REDUCING OXIDES OF NITROGEN EMISSIONS FROM WASTE-TO-ENERGY FACILITIES WITH OPERATIONAL CONTROLS

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ABSTRACT

Combustion control may be a feasible method to reduce oxides of nitrogen emissions below those generally seen for the waste-to-energy industry. This paper provides test data which indicate that, by modifying the distribution of primary and secondary air in a mass burn facility, the oxides of nitrogen, (NO_x) emissions can be reduced without compromising combustion efficiency. Further research to determine the potential for NO_x reduction via combustion control is encouraged before any regulatory requirements are established which rely on add-on oxides of nitrogen control equipment.

INTRODUCTION

Due to concern over minimizing dioxin emissions, operational controls for reducing oxides of nitrogen, (NO_x) emissions have not been thoroughly explored in the waste-to-energy industry to date. New facilities have proven that their proposed NO_x emissions have not exceeded National Ambient Air Quality Standards, (NAAQS) and some have argued that the trend of higher NO_x emissions in the industry is due to the stringent requirements to control carbon monoxide and dioxin emissions. Currently, pressure is mounting in the regulatory community to require further control of oxides of nitrogen emissions, especially given the requirement in California for thermal deNO_x systems on new waste-to-energy facilities.

In this paper, we contend that combustion control may be a feasible method for sufficiently reducing oxides of nitrogen emissions below those generally seen for the waste-to-energy industry. It may be possible to reduce the typical concentration of 250 ppm NO_x corrected to 7% oxygen concentration to a lower level by applying combustion control for the reduction of NO_x, while still maintaining acceptable carbon monoxide levels, combustion efficiency, and low dioxin emissions as currently seen in the industry.

In addition, combustion control results in better understood emissions with lower potential for forming undesirable trace nitrogen compounds. Because thermal deNO_x systems require urea or ammonia injection, the potential exists for producing undesirable trace nitrogen compounds. Neither ammonia nor urea is required with combustion control. Thus, the potential for undesirable trace nitrogen compounds is reduced. In addition, the use of combustion control does not require the transportation of large quantities of hazardous materials (urea or anhydrous ammonia) with the attendant risk of an accident resulting in a spill.

Combustion control of NO_x was studied by Blount Energy Resource Corporation at the MVA Oslo waste-to-energy facility in Oslo Norway. Results of this testing show that combustion control for NO_x is feasible, resulting in a 30% reduction of NO_x. The techniques developed from this test program are used today at the Warren County New Jersey Resource Recovery Project with good results.

TEST OVERVIEW

The MVA Oslo waste-to-energy facility in Norway underwent a testing program in April 1987. This testing was performed as part of a research effort to determine plant performance during a series of firing conditions outside of the traditional and proven conditions prescribed by W+E, the designer of the facility. Testing was performed by Miljokonsulterna, (the local environmental consultant). Specifically, while maintaining good combustion efficiency and low carbon monoxide concentrations in the exhaust gases, the ratio of primary to secondary air was modified greatly from the prescribed ratios for both full load and part load operation.

The MVA Oslo facility is a municipal solid waste (MSW), mass burn facility. The facility consists of two 264 TPD (240,000 kg/day) trains, each generating 64,000 lb/hr (29,000 kg/h) steam at a temperature of 676°F (358°C) and pressure of 544 psia (37 bars). The facility includes a back-pressure turbine with low-pressure steam used for district heating. Some recyclable material is reclaimed prior to the MSW being introduced into the furnace. Electrostatic precipitators are used for the flue gas control. The facility began operating in June of 1985.

Due to the recycling efforts currently in place at the MVA Oslo facility, the waste stream composition is not thought to be significantly different from the typical waste stream encountered in U.S. waste-to-energy facilities, especially as source separation becomes more prevalent in this country. However, no information was obtained on the waste stream characteristics at the MVA Oslo facility.

