

MERCURY CONTROL USING SORBALIME AT AMERICAN REF-FUEL'S NIAGARA FALLS FACILITY

Gregory H. Gesell
Safety and Environment
American Ref-Fuel Company
Houston, Texas

Anthony Licata
Licata Energy & Environmental Consultants, Inc.
Yonkers, New York

ABSTRACT

In 1994 American Ref-Fuel Company of Niagara (Ref-Fuel) began a major retrofit of its Niagara Falls, New York Municipal Waste Combustor (MWC). The 821,250 ton per year (TPY) Niagara Falls plant was originally constructed in 1980 using a Refuse Derived Fuel (RDF) technology. The air pollution control equipment consisted of a hot side Electrostatic Precipitator (ESP). As part of a permit modification, new air pollution controls and boiler modifications were completed. The 1991 Emission Guideline was used as a basis for certain pollutants. Ref-Fuel concluded that it would be more practical to replace the RDF boilers with new Deutsche Babcock Anlagen (DBA) boilers equipped with mass burn roller grates to achieve these requirements.

During the permitting of the new mass burn units, the emission projections were based on the spray dryer fabric filter technology used at Ref-Fuel's Hempstead, New York plant. This facility currently meets the MACT standards for mercury and dioxins without the use of a carbon technology for mercury and dioxin control. However, once the Niagara Falls facility began operations, it was noted that the mercury emissions for this plant were different and that additional controls would have to be installed.

Ref-Fuel undertook a test program to evaluate Sorbalime™ to control mercury emissions. Based on the test program results, Ref-Fuel signed a long-term agreement to use Sorbalime. Criteria in selecting Sorbalime included that it could be installed without capital expenditure and operation could begin within a very short time interval.

This paper discusses the test program, the installation, and the start-up of the system.

INTRODUCTION

The Niagara Resource Recovery Facility is located in Niagara Falls, New York. It was originally designed to provide steam for the Occidental Petroleum (Occidental) manufacturing complex and electricity for sale to Niagara Mohawk. It was designed and constructed using refuse-derived fuel technology to shred the incoming waste prior to energy recovery in two Foster Wheeler boilers. The facility was capable of processing up to 2250 tons of RDF per day. Steam was produced at superheated conditions and two 40 MW steam topping turbines generated electricity. Up to 300,000 lbs./hr of steam was also sold directly to Occidental. The steam was extracted from each turbine and routed to the manufacturing complex for industrial purposes. In the event the turbines were unavailable, the steam could be desuperheated to provide energy for Occidental. Backup boilers were also maintained for use during scheduled or unscheduled outages of the RDF boilers.

The facility was originally built in 1980. At that time, state of the art air pollution control technology was hot-side electrostatic precipitators (ESPs) to control particulate and particulate-related emissions. Combustion controls were used to manage carbon monoxide emissions. No acid gas control was provided for in the original design. Operating in this manner, the facility had a successful, although eventful, operating history.

In 1993 American Ref-Fuel Company of Niagara (Ref-Fuel) acquired the Niagara waste-to-energy facility from Occidental.

The partnership concept would allow Occidental to focus on its primary businesses and Ref-Fuel would do what it knew best, operate waste-to-energy facilities. The mission of the facility remained the same, to provide steam for industrial use and generate additional electricity for sale while processing waste in a clean and environmentally sound manner.

FACILITY RETROFIT

Ref-Fuel completed an economic and technical evaluation of the facility. Due to the age of the facility and changing emission requirements, a significant investment was required to bring the facility up to current emissions standards. A number of factors influenced Ref-Fuel's decisions. The Federal EPA MACT standards for municipal waste combustors (MWCs) were anticipated to require significant changes to the facility's air pollution control devices. In addition, the facility already had a pre-1993 permit condition with the New York Department of Environmental Conservation (NYDEC) which would require additional emissions control. Hot-side ESPs had been identified with de novo dioxin formation. Plant availability for the aging facility was less than desired and limited operating flexibility. Safety concerns and operating costs for the RDF processing system were also very high. It was determined that a major retrofit of the Niagara Falls waste-to-energy facility would be required.

American Ref-Fuel determined the best solution which addressed identified concerns, was to install two new mass burn boilers and air pollution control systems to replace the two existing RDF boilers. Two boilers designed by Deutsche Babcock Anlagen (DBA) were installed. A traditional pit and crane feed system was installed to one side of the original tipping floor to feed the new boilers as shown in Figure 1. The seven and one half meter DBA Roller grates are the largest DBA had ever manufactured. The grate has six rollers with interlocking grate bars angled at twenty degrees. A single oversized ash extractor quenches the ash before it is processed for ferrous and nonferrous metal recovery. The boilers located above the grates are a new low excess air parallel flow design as shown in Figure 2. The 1200 psig 750°F steam produced is routed to the existing turbines and steam line. The retrofit was completed while the existing plant continued to operate. No interruptions to steam supply occurred during construction.

Each process train was provided with a spray dryer equipped with rotary atomizers, a reverse air baghouse, a selective non-catalytic reduction (SNCR) NO_x control system, and an automated combustion control system. A mixture of river water and heated deionized water is used for slaking. The temperature of the combined water stream is maintained at 60 – 80°F. During the original permitting process for the retrofitted facility, New York State permitted the plant to be constructed without a mercury (Hg) control system. This was based upon test results from American Ref-Fuel's Hempstead, N.Y. waste-to-energy facility.

