containing promoter to form a promoted brominated sorbent, wherein the bromine containing promoter is in gaseous form, vapor form, or non-aqueous liquid form, and wherein the activated carbon contains graphene sheets having carbene species edge sites which react with the bromine containing promoter to form a carbocation paired with a bromide anion in the promoted brominated sorbent for oxidation of the mercury.

235. In particular, Dr. Niksa equates this limitation with heterogenous oxidation of mercury, rather than homogeneous oxidation. For example he states: “*Since Claim 1 describes only a heterogeneous mercury reaction process on promoted PAC, the teaching of the ’147 patent does not instruct a POSA how to ensure or determine that the claimed heterogenous path*

⁷³ Ref. 239, Pgs. 163 – 167.

⁷⁴ Ref. 6, Col. 6, Lines 44 – 48:

form a gasification system streams. In a preferred embodiment illustrated by path 10-20, block 10 illustrates providing a base activated carbon, and adding a halogen or halide promoter that reacts with the carbon, illustrated at block 20, to produce a product promoted carbon sorbent. In embodiments

happens instead of the homogenous path.” However, the claims of the ’147 patent do not require that heterogeneous oxidation happen “instead of” homogeneous oxidation.

236. The ’147 patent provides a chemical model to explain this limitation:⁷⁵

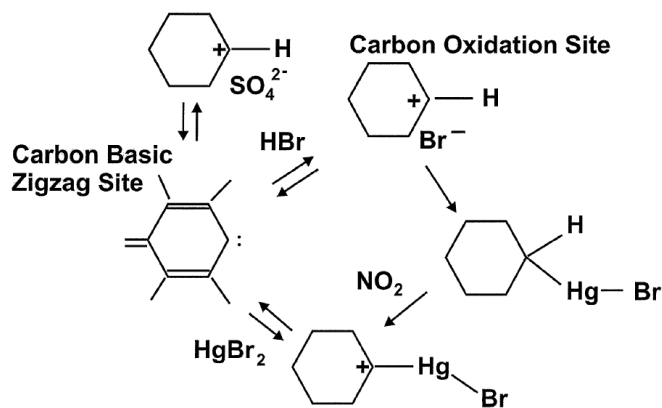


FIG. 2

Referring now to FIG. 2, there is illustrated a theory developed from scientific evidence to explain the nature of the promoting compounds. For example, as illustrated in FIG. 2, hydrogen bromide reacts with the unsaturated structure of the activated carbon. This may be, by way of illustration only, a carbene species on the edge of the graphene sheet structures of the carbon. Molecular bromine or a bromine compound

⁷⁵ Ref. 6, fig. 2, Col. 7, Line 61 – Col. 8, Line 20.

reacts to form a similar structure, with a positive carbon that is active for oxidizing the mercury with subsequent capture by the sorbent.

It has now been found that the formation of the new bromide compound with carbon increases their reactivity toward mercury and other pollutants. Additionally, the resulting bromide compound is uniquely suited to facilitate oxidation of the mercury. The effectiveness of the oxidation apparently results from the promotion effect of the halide, exerted on the developing positive charge on the mercury during the oxidation, known in the chemical art as a specific catalytic effect. Thus, as the mercury electrons are drawn toward the positive carbon, the halide anion electrons are pushing in from the other side, stabilizing the positive charge developing on the mercury and lowering the energy requirement for the oxidation process. Bromide is especially reactive, owing to the highly polarizable electrons in the outer 4p orbitals of the ion. Thus, adding HBr or Br₂ to the carbon forms a similar carbon bromide, in which the positive carbon oxidizes the mercury with the assistance of the bromide ion.

237. The description of this chemical model does not limit the occurrence of this heterogeneous reaction to specialized embodiments. And as explained in my opening report (see claim chart for '147 patent) work by the inventors and others has demonstrated that this reaction does occur.

238. Moreover, I understand that a proper enablement analysis requires consideration of the "*Wands*" factors. These factors include: (1) the quantity of experimentation necessary; (2) the amount of direction or guidance presented; (3) the presence or absence of working examples; (4) the nature of the invention; (5) the state of the prior art; (6) the relative skill of those in the art; (7) the predictability or unpredictability of the art; and (8) the breadth of the claims. Because Dr. Niksa has not provided an analysis of these factors, he has not presented clear and convincing evidence of invalidity.

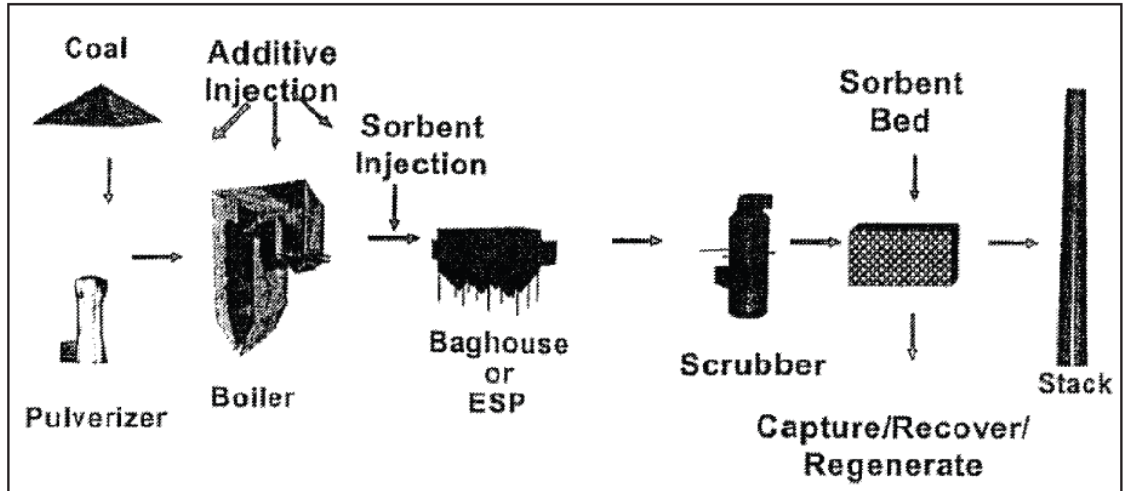
[REDACTED]

239. Moreover, there is evidence indicating that these factors weigh in favor of finding the patents not invalid. As explained above, the patents provide a chemical model related to this limitation, and they also include numerous examples to explain how to implement the invention. A POSITA could simply follow these examples to achieve the claimed heterogeneous reaction, with reasonably low requirements for experimentation. Moreover, while the idea of mixing bromine additives and activated carbon in flight for mercury capture, was novel and contrary to the conventional wisdom, once a POSITA is informed of that idea, the implementation of that method is fairly straightforward. For example, a POSITA would be fully capable of adding bromine additive and activated carbon separately for mercury capture as this would require only the use of straightforward mechanical components.

9.3. Dr. Niksa Has Failed to Show that the '114, '225, '517 and '430 Patents Lack Written Description With Regard to Adding Bromine to Coal

240. According to Dr. Niksa, each of the '114, '225, '517 and '430 patents lack sufficient written description of the addition of a bromine species to the coal upstream (or before) the combustion chamber. Specifically, Dr. Niksa opines that Figure 6 of the '114 patent (which is Figure 11 of the '430 and '517 patents) fails to show the addition of bromine to coal.

241. This is the same argument Dr. Niksa raised with regard to priority date, and I address it above. As explained above, the figures and description in the provisional application disclose this limitation, and that same material is included in the specifications of the '114, 430, and '517 patents. For example, they each include the same figure and description of bromine additive that can be added before, after, or within the boiler:



'114 Patent at 29:60 – 30:4:

FIG. 6 is a block diagram illustrating the use of the invention in a coal fueled facility. Of course, the invention can also be used in any other desired type of facility. FIG. 6 shows a boiler for burning pulverized coal. The facility utilizes various devices to clean the exhaust of the boiler. In this example, a baghouse or ESP is used to collect particulates in the exhaust. A scrubber and sorbent bed are also used to remove undesired constituents from the flue gas stream, before being fed to the stack. In the example shown, the sorbent is injected into the flue gas after the boiler. The additive can be injected where desired (e.g., before, after, or within the boiler).

'430 Patent at 32:32- 32:43:

FIG. 11 is a block diagram illustrating the use of the invention in a coal fueled facility. Of course, the invention can also be used in any other desired type of facility. FIG. 11 shows a boiler for burning pulverized coal. The facility utilizes various devices to clean the exhaust of the boiler. In this example, a baghouse or ESP is used to collect particulates in the exhaust. A scrubber and sorbent bed are also used to remove undesired constituents from the flue gas stream, before being fed to the stack. In the example shown, the sorbent is injected into the flue gas after the boiler. The additive can be injected where desired (e.g., before, after, or within the boiler).

'517 Patent at 32:50 – 32:61:

FIG. 11 is a block diagram illustrating the use of the invention in a coal fueled facility. Of course, the invention can also be used in any other desired type of facility. FIG. 11 shows a boiler for burning pulverized coal. The facility utilizes various devices to clean the exhaust of the boiler. In this example, a baghouse or ESP is used to collect particulates in the exhaust. A scrubber and sorbent bed are also used to remove undesired constituents from the flue gas stream, before being fed to the stack. In the example shown, the sorbent is injected into the flue gas after the boiler. The additive can be injected where desired (e.g., before, after, or within the boiler).

242. The '225 patent does not contain this identical disclosure, but it does contain similar disclosure of using the inventive sorbent before, after, or within the boiler:

'225 Patent at 20:26 – 20:35:

In this example, a baghouse (fabric filter) or ESP was used to collect particulates in the exhaust of a full-scale commercial pulverized coal-burning facility. A scrubber and sorbent bed were also used to remove undesired constituents from the flue gas stream, before being fed to the stack. In this example, the halogen/halide promoted carbon sorbent was injected into the flue gas after the boiler. In general however, the inventive sorbent can be injected where desired (e.g., before, after, or within the boiler).

243. A POSITA would recognize that this would include combining the inventive sorbent, i.e., bromine and sorbent, with coal. Accordingly, Dr. Niksa has failed to show lack of written description on this ground.

9.4. Dr. Niksa Has Failed to Show that the '225 Claims Lack Written Description with Regard to Pyrolysis Char Limitations.

244. According to Dr. Niksa, the '225 patent fails to provide written description for the limitation: “combusting a mixture comprising coal, pyrolysis char, and a [bromine] additive.”

[REDACTED]

245. However, as noted above, the '225 patent discloses mixing the inventive sorbent with coal.⁷⁶ It also discloses that the inventive sorbent may contain pyrolysis char and halogen, e.g., bromine.⁷⁷ Thus, it discloses combusting a mixture of coal, pyrolysis char and bromine additive.

246. Dr. Niksa contends that the pyrolysis char present in the combustion chamber would have limited utility, but that does not change the fact that the patents provide written description of this limitation.

247. In addition, as explained in my opening report, coal combustion naturally produces some unburnt carbon referred to as pyrolysis char. Dr. Niksa agrees that this unburnt carbon is produced.⁷⁸ When discussing this § 112 theory of invalidity, he contends that he would not refer to that carbon as pyrolysis char. However, elsewhere in his report he states: “I agree with Defendants that some pyrolysis char inevitably will be formed whenever coal is being

⁷⁶ Ref. 8, Col. 20, Lines 26 – 35 (describing adding the inventive sorbent before or within the boiler).

In this example, a baghouse (fabric filter) or ESP was used to collect particulates in the exhaust of a full-scale commercial pulverized coal-burning facility. A scrubber and sorbent bed were also used to remove undesired constituents from the flue gas stream, before being fed to the stack. In this example, the halogen/halide promoted carbon sorbent was injected into the flue gas after the boiler. In general however, the inventive sorbent can be injected where desired (e.g., before, after, or within the boiler).

⁷⁷ Ref. 8, Col. 2, Lines 56 – 66:

In an embodiment, a promoted carbon sorbent is provided wherein the base activated carbon is selected from the group consisting of powdered activated carbon, granular activated carbon, carbon black, carbon fiber, aerogel carbon, pyrolysis char, activated carbon with an average particle size greater than that of flyash produced such that it is physically separable therefrom, and combinations thereof, and the promoter is selected from the group consisting of molecular halogens, Group V (CAS nomenclature is used throughout) halides, Group VI halides, hydrohalides, and combinations thereof. In an embodiment, the base activated carbon may

⁷⁸ Ref. 239, Pg. 327.

[REDACTED]

combusted.”⁷⁹ In short, coal combustion produces pyrolysis char even if Dr. Niksa would use a different name to describe it.

248. Because production of pyrolysis char from coal combustion would be well known to a POSITA, a POSITA would understand that when the inventors describe combusting coal with added bromine, this will also necessarily involve combustion of coal with added bromine and pyrolysis char.

249. Dr. Niksa also contends that dependent claims reciting “promoted pyrolysis char” lack written description because pyrolysis char in the combustion zone would be too hot to react with bromine. However, this reaction could occur downstream of the combustion zone.

9.5. Dr. Niksa Has Failed to Show that the ’225 Claims Are Not Enabled.

250. According to Dr. Niksa, a POSITA would not be enabled to practice the claims of the ’225 patent because the POSITA would not know the role of pyrolysis char in mercury capture with the invention. However, I understand that the enablement requirement does not require an inventor to explain the scientific principles that cause an invention to work, rather, it only requires that the patent disclosure enable a POSITA to practice the invention as claimed.

251. Again, Dr. Niksa fails to analyze the *Wands* factors related to enablement. Regardless, a POSITA would understand and be able to practice the claims either by adding pyrolysis char to coal or by recognizing that the combustion of the coal will produce pyrolysis char.

