

NO_x Compliance Using the NO_xOUT® SNCR Process in the 1200 TPD Montgomery County Resource Recovery Facility

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ABSTRACT

When the Montenay Energy Resources of Montgomery County, Inc. (MERMCI) facility began operation in 1992, the operating permit emission limit for Nitrogen Oxides (NO_x) was 300 parts per million (ppm) on a 24-hour daily average. In 1994 the United States Environmental Protection Agency (USEPA) promulgated emission guidelines called “Reasonably Achievable Control Technology” (RACT). RACT required the facility to meet a more stringent NO_x emission standard of 205 ppm on a 24-hour daily average.

MERMCI’s Continuous Emissions Monitoring System (CEMS) has been monitoring the NO_x outlet levels and has recorded these readings on their Data Acquisition System (DAS). The normal NO_x levels prior to the new NO_xOUT® process, were between 220 and 280 ppm, depending on the waste stream.

MERMCI and the Waste System Authority of Montgomery County (WSA) evaluated the different NO_x reduction systems. A joint decision was made to contract FuelTech to install their NO_xOUT® Selective Non-Catalytic Reduction (SNCR) system. The NO_xOUT® process is a post combustion NO_x reduction method that reduces NO_x through a controlled injection of NO_xOUT® A reagent into the combustion gas path of a waste-fired incinerator. NO_xOUT® A is a 50% urea solution plus a small amount of additives for scale and corrosion control. Flue gas temperature and reagent distribution are two key parameters that affect the process performance.

In September of 1999 MERMCI commenced operation of the NO_xOUT® system. The DAS and stack testing indicated compliance with the USEPA guidelines for NO_x.

This paper explains the NO_xOUT® process in achieving compliance with the new NO_x regulations at four facilities

INTRODUCTION

Combustion has been a major option for the disposal of solid wastes in Europe for a number of years. This method has grown in the United States as landfill sites become increasingly scarce. Operation of a Municipal Waste Combuster (MWC) facility in an environmentally acceptable manner requires control to minimize the emissions of potentially hazardous substances including total carbon, particulates, chlorides, heavy metals, sulfur oxides and oxides of nitrogen (NO_x).

Methods for control of NO_x include combustion modifications and post-combustion treatment processes. Combustion modifications generally involve techniques to reduce excess oxygen and flame temperature. Such modifications have been successfully employed to achieve 25-70% reduction in NO_x from fossil-fueled combustors (Hein, 1989). However, the requirement to achieve complete combustion and eliminate hazardous substances, such as dioxins, generally limits the applicability of combustion modification for MWC’s.

Post-combustion processes for NO_x control include selective catalytic reduction (SCR), selective non-catalytic reduction (SNCR) and wet scrubbing. The catalytic process involves the reaction of NH₃ with NO_x over a catalyst at a temperature of about 700°F to yield N₂ and H₂O. In order to avoid catalyst poisoning, an SCR unit must be installed downstream of the units for SO₂, HCl, dust and heavy metals removal. The capital investment and operating costs for SCR are generally high (Radian Corp., 1988). Despite precautions, catalyst replacement in this service is expected to be frequent and catalyst disposal presents an additional solid waste concern. In addition, due to large fluctuations in NO_x concentration from MWC’s, the risk of getting excess NH₃ slip downstream of an SCR unit is very high. Wet scrubbing can be effective for the capture of NO₂ but has not been considered herein because 90+% of the NO_x from MWC’s is in the form of NO.

Selective non-catalytic reduction involves the reaction of NO_x with the reductant chemical at high temperature, thus avoiding large capital costs for equipment and catalyst.

Reductant chemicals include NH₃, urea (NH₂CONH₂) and low temperature chemicals.

The use of NH₃ for the control of NO_x from MWC's has been described by Hurst et al. (1986, 1989). The use of urea for the control of NO_x from an MWC was described recently by Jones (1989) and Martin (1989). The use of urea for post-combustion NO_x control was originally developed under sponsorship of the Electric Power Research Institute (EPRI) (Munzio 1976). Fuel Tech became EPRI's exclusive agent for licensing the urea-based technology in 1986. Fuel Tech has continued the development of this technology under the trademark NO_xOUT. The NO_xOUT Process has been used for NO_x control in a variety of demonstrations (Epperly 1988) (Hofmann 1989) using coal, fuel oil or natural gas as the fuel.