The Hempstead facility, which has been in operation since 1989, has been tested annually for mercury emissions and has met the current USEPA MACT standard of 80 ug/dscm @ 7% O₂ or 85% reduction without mercury controls. The

Hempstead Facility is equipped with three DBA 835 TPD mass burn boilers, roller grates, spray dryers and reverse air baghouses. The Niagara Falls plant air pollution control equipment was expected to meet or exceed the performance achieved at the Hempstead Facility.

The permit to construct the Niagara Falls plant contained a mercury emission standard of 95 ug/dscm @ 7% O₂ and a requirement to achieve the EPA MACT standard once the rule was finalized. A provision was written into the permit that would allow the facility to be constructed and to start-up without installation of specific mercury control equipment. If the mercury emission rate was not as anticipated and did not meet the emission standard, installation of additional mercury controls would be required.

Initial testing after the retrofit at the Niagara Falls plant showed the baghouse outlet mercury emissions were around 150 ug/dscm at 7% O₂. American Ref-Fuel undertook an investigation to determine why there was a difference between the emissions from Hempstead and Niagara Falls, and to find a mercury control technology that could be installed on short notice with minimum capital expense.

DISCUSSION

American Ref-Fuel initiated discussions with Dravo Lime Company on the application of Sorbalime™ or Sorbalit^R for mercury control at Niagara Falls and to determine if Sorbalime or Sorbalit could meet Ref-Fuel's economic and operating criteria.

Sorbalit is a patented air pollution control system that reduces pollutants such as volatile heavy metals (mercury), organics (dioxin and PCBs), and acid gases (SO₂ and HCl). The Sorbalit process produces a sorbent consisting of a formulation of lime, activated carbon, and other proprietary sulfur components. These lime-based products reduce several pollutants in a single application. Sorbalit is formulated with hydrated lime [Ca(OH)₂] and Sorbalime uses quicklime (CaO) in its manufacture.

Sorbalit is a technology, not a product. The sorbent is blended for each source of emissions. Applications of Sorbalit range in carbon formulations from 1% to 65%. In most cases where a spray dryer is used, a quicklime-based process is the most economically attractive. The high calcium quicklime product normally used for acid gas control is simply replaced with Sorbalime. The amount of lime used is dictated by acid gas control requirements. Carbon is blended with the lime during production to obtain a uniform and consistent mix. The quantity of carbon is based upon the required mercury and dioxin control. Sulfur compounds may also be added to the blend. These compounds help the carbon capture more of the vapor phase mercury.

The primary advantage for the application of a Sorbalime retrofit over other mercury control technologies is that no major additional equipment is required beyond the existing lime slaking system, spray dryer absorber, and fabric filter. This reduces both capital expenses and compliance time. Only minor changes to slaking operating practices are normally required to complete the change. Sorbalime, which was Dravo's recommended technology for Niagara Falls, would replace the quicklime used in the existing slaking system. Sorbalime is produced off site at a Dravo licensed facility. Once agreements are in place to provide Sorbalime, changes can be made to the product by contacting the manufacturing plant. Once arrangements are complete, the total time to bring a facility into compliance with its mercury regulations requires a few days to use up the quicklime that is in the silo so that the Sorbalime can be slaked and sprayed into the air pollution control system.

This quick change aspect was useful when demonstration testing was completed at Niagara. One of the facility's two lime silos was allowed to drop to a low level. It was then filled with Sorbalime containing a known quantity of carbon. A second level of control was demonstrated by adding additional Sorbalime to the silo with a different mix of carbon.

Ref-Fuel requested an extensive test program to determine the following:

- What is the minimum carbon concentration that would be required to meet the mercury emission limit?
- Would the Sorbalime slake at least as well as the normal quicklime the plant had been using?
- What would be the long-term affect on plant operations such as wear on rotary atomizer wheels, control valves, and piping?
- Would there be any impact on the ash handling equipment?
- Would Sorbalime reduce acid gas emissions to the same level as quicklime?

American Ref-Fuel and Dravo Lime developed a test protocol that used the following concepts:

- Since the plant had two independent lime storage silos, slakers, and lime slurry systems, Unit 3 was fed normal quicklime during the test period and Sorbalime was used for the test in Unit 4. In this manner, lime consumption rates, operating characteristics, and acid gas emission (SO₂) differences between the two units could be monitored and compared during the test period. If a problem developed where acid gas control could not be maintained due to the loss of a slaker or lime feed, isolation valves could be opened to allow the operating system to supply both processing trains.
- Two different carbon concentrations were tested -- 2% and 4%. Tests were also undertaken with quicklime (0%

carbon or sulfur added) just prior to the Sorbalime test program. This data was used as a baseline.

- Sorbalime was used for at least two weeks in order to determine the impact on plant operations, condition the bags, and allow the operators to adjust for any unseen issues prior to the test measurements. The first test run used 2% carbon. This test was followed by the 4% carbon formulation. This was completed to minimize "imprinting" of control from any residual carbon remaining on the bags between tests. For compliance testing, the formulation of Sorbalime was used for three weeks prior to stack testing to allow the system to stabilize and to observe any operating problems.
- During the entire test period, Units 3 and 4 were run in normal operating mode, controlling SO₂ emissions using percent reduction or outlet concentration as the controller for a lime slurry feed rate. All testing was conducted at 100% boiler design steam flow.
- All emission testing was conducted using U.S. EPA test methods. Method 29 was used to measure mercury concentration at the boiler outlet and at the stack. HCl emissions were measured using Method 26A, and SO₂ was measured using Method 6 and the plants Continuous Emission Monitoring System (CEMS).