10. Response to Dr. Niksa’s Statements Regarding Inequitable Conduct

252. I understand that Defendants have alleged that the patent applicants, including the inventors, committed “inequitable conduct” during prosecution of the applications that led to the

⁷⁹ Ref. 239, Pg. 535.

[REDACTED]

asserted patents. I understand that inequitable conduct requires a finding that applicants misrepresented or omitted material information to the patent office, and that they did so with an intent to deceive. I have reviewed Dr. Niksa's opinions related to inequitable conduct and provide my response below.

253. Dr. Niksa's opinions suffer from a misunderstanding of the difference between inherent and explicit disclosure in a prior art reference. I understand that a prior art reference explicitly discloses a limitation if it actually describes the limitation such that a POSITA would be able to practice the claimed invention. I understand that even if a prior art reference does not explicitly disclose all limitations of a claim, it could nonetheless still invalidate the claim if the undisclosed limitation is "inherent" in the prior art reference. A limitation is inherent in a prior art reference if the product, process, etc. disclosed in the prior art reference would necessarily result in the limitation at issue.

254. Dr. Niksa explains that, in 2011, the patent examiner allowed the applicants to overcome a rejection of their patent claims over the Nelson reference because the Nelson reference *"does not disclose the activated carbon being graphene sheets and the binding sites being carbene species edge sites."* According to Dr. Niksa, *"That statement was not correct, and persons of knowledge in the field would have known at the time that it was not correct."*⁸⁰

255. Dr. Niksa does not explain the basis for this opinion. For example, he fails to identify any statement in Nelson that the activated carbon at issue contains graphene sheets or binding sites being carbene edge sites. I have reviewed Nelson and found no such statement. Dr. Niksa appears to argue that, while Nelson does not explicitly disclose that activated carbon contains graphene or that the binding sites would be carbene species edge sites, a POSITA would

⁸⁰ Ref. 239, Pg. 1119.

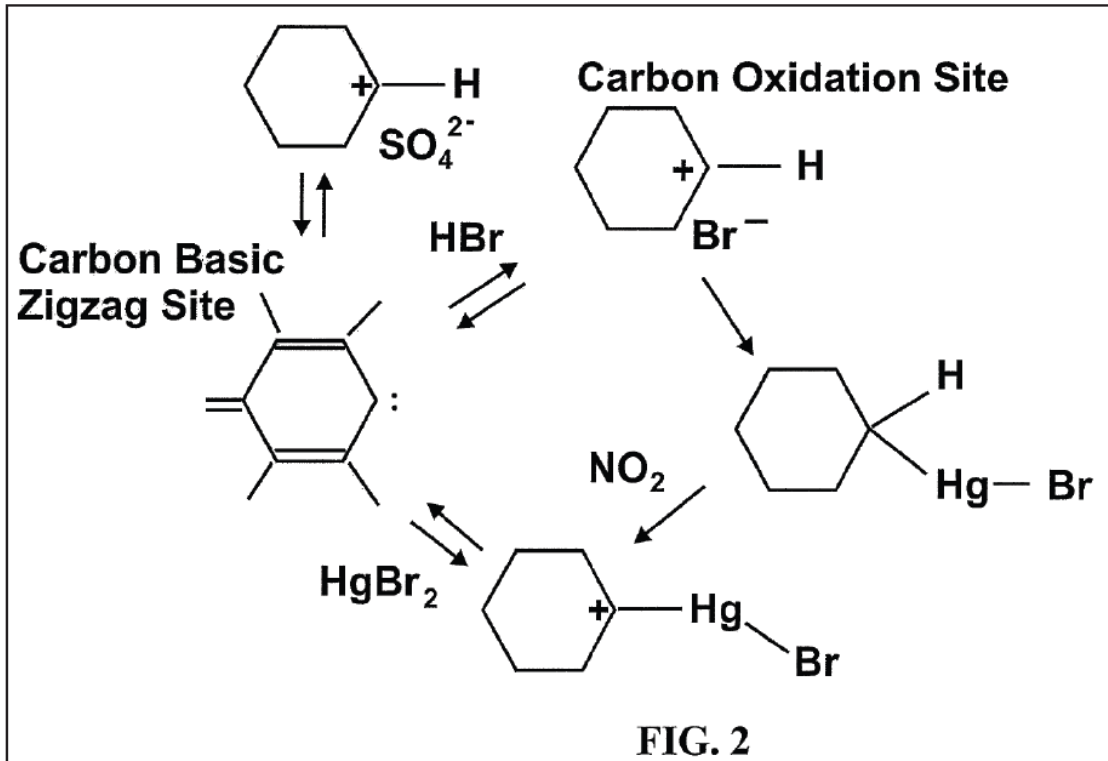
[REDACTED]

nonetheless be aware that activated carbon inherently contains graphene and carbene species edge sites. For example, Dr. Niksa states: *“it was proposed since at least the 1980s that activated carbon (at least in a clean laboratory setting) has graphene sheets having carbene species edge sites. Thus, the inventors of the ’147 patent were just describing a property of graphene that had been theorized decades earlier to those of skill in the art.”*⁸¹ Dr. Niksa contends that this inherent fact about activated carbon was both known in the art since the 1980s, but also not disclosed to the patent office.

256. That is incorrect, the application for the ’147 patent discloses these facts about activated carbon. For example it states:

Referring now to FIG. 2, there is illustrated a theory developed from scientific evidence to explain the nature of the promoting compounds. For example, as illustrated in FIG. 2, hydrogen bromide reacts with the unsaturated structure of the activated carbon. This may be, by way of illustration only, a carbene species on the edge of the graphene sheet structures of the carbon. Molecular bromine or a bromine compound reacts to form a similar structure, with a positive carbon that is active for oxidizing the mercury with subsequent capture by the sorbent.

⁸¹ Ref. 239, Pg. 623.



257. Note that neither figure 2, nor the passage above states that graphene or carbene species edge sites are a feature of some unique form of activated carbon, rather, they disclose that these are general features of activated carbon. Moreover, the specification refers to NORIT FGD as a type of activated carbon that can be used with the invention.

258. Thus, Dr. Niksa claims that the applicants withheld the information necessary for the patent examiner to issue a rejection based on “inherent” disclosure of the claimed invention in Nelson. However, all of the information that Dr. Niksa identifies as being withheld was already known in the art and actually provided to the examiner. Thus, I disagree that Dr. Niksa has shown that an individual involved in the prosecution of the '147 patent withheld or misrepresented material information.

[REDACTED]

259. In section 6 of my opening report regarding infringement of the patents-in-suit I identified evidence of activated carbon use at various power plants. I understand that additional evidence has been produced regarding activated carbon use at the Big Cajun II plant that was not available at the time I prepared my opening report. This evidence includes the November 2022 declaration of Jack Grant and accompanying records. That evidence confirms the use of activated carbon use at Big Cajun II on a monthly basis.⁸²

260. If called upon to testify at trial, I expect to prepare additional demonstrative materials reflecting the opinions in this report. In doing so, I may rely upon documents identified in this report.

EXECUTED ON: 12-20-2022


Philip J. O'Keefe, PE

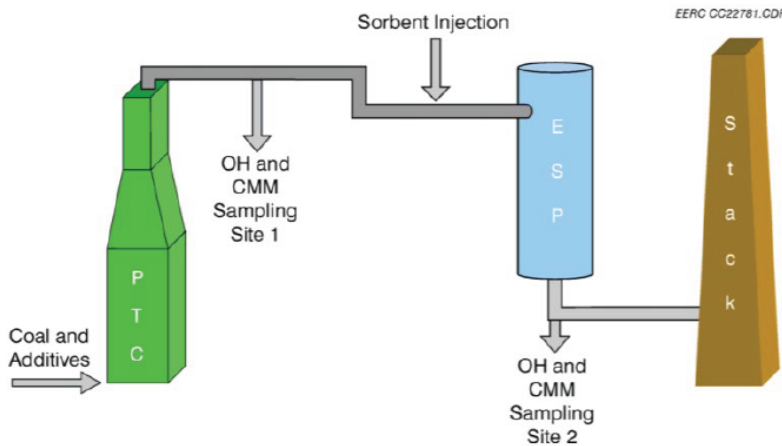
⁸² CLECO0001 – 0003.

Appendix A - Claim Charts

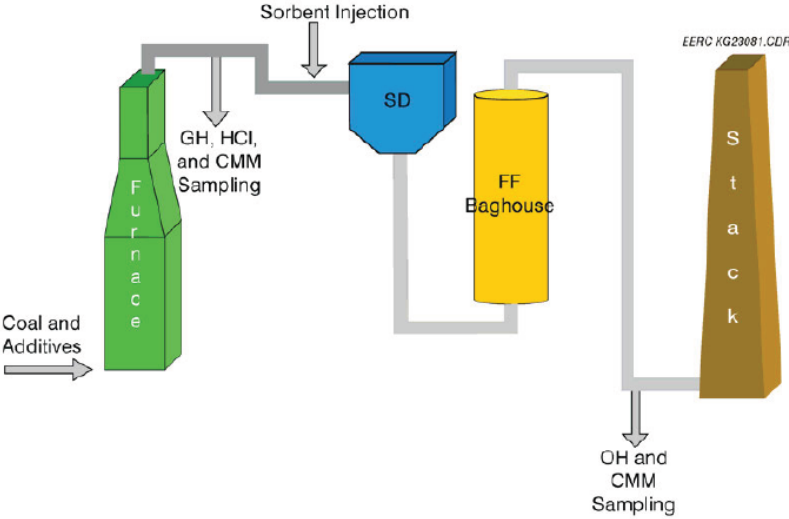
The '114 Patent to Olson

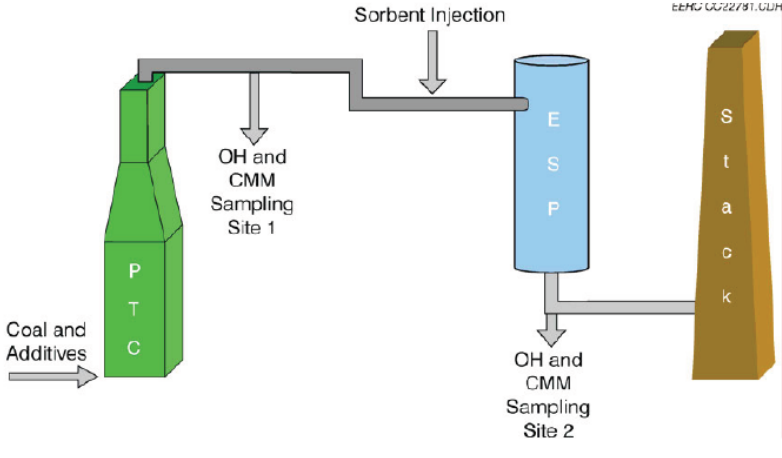
No.	'114 Claim Element	Evidence of Reduction to Practice
1a	A method of separating mercury from a mercury-containing gas, the method comprising:	The Feb. 2004 Report describes the September 2003 testing (Ref. 246, Pg. 10): The pilot-scale test was started on September 8, 2003, and was completed on September 19, 2003. A 550,000-Btu/lr 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 <i>Advanced Hybrid™</i> filter and are summarized under Task 4 Results and Discussion. The Feb. 2004 Report also describes additional testing in December 2003 (Ref. 246, Pgs. 14-15): 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. Production 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, CaCl₂, 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

No.	'114 Claim Element	Evidence of Reduction to Practice
		The October 2005 Report describes additional testing in February 2004 (Ref. 253, Pg. 20): sulfuric acid (H₂SO₄)–potassium permanganate (KMnO₄) 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 provide the mercury-containing gas,	The Feb. 2004 Report explains that coal was combusted in a 550,000-Btu/hr pc-fire combustor (known as the PTC) (Ref. 246, Pg. 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.
1c	wherein the mercury-containing gas comprises a halogen or halide promoter comprising HBr, Br[−], or a combination thereof, wherein the coal comprises added Br₂, HBr, Br[−], or a combination thereof, added to the coal upstream of the combustion chamber,	The Feb. 2004 Report describes adding coal and additives (including SEA 2) to the combustion chamber during the September 2003 testing (Ref. 246, Pg. 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.