The NO_xOUT Process has several important features which distinguishes it from other SNCR processes. These features include:

Use of multi level chemical injection in which both the flue gas temperature and chemical mixture are matched in order to maximize NO_x reduction and minimize NH₃ slip.

Use of low temperature chemicals which extend the range of applicability of the process while continuing to minimize NH₃ slip.

Use of propriety injection nozzles which match liquid droplet size and droplet velocity to the boiler geometry and flue gas conditions.

The NO_xOUT Process has now been demonstrated in four mass burn MWC's: one in Millbury, MA during August 1989 (A), one in Switzerland during February 1988 (B), one in Frankfurt, Fed. Rep. of Germany during November 1989 (C), and one in Conshohocken, PA (Montenay) during August 1999 (D).

The operating characteristics for these four plants are summarized below:

TABLE 1
Plant Operating Characteristics

Plant	A	B	C	
Fuel, TD	750	240	360	600
Steam Gen., 1lbs/Hr	190,000	60,000	90,000	162,000
Excess O ₂ ,	9-10	13.5	9	10
Approx. Furnace Exit Temp. °F	1,650*	1,600	1,560	1,600

*Estimate; temperature not measured.

All four plants burned unsorted municipal solid waste and used an inclined traveling grate. Each plant was already equipped with various pollution control devices. Plant A has a spray dryer SO₂ scrubber and an electrostatic precipitator. Plant B has an electrostatic precipitator and an aqueous scrubber for control of SO₂, halides and heavy metals. Plant C has a spray absorber for SO₂ and halide control, an electrostatic precipitator and a bag filter. Plant D has a spray dryer scrubber and a reverse air baghouse.

Test Procedures

Each of the four plants was retrofitted for the application of NO_xOUT. In the case of plant A, eight existing ports located approximately 25 feet above the grate were used for insertion of the injection lances. At plant B, a total of 16 penetrations having a diameter of 2 inches were added in the upper furnace region to two side-walls of the unit. At plant C the first stage of injection was into the overfire air. The second stage consisted of four ports some 18 feet above the overfire air and the third stage consisted of four ports about 44 feet above the overfire air ports. At plant D, a total of 12 penetrations through the membrane of the boiler wall tubes were used. The first stage consisted of six ports above the overfire air nozzles on three sides of the furnace, the second stage consisted of six ports in the refractory area of the furnace and were retractable injectors. In each case tankage was provided for chemical storage and chemical was delivered to the injections using portable pumping/metering skids.

The primary chemical used in each case was NO_xOUT A. NO_xOUT A is a concentrated solution of urea in water containing small quantities of other chemicals to minimize scaling and corrosion and to facilitate atomization. The NO_xOUT A solution is further diluted with water such that the final solution contains about 10 wt. % urea. The demonstrations at plants B and C also included the injection of NO_xOUT 34. NO_xOUT 34 is a proprietary chemical which shifts the temperature window for reaction between urea and NO_x (Epperly 1988) and lowers NH₃ slip (Epperly 1989). In addition, the injection of a low temperature chemical, NO_xOUT 83, was evaluated at plant C.

Chemical solutions were injected into the upper furnace region upstream of the first bank of convective heat exchange tubes. Air was used for atomization and cooling of the injectors in all four cases, although steam would have worked as efficiently. In two cases the injectors were of the internal mix type. That is, liquid and atomization air are mixed internally in the injector before passing through an orifice and entering the flue gas. At plant B, external mix injectors were

employed. In this case, air atomizes the liquid stream after the liquid has passed through an exit orifice.

Table 2
Description of NOxOUT Injection

Plant	A	B	C	D
Types of Injectors	Internal Mix	External Mix	Internal Mix	Internal Mix
No. of Injection Stages	1	2	3	2
Approx. Temp. at Plane of Injection, °F				
Stage 1	1,800*	1,760	>2,000	>2,000
Stage 2		1,650	1,620	>2,000
Stage 3			1,560	

* Estimate; temperature not measured.

The flue gas was analyzed for NOx, O₂, CO and NH₃. Conventional continuous emission monitors were used for NOx, O₂ and CO. Samples for NH₃ analysis were withdrawn extractively upstream of the air heater and absorbed into dilute sulfuric acid. NH₃ content was determined with an ion specific electrode.

The rate of urea addition is measured in terms of the stoichiometric ratio between urea and baseline NOx, a molar ratio of 1 is converted to a normalized stoichiometric ratio (NSR) of 2.