ANALYSIS OF THE PROBLEM

The first step in the test program was to search for the origin of the difference between the mercury emissions at the Hempstead and the Niagara Falls facilities. Operating conditions were reviewed for any variations. Some of the major areas reviewed included the following:

- Boiler exit temperature
- Baghouse operating temperature
- Acid gas concentrations
- Types of filter material
- Physical differences between the Hempstead and the Niagara boilers and pollution control systems

No significant differences were observed between the temperatures and acid gas concentrations at Niagara and the range of conditions observed at Hempstead since it began operation. While the Niagara area is heavily commercialized, washed differences were not specifically identified as a cause.

Both facilities are equipped with spray dryer absorbers and fabric filters. Different vendors manufactured the fabric filters, but both are low air-to-cloth ratio reverse air designs. Both facilities use conventional Teflon-coated fiberglass filters of approximately the same size and shape. The Hempstead Facility has 12 compartments per fabric filter while the Niagara Facility has eight with approximately the same air-to-cloth ratio. The spray dryers differ in that the Hempstead facility is equipped with dual fluid nozzle

technology and Niagara with rotary atomizer heads. Niagara is also equipped with an SNCR NO_x system while the Hempstead facility did not have this control. These process variances were considered to not be significant with regard to mercury control.

The boiler designs are different because the Hempstead facility is equipped with center flow four-pass vertical design boilers and the Niagara boilers are parallel flow three-pass vertical design. Both technologies were developed by DBA. The Hempstead boiler is designed to operate with about 90 percent excess air while the more efficient Niagara boiler is designed to operate at about 60 percent excess air. Combustion temperatures and furnace retention times are higher for the Niagara design. DBA experience with the parallel flow design in Europe demonstrated improved uncontrolled emissions performance, particularly for CO, NO_x, and dioxins. Particulate carryover and flyash carbon content were expected to be lower for the parallel flow boiler. Limited test results did not clearly show a major reduction in uncontrolled flyash or carbon content. Comparison of mercury data was not possible due to washed and other potential differences between Niagara and European data.

The review of the design and operations between the two plants found no substantial differences that could specifically explain the incongruity in mercury performance. Variations in operating methods and in the data were within normal range. The second step was to look at the stack test data and test methods. For the first three years of operations, Hempstead was required to use EPA Method 101A and no inlet samples were taken. Therefore, comparable data with the test work that was performed at Niagara Falls was not readily available. However, a few inlet and outlet test runs had been completed at Hempstead using Method 29. In reviewing the Hempstead data, a considerable difference in the distribution of the mercury in the sampling train was observed.

The primary difference between the inlet mercury concentrations was the percentage captured on the Method 29 filter between the two plants. At Niagara Falls less than 50% of the total Hg was captured on the filter while more than 80% was typically captured on the filter at Hempstead. A summary of the mercury distribution for the two plants is presented in Table 1. (Note: EPA has stated that Method 29, particularly on inlet samples, should not be used for speciation of Hg).

Mercury is present in flue gas either as elemental (Hg⁰), metallic (HgO), or as an ionic form (Hg²⁺). In the presence of Cl, the preferred ionic form is HgCl₂. In the absence of Cl, HgO is the primary ionic form. SO₂ in the flue gas is believed to reduce ionic mercury to Hg⁰. The outlet (i.e. stack) mercury emissions from MWCs primarily exists as a vapor. A small amount of mercury may also be present at the outlet as a very fine particulate (generally less than 2 microns). At the inlet sampling locations (prior to the air pollution control

equipment), a significant portion of the total mercury may be particulate associated, depending on the flue gas temperature.

The major species of mercury from MWCs is HgCl₂. Hg⁰ only accounts for 5 to 15 % of the emissions. HgCl₂ and Hg⁰ are vaporous at these conditions with a mean size of HgCl₂ of about 4.5 angstroms and for Hg⁰ of about 1.5 angstroms. Of significance to sampling train operation, air pollution control equipment performance and atmospheric transport, HgCl₂ is highly soluble in water, HgO is slightly soluble, and Hg⁰ is insoluble. HgCl₂ is relatively easy to capture (90 - 99%) using carbon-based technology, while the Hg⁰ is significantly more difficult to capture, (10 - 50%) depending on the type of carbon used. The purpose of potassium permanganate (KMnO₄) in the sampling train is to oxidize Hg⁰ to soluble Hg²⁺ to make it easier to capture.

From the comparison of the data from the two facilities, it appears that there is considerably more filterable mercury in the Hempstead flue gas than in the Niagara boiler outlet. At Niagara, it appears that less of the mercury is bound to the particulate matter and, therefore, is not removed in the fabric filter as it is in Hempstead. More mercury emissions from Niagara appear to be in the vapor state than at Hempstead. Therefore, additional controls would be required to reduce the emissions to comply with the emission standard. This analysis assumes that all testing conditions would allow the captured mercury to react in the same manner.

TEST USING SORBALIME

In February of 1997, American Ref-Fuel and Dravo Lime Company entered into a test program to determine the most economical Sorbalime formulation and to determine the impact on plant operations as outlined above.