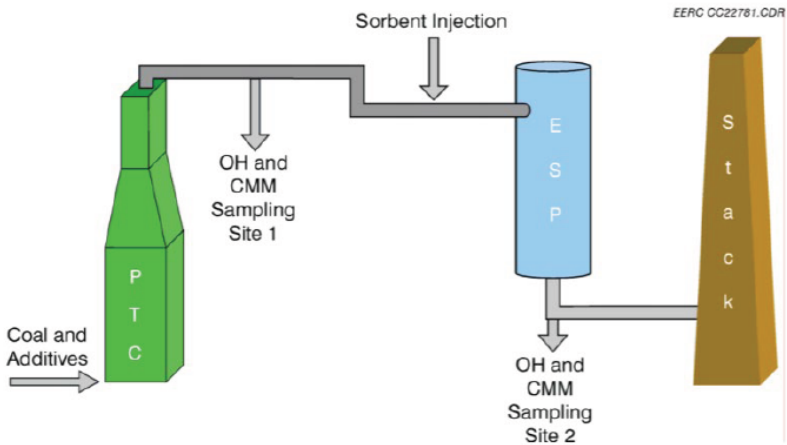
No.	'114 Claim Element	Evidence of Reduction to Practice								
	or the combustion chamber comprises added Br ₂ , HBr, Br ⁻ , or a combination thereof, or a combination thereof;	 Figure 4. Injection and sampling schematic of the PTC with an ESP. See also Ref. 246, Pg. 17 (“mercury oxidants including NaCl, SEA 2, and zinc were examined for their impacts on mercury removal.”); Pg. 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 issues) were evaluated.”); Ref. 253, Pg. 25 (“SEA2 is a proprietary Hg⁰ 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⁻. <table border="1" data-bbox="728 1148 1516 1286"><tr><td>1836</td><td>STARTED SODIUM BROMIDE FEEDER @ 40g/hr 375561</td></tr><tr><td>1904</td><td>Added 207 lbs Coal</td></tr><tr><td>1926</td><td>Added new batch Sodium Bromide Coal to Feeder</td></tr><tr><td></td><td>Same blend 31bs @ 48g SB @ 40gr/hr</td></tr></table>	1836	STARTED SODIUM BROMIDE FEEDER @ 40g/hr 375561	1904	Added 207 lbs Coal	1926	Added new batch Sodium Bromide Coal to Feeder		Same blend 31bs @ 48g SB @ 40gr/hr
1836	STARTED SODIUM BROMIDE FEEDER @ 40g/hr 375561									
1904	Added 207 lbs Coal									
1926	Added new batch Sodium Bromide Coal to Feeder									
	Same blend 31bs @ 48g SB @ 40gr/hr									

No.	'114 Claim Element	Evidence of Reduction to Practice
		SEA2 and activated carbon were similarly used during the December 2003 testing. <i>See</i> Ref. 246, Pg. 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. Production 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, CaCl₂, 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 <i>See</i> Ref. 252, Pg. 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."); Pg. 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."); Pg. 25:

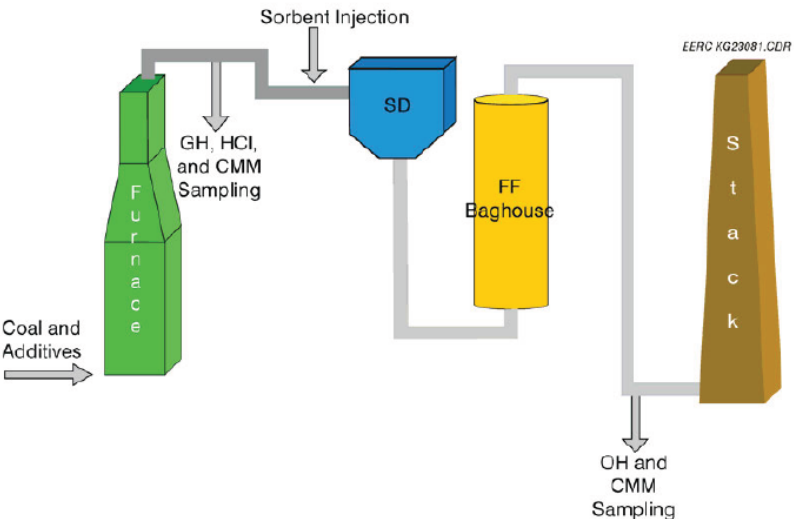
No.	'114 Claim Element	Evidence of Reduction to Practice
		 SEAA2 and activated carbon were also used in the February 2004 testing. Ref. 253, Pg. 20: sulfuric acid (H₂SO₄)–potassium permanganate (KMnO₄) solutions. EPA Method 29 was used for trace element sampling of the flue gas during Week 1 (February 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. Ref. 253, Pg. 26:

No.	'114 Claim Element	Evidence of Reduction to Practice
		
1d	injecting a sorbent material comprising activated carbon into the mercury-containing gas downstream of the combustion chamber;	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 (Ref. 246, Pg. 11):

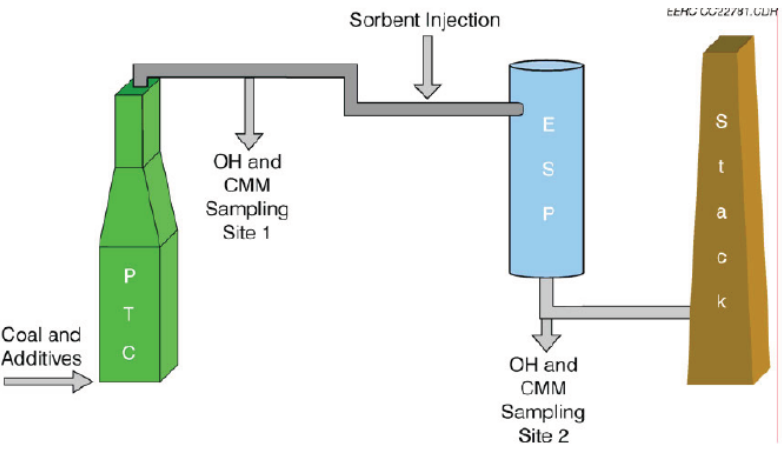
No.	'114 Claim Element	Evidence of Reduction to Practice																																																																																				
		<table><tr><th colspan="5">Table 1. Test Matrix for Unscrubbed Systems Equipped with ESPs</th></tr><tr><th rowspan="2">Test No.</th><th colspan="2">Mercury Oxidant Additive</th><th colspan="2">Sorbent</th></tr><tr><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>Na₂S₄ (solution)</td><td>0.89–6.67</td></tr><tr><td>T1-13</td><td>CaCl₂</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> Ref. 246, Pg. 15 (describing “DARCO® FGD activated carbon, supplied by NORIT Americas, Inc.; an EERC-treated activated carbon”)	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 ₂ S 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
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 ₂ S 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																																																																																		

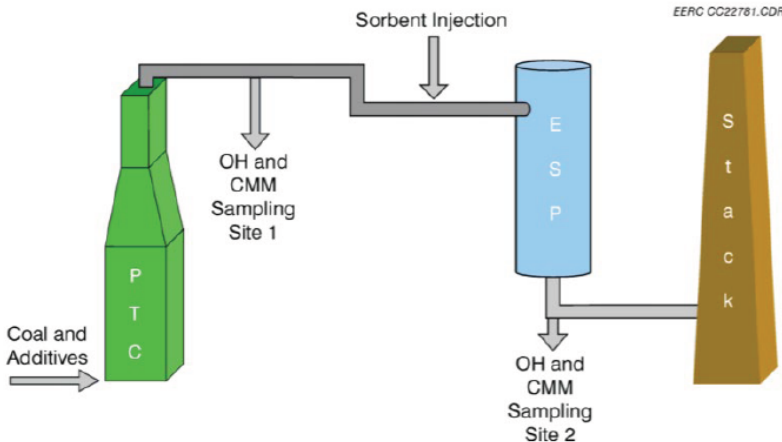
No.	'114 Claim Element	Evidence of Reduction to Practice
		 Figure 4. Injection and sampling schematic of the PTC with an ESP. The Feb. 2004 Report also describes injecting activated carbon sorbent during the December 2003 testing:

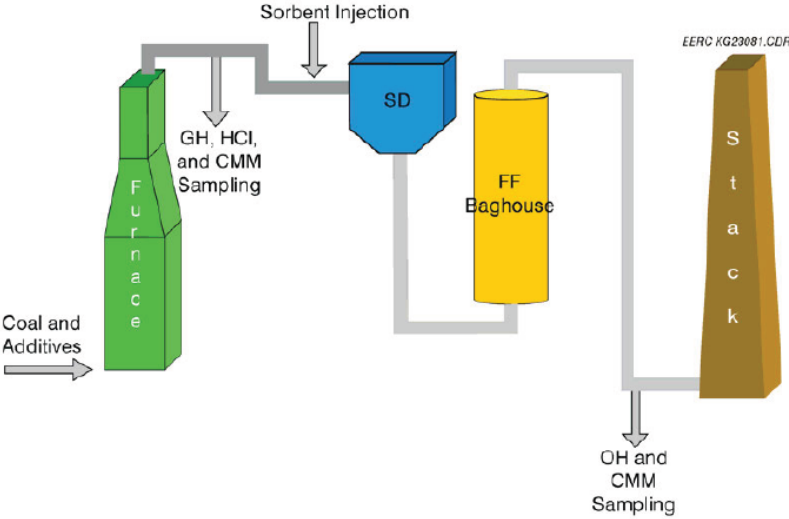
No.	'114 Claim Element	Evidence of Reduction to Practice																																																				
		<table><tr><th colspan="4">Table 4. Spray Dryer Test Sample Matrix (December 2004 run)</th></tr><tr><th colspan="2">Mercury Oxidation Additive</th><th colspan="2">Sorbent</th></tr><tr><th>Type</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>CaCl₂</td><td>3.67 – 11.02</td><td>None</td><td>NA</td></tr><tr><td>CaCl₂</td><td>3.67 – 11.03</td><td>DARCO® FGD</td><td>3.67</td></tr></table> <i>See also Ref. 252, Pg. 25:</i>	Table 4. Spray Dryer Test Sample Matrix (December 2004 run)				Mercury Oxidation Additive		Sorbent		Type	Feed Rate, lb/Macf	Type	Injection Rate, lb/Macf	None	NA	None	NA	None	NA	DARCO® FGD	1.84 – 11.02	None	NA	EERC-Treated FGD	1.84 – 7.35	None	NA	Amended Silicate™	7.35	NaCl	3.67 – 11.02	None	NA	NaCl	3.67 – 11.02	DARCO® FGD	3.67	SEA 2	1.84 – 3.67	None	NA	SEA 2	1.84 – 3.67	DARCO® FGD	1.84	CaCl ₂	3.67 – 11.02	None	NA	CaCl ₂	3.67 – 11.03	DARCO® FGD	3.67
Table 4. Spray Dryer Test Sample Matrix (December 2004 run)																																																						
Mercury Oxidation Additive		Sorbent																																																				
Type	Feed Rate, lb/Macf	Type	Injection Rate, lb/Macf																																																			
None	NA	None	NA																																																			
None	NA	DARCO® FGD	1.84 – 11.02																																																			
None	NA	EERC-Treated FGD	1.84 – 7.35																																																			
None	NA	Amended Silicate™	7.35																																																			
NaCl	3.67 – 11.02	None	NA																																																			
NaCl	3.67 – 11.02	DARCO® FGD	3.67																																																			
SEA 2	1.84 – 3.67	None	NA																																																			
SEA 2	1.84 – 3.67	DARCO® FGD	1.84																																																			
CaCl ₂	3.67 – 11.02	None	NA																																																			
CaCl ₂	3.67 – 11.03	DARCO® FGD	3.67																																																			

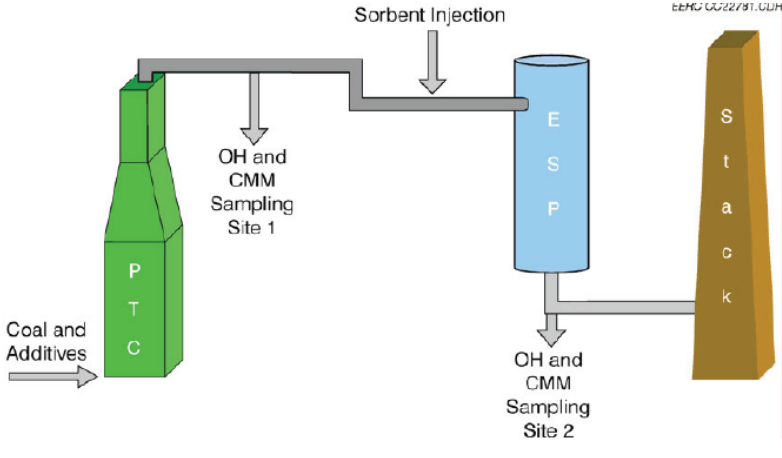
No.	'114 Claim Element	Evidence of Reduction to Practice
		 The diagram illustrates a coal gasification process. It begins with 'Coal and Additives' entering a green 'Furnace'. A gas stream exits the furnace and passes through a 'Sorbent Injection' point. Sampling points for 'GH, HCl, and CMM Sampling' are located just before the gas enters a blue 'SD' (Sorbent Desorption) unit. The gas then flows into a yellow 'FF Baghouse' (Fabric Filter Baghouse). Finally, the gas exits the baghouse and goes to a brown 'Stack'. Sampling points for 'OH and CMM Sampling' are located just before the gas enters the stack. The text 'EERC KG23081.CDR' is visible in the upper right corner of the diagram area. The Oct. 2005 Report describes injecting activated carbon sorbent during the February 2004 testing (Ref. 253, Pgs. 26–27):

