BEFORE THE ILLINOIS POLLUTION CONTROL BOARD

IN THE MATTER OF:	)	
	)	R08-19
NITROGEN OXIDES EMISSIONS FROM	)	(Rulemaking - Air)
VARIOUS SOURCE CATEGORIES:	)	
AMENDMENTS TO 35 ILL. ADM. CODE	)	
PARTS 211 and 217	)	

NOTICE OF FILING

TO: Mr. John T. Therriault
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(VIA ELECTRONIC MAIL)

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(SEE PERSONS ON ATTACHED SERVICE LIST)

PLEASE TAKE NOTICE that I have today filed with the Office of the Clerk of the Illinois Pollution Control Board the **PRE-FILED TESTIMONY OF BLAKE E. STAPPER ON BEHALF OF UNITED STATES STEEL CORPORATION**, a copy of which is herewith served upon you.

Respectfully submitted,

UNITED STATES STEEL CORPORATION,

Dated: February 2, 2009

By: /s/ Katherine D. Hodge
Katherine D. Hodge

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PRE-FILED TESTIMONY OF BLAKE E. STAPPER
ON BEHALF OF UNITED STATES STEEL CORPORATION

NOW COMES the UNITED STATES STEEL CORPORATION ("U.S. Steel"), by and through its attorneys, HODGE DWYER ZEMAN, and submits the following PRE-FILED TESTIMONY OF BLAKE E. STAPPER for presentation at the February 3, 2009 hearing scheduled in the above-referenced matter.

PRE-FILED TESTIMONY OF BLAKE E. STAPPER

I. INTRODUCTION

Good morning. My name is Blake Stapper. I am a Principal Engineer for URS Corporation ("URS"), and I previously testified before the Illinois Pollution Control Board ("Board") in this matter on December 10, 2008. The purpose of my testimony today is to provide information in support of the Reasonably Available Control Technology ("RACT") determination for Boilers 11 and 12 at U.S. Steel's Granite City Works ("GCW"). In particular, I wish to respond to the comments offered by Dr. James E. Staudt in his prefiled testimony filed with the Board on January 20, 2009.

In his testimony, Dr. Staudt contended that the URS study, which was commissioned by U.S. Steel, is suspect because of errors and inconsistencies that he identified and suggested that URS did not perform a complete and diligent analysis. Testimony of James E. Staudt, Ph.D, *In the Matter of: Nitrogen Oxides Emissions From*

Various Source Categories: Amendments to 35 Ill. Adm. Code Parts 211 and 217, R08-19 at 5-15 (Ill.Pol.Control.Bd. Jan. 20, 2009) ("Staudt Testimony"). To support his conclusions, he noted that URS did not contact any burner or boiler suppliers directly about the application of their technologies to Boilers 11 and 12. *Id.* at 5-6. Dr. Staudt disputed URS's claim that there are no Low-NOx burners suitable for application to Boilers 11 and 12 by referencing communications he had with four burner vendors who all indicated that they could provide Low-NOx burners for multi-fuel applications. *Id.* at 6. I would like to address each of these points in turn.

II. INFORMATION FROM BURNER VENDORS

At any given time, URS is executing numerous projects to implement NOx controls on industrial boilers. These turnkey projects involve engineering, procurement, construction, and startup. These projects include burner replacement with and without flue gas recirculation ("FGR"), FGR addition to existing burners, Selective Catalytic Reduction ("SCR") installations, and a few Selective Non-Catalytic Reduction ("SNCR") installations. The contract terms generally require URS to provide emissions guarantees. As such, URS places both its professional reputation and its financial interest at stake when performing these projects, and we work diligently to protect both.

The success of these projects requires URS to have relationships with a number of burner manufacturers and boiler suppliers. As such, we not only have access to the most current information on available technologies, but we also have practical knowledge of how such technologies perform in a variety of real-world applications. As a result of our ongoing experience with these installations, it is not necessary for us to contact vendors when we conduct a study, such as the one that we completed for U.S. Steel.

It should be understood that burner vendors are in the business of selling burners. One must draw a distinction between what a vendor thinks its technology can do, and what the vendor is willing to guarantee. A vendor may suggest that its technology is capable of meeting a certain emission level, but, when faced with the specifics of an unusual application (not to mention the requirement to sign a contract to guarantee performance), the vendor may reconsider its original estimate.