A summary of mercury emission test results completed during the demonstration test is presented in Table 2. This table also includes tests that were conducted without Sorbalime. Regression analysis in Figure 3 demonstrated that the Sorbalime with a 2% carbon formulation would meet the MACT standard for mercury control with a safety margin.

Other analysis and observations that were made during this two-month test period that impacted plant operations included:

- Sorbalime slaked better than the quicklime Niagara was using. The operators preferred the Sorbalime product over the locally available quicklime.
- No increased wear on the spray dryer rotary disk or in the motor operated valves was noted.
- There was a slight improvement in the acid gas removal efficiency with Sorbalime when compared to quicklime. Tests were conducted with quicklime and Sorbalime with the lime slurry feed held at 18 gpm; the test results are presented in Table 3. While there may not be a statistical difference, there appears to be an improvement.

Based on the test results, American Ref-Fuel and Dravo Lime entered into a long-term agreement to provide 2% carbon based Sorbalime for the Niagara Falls facility. In December 1997, official New York State compliance tests were conducted at the facility. A summary of these test results, as well as some additional outlet-only testing that was completed in January 1998, is presented in Table 4. Table 5 presents compliance data obtained in 1999. While Sorbalime was not used to control tetra through octa polychlorinated dibenzo-p-dioxins and tetra through octa polychlorinated dibenzofurans (dioxins), and a demonstration of effectiveness was not completed for dioxins, results from the most recent test are also presented. The facility consumes lime very efficiently, using less than 20lb of lime per ton of MSW processed. This translates into a low carbon feedrate of about 0.36 lb/ton of MSW. A second compliance demonstration for mercury since Sorbalime has been in use at the facility is also presented in the table.

CONCLUSIONS

There appears to be a substantial difference in the form, particle size, and/or species of mercury being emitted from the boilers at the Hempstead and Niagara Falls facilities. We could not confirm if this difference in emissions was caused by the differences in the waste, facility design, and/or the

operation of the facilities. Sorbalime, however, has been shown to be a cost-effective sorbent technology to control mercury emissions at Niagara Falls. This technology was implemented with no significant capital cost or interruption of the operating procedures.

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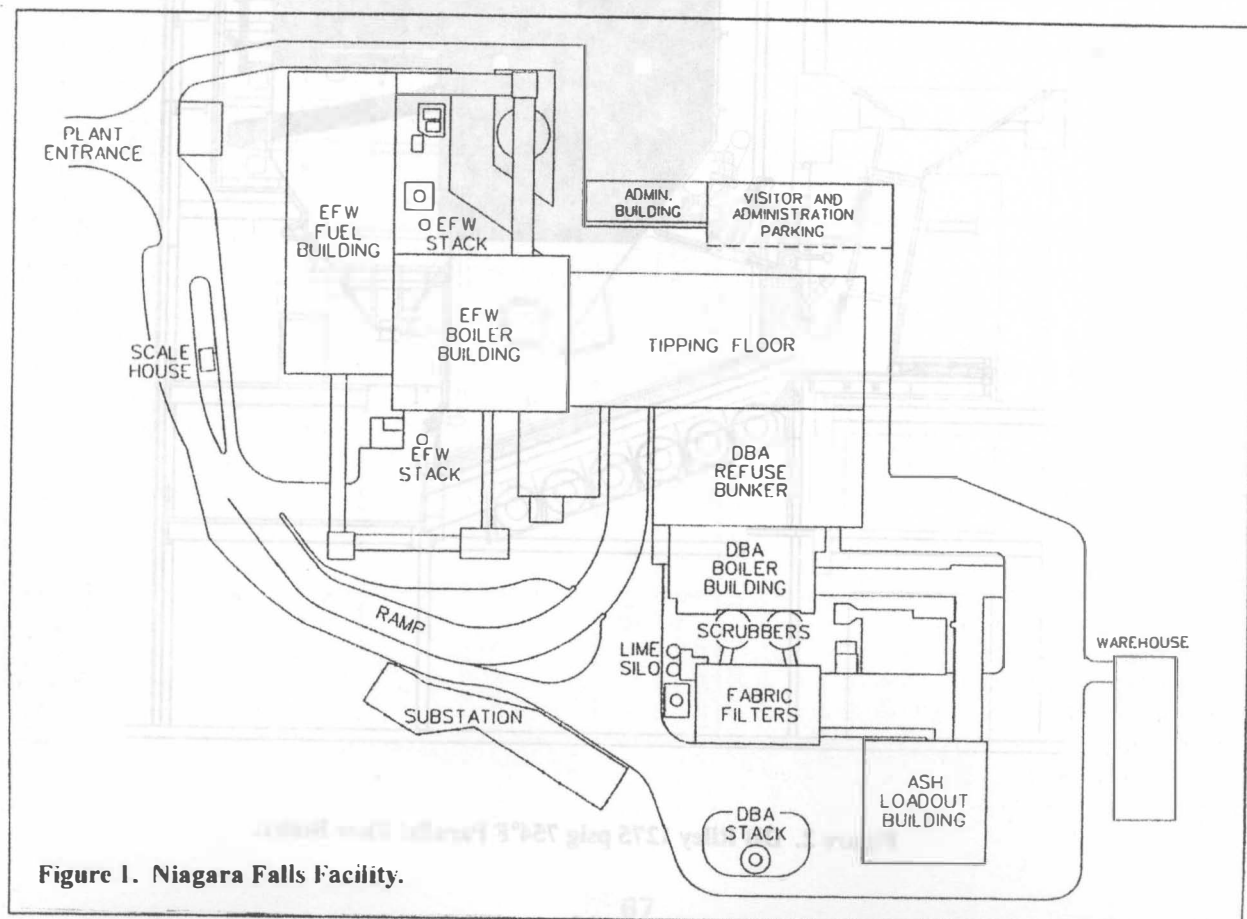


Figure 1. Niagara Falls Facility.