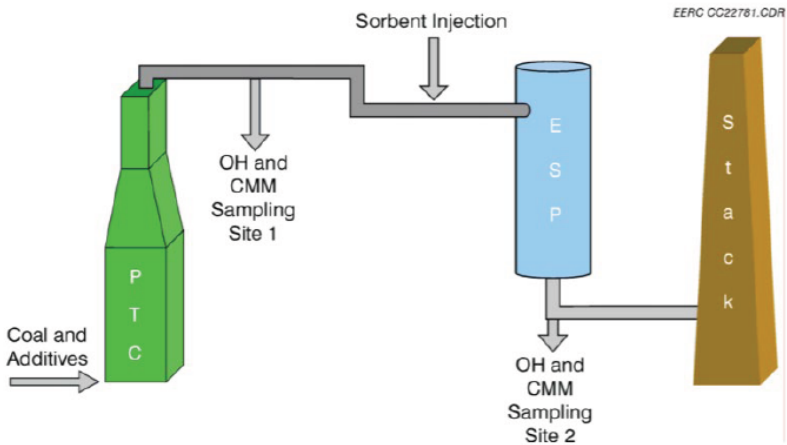
No.	'114 Claim Element	Evidence of Reduction to Practice																																																																																																																																																																																																																																																																														
		<table><tr><th colspan="9">Table 9-2. Week 1 – Test Matrix</th></tr><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>2/2/04</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>M-29</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>DARCO</td><td>25.0</td><td>7.03</td><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td><td>DARCO</td><td>28.0</td><td>7.84</td><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td><td>DARCO</td><td>32.0</td><td>8.96</td><td></td><td></td><td></td></tr><tr><td></td><td></td><td>OH</td><td>DARCO</td><td>45.0</td><td>12.60</td><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td><td>DARCO</td><td>69.0</td><td>19.20</td><td></td><td></td><td></td></tr><tr><td>2/3/04</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>15.2</td><td>4.28</td></tr><tr><td></td><td></td><td></td><td></td><td></td><td></td><td>SEA1</td><td>29.8</td><td>8.38</td></tr><tr><td></td><td>OH</td><td>OH</td><td>DARCO</td><td>25.0</td><td>7.03</td><td>SEA1</td><td>29.8</td><td>8.38</td></tr><tr><td></td><td>M-29</td><td></td><td>DARCO</td><td>25.0</td><td>7.03</td><td>SEA1</td><td>45.5</td><td>12.80</td></tr><tr><td></td><td></td><td></td><td>DARCO</td><td>25.0</td><td>7.03</td><td>SEA1</td><td>59.9</td><td>16.73</td></tr><tr><td></td><td></td><td></td><td>DARCO</td><td>25.0</td><td>7.03</td><td>SEA1</td><td>15.2</td><td>4.28</td></tr><tr><td>2/4/04</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>SEA2</td><td>9.8</td><td>2.73</td></tr><tr><td></td><td></td><td></td><td>DARCO</td><td>25.0</td><td>6.96</td><td>SEA2</td><td>9.8</td><td>2.73</td></tr><tr><td></td><td>OH</td><td>OH</td><td>DARCO</td><td>15.0</td><td>4.18</td><td>SEA2</td><td>9.8</td><td>2.73</td></tr><tr><td></td><td></td><td></td><td>DARCO</td><td>15.0</td><td>4.18</td><td></td><td></td><td></td></tr><tr><td></td><td>M-29</td><td></td><td>DARCO</td><td>15.0</td><td>4.18</td><td>SEA2</td><td>6.9</td><td>1.92</td></tr><tr><td></td><td></td><td></td><td>DARCO</td><td>15.0</td><td>4.18</td><td>SEA2</td><td>4.3</td><td>1.20</td></tr><tr><td></td><td></td><td></td><td>DARCO</td><td>15.0</td><td>4.18</td><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td><td>DARCO</td><td>15.0</td><td>4.18</td><td>SEA1-SEA2</td><td>2.6</td><td>0.72</td></tr><tr><td>2/5/2004</td><td></td><td></td><td>Baseline</td><td></td><td></td><td></td><td></td><td></td></tr><tr><td></td><td>OH</td><td>OH</td><td>EERC carbon</td><td>25.0</td><td>6.97</td><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td><td>EERC carbon</td><td>35.0</td><td>9.76</td><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td><td>Am. Silicate</td><td>25.0</td><td>6.91</td><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td><td>Am. Silicate</td><td>50.0</td><td>13.82</td><td></td><td></td><td></td></tr></table> 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 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		OH	OH	DARCO	25.0	7.03	SEA1	29.8	8.38		M-29		DARCO	25.0	7.03	SEA1	45.5	12.80				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			
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																																																																																																																																																																																																																																																																								
	OH	OH	DARCO	25.0	7.03	SEA1	29.8	8.38																																																																																																																																																																																																																																																																								
	M-29		DARCO	25.0	7.03	SEA1	45.5	12.80																																																																																																																																																																																																																																																																								
			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																																																																																																																																																																																																																																																																											

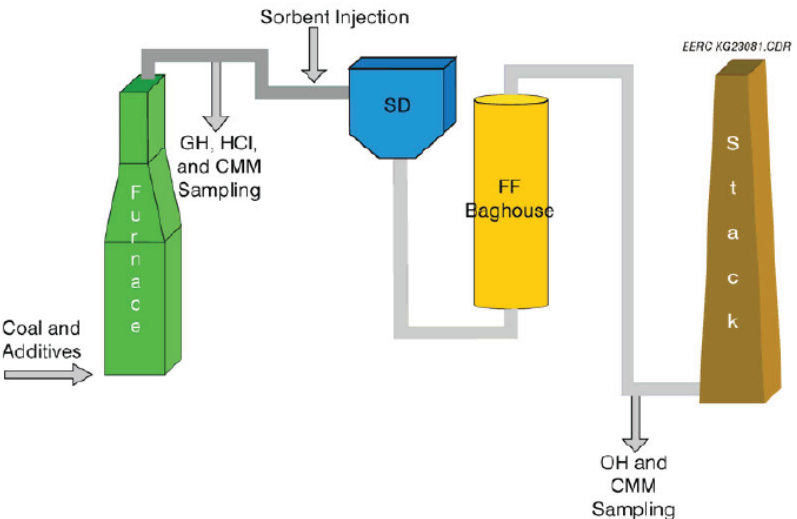
No.	'114 Claim Element	Evidence of Reduction to Practice
		
1e	contacting mercury in the mercury-containing gas with the sorbent, to form a mercury/sorbent composition;	Because the coal and sodium bromide were combusted which formed the mercury containing gas, and activated carbon was injecting into the emission gas, the sorbent and mercury formed a mercury/sorbent composition. <i>See, e.g.,</i> Ref. 246, Pg. 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.”); <i>see also</i> Ref. 252, Pg. 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 mercury/sorbent	The mercury/sorbent composition was separated using an electrostatic precipitator during the September 2003 testing. Ref. 246, Pgs. 10 – 11 (“Fourteen tests were completed to evaluate

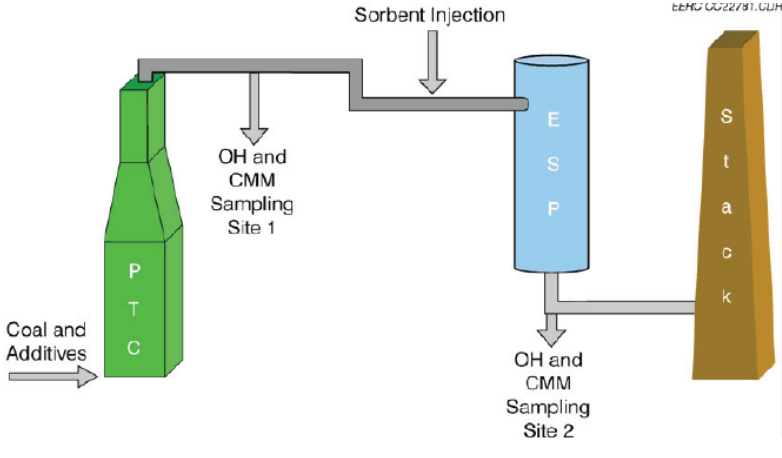
No.	'114 Claim Element	Evidence of Reduction to Practice
	composition from the mercury-containing gas, to form a cleaned gas;	various sorbent and mercury oxidant performance on mercury removal across the ESP as functions of feed rate.”):  Figure 4. Injection and sampling schematic of the PTC with an ESP. The mercury/sorbent composition was separated using a scrubbed baghouse system during the December 2003 testing. Ref. 246, Pg. 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.”); <i>see also</i> Ref. 252, Pg. 25:

No.	'114 Claim Element	Evidence of Reduction to Practice
		 The mercury/sorbent composition was separated using an electrostatic precipitator during the February 2004 testing. Ref. 253, Pg. 26 ("ESP Hg removal testing was performed with the PTC firing Caballo subbituminous coal."):

No.	'114 Claim Element	Evidence of Reduction to Practice
		
1g	monitoring the mercury content of the cleaned gas; and	The Feb. 2004 Report describes the use of “Continuous Mercury Monitors” during the September 2003 testing and December 2003 testing. Ref. 246, Pg. 8 (“Hg⁰ and total Hg levels will be measured on a nearly continuous basis using a continuous mercury monitor (CMM)”); Pg. 10:

No.	'114 Claim Element	Evidence of Reduction to Practice
		 Figure 4. Injection and sampling schematic of the PTC with an ESP. <i>See also Ref. 252, Pg. 25:</i>

No.	'114 Claim Element	Evidence of Reduction to Practice
		 The diagram illustrates a coal gasification process. It begins with 'Coal and Additives' entering a green 'Furnace'. From the furnace, a gas stream flows to a blue 'SD' (Sorbent Desorber) unit, where 'Sorbent Injection' occurs. A sampling point for 'GH, HCl, and CMM Sampling' is located between the furnace and the SD unit. The gas then passes through a yellow 'FF Baghouse' (Fabric Filter Baghouse). Finally, the gas exits through a brown 'Stack'. A sampling point for 'OH and CMM Sampling' is located at the exit of the stack. The reference 'EERC KG23081.CDR' is noted near the stack. <i>See also Ref. 253, Pg. 26:</i>

No.	'114 Claim Element	Evidence of Reduction to Practice
		
1h	controlling, in response to the monitored mercury content of the cleaned gas, an injection rate of injecting the sorbent into the mercury-containing gas, the sorbent composition, or a combination thereof, so that the mercury content of the cleaned	The Feb. 2004 Report describes adjusting the additive and sorbent injection rate. Both options result in changes to the sorbent composition. Ref. 246, Pg. 9 (“Specific sorbent injection rates will be determined based on the measured Hg concentration in the flue gas.”); Pg. 10 (“For continuous injection, the feed rate will be varied from 2500–12,000 lb sorbent/lb Hg”); Pg. 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 Ref. 252, Pg. 15:

No.	'114 Claim Element	Evidence of Reduction to Practice																																																
	gas is maintained at or below a desired level.	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>CaCl₂</td><td>3.67 – 11.02</td><td>None</td><td>NA</td></tr><tr><td>CaCl₂</td><td>3.67 – 11.03</td><td>DARCO® FGD</td><td>3.67</td></tr></table> <i>See also Ref. 253, Pg. 27:</i>	Mercury Oxidation Additive		Sorbent		Type	Feed Rate, lb/Macf	Type	Injection Rate, lb/Macf	None	NA	None	NA	None	NA	DARCO® FGD	1.84 – 11.02	None	NA	EERC-Treated FGD	1.84 – 7.35	None	NA	Amended Silicate™	7.35	NaCl	3.67 – 11.02	None	NA	NaCl	3.67 – 11.02	DARCO® FGD	3.67	SEA 2	1.84 – 3.67	None	NA	SEA 2	1.84 – 3.67	DARCO® FGD	1.84	CaCl ₂	3.67 – 11.02	None	NA	CaCl ₂	3.67 – 11.03	DARCO® FGD	3.67
Mercury Oxidation Additive		Sorbent																																																
Type	Feed Rate, lb/Macf	Type	Injection Rate, lb/Macf																																															
None	NA	None	NA																																															
None	NA	DARCO® FGD	1.84 – 11.02																																															
None	NA	EERC-Treated FGD	1.84 – 7.35																																															
None	NA	Amended Silicate™	7.35																																															
NaCl	3.67 – 11.02	None	NA																																															
NaCl	3.67 – 11.02	DARCO® FGD	3.67																																															
SEA 2	1.84 – 3.67	None	NA																																															
SEA 2	1.84 – 3.67	DARCO® FGD	1.84																																															
CaCl ₂	3.67 – 11.02	None	NA																																															
CaCl ₂	3.67 – 11.03	DARCO® FGD	3.67																																															
2	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. <i>See Ref. 252, Pg. 73:</i> – 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. <i>See Ref. 253, Pg. 49:</i> 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 Hg⁰ 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 Hg⁰, some Hg²⁺ 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.	'114 Claim Element	Evidence of Reduction to Practice
3	The method of claim 1, comprising removing greater than 70 wt % of the mercury in the mercury-containing gas on the sorbent.	See claim 2.
4	The method of claim 1, wherein the sorbent in the mercury-containing gas comprises about 1 g to about 30 g of the halogen or halide promoter per 100 g of the sorbent material.	The February 2004 testing used bromine injection rates within this range. <i>See</i> Ref. 253, Pg. 27:

