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U. S. Steel
Gary Works
One North Broadway
Gary, IN 46402-3199

April 18, 2002

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State of Indiana
Department of Environmental Management
Office of Air Quality

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Air Programs Branch Som 312-353-5792
Office of Air Quality
Indiana Department of Environmental Management
100 North Senate Avenue
P.O. Box 6015
Indianapolis, Indiana 46206-6015

Re: U.S. Steel - Gary Works Blast Furnace Casthouse, Blast Furnace Slag Pit and Hot Metal Desulfurization Station Sulfur Dioxide (SO_2) Emission Estimates, Lake County State Implementation Plan

Dear Ms. Watson:

The purpose of this letter is to respond to your letter of January 9, 2002 concerning the same subject. The letter requested that U.S. Steel - Gary Works, Ispat Inland, Inc. and LTV Steel Company quantify and then model sulfur dioxide (SO_2) emissions from the following:

- Blast furnace casthouses during casting including the trough area, iron runners, iron spouts and slag runners including emissions vented through a stack or as fugitives.
- Blast furnace slag pit vented through a stack or as fugitives.
- Hot metal desulfurization operations vented through a stack and all fugitives.

Along with quantifying emissions from the above operations, the letter requested the definition of the sulfur dioxide release characteristics for use in the air dispersion modeling exercise.

U.S. Steel has initiated its work to estimate SO_2 emissions for the operations of interest by conducting emissions tests, measuring SO_2 concentrations in a blast furnace casthouse and applying engineering judgment. It must be emphasized that for reasons explained below, the SO_2 emissions estimates are preliminary pending further testing and measurement.

Preliminary Estimates of SO_2 Emissions from Blast Furnace Casthouses During Casting

Release Mechanism

The release mechanism for SO_2 during the casting/slagging operations is the release and subsequent oxidation (combustion) of hydrogen sulfide (H_2S) gas emitted from hot metal and slag. The H_2S gas is liberated from molten iron (hot metal) as it exits the tap hole, enters the iron trough, flows through iron runners and drops into torpedo cars. Hydrogen sulfide gas is also released from slag as it exits the tap hole, enters the iron trough where it is skimmed from the hot metal, flows through the slag runner and drops to the slag granulator and/or slag pit.

The H_2S released from the hot metal and slag is burned in the presence of oxygen to form SO_2 in air in regions where the air temperature is above the ignition temperature of H_2S and the

concentrations of H_2S are between the lower and upper flammability limits for H_2S. In general, these conditions exist within a few inches above the molten metal or slag streams.

Configuration of Fume Capture and Control System at No. 13 Blast Furnace

The Gary Works No. 13 Blast Furnace is equipped with a PM_{10} casthouse emissions control system. The system includes close capture hoods that essentially enclose the tap holes, iron troughs and large portions of the iron runners. Another series of hoods cover the locations where the iron spouts deliver molten iron to torpedo cars under the casthouse floor. All of the hoods are ducted to a common baghouse. The exhaust air drawn through the hood provides oxygen for the oxidation of H_2S to SO_2. The SO_2 is drawn through the ductwork, through the baghouse, and discharged through the baghouse stack to the atmosphere. As a result of the close capture afforded by the system, the SO_2 reporting to the baghouse stack should include almost all of the SO_2 formed in the casthouse during casting operations.

Results of Testing

To estimate emissions of SO_2 from the No. 13 Blast Furnace casthouse, stack testing was conducted at the baghouse stack on March 11, 2002. Stack gas flowrates were measured using EPA Reference Methods 1 through 4. Concentrations of SO_2 in the stack gas were measured using EPA Reference Method 6C. The results of the test are presented in Table 1, attached. Testing was conducted over a period of 5 hours and 20 minutes between 0840 hours to 1400 hours. The total SO_2 emitted during the test period was approximately 565.3 pounds. The estimated amount of hot metal that was cast during the test is approximately 1,293.6 tons. These data preliminarily indicate a daily average SO_2 emission factor from the casthouse of 0.44 pounds of SO_2 per ton of hot metal cast. As there are no SO_2 control mechanisms at No. 13 Blast Furnace, this preliminarily estimated emission factor is considered to represent uncontrolled SO_2 emissions from the casthouse. As shown in Table 1, there is considerable variability in the hour-by-hour SO_2 emission rates. This demonstrates the need for additional testing.

