BICARB BULLETIN

Comparison of Dry Sorbent Injection of Sodium Bicarbonate, Lime, and Carbon and Their Control of Dioxins/Furans, Mercury, Chlorides and Sulfur Dioxide

Acid Gas and Toxics Removal at WCA Hospital, Jamestown, NY

Abstract

As a result of recent proposed regulations by the EPA that further limit air emissions from Medical Waste Incinerators (particularly mercury and dioxins/furans) Church & Dwight Co., Inc. sponsored a study at a hospital's Medical Waste Incinerator in upstate New York. This study analyzed the incinerator flue gas while operating prior to dry injection of a sorbent and after filtration of the gas in a fabric filter baghouse. The analysis was done per the EPA methods for hydrochloric acid, mercury, particulate matter (PM), carbon monoxide, dioxin/furan, sulfur dioxide, velocity, flow rate, moisture, carbon dioxide and oxygen. Actual operating data will be presented along with the analysis of the incinerator's flue gas and a discussion and comparison of the test results. The incinerator is a typical hospital unit with a charging rate of 625 lbs/hr and runs 24 hours every day of the year. The pollution control system is a quenching tower with dry-scrubber and a fabric filter baghouse. The study compares the operating data and gas analyses following the separate addition of lime and carbon, sodium bicarbonate and carbon added separately, and SORB-N-C® a blended sodium bicarbonate/carbon product.

Site and Test Description

The emission tests were conducted at the Medical Waste Incinerator (MWI) of WCA Hospital in Jamestown, NY on October 3rd through 5th, 1995. The objective of this test program was to evaluate the efficiency of various sorbent combinations in removing acid gases, dioxin/furans and heavy metals. Testing was conducted simultaneously at the inlet and outlet of the MWI air pollution control equipment. Three distinct emissions control conditions were tested using separate types of sorbents. On October 3rd, 1995, forty-four pounds per hour of SORB-N-C® was used (forty pounds of sodium bicarbonate and four pounds of carbon as a combined product). On October 4th, 1995, a combination sorbent averaging forty-seven pounds per hour of sodium bicarbonate and five pounds per hour of carbon (two separate products) was used. On October 5th, 1995, a combination sorbent averaging forty-four pounds per hour of lime and five pounds per hour of carbon was used.

The MWI is Consumat Systems, model C-225-PAT1, two chamber incinerator with auxiliary boilers. The pollution control system consists of a quenching tower, a dry-scrubber with ports for sodium bicarbonate and carbon injection, and a baghouse. The unit is permitted to operate 365 days a year, 24 hours a day. The maximum charging rate is 625 lbs/hr. A waste heat boiler typically runs 24 hr/day and maintains 300°F at the baghouse outlet. When a lockout temperature is reached (the waste heat boiler is steaming, and the scrubber and baghouse are warm), the injection system will phase into operation. The baghouse contains 120 fabric filter bags (5” x 120”) equivalent to 1571 ft^2 of filter area. During testing, the dry-scrubber was fed a combination of sodium bicarbonate, lime and carbon using a gravity fed eductor system. Waste is inserted by the loader ram into the incinerator at preset intervals to ensure good operating practices. Under normal operations, the underfire air, water sprays, burners, and secondary modulated mixing air are all functioning in order to maintain proper stoichiometric ratios.

The inlet test location is located prior to the system’s pollution control devices. The inlet location is circular with an inner diameter of 16-inches. The stack has two ports 90 degrees apart, which meets EPA Method 2 requirements. The nearest downstream disturbance is at least 6 duct diameters and the nearest upstream disturbance is at least 2 duct diameters. The outlet is located after the baghouse. The outlet is rectangular with dimensions of 12-inches x 18-inches. The duct has four ports located 4.5-inches apart; two on each side of the duct. The stack has a 36-inch diameter and 114-ft height. The unit has expected conditions of 3,367 ACFM at 300°F, which corresponds to an exit velocity of 7.94 ft/sec.

Sampling and Test Methods

The Medical Waste Incinerator of WCA Hospital was tested using EPA mandated stack sampling runs while the boiler was operated under the process conditions set forth in the Site Specific Test Plan and described in Section 3. Each test run was approximately one hundred minutes, including (3) 100 minute sampling trains. The three manual sampling trains included a combined M6/26 or M26A train; a mercury train; and a dioxin train. A continuous emission monitoring system (CEMS) was also operated during each test run to measure stack gas concentrations of oxygen (O_2), carbon dioxide (CO_2), sulfur dioxide (SO_2), and carbon monoxide (CO).