No.	'114 Claim Element	Evidence of Reduction to Practice																																																																																																																																																																																																																																																																					
		<table><tr><th colspan="9">Table 9-2. Week 1 – Test Matrix</th></tr><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>2/2/04</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>M-29</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>DARCO</td><td>25.0</td><td>7.03</td><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td><td>DARCO</td><td>28.0</td><td>7.84</td><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td><td>DARCO</td><td>32.0</td><td>8.96</td><td></td><td></td><td></td></tr><tr><td></td><td></td><td>OH</td><td>DARCO</td><td>45.0</td><td>12.60</td><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td><td>DARCO</td><td>69.0</td><td>19.20</td><td></td><td></td><td></td></tr><tr><td>2/3/04</td><td></td><td></td><td>Baseline</td><td></td><td></td><td>SEA1</td><td>15.2</td><td>4.28</td></tr><tr><td></td><td></td><td></td><td></td><td></td><td></td><td>SEA1</td><td>29.8</td><td>8.38</td></tr><tr><td></td><td>OH</td><td>OH</td><td>DARCO</td><td>25.0</td><td>7.03</td><td>SEA1</td><td>29.8</td><td>8.38</td></tr><tr><td></td><td>M-29</td><td></td><td>DARCO</td><td>25.0</td><td>7.03</td><td>SEA1</td><td>45.5</td><td>12.80</td></tr><tr><td></td><td></td><td></td><td>DARCO</td><td>25.0</td><td>7.03</td><td>SEA1</td><td>59.9</td><td>16.73</td></tr><tr><td></td><td></td><td></td><td>DARCO</td><td>25.0</td><td>7.03</td><td>SEA1</td><td>15.2</td><td>4.28</td></tr><tr><td>2/4/04</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>SEA2</td><td>9.8</td><td>2.73</td></tr><tr><td></td><td></td><td></td><td>DARCO</td><td>25.0</td><td>6.96</td><td>SEA2</td><td>9.8</td><td>2.73</td></tr><tr><td></td><td>OH</td><td>OH</td><td>DARCO</td><td>15.0</td><td>4.18</td><td>SEA2</td><td>9.8</td><td>2.73</td></tr><tr><td></td><td></td><td></td><td>DARCO</td><td>15.0</td><td>4.18</td><td></td><td></td><td></td></tr><tr><td></td><td>M-29</td><td></td><td>DARCO</td><td>15.0</td><td>4.18</td><td>SEA2</td><td>6.9</td><td>1.92</td></tr><tr><td></td><td></td><td></td><td>DARCO</td><td>15.0</td><td>4.18</td><td>SEA2</td><td>4.3</td><td>1.20</td></tr><tr><td></td><td></td><td></td><td>DARCO</td><td>15.0</td><td>4.18</td><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td><td>DARCO</td><td>15.0</td><td>4.18</td><td>SEA1-SEA2</td><td>2.6</td><td>0.72</td></tr><tr><td>2/5/2004</td><td></td><td></td><td>Baseline</td><td></td><td></td><td></td><td></td><td></td></tr><tr><td></td><td>OH</td><td>OH</td><td>EERC carbon</td><td>25.0</td><td>6.97</td><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td><td>EERC carbon</td><td>35.0</td><td>9.76</td><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td><td>Am. Silicate</td><td>25.0</td><td>6.91</td><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td><td>Am. Silicate</td><td>50.0</td><td>13.82</td><td></td><td></td><td></td></tr></table> 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 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		OH	OH	DARCO	25.0	7.03	SEA1	29.8	8.38		M-29		DARCO	25.0	7.03	SEA1	45.5	12.80				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			
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																																																																																																																																																																																																																																																															
	OH	OH	DARCO	25.0	7.03	SEA1	29.8	8.38																																																																																																																																																																																																																																																															
	M-29		DARCO	25.0	7.03	SEA1	45.5	12.80																																																																																																																																																																																																																																																															
			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																																																																																																																																																																																																																																																																		
		Ref. 253, Pg. 30:																																																																																																																																																																																																																																																																					

No.	'114 Claim Element	Evidence of Reduction to Practice																																																																																																																																																																																																																																																												
		<table><tr><th colspan="9">Table 9-4. Week 2 – Test Matrix</th></tr><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 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>SEA1</td><td>25</td><td>5.82</td></tr><tr><td>SDA-ESP 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>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>SEA2</td><td>1</td><td>0.23</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>2.5</td><td>0.58</td></tr><tr><td></td><td></td><td></td><td></td><td></td><td></td><td>SEA2</td><td>5</td><td>1.16</td></tr><tr><td>SDA-FF 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>OH</td><td>OH</td><td>DARCO</td><td>10</td><td>2.33</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>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>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 2/20/2004</td><td></td><td></td><td>Baseline</td><td></td><td></td><td>SEA2</td><td>1</td><td>0.23</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>1.5</td><td>0.35</td></tr><tr><td></td><td></td><td></td><td>Baseline</td><td></td><td></td><td>SEA2</td><td>0.5</td><td>0.12</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>	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							OH	OH	DARCO	25	5.82	SEA1	25	5.82				DARCO	25	5.82	SEA1	35	8.14				Baseline			SEA2	1	0.23			OH	DARCO	10	2.33	SEA2	2.5	0.58				DARCO	10	2.33	SEA2	2.5	0.58							SEA2	5	1.16	SDA-FF 2/19/04		OH	Baseline							OH	OH	DARCO	10	2.33							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			OH	DARCO	10	2.33	SEA2	1.5	0.35				DARCO	10	2.33	SEA2	1.5	0.35				Baseline			SEA2	0.5	0.12				Am. Silicate	15	3.49							Am. Silicate	30	6.98			
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																																																																																																																																																																																																																																																											
	OH	OH	DARCO	25	5.82	SEA1	25	5.82																																																																																																																																																																																																																																																						
			DARCO	25	5.82	SEA1	35	8.14																																																																																																																																																																																																																																																						
			Baseline			SEA2	1	0.23																																																																																																																																																																																																																																																						
		OH	DARCO	10	2.33	SEA2	2.5	0.58																																																																																																																																																																																																																																																						
			DARCO	10	2.33	SEA2	2.5	0.58																																																																																																																																																																																																																																																						
						SEA2	5	1.16																																																																																																																																																																																																																																																						
SDA-FF 2/19/04		OH	Baseline																																																																																																																																																																																																																																																											
	OH	OH	DARCO	10	2.33																																																																																																																																																																																																																																																									
			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																																																																																																																																																																																																																																																						
		OH	DARCO	10	2.33	SEA2	1.5	0.35																																																																																																																																																																																																																																																						
			DARCO	10	2.33	SEA2	1.5	0.35																																																																																																																																																																																																																																																						
			Baseline			SEA2	0.5	0.12																																																																																																																																																																																																																																																						
			Am. Silicate	15	3.49																																																																																																																																																																																																																																																									
			Am. Silicate	30	6.98																																																																																																																																																																																																																																																									
5	The method of claim 1, wherein the combustion chamber	See 1c.																																																																																																																																																																																																																																																												

No.	'114 Claim Element	Evidence of Reduction to Practice
	comprises the halogen or halide promoter.	
6	The method of claim 1, wherein the coal comprises added Br ₂ , HBr, Br ⁻ , or a combination thereof, added to the coal upstream of the combustion chamber.	See 1c.
7	The method of claim 1, wherein the promoter is contacted with the sorbent in vapor form, gaseous form, liquid form, or in an organic solvent.	Given the temperatures of coal combustion, the halide additive (NaBr) provides the promoter (Br ₂ , HBr, Br ⁻)) in gaseous form.
12	The method of claim 1, wherein the activated carbon comprises powdered activated carbon, granular activated	See 1d.

No.	'114 Claim Element	Evidence of Reduction to Practice
	carbon, or a combination thereof.	
15	The method of claim 1, wherein the combustion chamber comprises a boiler	See 1a.
16	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.
18	The method of claim 1, wherein the injection of the sorbent material into the mercury-containing gas occurs upstream of a particulate separator or a scrubber.	See 1d.
20	The method of claim 1, wherein the combustion chamber comprises added Br ₂ ,	See 1c.

No.	'114 Claim Element	Evidence of Reduction to Practice
	HBr, Br ⁻ , or a combination thereof.	
23a	A method of separating mercury from a mercury-containing gas, the method comprising:	See 1a.
23b	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.
23c	wherein the mercury-containing gas comprises a halogen or halide promoter comprising HBr, Br ⁻ , or a combination	See 1c.

No.	'114 Claim Element	Evidence of Reduction to Practice
	thereof, wherein the coal comprises added Br ₂ , HBr, Br ⁻ , or a combination thereof, added to the coal upstream of the combustion chamber, or the combustion chamber comprises added Br ₂ , HBr, Br ⁻ , or a combination thereof, or a combination thereof;	
23d	injecting a sorbent material comprising activated carbon into the mercury-containing gas downstream of the combustion chamber;	See 1d.
23e	contacting mercury in the mercury-containing gas with the sorbent, to form a	See 1e.

No.	'114 Claim Element	Evidence of Reduction to Practice
	mercury/sorbent composition; and	
23f	separating the mercury/sorbent composition from the mercury-containing gas, to form a cleaned gas.	See 1f.
24a	A method of separating mercury from a mercury-containing gas, the method comprising:	See 1a.
24b	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.

No.	'114 Claim Element	Evidence of Reduction to Practice
24c	wherein the mercury-containing gas comprises a halogen or halide promoter comprising HBr, Br⁻, or a combination thereof, wherein the coal comprises added Br₂, HBr, Br⁻, or a combination thereof, added to the coal upstream of the combustion chamber, or the combustion chamber comprises added Br₂, HBr, Br⁻, or a combination thereof, or a combination thereof;	See 1c.
24d	injecting a sorbent material comprising activated carbon into the mercury-containing gas downstream of the combustion chamber	See 1d.

No.	'114 Claim Element	Evidence of Reduction to Practice
	such that the activated carbon reacts with the halogen or halide promoter in the mercury-containing gas to form a promoted sorbent;	
24e	such that the activated carbon reacts with the halogen or halide promoter in the mercury-containing gas to form a promoted sorbent;	The Feb. 2004 Report and Final Report both explain that the tests performed with sorbent and SEA2 demonstrated higher levels of mercury capture as compared to tests performed only with sorbent, and that the reactivity of the sorbent was enhanced when a halide additive (NaBr) was added to the coal. This confirms that the activated carbon sorbent and halogen/halide promoter reacted to form a promoted sorbent that enhanced (improved) its performance to capture mercury.
24f	contacting mercury in the mercury-containing gas with the promoted sorbent, to form a mercury/sorbent composition;	See 1e.
24g	separating the mercury/sorbent	See 1f.

No.	'114 Claim Element	Evidence of Reduction to Practice
	composition from the mercury-containing gas, to form a cleaned gas;	
24h	monitoring the mercury content of the cleaned gas; and	See 1g.
24i	controlling, in response to the mercury content of the cleaned gas, an injection rate of injecting the sorbent into the mercury-containing gas, a rate of addition to the coal or the combustion chamber of the added Br ₂ , HBr, the bromide compound, or a combination thereof, or a combination thereof, so that the mercury content of the cleaned	See 1h.

No.	'114 Claim Element	Evidence of Reduction to Practice
	gas is maintained at or below a desired level.	
25a	A method of separating mercury from a mercury-containing gas, the method comprising:	See 1a.
25b	combusting coal in a combustion chamber, to provide the mercury-containing gas, wherein	See 1b.
25c	the coal comprises added Br ₂ , HBr, a bromide compound, or a combination thereof, added to the coal upstream of the combustion chamber, or the combustion chamber comprises added Br ₂ , HBr, a bromide compound, or a combination	See 1c.

No.	'114 Claim Element	Evidence of Reduction to Practice
	thereof, or a combination thereof,	
25d	injecting a sorbent material comprising activated carbon into the mercury-containing gas downstream of the combustion chamber;	See 1d.
25e	contacting mercury in the mercury-containing gas with the sorbent, to form a mercury/sorbent composition; and	See 1e.
25f	separating the mercury/sorbent composition from the mercury-containing gas, to form a cleaned gas.	See 1f.
26	The method of claim 25, wherein the coal comprises the added	See 1c.

No.	'114 Claim Element	Evidence of Reduction to Practice
	Br ₂ , HBr, the bromide compound, or a combination thereof, added to the coal upstream of the combustion chamber.	
27	The method of claim 25, wherein the combustion chamber comprises the added Br ₂ , HBr, the bromide compound, or a combination thereof.	See 1c.
28a	The method of claim 25, further comprising monitoring the mercury content of the cleaned gas; and	See 1g.
28b	controlling, in response to the mercury content of the cleaned gas, an injection rate of	See 1h.

No.	'114 Claim Element	Evidence of Reduction to Practice
	injecting the sorbent into the mercury-containing gas, a rate of addition to the coal or the combustion chamber of the added Br₂, HBr, the bromide compound, or a combination thereof, or a combination thereof, so that the mercury content of the cleaned gas is maintained at or below a desired level.	
29	The method of claim 25, wherein the mercury-containing gas comprises about 1 g to about 30 g of the element bromine per 100 g of the sorbent.	See claim 4.

No.	'114 Claim Element	Evidence of Reduction to Practice
30	The method of claim 25, wherein the mercury/sorbent composition comprises the element bromine, the sorbent material, and mercury.	See 24e.

