# $NO_x$ Reduction Techniques and Control Measures

## Why Reduce Nitrogen Oxide ("$NO_x$") Emissions?

The federal Environmental Protection Agency ("EPA") establishes the health based standards for various pollutants including ozone. In 1997, EPA promulgated a new 8-hour ozone standard to replace the 1-hour standard. All monitoring data indicates that Mecklenburg County has never met this standard. Compliance with this standard continues to be a high priority issue and concern for all citizens and businesses in the Charlotte-Mecklenburg region. On March 12, 2008, EPA strengthened the ozone air quality standard from 0.08 ppm to 0.075 ppm.


Because of our non-compliance status, North Carolina has to implement regulations such as Reasonably Available Control Technology ("RACT") requirements to reduce emissions, and to improve the air quality. The RACT have become effective at major sources, i.e., potential to emit ("PTE") greater than 100 tons per year. It requires additional controls for the ozone precursor pollutants – nitrogen oxides ("$NO_x$") and volatile organic compounds ("VOC"). In 2010, the NOx control requirements will become mandatory for current minor sources, i.e., PTE less than 100 tons per year, with continued violations of the ozone standard.

Mecklenburg County is a "$NO_x$ limited" area. This means that $NO_x$ is a limiting factor for the formation of ozone and the primary precursor pollutant of concern. Mecklenburg County Air Quality ("MCAQ") is actively seeking voluntary measures that businesses can take to minimize $NO_x$ emissions. The purpose of this handout is to highlight the most common and effective $NO_x$ reduction techniques. MCAQ requests your consideration of these control measures and asks for efforts from your facility to reduce $NO_x$.

## Operating Limitations

Significant reduction in $NO_x$ emissions can be achieved by making operational changes at your facility. Data shows that most NOx emissions in Mecklenburg County come from combustion sources like internal combustion engines, boilers, incinerators, and process heaters. Making operational changes can be a cost effective control measure that results in lower $NO_x$ emissions.

Example actions include:

- Reduced or rescheduled emergency generator testing
- Modification, maintaining and tuning combustion equipment
- Fuel switching
- Limiting operations on ozone action days
- Reduced engine idling
- Conserve electricity

## Combustion Modifications for Boilers

$NO_x$ reduction can be achieved through combustion modification techniques. The principles of combustion modifications are based on $NO_x$ formation chemistry and focus on minimizing peak combustion temperatures and the residence time at peak temperature. These techniques include low excess air combustion, staged combustion, flue gas recirculation, low $NO_x$ burners, and $NO_x$ reburning.

***Low excess air (LEA) combustion***

Technique is based on reducing surplus $O_2$ at the burner flame where gas temperatures are highest resulting in lower peak flame temperature and less $NO_x$ formation. Use of LEA reduces the amount of air introduced into the boiler resulting in increased thermal efficiency provided stoichiometric requirements are met. LEA can be the easiest approach to implement for reducing $NO_x$ emissions since adjustments to a combustion controller may be the only physical modification required.

***Staged Combustion (SC)***

Combustion occurs in two zones. Fuel in the first combustion area is fired with less than stoichiometric amount of air, creating a fuel-rich condition near the primary flame. In the second area, the rest of the combustion air is introduced to complete the fuel consumption. The deficiency of $O_2$ in the first zone and the low temperature in the second zone both contribute to a reduction in $NO_x$ formation.

***Flue Gas Recirculation (FGR)***

FGR involves recycling a portion of the combustion gases from the stack to the boiler windbox. 10 – 30% of the flue gas exhaust is recycled to the main combustion chamber from the effluent gas stream, mixed with secondary air entering the wind box, lowering the flame temperature, diluting the $O_2$ and reducing $NO_x$. This technology is primarily for large coal, oil or gas boilers.

***Low $NO_x$ Burners (LNB)***
$NO_x$ control from these special burners is based on combustion modification techniques. Precise mixing of fuel and air is used to keep the flame temperature low and to dissipate heat quickly through the use of low excess air, off stoichiometric combustion and combustion gas recirculation. The Electric Power Research Institute estimates 50 – 80% of existing boilers could be retrofitted with LNB.

***$NO_x$ Reburning***
Reburning is a $NO_x$ staged combustion control technique that suppresses the formation of $NO_x$ in burners and then provides for additional $NO_x$ reduction in the furnace area of the boiler. Reburning can be applied to any type of boiler, provided the gas stream residence time is long enough to allow the reburn fuel to burn completely. $NO_x$ reductions of 50% to 70% are possible. Reburning can be used in combination with a number of other $NO_x$ control techniques. $NO_x$ reburning is also called reburn, in-furnace $NO_x$ reduction, and staged fuel injection.

## Catalytic and Non-catalytic Control Measures
Additional techniques are available for $NO_x$ reduction that involve installation of post combustion controls. These include selective catalytic reduction and selective non-catalytic reduction systems.

***Selective Catalytic Reduction (SCR)***
In an SCR system, exhaust gas from the combustion process is cooled and ammonia-containing air is injected into the flue gas prior to it passing over a catalyst. The catalyst promotes a reaction between $NO_x$ and ammonia to form nitrogen and water vapor. When properly designed and operated, SCR systems commonly provide $NO_x$ reductions in the range of 50% to 90%. Some limitations exist with the use of an SCR system. These include disposal of spent catalyst, high capital and operating costs, and complexity of the system.

***Selective Non-catalytic Reduction (SNCR)***
SNCR systems use gas phase homogeneous chemical reactions to chemically reduce a portion of the $NO_x$ emissions. Temperature is critical to ensuring that the SNCR will operate at maximum efficiency. Because of the non-uniformity of gas temperatures in any area of the combustion system, SNCR systems are often limited to overall $NO_x$ reduction efficiencies of less than 50%.

## Reciprocating Internal Combustion Engines (RICE)
In a reciprocating engine, air or fuel-air mixture is compressed in a cylinder above the piston and ignited. Upon combustion, the piston is forced through the cylinder, the shaft turns, and the piston then returns to the original position, exhausting the combustion products. The cycle is then repeated. Reciprocating engines generally have lower $NO_x$ emissions (2.3 lb/mmBtu to 3.2 lb/mmBtu range). $NO_x$ emissions can reduced through engine tune-ups and use of oxidation catalysts.

**Most Common Permitted NOx Sources in Mecklenburg County**
- **Emergency generators**
- **Stationary internal combustion engines**
- **Boilers**
- **Incinerators**
- **Process heaters**

**Summary of $NO_x$ Reduction Techniques**

| $NO_x$ Reduction Technique | $NO_x$ Reduction Achieved |
|---|---|
| Less generator testing | |
| Generator fuel switch | |
| LEA (~ 2 – 7%) | 16 – 20 % |
| SC | 20 % |
| SC (~ 25 – 30 % burners out of service; BOOS) | 30 – 40 % |
| FGR | 15 % |
| LNB | 20 – 50 % |
| Reburning | 50 – 70% |
| SCR | 50 – 90% |
| SNCR | 50% |
| RICE | Low emissions (2.3 – 3.2 lb/mmBtu range) |

*Process overview and $NO_x$ reduction information from USEPA Control of Nitrogen Oxides Emissions, APTI Course 418 Manual, September 2000*

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