THE UNITED STATES COURT
FOR THE EASTERN DISTRICT OF MICHIGAN
SOUTHERN DIVISION

- x
UNITED STATES OF AMERICA,

Plaintiff,

v.

No. 11-cv-12181
Honorable David M. Lawson

CITY OF WYANDOTTE,

Defendant.
- x

APPENDIX A TO AMENDED CONSENT DECREE

BARR

WMS Unit 8 Limestone Feed System Upgrade Test Report

Limestone Feed System Upgrades for Improved SO_2 Control

Prepared for
Wyandotte Municipal Services
22/82-1018.10

April 2015

WMS Unit 8 Limestone Feed System Upgrade Test Report

April 2015

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1.0 Executive Summary

This report presents the results of a performance test conducted to evaluate sulfur dioxide (SO_2) control performance for Unit 8 when using an upgraded limestone feeder control system to achieve an additional 25% SO_2 removal to demonstrate compliance with the Title V permit emission limit pursuant to paragraph V.B.26 of the September 2011 consent decree (CD) between Wyandotte Municipal Services (WMS) and the U.S. Environmental Protection Agency (USEPA). The test was conducted by WMS for Unit 8 on March 25, 2015. The results of the limestone feed control performance test are submitted according to the limestone injection upgrade project schedule included as a part of the *WMS Boiler 8 Limestone Injection System Upgrade Study* that was submitted in May 2014. (Note that this report adopts the term "feeder" instead of "injection" as cited in the CD because it is a more accurate descriptor of the system design.)

WMS Unit 8 is a 900 psig fluidized bed (FB) boiler with designed capacity of 25 MW to generate steam and electricity for its customers. The boiler's permitted SO_2 emissions limit is 0.496 lb SO_2/MMBtu on a 24-hour average, and a 25% reduction of that limit equates to a target of 0.372 lb SO_2/MMBtu on a 24-hour average to demonstrate continuous compliance with the Title V permit emission limit.

The limestone feed system test for Unit 8 conducted in March 2015 was designed to evaluate SO_2 control performance for Unit 8 when using an upgraded limestone feeder control system. The test was conducted for a span of eight (8) hours on March 25, 2015, under normal operating conditions. The testing focused on normal operating conditions to limit the variables for evaluation during the test. Throughout the test, the WMS limestone feed system operated automatically, following a logic scheme that was upgraded to adjust the rate of limestone feed to the boiler based upon a set solid fuel-to-limestone ratio. (See Section 2.3 for additional information of the logic scheme.) The solid fuel-to-limestone ratio was tested to maintain a Calcium-to-Sulfur ratio of 3.0 in the boiler feed materials as recommended as a testing scenario by the *WMS Boiler 8 Limestone Injection System Upgrade Study* submitted in May 2014.

The test results indicated that the upgraded limestone feeder control system is capable of Unit 8 SO_2 meeting the 0.372 lb SO_2/MMBtu 24-hour average CD target to achieve 25% reduction to demonstrate compliance with the Title V permit emission limit during normal operations. Note that the upgraded logic control for this performance test was designed to verify that the concept of establishing a minimum limestone feed rate based upon a stoichiometric ratio could achieve SO_2 emissions reductions of 25% to ensure continuous compliance with the Title V permitted limit as cited in the CD. WMS may further adjust the stoichiometric ratio and will continue to meet the 25% reduction of SO_2 and demonstrate compliance with the Title V permit SO_2 emission limit for Unit 8.

2.0 Overview of Limestone Feed System Upgrade

2.1 Description of WMS Unit 8 and Limestone Feed System for SO_2 Control

This section provides detail on the existing boiler and limestone feed system, which controls the SO_2 emissions.