The '147 Patent to Olson

No.	'147 Claim Element	Evidence of Reduction to Practice
1a	A method for separating mercury from a mercury containing gas comprising:	See '114 1a.
1b	promoting at least a portion of a particulate sorbent material comprising activated carbon by chemically reacting the sorbent material with a bromine containing promoter to form a promoted brominated sorbent, wherein the bromine containing promoter is in gaseous form, vapor form, or non-aqueous liquid form,	The inventors added sodium bromide to the coal to be combusted. This includes sodium and bromine atoms. These atoms of bromine are the promoter. Moreover, given the high temperature of the coal combustion chamber, the bromine exits the combustion chamber in a gaseous state. The inventors further injected activated carbon downstream of the combustion chamber. Thus, this activated carbon and the bromine come into contact and form a promoted brominated sorbent, i.e., a sorbent particle that is bound with the bromine.
1c	and wherein the activated carbon contains graphene sheets having carbene species edge sites which react with the bromine containing promoter to form a carbocation paired with a bromide anion in the promoted brominated	Activated carbon contains graphene sheets having carbene species edge sites. See deposition of E. Olson at Pg. 201, Line 21- Pg. 202, Line 8: 21 So is that generally true of 22 activated carbons, that they are graphene 23 sheets with carbene edge species sites? 24 A. Generally. As far as I know, 25 there are only one or two carbons that 1 were ever actually demonstrated to have 2 these graphene sheets or graphene ribbons 3 by electron diffraction studies in the 4 '90s. But this idea was universally 5 accepted by virtually every carbon 6 chemist, and I never heard anybody say 7 that an activated carbon did not have 8 graphene sheets or graphene ribbons.

	sorbent for oxidation of the mercury;	Ref. 238 to my opening report, Declaration of Stephen Niksa discussing structure of activated carbon and citations to Bansal, section VII.C.2 . That this claimed reaction occurs has been demonstrated by the inventors and others. See section 3 explaining that activated carbon provides a catalyst for mercury oxidation. Ref. 179 to my opening report: Olsen <i>et al.</i> [76] suggested that Hg has the propensity to be oxidized by donating its electrons to a surface or another gas-phase molecule; therefore, in its elemental More recent investigations have used plane-wave DFT to model AC, which allows for the use of periodic systems such as a graphene. Graphene ribbons with exposed edge sites have been used for investigations of the reactivity of carbonaceous surfaces to various gas species [77]. Several investigations support the zigzag carbene structure model, where the zigzag edge site acts as a Lewis base and reacts with acid gas components thereby serving as a potential adsorption site for oxidized Hg [77, 78]. A recent DFT study [79] on the effect of chemical functional groups on Hg adsorption on carbon surfaces supports this suggestion. The study indicates that an embedded halogen atom promotes chemisorption on the neighboring site, which is consistent with experimental results, and indicative of Hg oxidation. Results also indicate a varying effect Oxidation of mercury by a reaction of mercury with a gas (e.g., gaseous bromine) is referred to as homogeneous oxidation. Oxidation of mercury through a reaction involving gas and surface interactions (e.g. with activated carbon and bromine) is referred to as heterogeneous oxidation. It is well accepted that both homogeneous and heterogeneous reactions must take place. Thus, for example, mercury leaving the combustion chamber would not be fully oxidized by the time it reaches the activated carbon. Ref. 179 to my opening report: Understanding the speciation of mercury throughout the coal-combustion process is crucial to the design of efficient and effective mercury removal technologies. Mercury oxidation takes place through combined homogeneous (i.e., strictly in the gas phase) and heterogeneous (i.e., gas-surface interactions) pathways. Both bench-scale combustion experiments [1] and quantum-chemistry-based theoretical model efforts [2, 3] indicate that homogeneous mercury oxidation is responsible for, at most, 10% of the overall oxidation in a typical coal-fired flue gas with chlorine levels at 500 ppmv (e.g., HCl equivalent).
1d	chemically reacting elemental mercury in the mercury containing gas with the promoted brominated sorbent to form a mercury/sorbent	As explained above in 1c, the elemental mercury in the mercury containing gas chemically reacts with the promoted brominated sorbent to form a mercury/sorbent chemical composition

	chemical composition; and	
1e	separating particulates from the mercury containing gas, the particulates including ash and the mercury/sorbent chemical composition.	See '114 claim 1f.
17a	A method according to claim 1, further comprising injecting the particulate sorbent material at a sorbent material injection rate and injecting separately the bromine containing promoter into a gas stream whereby in-flight reaction produces the promoted brominated sorbent, wherein the promoter is reacted in the gas phase or as a vapor,	The inventors used separate apparatuses to add the sodium bromide and activated carbon. Sodium bromide was added upstream of the combustion chamber and activated carbon was added downstream of the combustion chamber. Thus they were added separately with their own injection rates. Moreover, because these materials came into contact in the flue gas, the promoter reacted with the sorbent in flight and in the gas phase.
17b	wherein the promoter is added at from about 1 to about 30 grams per 100 grams of the sorbent material.	See '114 4.

18	A method according to claim 17, wherein the gas stream is a mercury containing gas.	Each of the inventor's tests involved the addition of sodium bromide to coal. Coal inherently contains mercury. Thus, the gas stream blowing the coal and sodium bromide through the system is a mercury containing gas stream.
19	A method according to claim 18, wherein the gas stream is a transport gas.	See claim 18. This gas stream transports the pulverized coal, sodium bromide, activated carbon, and resulting emissions, thus it is a transport gas.
20	A method according to claim 17, wherein the promoter injection rate and the sorbent injection rate into the gas are determined at least in part on the monitored mercury content of the cleaned gas.	See '114 1g, 1h.

The '225 Patent to Olson

No.	'225 Claim Element	Accused Conduct
1a	A method for treating a mercury-containing gas, the method comprising:	See '114 1a.
1b	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 '114 1b, 1c. In addition, when coal is combusted, it produces some amount of pyrolysis char as explained in my opening report.
1c	adding a particulate sorbent material comprising activated carbon into the mercury-containing gas.	See '114 1d.
2	The method of claim 1, wherein the pyrolysis char is a promoted pyrolysis char.	The pyrolysis char forms in the presence of bromine that has been added to the coal. Thus, it is promoted pyrolysis char.
5	The method of Claim 1, further comprising using a particle separation device to remove mercury from	See '114 4.

	the flue gas and comprising collecting greater than 70 wt % of the mercury in the mercury-containing gas to produce a cleaned gas.	
6a	The method of Claim 5, further comprising:	
6b	measuring the mercury content of the mercury-containing gas; and	See '114 1g.
6c	modifying, in response to the measured mercury content:	See '114h.
6d	an injection rate of injecting the sorbent into the mercury-containing gas,	See '114 1h.
6e	an amount of the additive in the mixture, or	See '114 1h.
6f	a combination thereof.	See '114 1h.
8	The method of claim 1 , wherein the sorbent material is chosen from	See '114 12.

	powdered activated carbon, granular activated carbon, carbon black, carbon fiber, aerogel carbon, pyrolysis char, and combinations thereof.	
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.	According to Dr. Niksa, calcium or sodium bromide would satisfy this limitation. Under that interpretation, the inventors practiced this limitation during the September 2003, December 2003, and February 2004 testing. See '114 claim 1.
14a	A method for treating a mercury-containing gas, the method comprising:	See '225 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-containing gas; and	See '225 1b.
14c	adding a particulate sorbent material comprising activated	See '225 1c.

	carbon into the mercury-containing gas.	
15	The method of claim 14, wherein the pyrolysis char is a promoted pyrolysis char.	See '225 2.
17a	A method for treating a mercury-containing gas, the method comprising:	See '225 1a.
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 '225 1b.
17c	adding a sorbent material comprising activated carbon into the mercury-containing gas.	See '225 1c.
18a	The method of claim 1, further comprising	See '225 6a.

18b	modifying, in response to a measured mercury content,	See '225 6c.
18c	an injection rate of injecting the sorbent into the mercury-containing gas,	See '225 6d.
18d	an amount of the additive in the mixture, or	See '225 6e.
18e	a combination thereof.	See '225 6f.
20	The method of claim 1, wherein the coal is combusted in a combustion chamber at a coal-combustion 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-combustion facility.	See '114 1c.

22

The method of claim 1, wherein the sorbent is contacted with a halogen or halide promoter prior to the addition of the sorbent to the mercury-containing gas.

The Feb. 2004 Report describes injecting treated carbon into the mercury-containing gas downstream of the combustion chamber during the September 2003 testing (page 11):

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 ₂ S 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

See also Feb. 2004 Report at 15 (describing “DARCO® FGD activated carbon, supplied by NORIT Americas, Inc.; an EERC-treated activated carbon”). This carbon was treated with a halide promoter. See Ref. 246 claim chart at page 64. The PTC logbook on September 19, 2003 shows the injection of a bromine treated activated carbon and addition of NaBr to the coal.

151	Started Carbon Injection 10g/hr (Br treated)	10g/hr	10g/hr
459	Zero & Spanned SO2 Sample part #1		10g/hr
5:18	Increase br treated carbon to 15g/hr		10g/hr
542	Added coal 122/55		10g/hr
4:59	Started Feeder NaBr, 10g/hr.	10 gr per hour Sodium Bromide	10g/hr
Read & Understood by me,		Date 9-19-03	Invented by
			Date
		Recorded by	

		PTC-FM-639 Project No. 4259/4305 Reqs No. 179 Page No. 553 Blew out Sample port #1 Probe and static 1 hrs 16:08 Drained Ice bath Condensor 16:22 stop NaBr injection stop Br treated carbon injection 1H/KS JH
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.	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 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 ₂ S 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

See also Feb. 2004 Report at 15 (describing “DARCO® FGD activated carbon, supplied by NORIT Americas, Inc.; an EERC-treated activated carbon”). Darco FGD is an untreated activated carbon free of contact with halogen or halide.

The Feb. 2004 Report also describes injecting activated carbon sorbent during the December 2003 testing:

		Table 4. Spray Dryer Test Sample Matrix (December 2004 run)	
		Mercury Oxidation Additive	Sorbent
	Type	Feed Rate, lb/Macf	Type Injection Rate, lb/Macf
	None	NA	None NA
	None	NA	DARCO® FGD 1.84 – 11.02
	None	NA	EERC-Treated FGD 1.84 – 7.35
	None	NA	Amended Silicate™ 7.35
	NaCl	3.67 – 11.02	None NA
	NaCl	3.67 – 11.02	DARCO® FGD 3.67
	SEA 2	1.84 – 3.67	None NA
	SEA 2	1.84 – 3.67	DARCO® FGD 1.84
	CaCl ₂	3.67 – 11.02	None NA
	CaCl ₂	3.67 – 11.03	DARCO® FGD 3.67
		<i>See also Feb. 2005 Report at 25:</i>	
		The Oct. 2005 Report describes injecting activated carbon sorbent during the February 2004 testing (pages 26-27):	

		<table><tr><th colspan="9">Table 9-2. Week 1 – Test Matrix</th></tr><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 rowspan="6">2/2/04</td><td rowspan="6">OH M-29</td><td rowspan="6">OH</td><td>Baseline</td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>Baseline</td><td></td><td></td><td></td><td></td></tr><tr><td>DARCO</td><td>25.0</td><td>7.03</td><td></td><td></td></tr><tr><td>DARCO</td><td>28.0</td><td>7.84</td><td></td><td></td></tr><tr><td>DARCO</td><td>32.0</td><td>8.96</td><td></td><td></td></tr><tr><td>DARCO</td><td>45.0</td><td>12.60</td><td></td><td></td></tr><tr><td></td><td></td><td>OH</td><td>DARCO</td><td>69.0</td><td>19.20</td><td></td><td></td><td></td></tr><tr><td rowspan="6">2/3/04</td><td rowspan="6">OH M-29</td><td rowspan="6">OH</td><td>Baseline</td><td></td><td></td><td>SEA1</td><td>15.2</td><td>4.28</td></tr><tr><td></td><td></td><td>SEA1</td><td>29.8</td><td>8.38</td></tr><tr><td>DARCO</td><td>25.0</td><td>7.03</td><td>SEA1</td><td>29.8</td><td>8.38</td></tr><tr><td>DARCO</td><td>25.0</td><td>7.03</td><td>SEA1</td><td>45.5</td><td>12.80</td></tr><tr><td>DARCO</td><td>25.0</td><td>7.03</td><td>SEA1</td><td>59.9</td><td>16.73</td></tr><tr><td>DARCO</td><td>25.0</td><td>7.03</td><td>SEA1</td><td>15.2</td><td>4.28</td></tr><tr><td rowspan="9">2/4/04</td><td rowspan="9">OH M-29</td><td rowspan="9">OH</td><td>Baseline</td><td></td><td></td><td>SEA2</td><td>9.8</td><td>2.73</td></tr><tr><td></td><td></td><td>SEA2</td><td>9.8</td><td>2.73</td></tr><tr><td>DARCO</td><td>25.0</td><td>6.96</td><td>SEA2</td><td>9.8</td><td>2.73</td></tr><tr><td>DARCO</td><td>15.0</td><td>4.18</td><td></td><td></td><td></td></tr><tr><td>DARCO</td><td>15.0</td><td>4.18</td><td></td><td></td><td></td></tr><tr><td>DARCO</td><td>15.0</td><td>4.18</td><td>SEA2</td><td>6.9</td><td>1.92</td></tr><tr><td>DARCO</td><td>15.0</td><td>4.18</td><td>SEA2</td><td>4.3</td><td>1.20</td></tr><tr><td>DARCO</td><td>15.0</td><td>4.18</td><td></td><td></td><td></td></tr><tr><td>DARCO</td><td>15.0</td><td>4.18</td><td>SEA1-SEA2</td><td>2.6</td><td>0.72</td></tr><tr><td rowspan="5">2/5/2004</td><td rowspan="5">OH</td><td rowspan="5">OH</td><td>Baseline</td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>EERC carbon</td><td>25.0</td><td>6.97</td><td></td><td></td><td></td></tr><tr><td>EERC carbon</td><td>35.0</td><td>9.76</td><td></td><td></td><td></td></tr><tr><td>Am. Silicate</td><td>25.0</td><td>6.91</td><td></td><td></td><td></td></tr><tr><td>Am. Silicate</td><td>50.0</td><td>13.82</td><td></td><td></td><td></td></tr><tr><td colspan="9">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.</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 M-29	OH	Baseline						Baseline					DARCO	25.0	7.03			DARCO	28.0	7.84			DARCO	32.0	8.96			DARCO	45.0	12.60					OH	DARCO	69.0	19.20				2/3/04	OH M-29	OH	Baseline			SEA1	15.2	4.28			SEA1	29.8	8.38	DARCO	25.0	7.03	SEA1	29.8	8.38	DARCO	25.0	7.03	SEA1	45.5	12.80	DARCO	25.0	7.03	SEA1	59.9	16.73	DARCO	25.0	7.03	SEA1	15.2	4.28	2/4/04	OH M-29	OH	Baseline			SEA2	9.8	2.73			SEA2	9.8	2.73	DARCO	25.0	6.96	SEA2	9.8	2.73	DARCO	15.0	4.18				DARCO	15.0	4.18				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	OH	OH	Baseline						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 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 M-29	OH	Baseline																																																																																																																																																																																																				
			Baseline																																																																																																																																																																																																				
			DARCO	25.0	7.03																																																																																																																																																																																																		
			DARCO	28.0	7.84																																																																																																																																																																																																		
			DARCO	32.0	8.96																																																																																																																																																																																																		
			DARCO	45.0	12.60																																																																																																																																																																																																		
		OH	DARCO	69.0	19.20																																																																																																																																																																																																		
2/3/04	OH M-29	OH	Baseline			SEA1	15.2	4.28																																																																																																																																																																																															
					SEA1	29.8	8.38																																																																																																																																																																																																
			DARCO	25.0	7.03	SEA1	29.8	8.38																																																																																																																																																																																															
			DARCO	25.0	7.03	SEA1	45.5	12.80																																																																																																																																																																																															
			DARCO	25.0	7.03	SEA1	59.9	16.73																																																																																																																																																																																															
			DARCO	25.0	7.03	SEA1	15.2	4.28																																																																																																																																																																																															
2/4/04	OH M-29	OH	Baseline			SEA2	9.8	2.73																																																																																																																																																																																															
					SEA2	9.8	2.73																																																																																																																																																																																																
			DARCO	25.0	6.96	SEA2	9.8	2.73																																																																																																																																																																																															
			DARCO	15.0	4.18																																																																																																																																																																																																		
			DARCO	15.0	4.18																																																																																																																																																																																																		
			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	OH	OH	Baseline																																																																																																																																																																																																				
			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.																																																																																																																																																																																																							
25	The method of claim 1, wherein the coal comprises subbituminous coal.	The Oct. 2005 Report explains that the February 2004 testing was conducted using subbituminous coal (pages 26-27): ESP Hg removal testing was performed with the PTC firing Caballo subbituminous coal.'																																																																																																																																																																																																					