Based on URS experience, we would not recommend the application of Ultra-Low-NOx burners to the GCW boilers. We have found that the addition of FGR to existing burners obtains the same NOx results as conventional Low-NOx burners with FGR. Given the risk of retrofitting U.S. Steel's boilers with a burner unproven using the fuel mix fired at GCW, URS recommended applying FGR to the existing burners as the best solution for controlling NOx. Before URS would consider replacing the burners at GCW the vendor would need to have demonstrated commercial experience with that burner design with a similar mix of fuels in a multi-burner application.

In his testimony, Dr. Staudt submitted correspondence that he had exchanged with four burner vendors. Staudt Testimony at Exhibit 1. The vendors include Bloom Engineering ("Bloom"), North American Manufacturing Company ("North American"), Coen Company, Inc. ("Coen"), and Hamworthy-Peabody Combustion ("Hamworthy-Peabody"). *Id.* The documentation shows that Dr. Staudt informed the vendors that the boilers were rated at 225 MMBtu/hr and that they fire a mixture of natural gas ("NG"), coke oven gas ("COG"), and blast furnace gas ("BFG"). In his correspondence to the vendors, he included examples of the particular blends that U.S. Steel used to estimate emissions, noting in the process that the COG would be desulfurized, and it could be assumed that most or all of the hydrogen cyanide ("HCN") would be removed. Finally, he informed the vendors that one boiler was wall-fired and the other corner-fired. *Id.* at Exhibit 1.

There is detailed information regarding the GCW boilers and operations at GCW that was not included in the information that Dr. Staudt provided to the vendors. Such detailed information would undoubtedly impact the vendors' responses to Dr. Staudt's inquiries. For example, one specific is that the COG would be desulfurized and have most or all of the HCN removed. The fact is that the scrubber vendor estimated that the scrubbed COG will still contain 130 ppm of HCN, which will have an impact on the NOx emissions. It should also be noted that U.S. Steel is permitted to operate for up to 35 days per year without the scrubber in operation. During those five weeks, the COG will contain 1900 ppm HCN. In addition, Dr. Staudt did not inform the vendors of the presence of the preheater on each boiler, which raises the combustion air temperature and the flame temperature, and therefore increases NOx emissions, compared to an application utilizing ambient combustion air. Coen, one of the vendors contacted by Dr. Staudt, stipulated that its analysis was made "assuming ambient combustion air."

However, the most critical omission in Dr. Staudt's correspondence with the vendors is his characterization of the fuel blends that would be fired. The blends he provided to the vendors were those that U.S. Steel used to calculate its average NOx emissions. These included a "normal operation" blend of 35% BFG, 25% NG, and 40% COG, and a "blast furnace down" blend of 40% NG and 60% COG. The problem is that these are averaged values that were used for emissions calculations. These values do not reflect the range over which the fuel blend might change at any one time, which includes the potential that the boilers would be firing a blend that is almost entirely made up of BFG. The BFG has a very low heating value and is especially hard to burn with a stable flame, even in a standard burner. Most Low-NOx burners are simply not capable of safely burning this fuel.

The burner vendors contacted by Dr. Staudt all indicated that they supply burners that can burn multiple fuels. Most noted that they would need more specific details regarding the boilers; however, one vendor did speculate what NOx emission rate could be achieved on Boilers 11 and 12 using its Low-NOx burner technologies. In the following paragraphs, I will comment on each of the vendor's responses.

Bloom provided information for its 1030 Series Burner. It provided specification sheets, which Bloom noted were based on a single fuel design and commented that a multiple fuel design would cause the burner to be bigger in size. The burner size is important, especially since the opening for the burners between the tubes in Boiler 11 is only 14 inches. The dimensions from Bloom suggest that the burner would be about 59" in diameter, making it necessary to reconstruct the boiler corners in order to accommodate installation of this burner. Similarly, the Bloom burner for Boiler 12 would have a diameter of 87" and a flame length of 36 feet. The current burner openings in the front wall of Boiler 12 are 52 inches, and the distance from the center of one burner to the other is only 73 inches. Further, the back wall of the boiler is only 18 feet from the front wall. Flame impingement on the back wall would create serious problems for the tubes and is not acceptable operating practice. Therefore, the burners identified by Bloom in its correspondence with Dr. Staudt would not fit into the boilers at GCW.