TEST PROGRAM

Miljokonsulterna took measurements during eighteen operating periods on boiler number 2 at the MVA Oslo Facility. The facility operators took great care during all the tests to ensure that the combustion efficiency was maintained at consistently high levels, as indicated by the continuous emission monitoring results for carbon monoxide and oxygen.

During the testing periods, the flue gas was continuously analyzed using the following instruments:

Parameter	Instrument	Measurement basis
Carbon dioxide (CO_2)	Binos IR	dry
Carbon monoxide (CO)	Binos IR	dry
Oxides of nitrogen	Bendix chemiluminisence	dry
Total Hydrocarbons	JUM flame ionization	wet

Instruments were calibrated before and after the test periods with test gas of known analysis. As can be expected with a boiler operation at a high combustion efficiency, total hydrocarbon concentrations were very low, never exceeding 3 ppm for any test at loads greater than 60%.

Each test measured the effect of change in load or primary air ratio on NO_x and CO emissions. In addition, furnace temperatures, grate temperatures and particulate matter emissions were measured during each test to ensure that acceptable operation of the unit was not impaired. A summary of the testing program is presented in Table 1.

TEST RESULTS

Test results as they relate to NO_x emissions reductions can be summarized as shown in Fig. 1–3.

Figure 1 shows emissions as a function of percent of the total combustion air provided by primary air under full load. Note that total combustion air was relatively constant during all of these test periods with a range between 60% and 85% excess air. Figure 1 shows a significant drop in NO_x concentrations during full load operations when the combustion air ratio of 40% primary, 60% secondary air is changed to provide more primary air and less secondary air. Wintertime concentrations of NO_x were shown to be reduced from an average in the range of 230 ppm NO_x corrected to 12% CO_2 to approximately 170 ppm NO_x corrected to 12% CO_2.[1] The reduction was fast and the lower concentration was stable for the duration of the test. A typical chart recording of the change from lower primary air to high primary air is presented in Fig. 2.

Carbon monoxide concentrations did increase with the increase in the primary air ratio. It is doubtful, however, that this change is unacceptable. Concentrations averaged approximately 17 ppm CO corrected to 12% CO_2 for the low primary air ratio. When the

[1] Concentrations are shown corrected to 12% CO_2 rather than the EPA preferred correction of 7% oxygen on a dry basis due to the instrumentation available at the facility. Typically for this type of facility, the correction to 12% CO_2 is very close to the correction to 7% O_2 on a dry basis.

TABLE 1 SUMMARY OF TESTING PROGRAM MVA OSLO FACILITY

Test No.	Date	Time	Load %	%Pri Air	NO_x* ppm	CO* ppm	CO_2 %	Particulate Emissions mg/Nm^3
1	4-3	0845-1045	98	46	184	12	9.1	26
2	4-3	1100-1300	99	50	185	12	9.1	19
3	4-3	1330-1530	99	74	128	25	9.0	17
4	4-6	0930-1130	63	40	123	4	8.0	10
5	4-6	1145-1345	64	50	121	14	7.8	9
6	4-6	1400-1600	65	76	113	25	7.5	10
7	4-6	1615-1635	65	96	124	30	7.7	13
8	4-7	1000-1100	64	45	122	12	8.2	16
9	4-7	1300-1500	64	51	145	12	8.7	16
10	4-7	1515-1715	65	73	122	16	8.4	6
11	4-8	0845-1045	65	40	143	9	7.3	25
12	4-8	1130-1330	65	49	138	12	7.7	10
13	4-8	1400-1600	61	77	113	37	7.5	10
14	4-9	0930-1130	41	51	79	28	6.9	9
15	4-9	1400-1600	102	76	132	30	10.0	32
16	4-10	0830-0945	95	45	200	10	9.7	36
17	4-10	1100-1300	97	76	119	18	10.2	11
18	4-10	1330-1530	108	50	170	21	10.5	14

* NO_x and CO concentrations presented here are analyzer readings and are not corrected to 12% CO_2

primary air ratio was increased, the CO concentrations increased to an average of approximately 30 ppm for the full load condition. This concentration is a very acceptable CO concentration. Generally, regulatory limits range from 50 to 100 ppm CO corrected to 12% CO_2. Even though there was an apparent increase in carbon monoxide concentrations, the level was low enough to indicate that combustion efficiency was still very high.