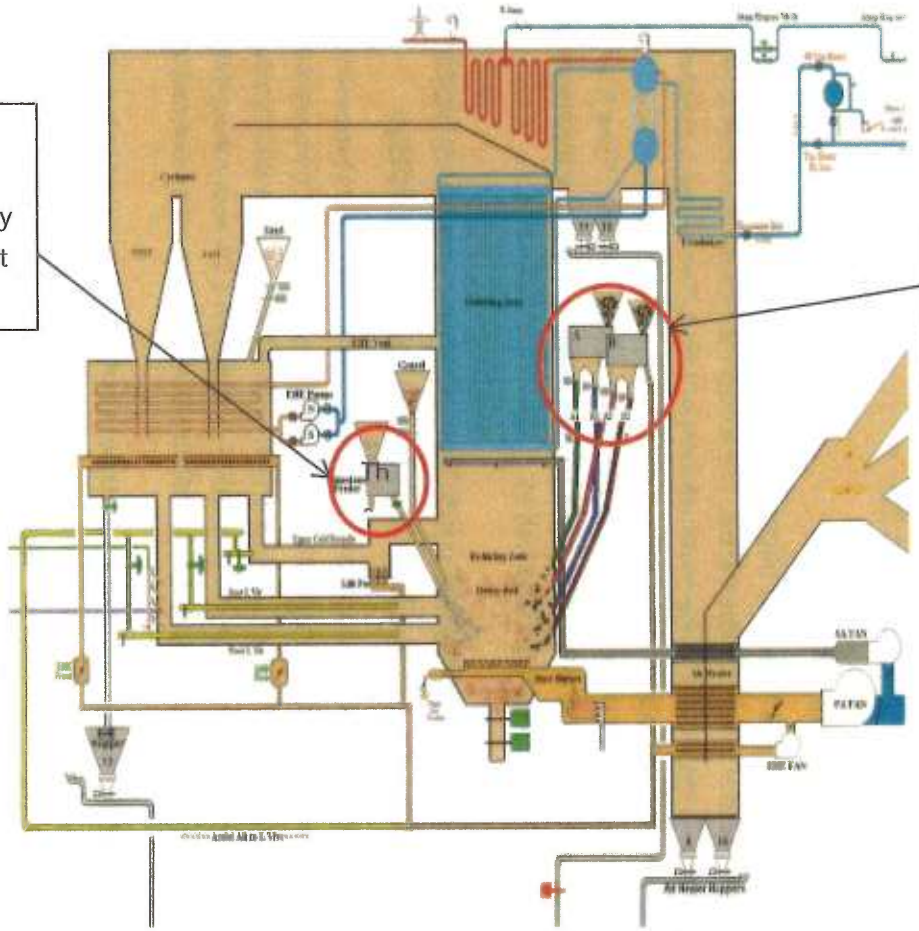
2.1.1 Unit 8 Description

The WMS Unit 8 design is a 25 MW, 900 psig fluidized bed (FB) boiler. The fluidized bed boiler design allows for varous types and combinations of solid fuels to be used as permitted including coal and tire-derived fuel (TDF). The boiler design also allows SO2 emissions to be controlled by feeding limestone directly into the FB dense bed. SO2 is controlled in the reaction zones above the boiler bed by transporting limestone feed onto the dense bed chamber at the lower portion of the combustion zone, where the boiler fuel is added. Under these conditions, the limestone is calcined. The resulting calcium oxide (CaO), or lime, reacts with SO2 forming calcium sulfate at the surface of the limestone to remove SO2 from the boiler flue gas. As the flue gas exits through the boiler combustion zone, SO2 continues to be captured by reaction with lime throughout the gasification phase of the circulating boiler, through the boiler economizer and air preheater sections, and then finally exhausts to to the baghouse as ash, which contains remaining lime particles (from limestone calcination).

Figure 2-1 displays a schematic representative of the Unit 8 system. The limestone and fuel transfer points have been highlighted.

Figure 2-1 Schematic of WMS Power Plant Unit 8 FB Limestone and Fuel Feed

The limestone feeder transports limestone from a chute directly onto the fluidized bed. This feeder is actually located at the same elevation, adjacent to the coal feeders.



The elevated coal feeders (A and B) transport coal in an adjacent chute onto the dense bed of the boiler in the lower combustion zone.

2.1.2 Limestone Feed System

The following describes the Unit 8 limestone feed system capacity and additional details.

2.1.2.1 System Capacity

The Unit 8 existing limestone 18-inch gravimetric feeder is provided with electronic weighing and microprocessor controls designed to handle a maximum capacity of 6.25 tons per hour of limestone continuous feed. The limestone feeder operating parameters identify a limestone density of 90 lbs. per cubic feet. The maximum motor speed capacity of the belt motor coupled to a 600:1 speed reducing gearbox is 1725 rpm (Riley Stoker, Vol. 3).

2.1.2.2 Limestone Addition

Limestone is fed from a limestone bin to an 18-inch double rack and pinion slide gate onto the gravimetric feeder directly below the bin. The feeder then carries the limestone at a controlled rate and discharges to a sloped discharge chute adjacent to Unit 8. The feeder is elevated above the boiler limestone feed inlet point. The limestone falls down the chute and is transported to the top of the boiler dense bed located at the lower point of the boiler combustion zone. There is an automatic pneumatic slide gate and manual hammer gate valve located between the boiler discharge and the limestone feeder for isolation (Riley Stoker Vol. 1 and Vol. 3).

2.2 CD Requirements and Recommendations from the Unit 8 Limestone Injection System Upgrade Study

Under the requirements of the CD, the upgrade analysis shall include proposed improvements to the system at Unit 8 to achieve at least an additional 25% removal of SO_2 from the flue gas exiting the stack at Unit 8 and ensure continuous compliance with WMS's Title V Renewable Operating Permit. A 25% reduction translates to a target of 0.372 lb SO_2/MMBtu on a 24-hour rolling average to ensure continuous compliance with the permitted limit of 0.496 lb SO_2/MMBtu on a 24-hour rolling average.