		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 M-29	OH	Baseline					
					Baseline					
					DARCO	25.0	7.03			
					DARCO	28.0	7.84			
					DARCO	32.0	8.96			
					DARCO	45.0	12.60			
				OH	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
					DARCO	25.0	7.03	SEA1	45.5	12.80
			OH	OH	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
								SEA2	9.8	2.73
					DARCO	25.0	6.96	SEA2	9.8	2.73
					DARCO	15.0	4.18	SEA2	9.8	2.73
					DARCO	15.0	4.18			
					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		OH	Baseline					
					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.								

27	The method of claim 1, wherein the mixture is combusted in a combustion chamber of a coal-combustion facility upstream of a scrubber, a particulate control system, or a combination thereof, wherein the particulate	See '114 claim 1f.
----	---	--------------------

	sorbent is added to the mercury-containing gas before the mercury-containing gas encounters the scrubber, the particulate control system, or the combination thereof.	
28	The method claim 26, wherein the particulate control system comprises an electrostatic precipitator, a baghouse, a fabric filter, or a combination thereof.	See '114 claim 1f.

The '517 Patent to Olson

No.	'517 Claim Element	Evidence of Reduction to Practice
1a	A method for reducing mercury in a mercury-containing gas, the method comprising:	See '114 1a.
1b	combusting coal in a combustion chamber, the coal comprising an additive comprising Br ₂ , HBr, a bromide compound, or a combination thereof, to form the mercury-containing gas; and	See '114 1b, 1c.
1c	collecting mercury in the mercury-containing gas with a sorbent added to the mercury-containing gas, the sorbent comprising activated carbon.	See '114 1d, 1f.
2	The method of claim 1, further comprising injecting an alkaline sorbent into the mercury-containing gas stream.	See '225 claim 9.
3	The method of claim 2, wherein the alkaline sorbent is selected from the group consisting of alkali elements, alkaline earth elements, alkali salts, alkaline earth salts, and combinations thereof.	See '517 2.

4	The method of claim 1, wherein the activated carbon is chosen from powdered activated carbon, granular activated carbon, carbon black, carbon fiber, aerogel carbon, pyrolysis char, and combinations thereof.	See '114 1d..
5	The method of claim 1, wherein the sorbent has a composition comprising from about 1 to about 30 grams of the element bromine per 100 grams of activated carbon.	See '114 4.
6	The method of claim 1, comprising collecting greater than 70 wt % of the mercury in the mercury-containing gas.	See '114 2
8a	The method of claim 1, further comprising:	See '114 1g.
8b	measuring mercury content of the mercury-containing gas; and	See '114 1g.
8c	modifying, in response to the measured mercury content,	See '114 1h.
8d	an injection rate of injecting the sorbent comprising activated carbon into the mercury-containing gas,	See '114 1h.
8e	n amount of the additive comprising the Br ₂ , HBr, bromide compound, or a combination thereof, added to the coal, or	See '114 1h.
8f	a combination thereof.	See '114 1h.

10a	The method of claim 1, further comprising:	See '114 1g.
10b	modifying, in response to a measured mercury content,	See '114 1h.
10c	an injection rate of injecting the sorbent comprising activated carbon into the mercury-containing gas,	See '114 1h.
10d	an amount of the Br ₂ , HBr, bromide compound, or a combination thereof, added to the coal, or	See '114 1h.
10e	or a combination thereof.	See '114 1h.
11	The method of claim 1, wherein the coal comprises a subbituminous coal.	See '225 23.
13	The method of claim 1, wherein the coal comprises the added Br ₂ , HBr, the bromide compound, or a combination thereof, added to the coal before the coal enters the combustion chamber.	See '114 6.
14	The method of claim 1, wherein the combustion chamber comprises the added Br ₂ , HBr, the bromide compound, or a combination thereof.	See '114 6.

15	The method of claim 1, wherein the coal is combusted in the combustion chamber at a coal-combustion facility, wherein 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 Br ₂ , HBr, bromide compound, or combination thereof, to the coal is performed at the coal-combustion facility.	See '225 20.
17	The method of claim 1, wherein the combustion chamber is an electric utility coal combustion chamber.	The EERC pilot test combustor a coal combustor which simulates performance of an electric utility coal combustor.
18a	The method of claim 1, further comprising:	
18b	measuring mercury content of the mercury-containing gas; and	See '114 1g.
18c	modifying, in response to the measured mercury content, an injection rate of injecting the sorbent comprising activated carbon into the mercury-containing gas.	See '114 1h.
19	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.	See '114 4.

21	The method of claim 1, wherein the 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.	See '114 4.
22	The method of claim 1, wherein the Br ₂ , HBr, or the bromide compound is contacted with the sorbent in vapor form, gaseous form, liquid form, or in an organic solvent.	See '114 7.
23	The method of claim 1, wherein the sorbent injected into the mercury-containing gas is a sorbent obtained by contacting a base sorbent with a halogen or halide promoter prior to injection of the sorbent to the mercury-containing gas.	See '225 20.
24	The method of claim 1, wherein the 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.	See '225 22.
25	The method of claim 1, wherein the injection of the sorbent into the mercury-containing gas occurs upstream of a particulate separator or a scrubber.	See '114 18.

26	The method of claim 25, wherein the particulate separator comprises an electrostatic precipitator, a baghouse, a fabric filter, or a combination thereof.	See '114 18.
29a	A method of separating mercury from a mercury-containing gas, the method comprising:	See '114 1a
29b	combusting coal in a combustion chamber, wherein	See '114 1b
29c	the coal comprises added Br ₂ , HBr, bromide compound, or a combination thereof, added to the coal before the coal enters the combustion chamber, or	See '114 1c
29d	the combustion chamber comprises added Br ₂ , HBr, bromide compound, or a combination thereof, or	See '114 1c
29e	a combination thereof; and	See '114 1c
29f	collecting mercury in the mercury-containing gas with a sorbent added to the mercury-containing gas, the sorbent comprising activated carbon.	See '114 1e
30a	A method of separating mercury from a mercury-containing gas, the method comprising:	See '114 1a

30b	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 ₂ , or a combination thereof, wherein	See '114 1b, 1c
30c	the coal comprises added Br ₂ , HBr, bromide compound, or a combination thereof, added to the coal before the coal enters the combustion chamber, or	See '114 1c
30d	the combustion chamber comprises added Br ₂ , HBr, bromide compound, or a combination thereof, or	See '114 1c
30e	or a combination thereof.	See '114 1c
30f	collecting mercury in the mercury-containing gas with a sorbent added to the mercury-containing gas, the sorbent comprising activated carbon;	See '114 1e
30g	separating the sorbent contacted with the mercury from the mercury-containing gas;	See '114 1f
30h	measuring the mercury content of the mercury-containing gas; and	See '114 1g

30i	modifying, in response to the measured mercury content of the mercury-containing gas,	See '114 1h
30j	an injection rate of injecting the sorbent into the mercury-containing gas,	See '114 1h
30k	an amount of the Br ₂ , HBr, bromide compound, or a combination thereof, added to the coal or the combustion chamber, or	See '114 1h
30l	a combination thereof.	See '114 1h

The '430 Patent to Olson

No.	'430 Claim Element	Evidence of Reduction to Practice
1a	A method of separating mercury from a mercury-containing gas, the method comprising:	See '114 1a
1b	combusting coal in a combustion chamber, to provide the mercury-containing gas, wherein	See '114 1b
1c	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 chamber, or	See '114 1c
1d	the combustion chamber comprises an additive comprising Br ₂ , HBr, a bromide compound, or a combination thereof or	See '114 1c
1e	a combination thereof;	See '114 1c
1f	injecting a sorbent comprising activated carbon into the mercury-containing gas downstream of the combustion chamber;	See '114 1d

1g	contacting mercury in the mercury-containing gas with the sorbent; and	See '114 1e
1h	separating the sorbent contacted with the mercury from the mercury-containing gas.	See '114 1f
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 '114 claim 6
3	The method of claim 1, wherein the combustion chamber comprises the additive comprising the Br ₂ , HBr, the bromide compound, or a combination thereof.	See '114 1c

4	The method of claim 1, wherein the coal is combusted in the combustion chamber at a coal-combustion facility, wherein 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 at the coal-combustion facility.	See '114 claim 6
6	The method of claim 1, wherein the combustion chamber is an electric utility coal combustion chamber.	See '517 17.
7	The method of claim 1, wherein the combustion chamber is a coal combustion furnace.	See '114 claim 1b
8	The method of claim 1, wherein the coal comprises a subbituminous coal.	See '225 claim 25
10a	The method of claim 1, further comprising	
10b	measuring the mercury content of the mercury-containing gas; and	See '114 1g

10c	modifying, in response to the measured mercury content of the mercury-containing gas,	See '114 1h
10d	an injection rate of injecting the sorbent into the mercury-containing gas,	See '114 1h
10e	an amount of the Br ₂ , HBr, the bromide compound, or a combination thereof, added to the coal or the combustion chamber, or	See '114 1h
10f	a combination thereof.	See '114 1h
11	The method of claim 10, wherein the measuring of the mercury content comprises continuous measurement.	See '114 1h
12a	The method of claim 1, further comprising:	See '225 claim 24
12b	modifying, in response to a measured mercury content,	See '114 1h
12c	an injection rate of injecting the sorbent into the mercury-containing gas,	See '114 1h

12d	an amount of the Br ₂ , HBr, the bromide compound, or a combination thereof, added to the coal or the combustion chamber, or	See '114 1h
12e	a combination thereof.	See '114 1h
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.	See '114 1h
14	The method of claim 1, wherein the sorbent contacted with the mercury comprises the element bromine and mercury.	See '114 4
15	The method of claim 1, comprising removing greater than 70 wt % of the mercury in the mercury-containing gas.	See '114 1f
16	The method of claim 1, comprising removing greater than 70 wt % of the mercury in the mercury-containing gas with the sorbent.	See '114 2

17	The method of claim 1, wherein the 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.	See '114 3
18	The method of claim 1, wherein the Br ₂ , HBr, or the bromide compound is contacted with the sorbent in vapor form, gaseous form, liquid form, or in an organic solvent.	See '114 4
19	The method of claim 1, wherein the activated carbon comprises powdered activated carbon, granular activated carbon, or a combination thereof.	See '114 7
20	The method of claim 1, wherein the sorbent injected into the mercury-containing gas is a sorbent obtained by contacting a sorbent with a halogen or halide promoter prior to the injection of the sorbent into the mercury- containing gas.	See '114 12

21	The method of claim 1, wherein the 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.	See '114 14
22	The method of claim 1, wherein the combustion chamber comprises a boiler.	See '114 13
23	The method of claim 1, wherein the mercury-containing gas is a flue gas.	See '114 1
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 '114 1
25	The method of claim 24, wherein the particulate separator comprises a baghouse, an electrostatic precipitator, a fabric filter, or a combination thereof.	See '114 18
28a	A method of separating mercury from a mercury-containing gas, the method comprising:	See '114 18

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 '114 1a
28c	the coal comprises an additive comprising, HBr, a bromide compound, or a combination thereof, wherein the additive is added to the coal before the coal enters the combustion chamber, or	See '114 1b, 1c
28d	the combustion chamber comprises an additive comprising Br HBr, a bromide compound, or a combination thereof, or	See '114 1c
28e	a combination thereof,	See '114 1c
28f	injecting a sorbent comprising activated carbon into the mercury-containing gas downstream of the combustion chamber;	See '114 1c
28g	contacting mercury in the mercury-containing gas with the sorbent; and	See '114 1d

28h	Separating the sorbent contacted with the mercury from the mercury-containing gas.	See '114 1e
29a	A method of separating mercury from a mercury-containing gas, the method comprising:	See '114 1f
29b	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 ₂ , or a combination thereof, wherein	See '114 1a
29c	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 chamber, or	See '114 1b, 1c
29d	the combustion chamber comprises an additive comprising Br ₂ , HBr, a bromide compound, or a combination thereof, or	See '114 1c
29e	a combination thereof;	See '114 1c