Figure 3 shows data relating to minimum load operation. The reduction in NO_x concentrations with the increase in the primary air ratio is not nearly as evident. In addition, while still acceptable and meeting current regulatory levels, CO concentrations are higher than desired.

DISCUSSION

Minimum load operation test results indicate that during part load operation, the mass burn furnace is operating at less than optimum efficiency with undesirably high emission levels, although still within current standards of compliance. This is as expected and is one reason why the industry generally runs the furnace/boiler units at maximum continuous rating.

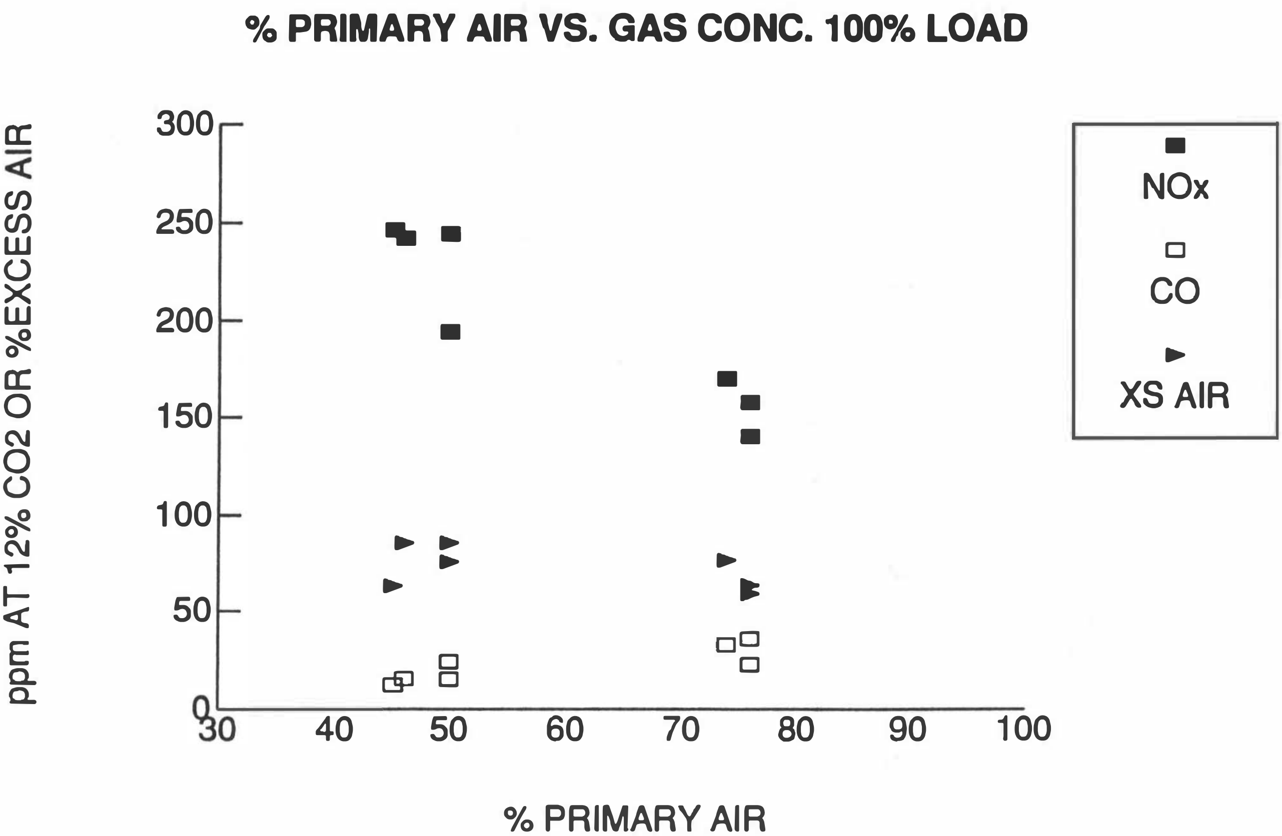

FIG. 1 MVA OSLO DATA

Waste-to-energy facilities operate best when base loaded rather than swing loaded. It is also a reason for maintaining the traditional 60/40 split between primary and secondary air flows. For a high primary air ratio during a low load situation, the carbon monoxide concentrations start to approach the current regulatory limits. The traditional split between primary and secondary air flows, however, results in a comfortable margin to maintain carbon monoxide levels within compliance throughout the range of loads.

As shown with the full load operation test results, NO_x emissions can be changed with changes in operating parameters. When more of the combustion air is used for primary air, an excess air condition is obtained below secondary air injection which contributes to a reduction in the maximum flame temperature. This has the expected result of lower thermal NO_x formation. Total air usage is not changed; therefore, furnace temperature 1–2 sec downstream of secondary air injection (a parameter used to determine compliance with operation requirements) is not affected. Adequate turbulence is maintained with a furnace that has a vortex nose or other "bumps" because the higher exhaust flows in the primary combustion area counteract the reduced secondary air flow and jet velocity.

While this test program provides some insights on emissions and operating conditions, it does not fully evaluate the long-term effects of operating a waste-to-energy facility in such a manner as to minimize emissions of oxides of nitrogen. Each test run duration was only 2 hr or less. While higher primary air flows would appear to increase grate life due to cooler grate temperatures, the long term effects of operating under the modified conditions, such as potential added slag formation, were not assessed. In addition, the adjustment times between the test periods were relatively short. While rapid equilibrium was obtained for the gas side flows, full equilibrium for such solid flows as bottom ash was not obtained.

CURRENT WASTE-TO-ENERGY EXPERIENCE

The Warren County New Jersey Resource Recovery Project is a 400 TPD mass burn facility consisting of two process trains. The facility is a state-of-the-art