On May 30, 2014, WMS submitted a limestone injection upgrade study developed by Barr Engineering (Barr) to the USEPA. The limestone injection upgrade study identified a relationship between SO_2 emissions and the molar ratio of Calcium (Ca) and Sulfur (S) being introduced into the boiler through the addition of limestone and solid fuel. The study recommended targeting limestone feed rates as a starting scenario to maintain a Ca/S molar ratio of 3.0 for meeting the 25 % SO_2 emission reduction to demonstrate compliance with the Title V permit emission limit for Unit 8 in the CD. This study was to establish if upgraded logic control using the concept of a limestone feed rate based upon a stoichiometric ratio could accomplish the 25% SO_2 reduction under normal operations.

2.3 Limestone Feeder Controller Upgrade Summary

To meet the SO_2 emission reduction demonstration of the CD, WMS upgraded the existing limestone feeder control system by implementing alternative control logic, which is the design of the upgraded limestone feed system. The limestone feeder control logic was upgraded to include a limestone feed controller output that considers the calculated ratio of solid fuel-to-limestone necessary to achieve a 25% additional SO2 reduction pursuant to the CD. See Appendix A for ratio calculations. Prior to controller logic upgrades, the limestone feed was controlled only on feedback from SO_2 emissions data from the continuous emissions monitoring systems (CEMS). The previous configuration controls SO_2 exhaust concentrations in a reactive nature by increasing limestone feed rate when high SO_2 emissions were already present. By also including a limestone feed controller output based upon a stoichiometric ratio, the updated configuration should proactively increase limestone feed when solid fuel feed also increases while still maintaining the ability to further increase limestone feed if high SO_2 emissions are indicated by the CEMS.

WMS completed the following steps to implement the upgraded control logic.

1. Tuned the current control system.
2. Re-configured the current control system to include feed-forward control dependent on the change in solid fuel feeder rate, and also maintain CEMS SO_2 outlet feedback control input, which is the design of the upgraded limestone feed system.
3. Implemented a minimum override in the controls which sets a minimum limestone feed rate controller output to maintain a stoichiometric Ca/S ratio in the boiler fuel and limestone feed.
    a. Conservative assumptions on the sulfur content of solid fuel and the calcium content of the limestone are used to predict a solid fuel-to-limestone ratio corresponding to a stoichiometric Ca/S ratio. This allows the controller to instantaneously predict and control the Ca/S ratio though adjustments to the limestone feed rate.
    b. Appendix A provides example calculations for the Ohio Bituminous coal utilized by WMS during the performance test. The calculations show the conversion of the stoichiometric Ca/S ratio into a corresponding solid fuel-to-limestone ratio which can be used by the limestone feeder controller to calculate a minimum limestone feed rate to the fuel feed rate. The calculations are conservatively based upon a range of sulfur content data observed for the solid fuels (coal and TDF). The solid fuel-to-limestone ratio should be re-evaluated following any significant change in coal sulfur content or limestone calcium content.
4. Tuned the updated control configuration.

Note that the upgraded logic control for this performance test was designed to verify that the concept of establishing a minimum limestone feed rate based upon a stoichiometric ratio could achieve SO_2

emissions reductions of 25% to ensure continuous compliance with the Title V permitted limit as cited in the CD.

Table 2-1 provides more detail on the key controller configuration changes implemented by WMS as part of this project.

Table 2-1 Limestone Controller Implementation Progress Summary

Date of Change	Description	Qualitative Results
October 2014	Implemented Feedforward control scheme as a secondary trim to guide the limestone feed rate based upon changes solid fuel feed rate.	Decreases controller response time
November & December 2014	Implemented a PID controller minimum override based upon the desired solid fuel-to-limestone ratio corresponding to a Ca/S stoichiometric ratio recommended by the May 2014 Limestone Injection Upgrade Study.	Minimizes limestone feed rate swings when SO_2 emissions are low
November & December 2014	Tuning adjustments made to PID controller integral and proportional parameters.	Minimizes the difference between controller output and desired output
March 2015	Adjusted integral and gain parameters on the PID towards optimal control trends with SO_2 outlet.	Normalizes controller output for minimum override and decreases controller response time

3.0 Limestone Feed System Testing Program

3.1 Test Approach

The test conducted by WMS in March 2015 was designed to evaluate SO_2 control performance when using an upgraded limestone feeder control system. The goal of the limestone feed test was to validate that the upgraded limestone feeder control system is capable of reducing Unit 8 SO_2 emissions by 25% to a target of 0.372 lb SO_2/MMBtu to ensure continuous compliance with the Title V emission limit of 0.496 lb SO2/MMBtu on a 24-hour rolling basis as provided in the CD. The test focused on normal operations of Unit 8, using an approximate 60/40 blend of Bituminous (BIT) coal and TDF fuel respectively, to minimize variables for evaluation.