Preliminary Estimates of SO_2 Emissions from the South Blast Furnaces

The South Blast Furnaces (Nos. 4, 6 and 8) at Gary Works are equipped with iron oxide fume suppression systems for PM_{10} emissions control. These systems consist of iron trough and runner covers with natural gas burners directed to project flames into the space between the molten metal/slag streams and the covers. These systems deprive the molten streams of oxygen and thus suppress the formation of iron oxide fume. It is most reasonable to assume that the oxygen deprivation also suppresses the oxidation of H_2S to SO_2. There is no known practical and safe method of testing the emissions of SO_2 from the casthouse roof monitors at the south furnaces. Daily average SO_2 emissions from these casthouses currently are being estimated by conservatively assuming a 50 percent suppression efficiency and assuming that the uncontrolled daily average emission factor preliminarily indicated by testing at No. 13 furnaces (0.44 lbs SO_2/ton hot metal) applies to each of the south furnaces. This indicates a daily average controlled emission factor at the south furnaces of 0.22 lbs SO_2/ton hot metal.

Blast Furnace Slag Pits

There are no known safe and practical methods of testing to quantify mass emission rates of SO_2 from blast furnace slag pits. At No. 13 Blast Furnace, there is a slag granulator which receives molten slag from the slag runner and granulates the molten slag thus producing a granular slag product. The granulator is partially enclosed and is fitted with a roof with a chimney-like structure (stack). Measurements of flowrates and SO_2 concentrations in the stack were made over a period of 65 minutes on March 8, 2002, between 1425 and 1530 hours. No. 13 Furnace casting operations ceased before the testing could be completed and damage to the sampling lines precluded further testing. The data that were obtained indicate an SO_2 emission rate of 10.1 lbs SO_2/hr. The hot metal casting rate during the test period is estimated to be approximately 525 tons of hot metal per hour. This indicates an SO_2 emission factor of approximately 0.019 lbs SO_2/ton hot metal. U.S. Steel will conduct further testing at the slag granulator in the near future.

Preliminary Estimates of SO_2 Emissions from Hot Metal Desulfurization Facilities

Release Mechanism

The release mechanism for SO_2 during hot metal desulfurization is the oxidation of H_2S emitted from the hot metal and slag that forms on the surface of the hot metal. Hot metal is desulfurized by the injection of powdered desulfurization agents (e.g., calcium carbide, lime-magnesium and lime-aluminum) to provide mixing of the agent with hot metal. The agent causes chemical reactions with the elemental sulfur and sulfur gases in the hot metal to produce solid sulfate, sulfide and sulfite compounds that report to the molten slag that floats on the surface of the liquid hot metal. Some of the sulfur bearing gases in the hot metal and slag are oxidized in contact with air to form SO_2. The overwhelming majority of sulfur removed from the hot metal during the desulfurization process reports to the slag formed during the process. The slag is skimmed from the molten metal prior to charging into the BOP and Q-BOP vessels where steelmaking is performed.

Results of Testing

There are two hot metal desulfurization facilities at Gary Works. One is located at the No. 1 BOP Shop and the other is located at the No. 2 Q-BOP Shop. To estimate the SO_2 emission factors for the desulfurization process at Gary Works, two stack tests were conducted.

Testing for SO_2 was conducted at the No. 1 BOP Shop Hot Metal Desulfurization Facility Baghouse inlet over three test runs on December 13 and 14, 2001. The test methods were the same as those employed during the testing at No. 13 Blast Furnace PM_{10} Emissions Control System Baghouse. Testing for SO_2 was conducted at the No. 2 Q-BOP Shop Hot Metal Desulfurization Facility Baghouse on February 7, 2002 using the same test methods.

Table 2, attached, presents the results of the testing at both locations. The measured SO_2 emission rates at the No. 1 BOP Shop facility indicate an average SO_2 emission rate of 0.020 lbs SO_2/ton hot metal with low run to run variability. The measured SO_2 emission rates at the No. 2

Q-BOP Shop facility indicate an average SO_2 emission rate of 0.03 lbs SO_2/ton hot metal with high run to run variability.

The desulfurization processes at both facilities are similar. Considering the high variability of emissions at the No. 2 Q-BOP facility and the low number of test runs at both facilities, additional testing is indicated.

Sulfur Dioxide Emission Rates for Preliminary Air Dispersion Modeling Runs

Tables 3 and 4, attached, present the SO_2 emission rates for blast furnace casthouses, blast furnace slag pits and hot metal desulfurization facilities that are currently being used in our preliminary SO_2 air dispersion modeling runs for blast furnaces and hot metal desulfurization facilities. These values are being used pending additional testing and analysis of the data.

With respect to the release characteristics for the SO_2 emissions, our consultant has been working with Mark Neyman in the Technical Support and Modeling Section in defining release mechanisms, release elevations and planar locational information.

We trust that this information meets your current needs. If there are any questions concerning this matter, please contact me at (219) 888-3387.