The duration of each demonstration was only about two weeks. Thus, it should be understood that these tests did not measure long term performance as it would be affected by seasonal variations in climate and waste composition and long term equipment reliability, particularly as regards

to those components exposed to the corrosive flue gas atmosphere.

Results:

Baseline levels of NOx, before treatment, are shown below:

Table 3
Average baseline NOx

NOx, ppm(v)		
Plant A (@ 7% O ₂ (dry))	240	
Plant B (@ 11% O ₂ (dry))	275	(385 @ 7% O ₂)
Plant C (@ 11% O ₂ (dry))	200	(280 @ 7% O ₂)
Plant D (@ 7% O ₂ (dry))	200	(260 @ 7% O ₂)

In all four cases, fluctuations in baseline NOx values were substantial. For Plant B, baseline swings from 210 ppm to 330 ppm were observed over a period of several hours. The net result of these swings was to increase variability of results and to prolong normal testing procedures as baseline values had to be re-established on a frequent basis.

These swings in the absolute concentration of NOx that are characteristic of MWC's are dampened by the addition of NOxOUT chemicals. Thus at plant C, it was observed that fluctuations in NOx concentration were reduced from about ± 35 ppm at baseline conditions to ± 8 ppm at a controlled NOx level of 45 ppm. The effect of these fluctuations on NH₃ slip levels is small in comparison with that expected in an SCR plant where reaction stoichiometry is tighter and excess reagent remains unconverted.

The extent of NOx reduction achieved as a function of NSR is shown for the four plants in Figure 1. Differences between the four plants can be attributed to temperature, residence time and distribution of chemicals (arising from number of and levels of injection and type of injector). Separation of these factors is difficult. Insufficient data are available from these four demonstrations to provide a quantifiable explanation for the differences. It is expected to further work, planned for the future, will permit separation of these factors. Excess reagent, above that required for NOx reduction, is converted primarily to N₂, CO₂, and H₂O. A small portion of the nitrogen is converted to NH₃, as described below.

Ammonia is a by-product of the reaction between urea and NOx. The amount of NH₃ observed, often referred to as NH₃ slip, is a function of temperature, distribution of chemicals, and the rate of chemical addition (Epperly 1989). Ammonia slip should be minimized because of the possibility of forming deposits of ammonium salts on cold-end surfaces and the possibility of forming a visible plume. Ammonium

bisulfate forms at temperatures below about 600°F and, in the presence of excess ammonia, will be converted to ammonium sulfate below about 400°F. Ammonium chloride formation starts at temperatures below 260°F. In the case of Plant A during operation at high NSR, when the NH₃ slip was expected to be high, a noticeable odor of NH₃ was observed in the ash collection area which became uncomfortable for the operators.

safety and ease in handling and storage of reactant chemicals, and the ability to control the release of ammonia. Further, it was demonstrated that the NOxOUT Process can effectively be installed in existing plants and would be applicable to new plants as well.

The amount of NH₃ slip for these four demonstrations is shown in Figure 2. These data show that it is possible to achieve 50+% reduction in NOx while maintaining NH₃ slip at less than 10 ppm. Chemical enhancers were used at Plants B and C to control NH₃ slip. The benefits of enhancers at Plants B and C are shown below:

Table 4
Summary of NOxOUT Performance

Plant	A	B		C		
Target NOx Red..	40	-----50-----		-----75-----		
NOxOUT Chemical(s)	A	A	A+34	A	A+34	A+83
NOxOUT Baseline, ppm	240	----275----		-----200-----		
Reduced NOx, ppm	96	116	116	50	58	50
NOx Reduction, %	60	58	58	75	71	75
NH ₃ Slip, ppm	9	21	12	26	12	10

*The amount of NH₃ slip at Plant D was less than 2 ppm.