The test program followed the outline below:

1. Performed 8-hour baseline testing while maintaining a typical approximate 60/40 weight percent blend of BIT coal/TDF fuel.
2. Operated the boiler under normal operating conditions. Based upon review of the boiler operating history between October 2013 and March 2015, normal operation is within a load of 110 to 149 Klb/hr steam. This represents approximately 97% of the operational hours during that time span.
3. Operated the limestone feeder automatically with the upgraded control logic described in Section 2.3.
4. Collected SO_2 emissions and boiler operational data in 1-hour blocks from the start of the test to the end of the test.
5. Analyzed test results to evaluate changes in boiler emissions performance attributable to upgraded SO_2 controls.

WMS operators recorded Unit 8 operating notes onto a test recordkeeping form and used a checklist to confirm normal operation prior to test initiation. Operation log sheets that were completed during testing are included in Appendix B.

3.2 Test Monitoring Parameters

Per the test approach in Section 3.1, Unit 8 combusted BIT coal and TDF at a typical steam capacity at normal load, and the limestone feeder operated automatically with upgraded limestone feed logic. To validate the ability of the upgraded limestone controller logic to maintain a desired solid fuel-to-limestone ratio, solid fuel and limestone feed rates were monitored.

The parameters listed below were evaluated as a part of this test:

1. Boiler load (Klbs steam per hour)
2. SO_2 emissions as monitored by the CEMS systems

3. Solid fuel (coal/TDF) feed rate for Feeders A and B (tons/hour)
4. Limestone feed rate (tons/hour)

3.3 Fuel and Limestone Sampling

Composite fuel samples and limestone samples were taken from the gravimetric feeders during testing to verify that sulfur and calcium contents were within the ranges considered when establishing the solid fuel-to-limestone ratio used by the limestone controller. To collect samples that would be representative of the boiler fuel and limestone during the 8-hour testing period, grab samples were collected from the middle of the fuel and limestone feeder belts at approximately the beginning (hour 0), middle (hour 3), and end (hour 6) of the test run. During each sampling period, solid fuel samples were taken from both Feeder A and B and composited together for a single sample. At the end of testing, solid fuel and limestone samples from each sampling period were composited into a single control test sample for each respective material.

In addition, a solid fuel "pre-test" sample was collected the day before testing to provide a basis of comparison for solid fuel samples collected during testing. This solid fuel sample was collected as a grab sample from the conveyor belt that transfers material from the yard to the fuel bunker. This sample was taken only for comparison purposes in the event that the control test sample results were atypical of the expected fuel characteristics or if there were shipping/sample analysis problems at the laboratory. Based upon the expected residence time in the boiler, fuel sampled from the conveyor the day before the test should be combusted during the test period.

Table 3-1 summarizes the fuel and limestone samples that were collected during the test and shipped to SGS North America, Inc. for analysis. A copy of the sampling log appears in Appendix C.

Table 3-1 Sample Test Parameters

Material	Test Parameter
Coal/TDF	Ultimate & Proximate analyses (includes sulfur content)
Limestone	Calcium Oxide
	Magnesium Oxide
	Calcium
	$CaCO_3$ Equivalence

4.0 Testing Results and Data Compilation

4.1 Boiler Operating Conditions

Throughout the test, WMS operators recorded Unit 8 operating notes (see Appendix B). Prior to and during the test, the operators did not identify any operating problems with the boiler. WMS staff noted that the dense bed level within the boiler was satisfactory during the morning, and was adjusted in the afternoon per normal daily procedure.

WMS operators monitored operating parameters associated with boiler efficiency throughout the limestone feed test using the WMS Digital Control Systems (DCS). Following the completion of the test, boiler operating data from the testing period was compiled from the WMS Process Information (PI) historian.

Table 4-1 Unit 8 Operating Conditions During the Limestone Feed Control Test

Time	Solid-Fuel Consumption (tn/hr)	Limestone Consumption (tn/hr)	Solid Fuel-to-Limestone Ratio	Dense Bed Temperature	Steam Flow (Klbs/hr)
Test Goal			≤3.9		110 – 149 Klbs/hr
3/25/15 08:00	6.99	1.86	3.75	1539.5	131.0
3/25/15 09:00	6.99	1.87	3.75	1540.8	130.7
3/25/15 10:00	6.99	1.86	3.75	1541.4	131.3
3/25/15 11:00	6.99	1.87	3.73	1541.0	131.6
3/25/15 12:00	6.99	1.86	3.75	1539.1	132.2
3/25/15 13:00	6.99	1.85	3.77	1529.7	131.4
3/25/15 14:00	6.99	1.86	3.77	1528.9	131.3
3/25/15 15:00	7.00	1.86	3.76	1537.6	131.1
Goal Met?	-	-	YES	-	YES

The data in Table 4-1 shows Unit 8 operation was consistent throughout the test with steam flow maintained around 131 Klbs/hr, within the normal range of 110 Klbs/hr to 149 Klbs/hr. The ratio of solid fuel and limestone being fed to the boiler never exceeded the maximum solid fuel-to-limestone ratio set point of 3.9 calculated based upon maintaining a stoichiometric Ca/S ratio of 3.0.