Stack sampling at the inlet and outlet was conducted by personnel from DEECO, Inc. Sample analysis was performed at Triangle Laboratories, Inc. in Research Triangle Park, NC. The sampling and analytical program was designed by DEECO, Inc. in order to demonstrate the capabilities of the Medical Waste Incinerator to comply with parameters set forth in the applicable New York State Department of Environmental Conservation (NYSDEC) and U.S. Environmental Protection Agency (EPA) regulations in addition to the investigation on the sorbent variation.

The measured and calculated stack gas parameters for the Medical Waste Incinerator were in good agreement among the three trains for each sampling run. Oxygen and carbon dioxide averages for the various trains were taken from continuous CEM data. All sampling runs on the Medical Waste Incinerator were performed within the acceptable isokinetic variation range.

Table 1 presents a summary of the overall sampling and analytical protocols used for the test program for the Medical Waste Incinerator. All sampling and analytical methods employed for this test program were performed in accordance with the procedures outlined in U.S. Environmental Protection Agency (EPA) Title 40, Part 60, Appendix A or Part 266, Appendix IX of the Code of Federal Regulations.

Summary of Results

The summary of results are presented in Tables 2 through 5.

Incinerator and Control Equipment Operations

As shown in Tables 2 though 5, the incinerator was operating at similar parameters during each of the sample conditions. The average flue gas flow rate for all conditions averaged approximately 3,450 dry standard cubic feet per minute (DSCFM). The combustion conditions in the incinerator were excellent, averaging less than 3 parts per million by volume (ppm) of carbon monoxide (CO) for all three conditions. The oxygen content of the stack gas was approximately 12.3 percent by volume for all three conditions. The moisture content of the stack gases averaged from 10 to 13 percent by volume for the three conditions.

Particulate Matter Emissions

As shown in Table 2, the particulate matter emissions from the discharge of the control equipment (stack) were extremely low. The SORB-N-C® condition was about half (0.031 lb/hr) of the bicarbonate/carbon (0.057 lb/hr) and lime/carbon (0.058 lb/hr) conditions. However, since the levels were extremely low, the results should be considered similar.

Hydrogen Chloride Emissions and Collection Efficiency

The hydrogen chloride (HCl) emissions (see Table 3) were highly variable during the testing due to the nonhomogenous composition of medical waste. The two conditions with bicarbonate averaged approximately 95% removal of HCl. The lime was only slightly better at 97.5%. The average stoichiometric ratio of the SORB-N-C® to HCl and SO_2 was 2.5 and the bicarbonate fed as a separate feed was 1.2. The average stoichiometric ratio of the lime to HCl and SO_2 was 3.7. Since the outlet emissions are well within the national allowable limits for HCl removal, the results should be considered similar.

Sulfur Dioxide Emissions and Collection Efficiency

The sulfur dioxide (SO_2) emissions were similar (see Table 3) from run to run. However, the continuous emission monitors (CEMs) strip charts show that the SO_2 concentrations were highly variable during the testing due to the nonhomogeneous composition of medical waste. The two test conditions with bicarbonate averaged approximately 76% removal of SO_2. The lime was only slightly better at 79%. The average stoichiometric ratio of the SORB-N-C® to HCl and SO_2 was 2.5 and the bicarbonate fed as a separate feed was 1.2. The average stoichiometric ratio of the lime to HCl and SO_2 was 3.7. The results on a pounds SO_2 per hour basis should be considered similar.

SO_2/HCl Removal

These results demonstrate that when a 75% removal of SO_2 is obtained, 95% removal of HCl is virtually assured.

Mercury Emissions and Collection Efficiency

The mercury concentrations from the incinerator (see Table 4) were also highly variable. The SORB-N-C® and bicarbonate with carbon both averaged 99.6% removal and the lime with carbon (93.8%).