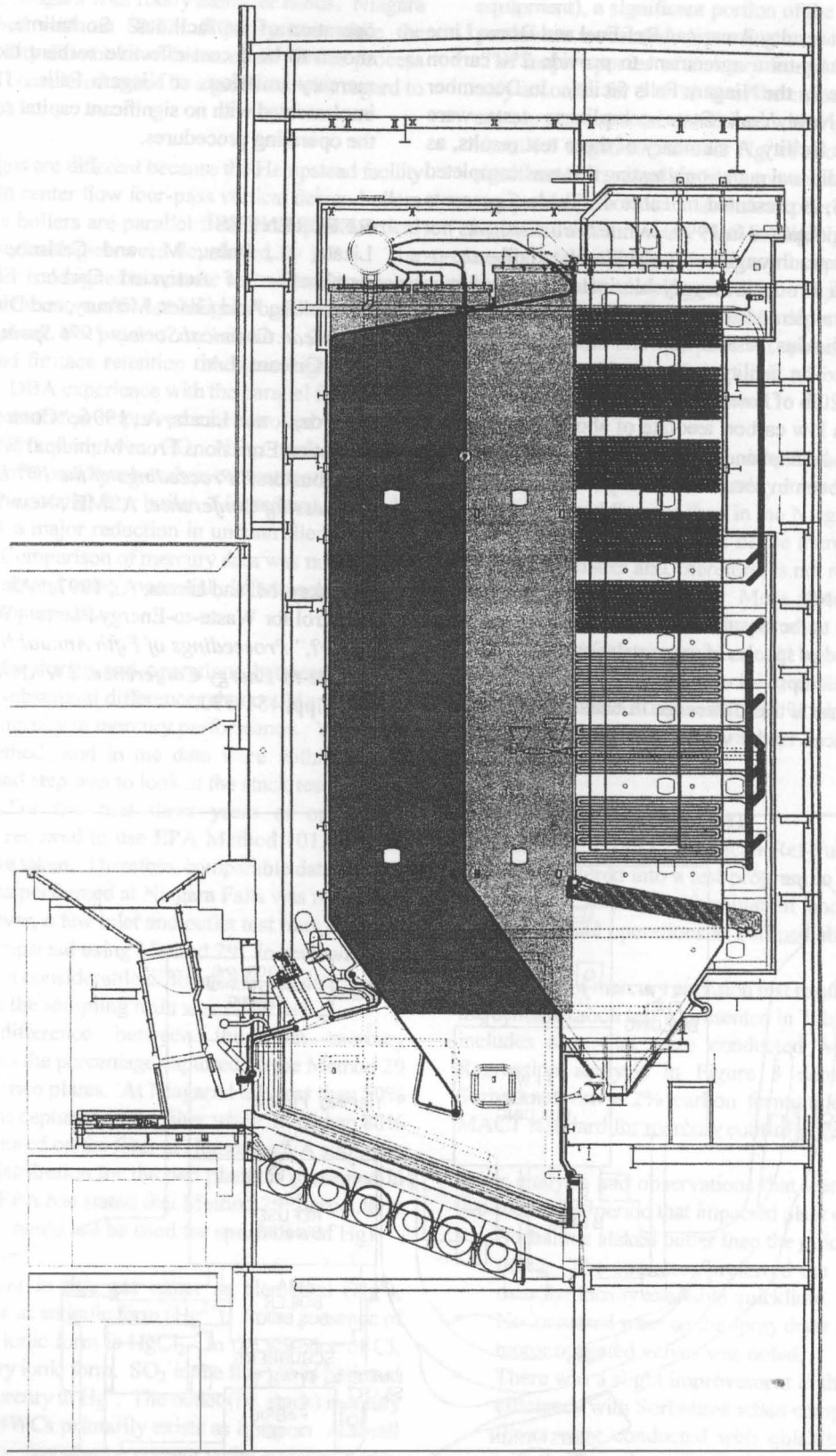


Figure 2. DB Riley 1275 psig 754°F Parallel Flow Boiler.

TABLE 1. TEST USING QUICKLIME ONLY.