Sincerely,

James Alexander
Manager, Environmental Air Compliance

Attachments

Table 1
U.S. Steel - Gary Works, Gary Iron and Steel Operations
Results of SO_2 Emissions Testing
No. 13 Blast Furnace PM_{10} Casthouse Emissions Control System Baghouse Stack

Run No.	Date	Time	Duration (min)	Casting Rate (tons/hr)	SO_2 Emission Rates	
					(lbs/hr)	(lbs/ton)
1	3/11/02	0840-0940	60	323	167.7	0.519
2	3/11/02	0941-1041	60	237	151.3	0.638
3*	3/11/02	1042-1142	60	194	79.2	0.408
4	3/11/02	1143-1243	60	231	116.3	0.503
5	3/11/02	1244-1400	76	341	40.1	0.117
Mean ($\bar{x}$)			63	**265**	**110.9**	**0.437**
Standard Deviation (s)			7	63	52.2	0.197
Relative Standard Deviation ($s/\bar{x}$)			0.111	0.237	0.471	0.450

* Calibrations were performed during Run No. 3.

Table 2
U.S. Steel - Gary Works, Gary Iron and Steel Operations
Results of SO_2 Emissions Testing
No. 1 BOP Shop and No. 2 Q-BOP Shop Hot Metal Desulfurization Facilities

No. 1 BOP Shop Desulfurization Facility						
Run No.	Date	Time	Duration (min)	Hot Metal Throughput Rate (tons/hr)	SO_2 Emission Rates	
					(lbs/hr)	(lbs/ton)
1	12/13/01	1520-1749	149	305.2[a]	5.55	0.018
2	12/14/01	0836-1310	274	313.6[b]	5.70	0.018
2A	12/14/01	0836-1325	289	238.9[a]	5.41	0.023
Mean ($\bar{x}$)				285.9	5.55	0.020
Standard Deviation (s)				40.9	0.14	0.003
Relative Standard Deviation ($s/\bar{x}$)				0.143	0.026	0.147
No. 2 Q-BOP Shop Desulfurization Facility						
Run No.	Date	Time	Duration (min)	Hot Metal Throughput Rate (tons/hr)	SO_2 Emission Rates	
					(lbs/hr)	(lbs/ton)
1	2/7/02	0751-1010	139	431.2	2.33	0.0054
2	2/7/02	1050-1223	93	469.3	23.00	0.0490
3	2/7/02	1241-1433	112	449.1	16.17	0.0360
Mean ($\bar{x}$)				449.9	13.83	0.0301
Standard Deviation (s)				19.06	10.53	0.022
Relative Standard Deviation ($s/\bar{x}$)				0.042	0.761	0.744

(a) Includes delay time in the calculation of hot metal throughput rate.
(b) Excludes delay time in the calculation of hot metal throughput rate.

Table 3
U.S. Steel - Gary Works, Gary Iron and Steel Operations
SO_2 Emission Rates for Preliminary Air Dispersion Modeling Study
Blast Furnace Nos. 4, 6, 8 and 13

Blast Furnace	Maximum Hot Metal Production Rate (tons HM/hr)	Location	SO_2 Emission Factor (lbs SO_2/ton)	SO_2 Emission Rate (lbs SO_2/hr)
4	200	Casthouse Roof Monitor	0.30[a]	60.0
		Slag Pit	0.02[b]	4.0
6	175	Casthouse Roof Monitor	0.30[a]	52.5
		Slag Pit	0.02[b]	3.5
8	158.3	Casthouse Roof Monitor	0.30[a]	47.5
		Slag Pit	0.02[b]	3.2
13	450	Casthouse Stack	0.60	270.0
		Casthouse Roof Monitor	0.01[c]	4.5
		Slag Pit	0.02[b]	9.0

(a) Uses preliminary SO_2 emission factor for No. 13 Furnace casthouse and conservatively assumes a 50% reduction for effect of iron oxide fume suppression system.
(b) Based on preliminary one-hour test at No. 13 Furnace slag granulator.
(c) Assumes 98% capture of casthouse SO_2 emissions.

Table 4
U.S. Steel - Gary Works, Gary Iron and Steel Operations
SO_2 Emission Rates for Preliminary Air Dispersion Modeling Study
Hot Metal Desulfurization Facilities

Facility Location	Maximum Hot Metal Throughput Rate (tons HM/hr)	Release Location	SO_2 Emission Factor (lbs SO_2/ton)	SO_2 Emission Rate (lbs SO_2/hr)
No. 1 BOP Shop	456.8[a]	Stack	0.05	22.84
		Fugitive	0.001[b]	0.46
No. 2 Q-BOP Shop	526.5[a]	Stack	0.05	26.32
		Fugitive	0.001[b]	0.53

(a) Based on 23,600 tons of hot metal per day distributed 46.46% to No. 1 BOP Shop and 53.54% to No. 2 Q-BOP Shop (No. 1 BOP Shop - 60 heats per day at 235 tons per heat; No. 2 Q-BOP Shop - 65 heats per day at 250 tons per heat).

(b) Assumes 98% capture of SO_2 emission.

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Third

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