Total Dioxin/Furans and 2,3,7,8–TCDD Toxic Equivalent Dioxin/Furan Emissions and Collection Efficiency

The average total dioxin/furan concentrations from the incinerator (see Table 5) were consistent when compared on a condition to condition basis. However, it is likely that concentrations were also highly variable with time. The state agencies and EPA are mainly interested in the toxic equivalent (TEQ) emissions. All three sorbents removed over 95% of the TEQ emissions. The total dioxin/furan and TEQ collection efficiencies were remarkably close. This is significant in light of the fact that the feed rate for SORB-N-C® delivered only 80% of the carbon fed for the comparison treatments.

Operational and Handling Characteristics

During the three days of testing certain operating and handling events occurred that need to be mentioned. First, handling the lime required special precautions because of the irritability of the dust to the workers. Secondly, feeding lime required constant monitoring because of bridging in the bin that required the bin vibrator to be run constantly. Feeding the other two sorbents allowed the operator to set the timer to a two minute on/five minute off-cycle.

The baghouse pressure was also affected. The bicarbonate sorbent and SORB-N-C® required only preventative periodic pulsing. The lime system consistently created a pressure drop of seven inches of water which was the set point for the bag pulsing system to operate. The bicarbonate and SORB-N-C® cake pressure drop ranged between three and five inches of water.

As a result of the high pressure drop across the bags during the lime test the back pressure caused three blower shutdowns and an equivalent number of smoking and back drafting incidents. This was never a problem with the bicarbonate sorbent or with SORB-N-C®.

It was very easy to monitor the feed rate of SORB-N-C® at 44 pounds per hour versus trying to accurately measure two feed streams. Especially, when one was between four and five pounds per hour and the other forty to fifty pounds per hour. The "flowability" of the SORB-N-C® was superior to the other sorbents—with ease of handling characteristics of sodium bicarbonate and the dispersability of the carbon. The SORB-N-C® product was by far the easiest sorbent to use. Sodium bicarbonate with a separate carbon feed was the next easiest. Lime was by far much more difficult to handle and feed accurately. The pressure drop problems, blower shutdowns, and conveyor plugging at the very end of the run created problems for the plant operation.

Conclusions

Collection efficiency for the three systems tested was comparable. All provided excellent removal efficiency for HCl, SO_2, mercury, and dioxin/furan. Sorbent selection can therefore be decided by other factors, i.e., handling, safety and operating characteristics.

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Table 1: Summary of sampling and analytical methods used for certification of compliance test program on the medical waste incinerator

Test Parameter	Sampling Procedure or Method	No. of Samples	Analytical Parameters	Analytical Procedure
Stack Gas Streams Stack Gas Flow	EPA Method 2 pitot tube	During each isokinetic test run	N/A	EPA Method 2 inclined manometer
Dry Gas Molecular Weight	EPA Method 3A continuous	During whole testing period	O_2, CO_2	EPA Method 3A electrochemical & nondispersive IR
Stack Gas Moisture	EPA Method 4 traverse integrated	During each isokinetic test run	Moisture content	EPA Method 4 condensation and gravimetric
Particulate Matter Concentration	EPA Method 5 isokinetic traverse integrated	Three 120-min test runs; 60 ft^3 minimum gas sample	Particulate matter	EPA Method 5 desiccation and gravimetric
Hydrochloric Acid Concentration	EPA Method 26A isokinetic traverse integrated back-half of EPA Method 5	Three 120-min test runs; 60 ft^3 minimum gas sample	HCl	EPA Method 9057 ion chromatography
Mercury Concentration	EPA M101A isokinetic traverse integrated	Three 120-min test runs; 45 ft^3 minimum gas sample	Hg	CVAAs EPA 7470 (Hg)
Dioxins/Furans	EPA Method 23A isokinetic traverse integrated	Three 120-min test runs; 45 ft^3 minimum gas sample	PCDD/DFs	SW846 8290 full screen
Sulfur Dioxide Concentration	EPA Method 6C continuous	During whole testing period	Sulfur dioxide	EPA Method 6C gas filter correlation NDIR
Carbon Monoxide Concentration	EPA Method 10 continuous	During whole testing period	Carbon monoxide	EPA Method 10 gas filter correlation NDIR

Table 2: Summary of flue gas flow rate conditions, and particulate emissions @ 7% O_2