4.2 Fuel and Limestone Analysis

As presented in Section 3.3, solid fuel and limestone used during the test were sampled at approximately hour zero, hour three, and hour six of the test to evaluate the qualities of the materials fed to the boiler

during testing ("control test sample". In addition, as a back-up comparison, solid fuel was also sampled from the conveyor belt that transfers fuel from the yard to the bunker on the day before testing ("pre-test sample). The materials from each sampling timeframe were composited for each respective material type.

Table 4-2 summarizes the results of the laboratory analyses performed on the materials sampled during the test. The sulfur content for the solid fuel was estimated to be 2.28% based on the fuel blend and sulfur content assumptions used in setting the solid fuel-to-limestone ratio and correlated well with the solid fuel analysis of the control test sample result at 2.23% (shown in Table 4-2). In addition, the $CaCO_3$ equivalence of the limestone sampled during the test period was above the estimated 92.8% with a control test sample result of 93.36% $CaCO_3$ and calcium carbon equivalence of 97.56%. See Appendix C for copies of the analytical results.

As shown in Appendix A, the solid fuel-to-limestone ratio estimated prior to the test to meet the Ca/S ratio is within the range expected for the coal/TDF mixture and is comparable to the solid fuel sulfur content assumed in establishing a conservative solid fuel-to-limestone ratio for use by the limestone feed controller.

Table 4-2 Solid Fuel & Limestone Analysis Results

Source	Parameter	Result [1]
Solid Fuel (Coal/TDF) Pre-Test Sample (3/24/15)	Sulfur	1.93 %
	Calorific Value	13,585 Btu/lb
Solid Fuel (Coal/TDF) Control Test Sample (3/25/15)	Sulfur	2.23 %
	Calorific Value	13,641 Btu/lb
Limestone	Calcium	93.36 %
	Magnesium	4.46 %
	$CaCO_3$ Equivalent	97.56 %

[1] All analyses reported on a dry basis.

4.3 Emission Monitoring Results

For each hour of the limestone feed test, pollutant data for SO_2 was collected on an hourly average and a 24-hour average basis. The CEMS system operated in accordance with the rigorous QA/QC requirements of 40 CFR Part 75 which includes daily and quarterly calibrations and testing along with relative accuracy test audits (RATA) testing. The CEMS system was in control with all Part 75 requirements during the limestone feed performance test and the data accurately represents emissions based upon QA/QC requirements for Part 75 emissions monitoring. Copies of the CEMS data appear in Appendix D.

Table 4-3 shows the hourly and 24-hour rolling average results for SO_2 lb/MMBtu emissions for Unit 8 throughout the limestone feed test. Table 4-3 also compares the average and standard deviation of the

test data with recent data from November 1 through 10, 2014 obtained just prior to the initiation of limestone feed controller system adjustments.

Table 4-3 SO_2 lb/MMBtu Emissions During Unit 8 Limestone Feed Test

Date/Time[1]	SO_2 lb/MMBtu Emissions	
	1-Hour Block Average	24-Hour Rolling Average
Test Goal	≤0.372 lb/MMBtu for all hours	≤ 0.372 lb/MMBtu for all hours
3/25/15 08:00	0.092	0.079
3/25/15 09:00	0.095	0.080
3/25/15 10:00	0.102	0.081
3/25/15 11:00	0.107	0.082
3/25/15 12:00	0.092	0.082
3/25/15 13:00	0.039	0.080
3/25/15 14:00	0.041	0.072
3/25/15 15:00	0.067	0.071
Test Average	**0.079**	**0.078**
Test Maximum	**0.107**	**0.082**
Test Standard Deviation	**0.027**	**0.004**
Goal Met?	**YES**	**YES**
Pre-Test[2] Average	**0.369**	**0.368**
Pre-Test[2] Standard Deviation	**0.192**	**0.040**

[1] Note, the CEMS does not adjust for daylight savings time so the CEMS data in Appendix D indicates one hour behind.

[2] Pre-test data obtained prior to limestone feed system controller upgrades between November 1, 2014 and morning of November 10, 2014.

Similar to the boiler operating conditions presented in section 4.1, Table 4-3 shows that Unit 8 SO_2 emissions were consistent throughout the test. The SO_2 emissions during the test validated that the upgraded controller system was able to achieve the 25% reduction and the 24-hour rolling average SO_2 CD target of 0.372 lb/MMBtu to meet the Title V permit limit.