Plant	Hg Fraction in Flue Gas			
	Fraction A Filterable Hg %	Fraction B 5% HNO ₃ and 10% H ₂ O ₂	Fraction C KMnO ₄ in 10% H ₂ SO ₄	Total Hg
Hempstead Inlet Outlet % Removal	60 - 85% 1 - 2% 80 - 95%	10 - 15% 90 - 97% 10 - 30%	5 - 10% 4 - 7% < 20%	80+%
Niagara Falls Inlet Outlet % Removal	45% 2% 98.09%	54% 94% 22.47%	1% 4% 45%	56.4%

**Table 2. Niagara Resource Recovery Facility Demonstration Testing - Unit 4
Mercury Removal Testing Without Using Sorbalime**

Run No.	Hg Fraction A			Hg Fraction B			Hg Fraction C			Total Hg	
	ug/dscm @	% Hg	% Hg	ug/dscm @	% Hg	% Hg	ug/dscm @	% Hg	% Hg	ug/dscm @	% Hg
	7% O2	% Total Hg	Removal	7% O2	% Total Hg	Removal	7% O2	% Total Hg	Removal	7% O2	Removal
1 Inlet	151	56%		115	42%		4.4	1.6%		270	
1 Outlet	0.53	0%	99.6	150	98%	-31	3.2	2.1%	27	153	43
2 Inlet	118	38%		188	61%		2.5	0.80%		309	
2 Outlet	3.2	2%	97.3	163	97%	14	2.1	1.2%	17	168	46
Inlet	160	42%		223	58%		0.77	0.20%		384	
3 Outlet	3.2	2%	98.0	204	98%	8.3	0.54	0.26%	30	208	46
4 Inlet	138	35%		251	63%		8.0	2.0%		397	
4 Outlet	8.0	4%	94.2	134	74%	46.7	38	21%	NG	180	55
5 Inlet	312	57%		228	42%		9.2	1.7%		549	
5 Outlet	0.92	1%	99.7	119	98%	47.8	1.6	1.3%	83	121	78
6 Inlet	272	44%		341	56%		1.5	0.25%		614	
6 Outlet	0.55	0%	99.8	174	99%	49.0	0.46	0.26%	70	175	72
Average In	192	45%		224	54%		4.4	1.1%		420	
Average Out	2.7	2%	98.1%	157	94%	22%	7.6	4.4%	45%	168	56%

Mercury Removal Testing Using Sorbalime Addition @ 2% Carbon Blend

1 Inlet	130	45%		151	52%		8.2	2.8%		289	
1 Outlet	0.31	0.61%	99.8	45	88%	70	5.8	11%	29	51	82
2 Inlet	243	64%		128	34%		5.6	1.5%		376	
2 Outlet	0.30	0.66%	99.9	42	92%	67	3.5	7.7%	37	46	88
3 Inlet	232	50%		227	49%		3.6	0.78%		463	
3 Outlet	0.29	0.91%	99.9	30	94%	87	1.5	4.7%	58	32	93
4 Inlet	87	41%		109	51%		16	7.5%		212	
4 Outlet	0.35	0.94%	99.6	35	94%	68	1.8	4.9%	89	37	82
Average In	173	50%		154	47%		8.4	3.2%		335	
Average Out	0.32	0.78%	99.8%	38	92%	73%	3.2	7.2%	53%	42	86%

Mercury Removal Testing Using Sorbalime Addition @ 4% Carbon Blend

5 Inlet	192	78%		51	21%		2.4	1.0%		245	
5 Outlet	0.32	2.0%	99.8	14	88%	73	1.7	10%	30	16	94
6 Inlet	163	65%		86	34%		1.2	0.50%		250	
6 Outlet	0.28	3.2%	99.8	7.0	80%	92	1.5	17%	-18	8.8	96
7 Inlet	5.4	1.4%		369	98%		3.6	1.0%		378	
7 Outlet	0.32	2.4%	94.1	11	85%	97	1.6	12%	54	13	96
8 Inlet	314	59%		214	40%		7.2	1.3%		535	
8 Outlet	0.32	2.1%	99.9	13	87%	94	1.7	11%	77	15	97
Average In	169	51%		180	48%		3.6	0.94%		352	
Average Out	0.31	2.4%	98.4%	11	85%	89%	1.6	13%	36%	13	96%