Location	Parameter	SORB-N-C®	Bicarbonate and Carbon	Lime and Carbon
Inlet	DSCFM	2510	2480	2320
	O_2, %	12.2	12.4	12.2
	CO, ppm	1.1	2.2	1.0
	CO, ppm (@ 7% O_2)	1.7	3.7	1.6
	CO, lb/hr	0.012	0.024	0.010
	SO_2, ppm	33.6	38.7	30.6
	SO_2, ppm (@ 7% O_2)	54.0	64.8	48.9
	SO_2, lb/hr	0.84	0.95	0.71
Outlet	DSCFM	3400	3340	3330
	O_2, %	14.3	14.2	14.1
	CO, ppm	0.6	1.6	0.73
	CO, ppm (@ 7% O_2)	1.2	3.3	1.5
	CO, lb/hr	0.009	0.023	0.011
	SO_2, ppm	5.3	6.6	4.07
	SO_2, ppm (@ 7% O_2)	10.8	13.9	8.33
	SO_2, lb/hr	0.120	0.226	0.135
	PM, gr/dscf (@ 7% O_2)	0.0021	0.0039	0.0041
	PM, lb/hr	0.031	0.057	0.058

Table 3: **Summary of hydrogen chloride and sulfur dioxide emissions @ 7% O_2**

Location	**Parameter**	**SORB-N-C®**	**Bicarbonate and Carbon**	**Lime and Carbon**
		Average	**Average**	**Average**
Inlet	DSCFM	2570	2460	2310
	Temp °F	399	410	427
	Moisture %	10.4	11.4	12.8
	HCl Conc. (mg/cf)	17.7	40.3	35.7
	HCl, (lb/hr)	5.9	13.3	11.0
	SO_2, lb/hr	0.84	0.95	0.71
	Stoichiometric Ratio	2.5	1.20	3.7
Outlet	DSCFM	3525	3590	3340
	Temp °F	275	264	269
	Moisture %	10.4	9.9	11.5
	HCl Conc. (mg/cf)	0.70	1.5	0.59
	HCl, (lb/hr)	0.33	0.70	0.26
	SO, lb/hr	0.12	0.23	0.14
HCl Collection Efficiency, %		94.4	94.7	97.5
SO_2 Collection Efficiency, %		76.9	76.2	79.4

Table 4: Summary of mercury emissions @ 7% O_2

Location	Parameter	SORB-N-C®	Bicarbonate and Carbon	Lime and Carbon
		Average	Average	Average
Inlet	DSCFM	2510	2480	2320
	Temp °F	399	414	427
	Moisture %	12.2	11.7	12.4
	Hg Conc. (gr/dscf)	8.67×10^{-4}	3.31×10^{-4}	8.81×10^{-6}
	Hg Mass Flow Rate (lb/hr)	0.0187	0.00700	0.000178
Outlet	DSCFM	3400	3340	3330
	Temp °F	283	281	277
	Moisture %	9.7	11.2	11.5
	Hg Conc. (gr/dscf)	2.38×10^{-6}	1.13×10^{-6}	3.84×10^{-7}
	Hg Mass Flow Rate (lb/hr)	6.96×10^{-5}	3.21×10^{-5}	1.10×10^{-5}
Collection Efficiency, %		99.6	99.6	93.8

Table 5: Summary of total cdd/cdf and toxic equivalents emissions @ 7% O_2

Location	Parameter	SORB-N-C®	Bicarbonate and Carbon	Lime and Carbon
		Average	**Average**	**Average**
Inlet	DSCFM	2520	2410	2250
	Temp °F	403	414	426
	Moisture %	12.1	12.2	13.0
	Total CDD/CDF conc., (ng/dscm)	610	926	767
	Total CDD/CDF (µg/hr)	1660	2330	1850
	TEQ conc., (µg/dscm)	16.7	19.8	14.5
	TEQ, (ug/hr)	45.3	49.9	35.0
Outlet	DSCFM	3440	3520	3260
	Temp °F	267	271	279
	Moisture %	9.1	11.2	12.3
	Total CDD/CDF conc., (ng/dscm)	42.6	19.4	7.5
	Total CDD/CDF (µg/hr)	120	55	20
	TEQ conc., (ng/dscm)	0.77	0.28	0.11
	TEQ, (µg/hr)	1.93	0.81	0.31
Total CDD/CDF Collection Efficiency, %		92.8	97.6	98.9
TEQ Collection Efficiency, %		95.7	98.4	99.1