Based on the limited information provided, Bloom estimated that the NOx emissions using its burner would be 0.114 lb/MMBtu on the "normal operation" blend of 40% BFG, 35% CFG, and 25% NG, although Bloom would not guarantee that emission rate. This value is remarkably similar to the 0.113 lb/MMBtu NOx emission rate that U.S. Steel is proposing. Note that this blend has a lower flame temperature than the "blast furnace down" blend of 60% NG and 40% COG, so it would have lower NOx emissions. Therefore, it would be expected that Bloom would estimate slightly higher emissions for the "blast furnace down blend," which again would be higher than the emissions that U.S. Steel is proposing to achieve with FGR.

As noted above, Dr. Staudt also contacted North American, which provided information for its Magna Flame LE series burner, a lean-premix burner design. URS contacted North American and verified that this is the burner that they would propose for the U.S. Steel boilers. The nature of a lean-premix burner design is that it requires some consistency in the fuel supply, especially for multiple fuel applications. It is not physically possible to operate a lean-premix burner across the fuel composition range anticipated for Boilers 11 and 12. It would not be able to support a stable flame at the high BFG conditions.

An inspection of the specifications for the Magna Flame LE dimensions indicates further problems for this application. Boiler 11 is rated at 225 MMBtu/hr and has four burners, so each burner must be rated at about 56 MMBtu/hr. In the materials submitted with Dr. Staudt's testimony, this would correspond to the Model 4211-62, which is shown to have an outer diameter of 57 inches. As mentioned previously, the burner openings in the corners of Boiler 11 are 14 inches wide. Installation of the burner would require a complete rebuild of the boiler corners at great expense. Boiler 12 has the same rating, but only two burners, so each much be rated at 112.5 MMBtu/hr, which would correspond to the Model 4211-116. The documentation states that this burner has a diameter of 76 inches, which is slightly larger than the distance between the centerlines of the two existing burners. Since the burners cannot overlap, the front wall of the boiler would have to be reconstructed to accommodate the new burners. In addition, the specifications show that this burner has a flame length of 24 feet. However, the back wall of the boiler is only about 18 feet away from the front wall. Flame impingement on the back wall would create serious problems for the tubes and is not acceptable operating practice. Thus, even if the Magna Flame LE could successfully burn the fuel blends at U.S. Steel, such burners would not physically fit Boilers 11 and 12.

Coen also responded to Dr. Staudt's inquiry with information based on the assumption that there was little HCN in the COG and that the combustion air was at ambient temperature (no air preheat). Neither of these is a correct assumption. For the "normal operation" fuel blend, Coen suggested the use of a "Low Btu Gas Scroll" to fire the BFG. In this design, the NG and COG would each have its own injector, and the BFG would be introduced via the scroll. The BFG acts to cool the NG and COG flames, resulting in lower NOx emissions. Because of the manner in which the BFG is introduced, it depends on the presence of the NG and COG flames to ignite and maintain steady combustion. Unfortunately, in the case where the boilers are burning almost all BFG, there is not enough heat present from the other fuels to maintain a stable BFG flame, creating a potentially dangerous situation.

URS contacted Scott Krahn at Coen, who stated that for the wall-fired boiler at GCW, they would use their DAF burner design with about 25% FGR. He said that the t-fired unit would be a custom burner design. He also noted that while Coen has applications that fire a combination of NG and COG, or NG and BFG, that he was not aware of any installations where they are firing a blend of NG, COG, and BFG. Mr. Krahn reiterated Coen's position that its burner would operate on the range of fuel blends that would occur on Boilers 11 and 12 and would achieve NOx emissions in the range of 0.03 to 0.05 lb/MMBtu during normal operation. However, these were not rates that Coen would be prepared to guarantee without having more information about the application.