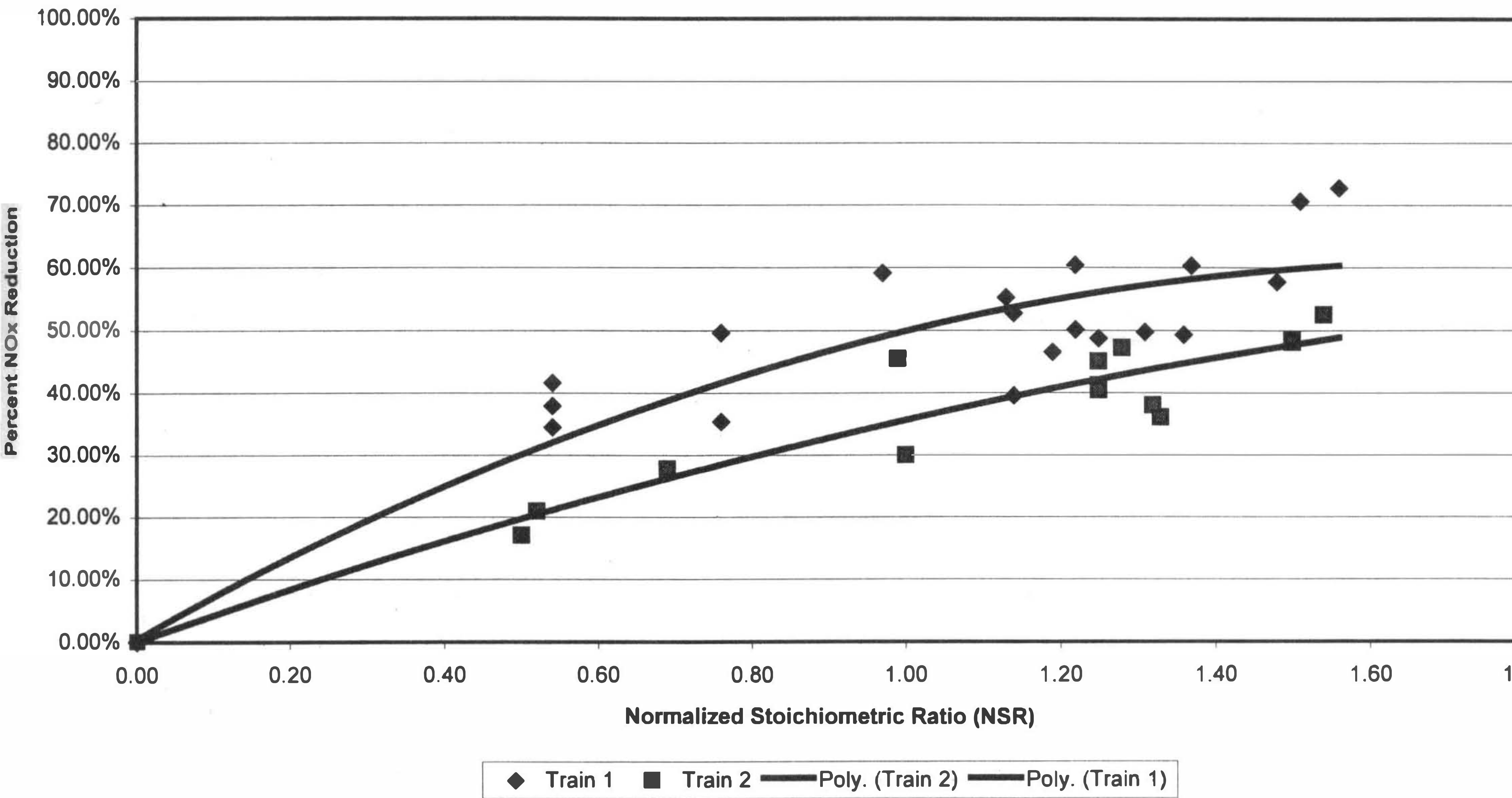
The enhancer chemical can be co-injected with the urea (Epperly 1989) or can be injected at a second stage after urea injection (Epperly 1989). At plant C the target of 75% NOx reduction was achieved with an NH₃ slip, of less than 12 ppm using NOxOUT A at the second stage of injection and NOxOUT – 83 at the third stage of injection. At this amount of NH₃ slip, it is expected that neither an aerosol separator nor NH₃ recovery downstream of a wet scrubbing system would be required.

Average CO increase were negligible (under 5 ppm) when NOxOUT A was a reagent. Some higher increases in CO were noticed at Plant B and C when NOxOUT 34 enhancer was used, but these were difficult to quantify because of fluctuations in the unit operation.

Conclusions

The present work, combined with previous studies(Hurst 1986)(Lemann 1989), illustrates that NOx emissions from MWC's can effectively be controlled by selective non-catalytic post-combustion techniques. Reduction in NOx emissions of 50-75% can be achieved with NH₃ slip limited to no more than 10 ppm. The NOxOUT Process is particularly well-suited for this application because of the

Comparison of NOxOUT Performance from MERMCI



NH3 Slip from NOxOUT at MERMCI