5.0 Conclusions and Recommendations

5.1 Conclusions

The test results from March 25, 2015 indicated that the upgraded limestone feeder control system is capable of reducing Unit 8 SO_2 emissions by 25% to achieve the 0.372 lb SO_2/MMBtu CD target to meet the Title V permit limit during normal operations. These results verified that the concept of establishing a minimum limestone feed rate based upon a stoichiometric ratio could achieve SO_2 emissions below the 25% reduction target of the CD. The test intentionally limited the testing to normal operations to isolate the review to the Ca/S molar ratio effect.

Fuel analysis showed the sulfur content for the solid fuel is within the range expected for the coal/TDF mixture and comparable to the solid fuel sulfur content assumed in establishing a conservative solid fuel-to-limestone ratio for use by the limestone feed controller. In addition, the $CaCO_3$ equivalence of the limestone sampled during the test period is slightly higher than the estimated range but is generally comparable to the content assumed in establishing the ratio set point.

5.2 Recommendations

During the limestone feed test, SO_2 lb/MMBtu emissions achieved a 25% reduction to ensure continuous compliance with the Title V Renewable Operating Permit limit of 0.496 lb SO_2/MMBtu as defined in CD. Based upon these test results, WMS should continue to pursue the concept of establishing a minimum limestone feed rate based upon a stoichiometric ratio to achieve SO_2 emissions with the 25% reduction target pursuant to the CD.

Appendix A

Sample Conversion of Stoichiometric Ratio to Solid Fuel-to-Limestone Ratio

Example Fuel to Limestone Ratio Calculations

ASSUMPTIONS

1. Goal is to calculate coal/limestone ratio to obtain a target (Ca/S) molar ratio
2. Inputs based on conservative estimates
3. TDF and Coal are the only sources of Sulfur
4. Limestone is the only source of calcium

INPUTS

Target Molar Ratio (Ca/S)	3.0	-
Coal Sulfur Content [1]	2.6	%
TDF Sulfur Content [1]	1.8	%
Calcium Carbonate in Limestone [2]	92.8	%
Calcination Conversion %[3]	90	%
Coal Ratio (Tons Coal per Ton Fuel)	0.6	-

DEPENDENT VARIABLES and CONSTANTS

TDF Ratio (Tons TDF per Ton Fuel)	0.4	-
Solid Fuel Sulfur Content (Coal/TDF Mix)	2.28	%
MW_{sulfur}	32	g/mol
$MW_{calcium}$	40	g/mol
MW_{CaCO3}	100	g/mol
Ton to Gram Conversion	907185	g/TN

[1] Coal and TDF sulfur contents are conservative estimates based upon the average sulfur content of sampling reports from 2014.
[2] Calcium carbonate content calculated from calcium analysis of 2014 Limestone samples.
[3] % of CaCO3 that converts in the calcination reaction. Conversion % assumed from literature discussed in the Lime Injection System Upgrade Study.

CALCULATION

$$Molar\ Ratio\left(\frac{Ca}{S}\right) = \frac{Moles\ Ca}{Moles\ S} \qquad Molar\ Ratio\left(\frac{Ca}{S}\right) = \frac{Moles\ Ca}{(Moles\ S_{Coal}) + (Moles\ S_{TDF})}$$

1.) Calculate Moles S and Ca (per ton fuel)

Moles S_{Coal} (per ton coal)=	737.09
Moles S_{TDF} (per ton TDF)=	510.29
Molar Ratio (Ca/S)=	3.0
Target Moles Ca (per ton fuel basis)=	1939.11

2.) Convert Target Moles Ca into Target Limestone Tons (per ton fuel)

Calcium Carbonate in Limestone [2]=	92.8%
Calcination Conversion [3]=	90.0%
Target Limestone Tons (per ton fuel basis)=	0.256

3.) Convert to Fuel-Limestone Ratio

Fuel/Limestone Ratio	≤ 3.9	TN TDF + Coal / TN Limestone

Appendix B

WMS Operator Log Sheets and Records

WYANDOTTE MUNICPAL SERVICES

UNIT # 8 SO2 CONTROL TEST BURN

PRE-TEST CHECKLIST

Project ID: _____

Date: 3/25/15

Unit Description: _____

Signature: Gerard T. Dwornik

Test Description: _____

Test No.: _____

_____

Clock Synch performed (Initials): [illegible]