In addition, Coen stated that the emissions would increase to 0.47 lb/MMBtu when firing the unscrubbed COG, due to the HCN content, and its conversion to NOx. This creates skepticism about Coen's previous estimate, since the scrubbed COG still contains 130 ppm HCN (about a 93% reduction from the unscrubbed case). Applying this reduction to the 0.47 lb/MMBtu value, results in a contribution of 0.032 lb/MMBtu for the HCN portion of the NOx during normal operation with scrubbed COG, which is just for the NOx from the fuel, and does not take into account any thermal NOx or prompt NOx. Yet, Coen's estimate for the overall NOx emissions during normal operation is 0.03 to 0.05 lb/MMBtu. Clearly, there is a discrepancy in Coen's estimates.

In a previous paragraph, I referred to a potentially dangerous situation in the application of Coen's solution for burning BFG. The primary cause for concern in applying Low-NOx burners in atypical service is that Low-NOx burners are less forgiving of fuel/air ratio excursions. They require better controls and also a highly educated operations staff who will not try to operate them in the same manner as a conventional burner. In my previous testimony, I described the increased potential for explosions of Low-NOx burners in multi-fuel applications. In his testimony, Dr. Staudt noted that I did not provide any information to support this statement. Staudt Testimony at 7. An example of the potential consequences occurred at the ConocoPhillips refinery located in Carson, California. On July 23, 2003, a boiler equipped with four Coen Low-NOx burners firing refinery gas exploded causing millions of dollars in damages. "Boiler Explodes at Refinery," Los Angeles Times at B-4 (July 24, 2003).

In California, which has been using Low-NOx and Ultra-Low-NOx burners for the longest time period, there have been numerous boiler explosions over the last ten years. These explosions have many causes, including improper use of a burner technology, operator error, improper design, and improper set-up. All of these boilers had safety systems in compliance with NFPA, but that alone does not guarantee safe operation. There are approximately 100 boilers with a heat input of 60 MMBtu/hr or greater located in the California Central Valley, and the list below, which represents about 10 percent of the boilers in the Central Valley, provides information on several of the boiler explosions that have occurred over the years.

- Coen QLN – Tomato cannery (total loss)
- NatCom – Cheese Plant (3 boilers all with explosions) major damage
- NatCom – Tomato Cannery (total loss)
- Todd Variflame – Tomato Cannery (major damage)
- Forney – Tomato Cannery (major damage)
- Rapid Mix – Tomato Cannery (minor damage)
- Rapid Mix – Tomato Cannery (minor damage)
- Coen QLN – Consumer Goods (total loss)

The fourth vendor to which Dr. Staudt provided information in his testimony was Hamworthy-Peabody. Hamworthy-Peabody simply responded that it had significant experience supplying burners to the steel industry for both new and retrofit applications firing multiple fuels and requested clarification of what Dr. Staudt defined as "Low-NOx." It did not provide any further information.

Ironically, in January 2008, U.S. Steel received a proposal from Hamworthy-Peabody to retrofit Boilers 11 and 12. The information contained in this proposal was made available to URS and provided a useful data point to support our conclusions. The proposal presented estimates for the NOx emissions from the two boilers when firing a typical blend of COG, BFG, and NG, using either Low-NOx burners only, or in combination with FGR. The estimates assumed that the COG was scrubbed. URS reviewed the proposed emission estimates and applied them to the various fuel blends on which the study is based (including 35 days of operation with unscrubbed COG), and found that the composite NOx emissions were slightly higher than the 0.113 lb/MMBtu number that U.S. Steel is proposing to achieve.

In his testimony, Dr. Staudt stated that, "multi-fuel burners are not as rare as Mr. Stapper asserted in his testimony and are commonly used in the steel industry as well as in the refining industry." Staudt Testimony at 6. In reality, my testimony was that 'Low-NOx' burners are not commonly used in the steel industry. Prefiled Testimony of Blake E. Stapper, *In the Matter of: Nitrogen Oxides Emissions From Various Source Categories: Amendments to 35 Ill. Adm. Code Parts 211 and 217,* R08-19 at 4 (Ill.Pol.Control.Bd. Nov. 25, 2008) (stating that "there is very limited recent experience in this country applying 'low NOx burners' technologies to steel plant gases. . . . [T]he specialized fuel requirements at a steel plant, particularly for BFG, mean many boiler burner technologies that have been developed for NG and/or refinery gas are not suitable for BFG applications"). I agree that multi-fuel burners are used in the steel industry and would point to the burners currently installed on Boilers 11 and 12. They operate safely and effectively, but, they are not what I would characterize as "Low-NOx" burners.