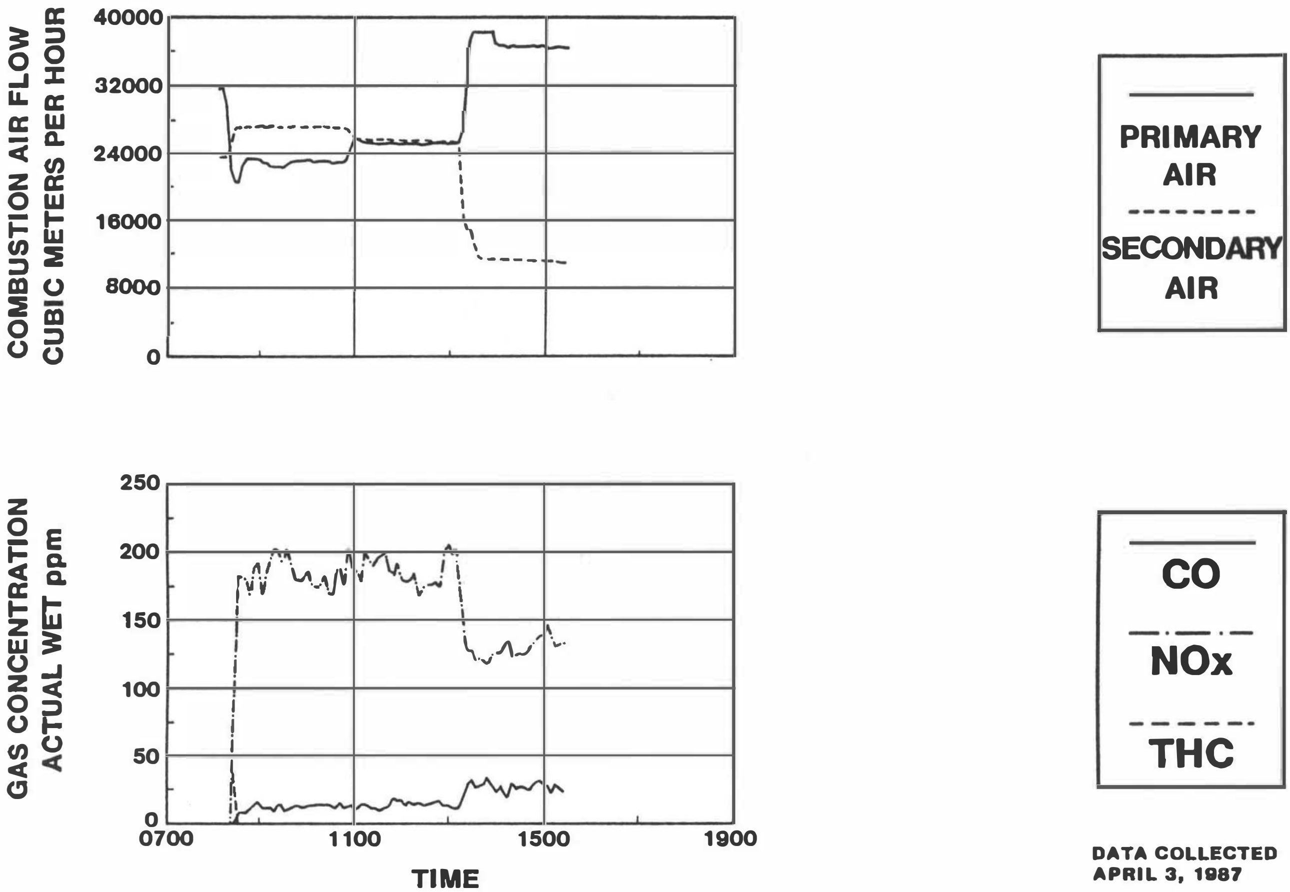

FIG. 2 MVA OSLO DATA CHART RECORDINGS OF TIME VS CONCENTRATIONS AND COMBUSTION AIR FLOW

design and includes a W+E mass burn grate, a high efficiency furnace/boiler, a spray dryer and 4 module fabric filter and an in-situ continuous emission monitoring system. A distributed control system is used for monitoring and controlling the facility operation. Steam is used to generate electricity, which is sold to Jersey Central Power and Light Company. The facility passed acceptance tests in April 1989.

Plant personnel at this facility maintain a 60%/40% primary, secondary air ratio automatically within the parameters as developed by the grate manufacturer. This ratio is sufficient to maintain NO_x concentrations well below the facility's permitted 3 hr average limit of 300 ppm corrected to 7% oxygen on a dry basis consistently. Occasionally, a transient peak for NO_x occurs which the operator addresses by removing automatic control of secondary air and reducing secondary air flow to 50–60% of the previously maintained flow. This results in a split of approximately 80%/20% primary to secondary air ratio and instantaneously lowers the NO_x concentration from approximately 300 ppm to approximately 225 ppm on a dry basis corrected to 7% oxygen. This change does not adversely affect monitored furnace temperatures, CO concentrations or opacity, all of which indicates that acceptable operation is maintained. When the transient event is over, the operator gradually returns the secondary air to automatic control.