Y/N	Operating Parameter	Comments/Notes
Y	Boiler is operating as expected for test run and soot blowing is complete	SOOT BLOWING COMPLETED AT (06:00)
Y	Bed operation is stable	(06:00) NOT LAPPING INTO PIPES CAUSING COAL PIPE ISSUES
Y	Boiler is stable	—
Y	No coal feeder issues	—
Y	No boiler feed pump issues	—
Y	Control room operator is ready for test	—
Y	Shift supervisor is ready and located where needed	—
Y	No Limestone feeder issues	LIMESTONE PIPE AND FEEDER THROAT CLEAR (08:32)
Y	Computer system is up and running, both PI and CEM's	1 8 OPACITY WENT INTO AUTO-CAL (08:50)
Y	All data to be collected is being recorded	—
Y	Staff are in the correct location and prepared to complete their assigned tasks	—
Y	Equipment and Instrumentation is calibrated and operational.	—
Y	There is proper and safe access to all sample locations	—

WYANDOTTE MUNICPAL SERVICES

UNIT # 8 SO2 CONTROL TEST BURN

BOILER OPERATOR VISUAL RECORD

Project ID: _____

Date: 3/25/15

Unit Description: _____

Signature: [signature]

Test Description: _____

Test No.: _____

_____

Clock Synch performed (Initials): [initials]

Operating Problems Occurring Prior Test:

Boiler Operation Notes: COMPARTMENT #4 (BAGHOUSE) HIGH LEVEL CLEAR (09:20) BAGHOUSE CLEANING (12:38) RAN FLY ASH (13:05)

Boiler Bed Notes: DENSE BED LEVEL SATISFACTORY (08:00) 14:45 TOOK ONE SHOT OUT OF EACH SIDE DOWN TO BED LEVEL

Operating Problems Occurring During Test:

Boiler 5 or 7 startup, shutdown or malfunction During Test:

Other Notes: #8 OPACITY WENT INTO AUTO-CALIBRATION (08:50)

*VISUAL OBSERVATIONS TO BE RECORDED DURING TESTING AND TIME NOTED

Appendix C

Solid Fuel and Limestone Sample Analysis

WYANDOTTE MUNICPAL SERVICES

UNIT # 8 SO2 CONTROL TEST BURN

FUEL AND LIMESTONE SAMPLE LOG FORM

WMS will validate that the limestone and fuel feeder belts are clear and properly maintained prior to testing. WMS will verify that all instrumentation has been calibrated and properly functioning prior to startup.

Project ID: _____

Unit Description: _____

Test Description: _____

Date: 3/25/15

Signature: [illegible]

Test No.: _____

Clock Synch performed (Initials): _____

	Baseline			Additional Run 1			Additional Run 2		
Limestone Sample	**Start**	**Middle**	**End**	**Start**	**Middle**	**End**	**Start**	**Middle**	**End**
Time	8:10 AM	11:05 am	305 pm						
Quantity	3lb 4.2 oz	4lb 6.1 oz	3lb 14.4 oz						
Initials of Sampler	GD/KK	GD/KK	GD/KK						
BIT Coal/TDF Sample	**Start**	**Middle**	**End**	**Start**	**Middle**	**End**	**Start**	**Middle**	**End**
Time	8:00am	11 am	2:00 pm						
Quantity	5lb .7 oz	6lb 4.8 oz	6lb 3 oz						
Initials of Sampler	GD/KK	GD/KK	GD/KK						

Notes: Limestone samples pulled from feeder belt (at the point where the bunker drops stone onto conveyor to boiler)

Coal/TDF pulled from end of the belt as it was dumping into combustor.

* All limestone samples composited / All Coal/TDF samples composited for one analysis for each type of sample. (3/25/15 samples only)

* Prior days pretest sample not separate for its own analysis

SGS

Analysis Report

April 09, 2015

BARR ENGINEERING CO
4700 WEST 77TH STREET
MINNEAPOLIS MN 55435

ATTN: Nicholas Hansen

Client Sample ID:	Pre Test Coal&TDF Sample	Sample ID By:	Barr Engineering
Date Sampled:	Mar 24, 2015	Sample Taken At:	WMS - Coal Belt
Date Received:	Mar 27, 2015	Sample Taken By:	GD/KK
Product Description:	Blend	Sample Type:	Coal / RDF mixed

SGS Minerals Sample ID: 491-1584831-003

	Method	As Received	Dry	DAF
Moisture, Total %	ASTM D3302	4.81		
Ash %	ASTM D3174/D7582	11.86	12.46	
Volatile Matter %	ASTM D3175/D7582	45.18	47.46	
Fixed Carbon %	ASTM D3172 (by diff)	38.15	40.08	
Sulfur %	ASTM D4239 (A)	1.84	1.93	
Gross Calorific Value Btu/lb	ASTM D5865	12931	13585	15519
Carbon %	ASTM D5373	70.17	73.72	
Hydrogen %	ASTM D5373	5.41	5.68	
Nitrogen %	ASTM D5373	0.99	1.05	
Oxygen %	ASTM D3176 (by diff)	4.92	5.17	

Samples for Ash are analyzed by either D7582 or D3174 depending on what equipment is available. For details on which method was utilized, request information from SGS South Holland.