I would also like to address the relative ambiguity of the term "Low-NOx" burner. Low-NOx burner development has been ongoing for the past 30 years, and what was once marketed as a Low-NOx burner in 1980 or 1990 does not resemble the design or capabilities of a contemporary model. It is also important to closely scrutinize each of the four vendors' "Low-NOx burner solutions." Note that each proposed solution includes the application of FGR to achieve the vendor's projected NOx levels. However, our review showed that these are the same NOx levels that U.S. Steel is proposing to achieve by applying FGR to their existing burners. This would seem to suggest one of two things: Either Boilers 11 and 12 are already equipped with Low-NOx burners and need only to have FGR applied to reach their full NOx reduction potential; or, the vendors contacted by Dr. Staudt are not actually proposing a true Low-NOx burner technology solution. They are merely offering up a burner and using another technology, *i.e.* FGR, to accomplish the actual NOx reduction. This highlights an important consideration in conducting a study such as this--burner vendors are in the business of selling burners.

III. SNCR

Dr. Staudt's testimony has also questioned the validity of URS's conclusions about the potential application of SNCR to Boilers 11 and 12 because we did not contact an SNCR vendor. Staudt Testimony at 8. Our position is that we have sufficient experience with and understanding of SNCR to analyze its suitability. However, in the interest of resolving the issue, I contacted Dr. Larry Muzio at Fossil Energy Research Corporation ("FERCo"). In the mid-1970s, Dr. Muzio participated in the original research into the use of urea injection into flue gas to reduce NOx emissions (SNCR), and continues to be a leader in the field. FERCo has implemented, tested, and optimized numerous SNCR systems over the past two decades. My original question to Dr. Muzio was whether it would be possible to adequately control the urea injection due to the changing NOx load and flue gas flow on Boilers 11 and 12. He replied that it did not really matter, because in his opinion, SNCR would not be able to reduce the emissions on the boilers to 0.08 lb/MMBtu, either if used on its own, or in combination with another technology, such as FGR.

IV. CONCLUSION

In summary, of the four burner vendors contacted by Dr. Staudt, all four proposed solutions using a combination of their own burners with FGR. Three of the four vendors estimated that their solution would result in NOx emissions at or above the 0.113 lb/MMBtu level that U.S. Steel has already proposed to achieve by adding FGR to its existing burners. The fourth vendor (Coen), while suggesting that it could achieve lower NOx emissions, noted that the burners for Boiler 11 would have to be a custom design. Coen also confirmed that it does not have a single application in which they are co-firing a blend of NG, COG, and BFG. In addition, URS contacted a widely respected expert in the design and operation of SNCR systems who stated that he did not think that SNCR would be able to achieve the NOx RACT emission limits proposed by the Illinois EPA, either as a stand-alone solution or applied in combination with another NOx control technology.

I would like to verify that URS conducted a complete and diligent analysis of the available NOx control technologies for Boilers 11 and 12 at U.S. Steel's GCW. Our conclusions were based on decades of practical experience in successfully applying NOx controls to a variety of combustion equipment. It is my contention that this experience is more relevant than the information that has been obtained by Dr. Staudt through Internet searches and via brief email exchanges with vendors that lacked the crucial specifics of this particular application.

Thank you for allowing me the opportunity to present my testimony. I am happy to answer any questions.

* * *

U.S. Steel reserves the right to supplement this testimony.

Respectfully submitted,

UNITED STATES STEEL
CORPORATION,

Dated: February 2, 2009

By: /s/ Katherine D. Hodge
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USSC:001/Fil/R08-19/Stapper Pre-Filed Testimony 2.02.2009

CERTIFICATE OF SERVICE

I, Katherine D. Hodge, the undersigned, hereby certify that I have served the attached PRE-FILED TESTIMONY OF BLAKE E. STAPPER ON BEHALF OF UNITED STATES STEEL CORPORATION, upon:

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Assistant Clerk of the Board
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/s/ Katherine D. Hodge
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USSC:001/Fil/R08-19/NOF-COS – Pre-Filed Testimony Stapper