**Figure 3. Niagara Resource Recovery Facility
February 1997 Sorbalime Testing**

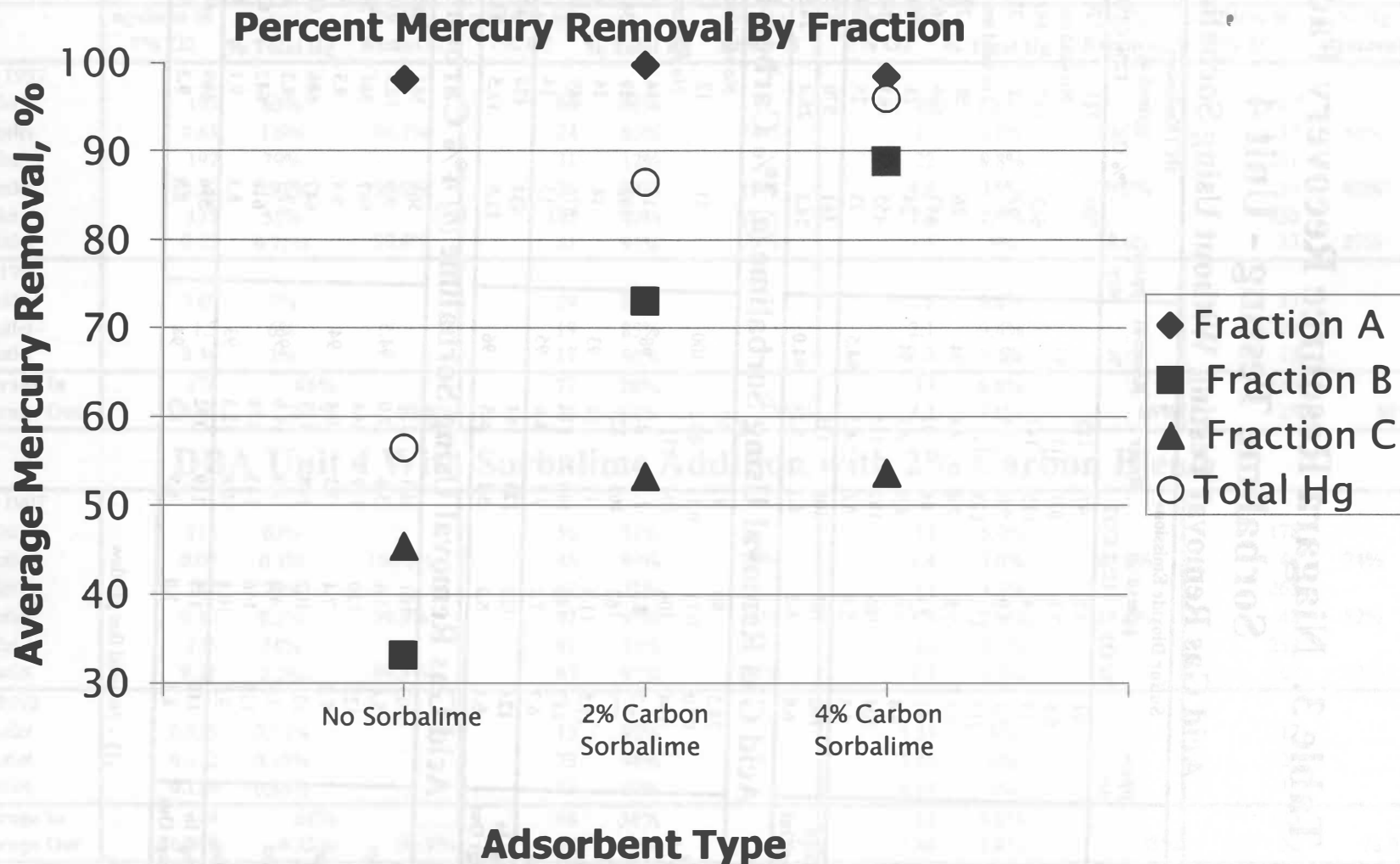


Table 3. Niagara Resource Recovery Facility Sorbalime Testing - Unit 4

Acid Gas Removal Testing Without Using Sorbalime

Run No.	Sulfur Dioxide Emissions				HCl Emissions					
	ppmv, dry	ppmvd @ 7% O2	ppmvd @ 12% CO2	lbs/hr	Removal %	ppmv, dry	ppmvd @ 7% O2	ppmvd @ 12% CO2	lbs/hr	Removal %
1 Inlet	94	97	97	113		700	721	724	473	
1 Outlet	6.8	7.1	6.9	(1)	93		No valid test			
2 Inlet	115	114	115	141		642	637	642	442	
2 Outlet	5.8	5.9	5.6	7.4	95	24	24	23	17	96
3 Inlet	117	123	123	(1)			No valid test			
3 Outlet	7.2	7.8	7.4	8.6	94	26	28	27	17	
4 Inlet	81	84	84	93		447	460	462	287	
4 Outlet	4.8	5.0	4.9	6.4	94	24	25	24	18	95
5 Inlet	104	106	107	115		455	461	466	282	
5 Outlet	5.5	5.8	5.6	6.5	94.5	23	25	24	16	95
Average In	102	105	105	115		561	570	573	371	
Average Out	6.0	6.3	6.1	7.2	94.0	24.2	25.4	24.5	16.9	95

Acid Gas Removal Using Sorbalime @ 2% Carbon Blend

1 Inlet	78.5	80	81	97			No valid test			
1 Outlet	0.10	0.11	0.11	0.12	100	11	12	12	7.8	
2 Inlet	104	104	104	(1)			No valid test			
2 Outlet	2.2	2.3	2.3	2.7	98	14	14	14	9.5	
3 Inlet	177	162	165	227		392	359	365	282	
3 Outlet	11.5	11.3	11	14	93	14	14	13	9.9	96
4 Inlet	137	140	140	170		576	589	586	400	
4 Outlet	6.7	7.2	7.1	8.6	95	13	14	14	9.2	98
Average In	124	122	123	164		484	474	475	341	
Average Out	5.1	5.2	5.1	6.5	96	12.9	13.5	13.3	9.1	97

Acid Gas Removal Using Sorbalime @ 4% Carbon Blend

1 Inlet	103	103	103	137		561	565	566	422	
1 Outlet	5.4	5.6	5.6	7.0	94.5	9.9	10.3	10.2	7.2	98
2 Inlet	125	120	119	164		567	544	540	418	
2 Outlet	7.5	7.4	7.3	9.4	94	9.4	9.3	9.2	6.7	98
3 Inlet	101	107	108	133		647	686	687	476	
3 Outlet	3.6	4.0	3.9	4.6	96	7.7	8.5	8.4	5.6	99
4 Inlet	139	146	145	174		610	642	636	430	
4 Outlet	9.9	10.8	10.6	12.3	93	8.3	9.1	8.9	5.8	99
Average In	117	119	119	152		596	609	607	437	
Average Out	6.6	7.0	6.9	8.3	94	8.8	9.3	9.2	6.3	98