Samples for Volatile Matter are analyzed by either D7582 or D3175 depending on what equipment is available. For details on which method was utilized, request information from SGS South Holland.

James P. Nelson
Great Lakes Operations Manager

SGS North America Inc. | Minerals Services Division
16130 Van Drunen Road South Holland IL 60473 t (708) 331-2900 f (708) 333-3060 www.sgs.com/minerals

Member of the SGS Group (Société Générale de Surveillance)

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SGS

Analysis Report

April 10, 2015

BARR ENGINEERING CO
4700 WEST 77TH STREET
MINNEAPOLIS MN 55435

ATTN: Nicholas Hansen

Client Sample ID:	Control Test-Limestone	Sample ID By:	Barr Engineering
Date Sampled:	Mar 25, 2015	Sample Taken At:	WMS - Limestone Feeder
Date Received:	Mar 27, 2015	Sample Taken By:	GD/KK
Product Description:	LIMESTONE		
Comments:	SAMPLES WERE SENT TO SGS DENVER FOR ANALYSIS AND THE FINDINGS REPORTED BY SGS DENVER WERE AS FOLLOWS:		

SGS Minerals Sample ID: 491-1584832-001

Tests	Result	Unit	Method
Calcium carbonate equivalence	97.56	---	ASTM C25
ANALYSIS OF ASH			
Basis	DRY	---	ASTM C1271
Calcium Oxide, CaO	52.31	%	ASTM C1271
Magnesium Oxide, MgO	2.13	%	ASTM C1271
Calcium, Ca	93.36	%	ASTM C1271
Magnesium, Mg	4.46	%	ASTM C1271

James P. Nelson
Great Lakes Operations Manager

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SGS

Analysis Report

April 10, 2015

BARR ENGINEERING CO
4700 WEST 77TH STREET
MINNEAPOLIS MN 55435

ATTN: Nicholas Hansen

Client Sample ID:	Control Test Coal&TDF Sample	Sample ID By:	Barr Engineering
Date Sampled:	Mar 25, 2015	Sample Taken At:	WMS - Coal/TDF Feeder
Date Received:	Mar 27, 2015	Sample Taken By:	GD/KK
Product Description:	Blend	Sample Type:	Coal / RDF mixed

SGS Minerals Sample ID: 491-1584833-003

	Method	As Received	Dry	DAF
Moisture, Total %	ASTM D3302	2.82		
Ash %	ASTM D3174/D7582	12.04	12.39	
Volatile Matter %	ASTM D3175/D7582	42.95	44.19	
Fixed Carbon %	ASTM D3172 (by diff)	42.19	43.43	
Sulfur %	ASTM D4239 (A)	2.16	2.23	
Gross Calorific Value Btu/lb	ASTM D5865	13257	13641	15569
Carbon %	ASTM D5373	72.34	74.44	
Hydrogen %	ASTM D5373	5.72	5.89	
Nitrogen %	ASTM D5373	1.00	1.03	
Oxygen %	ASTM D3176 (by diff)	3.92	4.06	

Samples for Ash are analyzed by either D7582 or D3174 depending on what equipment is available. For details on which method was utilized, request information from SGS South Holland.

Samples for Volatile Matter are analyzed by either D7582 or D3175 depending on what equipment is available. For details on which method was utilized, request information from SGS South Holland.

James P. Nelson
Great Lakes Operations Manager

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Appendix D

Raw CEMS Data

Average Data

Plant: Wyandotte Municipal Services-Power Plant
Interval: 1 Hour
Type: Block
Report Period: 03/25/2015 07:00 Through 03/25/2015 14:00
Time Online Criteria: 1 minute(s)

Source		UNIT8
Parameter		SO2#/MM
Unit		(LB/MMBTU)
03/25/15	07:00	0.092
03/25/15	08:00	0.095
03/25/15	09:00	0.102
03/25/15	10:00	0.107
03/25/15	11:00	0.092
03/25/15	12:00	0.039
03/25/15	13:00	0.041
03/25/15	14:00	0.067

Average	0.079
Minimum	0.039
Maximum	0.107

Total number of Data Points 8

Average Data

Plant: Wyandotte Municipal Services-Power Plant
Interval: 24 Hour
Type: Roll
Report Period: 03/25/2015 07:00 Through 03/25/2015 14:00
Time Online Criteria: 1 minute(s)

Source		UNIT8
Parameter Unit		SO2#/MM (LB/MMBTU)
03/25/15	07:00	0.079
03/25/15	08:00	0.080
03/25/15	09:00	0.081
03/25/15	10:00	0.082
03/25/15	11:00	0.082
03/25/15	12:00	0.080
03/25/15	13:00	0.072
03/25/15	14:00	0.071

Average	0.078
Minimum	0.071
Maximum	0.082

Total number of Data Points	8