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 '114 1c
29g	contacting mercury in the mercury-containing gas with the promoted sorbent;	See '114 1d
29h	separating the promoted sorbent contacted with the mercury from the mercury-containing gas;	See '114 1e, f
29i	measuring the mercury content of the mercury-containing gas; and	See '114 1g
29j	modifying, in response to the measured mercury content,	See '114 1h
29k	an injection rate of injecting the sorbent into the mercury-containing gas,	See '114 1h

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 '114 1h
29m	a combination thereof.	See '114 1h

Appendix B - List of References

1. Deposition transcript of Christopher Berkimer and related exhibits.
2. Deposition transcript of Vincent Inedino and related exhibits.
3. Deposition transcript of George Kotch and related exhibits.
4. Deposition transcript of Vincent Verschueren and related exhibits.
5. Deposition transcript of William Whitney and related exhibits.
6. US Patent No. 8,168,147
7. US Patent No. 10,343,114
8. US Patent No. 10,589,225
9. US Patent No. 10,596,517
10. US Patent No. 10,668,430
11. ME2C Responses to Interrogatories
12. CERT Defendants And Certain Refined Coal LLC Defendants' Responses And Objections To Plaintiffs Midwest Energy Emissions Corp. And Mes Inc.'s First Set Of Common Interrogatories (Nos. 1-17)
13. Deposition transcript of James Landreth and related exhibits.
14. ME2C-RC-00014587
15. <https://www.epa.gov/title-v-operating-permits/>
16. <https://www.epa.gov/clean-air-act-overview/1990-clean-air-act-amendment-summary-title-iii>
17. <https://www.epa.gov/mercury/mercury-study-report-congress>
18. <https://www.epa.gov/mats/study-hazardous-air-pollutant-emissions-electric-utility-steam-generating-units-final-report>
19. REF-COAL_00000685
20. CERT-0017228
21. SB_00001988
22. SB_00001099
23. SB_00001173
24. SB_00001228 - 1230
25. SB_00002503 – 2506
26. SB00003760
27. SB00002261
28. SB00002510
29. SB_00025047
30. SB_00001630

31. PortageFuels_00069248
32. Belle_00019997
33. Belle_00013373
34. SV_00003746
35. Belle_00018622
36. Belle_00044997
37. Belle_00018121
38. Belle_00018974
39. Coletto_0039
40. CERT-0017228
41. CERT-0034619
42. WHELAN-0000692
43. Deposition of Sally Batanian and related exhibits.
44. WHELAN-0000889
45. Belle_00018066
46. Belle_00063862
47. MIDAMERICAN – 1053
48. MIDAMERICAN – 0935
49. MIDAMERICAN – 0808
50. Belle_00108413
51. CERT-0023675
52. CERT-0022114
53. CERT-0017228
54. ME2C-RC-00209976 - ME2C-RC-00210044
55. ME2C-RC-00210099 - ME2C-RC-00210113
56. COAL_00000685
57. COAL_00000600
58. COAL_00000642
59. COAL_00000596
60. ME2C-RC-00072299 - 306
61. THE MULTIPLE SITE MODEL FOR FLUE GAS— MERCURY INTERACTIONS ON ACTIVATED CARBONS: THE BASIC SITE, Energy & Environmental Research Center University of NorthDakota, 2003.
62. ME2C-RC-00055476 - 479

63. ME2C-RC-00222689 - 696
64. A/N 15/99778,760 PATENT IN THE UNITED STATES PATENT AND TRADEMARK OFFICE , DECLARATION UNDER 37 CFR §1.132, Declaration A, John Pavlish, 5/14/2018.
65. A/N 15/99778,760 PATENT IN THE UNITED STATES PATENT AND TRADEMARK OFFICE , DECLARATION UNDER 37 CFR §1.132, Declaration B, John Pavlish, 5/14/2018.
66. A/N 15/99778,760 PATENT IN THE UNITED STATES PATENT AND TRADEMARK OFFICE , DECLARATION UNDER 37 CFR §1.132, Declaration C, John Pavlish, 5/14/2018.
67. A/N 15/99778,760 PATENT IN THE UNITED STATES PATENT AND TRADEMARK OFFICE , DECLARATION UNDER 37 CFR §1.132, Declaration D, John Pavlish, 5/14/2018.
68. ME2C-RC-00210099 - 113
69. <https://www.eia.gov/energyexplained/coal/>
70. https://www.epa.gov/sites/default/files/2018-05/documents/epa_platform_v6_documentation_-_chapter_7.pdf
71. ME2C-RC-00169727
72. 26 U.S.C. § 45(c)(7)(A)
73. Deposition transcript of Sally Batanian and related exhibits.
74. B. Prest & A. Krupnick, “How Clean is “Refined Coal”? An Empirical Assessment of a Billion-Dollar Tax Credit,” (2020)
75. https://www.epa.gov/sites/default/files/2018-05/documents/attachment_5-6_hg_control_cost_development_methodology.pdf at Pp. 2-3
76. ME2C-RC-00070738
77. Belle_00062312
78. SB_00001195
79. SB-00000917
80. Deposition transcript of Jeff Green and related exhibits
81. ArborFuels_00067791
82. W. Baasel, “Capital and Operating Costs of Wet Scrubbers Installed on Coal-Fired Utilities Impacting the East Coast” (2012)
83. <https://www.eescorp.com/solutions/kleenscrub/>
84. <https://www.eia.gov/energyexplained/coal/>
85. https://www.epa.gov/sites/default/files/2018-05/documents/epa_platform_v6_documentation_-_chapter_7.pdf
86. <https://www.epa.gov/title-v-operating-permits/>
87. <https://pubs.usgs.gov/fs/fs095-01/fs095-01.pdf>
88. SB_00041379
89. ME2C-RC-00218742
90. COAL_0001392

91. COAL_0001395
92. COAL_0001346
93. COAL_0001350
94. COAL_0001564
95. COAL_0007341
96. COAL_0007338
97. COAL_0007493
98. COAL_0007489
99. COAL_0007296
100. COAL_0007544
101. COAL_0007692
102. COAL_0007630
103. COAL_0007626
104. COAL_0007564
105. COAL_0000453
106. COAL_0000546
107. COAL_0000526
108. COAL_0000543
109. COAL_0000501
110. COAL_0000584
111. COAL_00018816
112. COAL_00019023
113. COAL_00018841
114. COAL_0009715
115. COAL_0009695
116. COAL_0009817
117. COAL_00015250
118. COAL_00015316
119. COAL_00015177
120. COAL_00017498
121. COAL_00017475
122. COAL_00017453
123. COAL_00012434

124. COAL_00012517
125. COAL_00013423
126. COAL_00012986
127. COAL_00012404
128. CGE_00002035
129. COAL_0000038
130. COAL_0000075
131. COAL_0000124
132. COAL_0000207
133. COAL_0000174
134. COAL_0000253
135. COAL_00010970
136. ArborFuels_0005205
137. COAL_0000988
138. COAL_00001048
139. COAL_00001052
140. Belle_00097581
141. COAL_00005641
142. PortageFuels_00050820
143. PortageFuels_00050850
144. COAL_00005672
145. Belle_00064886
146. COAL_00015976
147. COAL_00064812
148. CERT_0007688
149. CERT_0007641
150. CERT_0007240
151. CERT_0009735
152. CERT_0009770
153. CERT_0009823
154. CERT_0007729
155. CERT_0008275
156. CERT_0008315

157. CERT_0012710
158. CERT_0008397
159. CERT_0008446
160. CERT_0007433
161. CERT_0007401
162. CERT_0007346
163. CERT_0036918
164. CERT_0037063
165. CERT_0008039
166. CERT_0007554
167. CERT_0007521
168. CERT_0017134
169. CERT_0007878
170. CERT_0008165
172. CERT_0008205
173. CERT_0007958
174. CERT_0008841
175. CERT_0008871
176. CERT_0020032
177. 26 U.S.C. § 45(c)(7)(A)(i)(II)
178. Belle_00077846
179. ME2C-RC-00218742, J. Wilcox, Atomistic-Level Models from Mercury Control: for Coal-Derived Gas Streams (2015), and supporting references.
180. Declaration of inventor John Pavlish (July 27, 2020).
181. ArborFuels_00045831
182. REF-COAL_00020453
183. GCE_00002311
184. Deposition Transcript of Leah Schatt and related exhibits
185. Deposition Transcript of J. Finlinson and related exhibits
186. CERT_0023314
187. Belle_00052528
188. ArborFuels_0081059
189. ME2C-RC-0041150

190. Belle_0020814
191. ME2C-RC-00174356
192. SB_00026045
193. Belle_00113836
194. ME2C-RC-00172724
195. SB_00001257
196. ME2C-RC-00038657
197. ArborFuels_00080962
198. Belle_00018066
199. CERT-0012805
200. Deposition Transcript of L. Kuennen and related exhibits
201. SB_00041379
202. SB_00001195
203. SB_00041424
204. Deposition Transcript of J. Trettel and related exhibits
205. ArborFuels_00064263
206. CERT-0034624
207. ME2C-RC-00274666
208. DOMINION0000642
209. Belle_00089516
210. DEFTS00000542
211. GCE_00003117
212. GCE_00002311
213. U.S. Patent No. 7,507,083
214. U.S. Patent No. 7,468,170
215. CERT-0006822
216. U.S. Patent No. 6,808,692
217. U.S. Patent No. 8,845,986
218. Defendant Responses to ME2C Requests for Admission
219. Correspondence from J. Evall to J. Nemunaitis (January 28, 2022) ME2C-RC-00279352
220. CERT Responses to ME2C Requests for Admission
221. CERT Responses to ME2C's First Set of Interrogatories
222. MIDAMERICAN – 1142

223. CERT-0012026
224. CERT-0020032
225. ME2C-RC-00279293
226. ME2C-RC-00279374
227. SB_00041379
228. Defendant Responses to ME2C First Set of Interrogatories
229. Defendant Responses to ME2C Third Set of Interrogatories
230. Arbor Fuels_00067779
231. ME2C-RC-00048807
232. <https://www.eia.gov/energyexplained/coal/>
233. <https://www.epa.gov/clean-air-act-overview/1990-clean-air-act-amendment-summary-title-iii>
234. 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>
235. https://files.nc.gov/ncdeq/Air%20Quality/permits/psd/docs/cliffside/EPRI_SCR_Mercury_2004.pdf
236. ME2C-RC-00112336
237. https://content.edgar-online.com/ExternalLink/EDGAR/0001193125-12-462616.html?hash=df736b90461a1e917cab80f6fd53fbba63cf04b47b30778cd28cfad418ad29c7&dest=D398286DEX1058_HTM#D398286DEX1058_HTM
238. ME2C-RC-00048867
239. October 25, 2022 Opening Report of Dr. Stephen Niksa
240. ME2C-RC-00052326 – 342
241. ME2C-RC-00052343 – 365
242. JV TASK 45 – MERCURY CONTROL TECHNOLOGIES FOR ELECTRIC UTILITIES BURNING LIGNITE COAL, PHASE I, BENCH- AND PILOT-SCALE TESTING, FINAL REPORT (2003) (“the Oct. 2003 Report”)
243. ME2C-RC-00052366 – 414
244. ME2C-RC-00052415 – 446
245. ME2C-RC-00052447 – 566
246. PILOT- AND FULL-SCALE DEMONSTRATION OF ADVANCED MERCURY CONTROL TECHNOLOGIES FOR LIGNITE-FIRED POWER PLANTS (2004)
247. ME2C-RC-00053005 – 012
248. ME2C-RC-00053013

- 249. ME2C-RC-00053014 – 508
- 250. ME2C-RC-00053509 – 510
- 251. ME2C-RC-00053511 – 532
- 252. ME2C-RC-00052721 – 817
- 253. ME2C-RC-00052818 – 3004
- 254. ME2C-RC-00053538 – 647
- 255. ME2C-RC-00053533 – 537
- 256. ME2C-RC-00053648 – 653
- 257. IPR 2020-00834, Paper 18 (Institution Decision)
- 258. ME2C-RC-00051379 – 428
- 259. U.S. Patent No. 6,953,494
- 260. ME2C-RC-00064557 – 629
- 261. ME2C-RC-00065433 – 460
- 262. ME2C-RC-00038011 – 122
- 263. ME2C-RC-00203957 – 4029
- 264. Opening Report of Phillip J. O’Keefe, PE Regarding Infringement
- 265. Deposition Transcript of R. MacPherson and Related Exhibits
- 266. U.S. DEPARTMENT OF ENERGY, ENHANCING THE ENVIRONMENTAL PERFORMANCE OF COAL-FIRED POWER PLANTS: DOE’S INNOVATIONS FOR EXISTING PLANTS PROGRAM (2005)
- 267. U.S. ENVIRONMENTAL PROTECTION AGENCY, OFFICE OF RESEARCH & DEVELOPMENT, CONTROL OF MERCURY EMISSIONS FROM COAL-FIRED ELECTRIC UTILITY BOILERS: INTERIM REPORT, EPA-600/R-01-109 (2002)
- 268. U.S. ENVIRONMENTAL PROTECTION AGENCY, OFFICE OF RESEARCH & DEVELOPMENT, CONTROL OF MERCURY EMISSIONS FROM COAL-FIRED ELECTRIC BOILERS: AN UPDATE (2005)
- 269. ME2C-RC-00070714 – 737
- 270. ME2C-RC-00053658 – 661