Notes: (1) - No valid flue gas flow

**Table 4. Niagara Resource Recovery Facility Mercury Removal Testing.
DBA Unit 3 With Sorbalime Addition with 2% Carbon Blend**

Run No.	Hg Fraction A			Hg Fraction B			Hg Fraction C			Total Hg	
	ug/dscm @ 7% O2	% Total Hg	% Hg Removal	ug/dscm @ 7% O2	% Total Hg	% Hg Removal	ug/dscm @ 7% O2	% Total Hg	% Hg Removal	ug/dscm @ 7% O2	% Hg Removal
Dec 1997											
1 Inlet	193	63%		94	31%		20	6.6%		307	
1 Outlet	0.61	1.6%	99.7%	24	65%	74%	13	34%	37.7%	37	88%
2 Inlet	197	79%		31	12%		22	8.8%		251	
2 Outlet	0.27	0.91%	99.9%	25	84%	19%	4.6	15%	79.2%	30	88%
3 Inlet	137	55%		105	42%		7.3	2.9%		250	
3 Outlet	0.23	0.71%	99.8%	31	95%	70%	1.6	5%	78.6%	33	87%
Jan 1998											
2 Outlet	0.89	3%		29	89%		2.8	8.6%		33	
3 Outlet	1.3	6%		19	85%		2.1	9.4%		22	
4 Outlet	0.46	3%		17	90%		1.3	7.2%		18	
Average In	176	65%		77	28%		17	6.1%		269	
Average Out	0.62	2.4%	99.8%	24	84%	55%	4.2	13%	65%	29	88%

DBA Unit 4 With Sorbalime Addition with 2% Carbon Blend

Dec 1997											
1 Inlet	112	63%		56	31%		11	6.0%		178	
1 Outlet	0.05	0.1%	100.0%	45	97%	20%	1.4	3.0%	87.3%	46	74%
2 Inlet	187	70%		67	25%		11	4.3%		265	
2 Outlet	0.10	0.2%	99.9%	47	97%	31%	1.4	2.9%	88.0%	48	82%
3 Inlet	135	58%		81	35%		16	7.1%		232	
3 Outlet	0.11	0.2%	99.9%	63	97%	22%	2.1	3.2%	87.3%	65	72%
Jan 1998											
1 Outlet	0.025	0.15%		15	92%		1.34	8%		17	
2 Outlet	0.122	0.49%		23	94%		1.40	6%		25	
3 Outlet	0.124	0.86%		13	93%		0.84	6%		14	
Average In	144	64%		68	30%		13	5.8%		225	
Average Out	0.088	0.33%	99.9%	34	95%	24%	1.40	4.8%	88%	36	76.0%

**Table 5. Niagara Resource Recovery Facility 1999 Emissions Testing.
DBA Unit 3 With Sorbalime Addition with 2% Carbon Blend**

Run No.	Hg Fraction A			Hg Fraction B			Hg Fraction C			Total Hg	
	ug/dscm @ 7% O2	% Total Hg	% Hg Removal	ug/dscm @ 7% O2	% Total Hg	% Hg Removal	ug/dscm @ 7% O2	% Total Hg	% Hg Removal	ug/dscm @ 7% O2	% Hg Removal
Feb 1999											
1 Inlet	1.2	0.2%		518	99%		2.6	0.5%		522	
1 Outlet	0.02	0.0%	98.7%	82	96%	84%	3.1	4%	-16.6%	85	84%
2 Inlet	88	27%		238	72%		2.3	0.7%		329	
2 Outlet	0.02	0.02%	100.0%	78	99%	67%	0.49	0.6%	78.9%	79	76%
3 Inlet	87	21%		321	78%		1.2	0.3%		409	
3 Outlet	0.05	0.04%	99.9%	109	99%	66%	0.64	0.6%	44.1%	110	73%
Average In	59	16%		359	83%		2	0.5%		420	
Average Out	0.03	0.03%	99.5%	90	98%	72%	1.4	1.6%	35%	91	78%

DBA Unit 4 With Sorbalime Addition with 2% Carbon Blend

Feb 1999											
1 Inlet	87	40%		131	60%		1.0	0.4%		219	
1 Outlet	0.04	0.1%	99.9%	40	99%	70%	0.5	1.3%	44.5%	41	82%
2 Inlet	124	51%		118	49%		1.1	0.4%		243	
2 Outlet	0.01	0.0%	100.0%	37	99%	69%	0.2	0.5%	83.6%	37	85%
3 Inlet	90	49%		90	49%		3.7	2.0%		183	
3 Outlet	0.02	0.0%	100.0%	66	100%	27%	0.1	0.2%	96.2%	66	64%
Average In	100	47%		113	52%		2	1.0%		215	
Average Out	0.024	0.06%	100.0%	47	99%	55%	0.28	0.7%	75%	48	76.8%

Unit 3	Total, ng/dscm @ 7% O2	ITEQ, ng/dscm @ 7% O2
Dioxin Emissions		
Run 1	3.61	0.086
Run 2	1.41	0.023
Run 3	2.20	0.034
Average	2.41	0.048

Unit 4	Total, ng/dscm @ 7% O2	ITEQ, ng/dscm @ 7% O2
Dioxin Emissions		
Run 1	1.63	0.028
Run 2	1.42	0.024
Run 3	1.42	0.023
Average	1.49	0.025

Tetra through Octa Polychlorinated dibenzo-p-dioxins and Polychlorinated Dibenzofurans