Due to its tremendous concern over maintaining compliance, the industry may be reluctant to change the operating parameters at any facility beyond traditional operating parameters that provide acceptable operation under all loads. This conservative operating philosophy is reasonable in that it protects the public and the facility from potential excursions that might result from making changes to the established operating mode. However, because of this philosophy, we run the risk of bypassing easy, cost-effective, and mod-

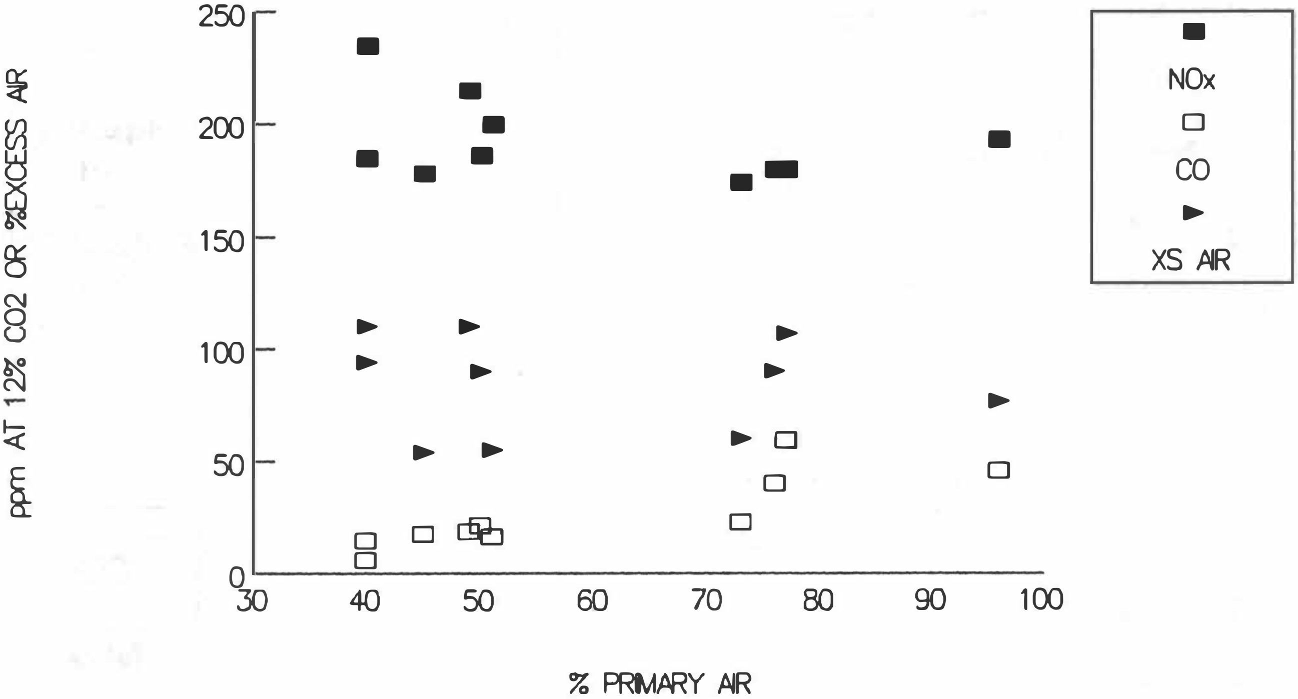

FIG. 3 MVA OSLO DATA % PRIMARY AIR VS GAS CONC. 65% LOAD

erate NO_x control, which would require no additional capital expenditures, in favor of expensive add-on control systems.

CONCLUSIONS

Oxides of Nitrogen emissions have tended to increase recently for waste-to-energy facilities. This increase could be expected given the industry's concern over improving combustion efficiency and the related lowering of acceptable carbon monoxide emissions in order to control dioxin emissions.

Oxides of Nitrogen emissions reduction should be addressed. However, before requiring the industry to provide expensive add-on controls for oxides of nitrogen which use significant quantities of hazardous materials, such as anhydrous ammonia, we should take the time to evaluate emission reductions based on acceptable adjustments in combustion control. In addition, if add-on controls are required, combustion control can be used to improve the overall performance of control.

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Key Words: Air Quality; Combustion; Control(s); Emissions; NO_x