EPA-452/F-03-031

Air Pollution Control Technology Fact Sheet

Name of Technology: Selective Non -Catalytic Reduction (SNCR)

Type of Technology: Control Device - Chemical reduction of a pollutant via a reducing agent.

Applicable Pollutants: Nitrogen Oxides (NO_X)

Achievable Emission Limits/Reductions:

NO_X reduction levels range from 30% to 50% (EPA, 2002). For SNCR applied in conjunction with combustion controls, such as low NO_X burners, reductions of 65% to 75% can be achieved (ICAC 2000).

Applicable Source Type: Point

Typical Industrial Applications:

There are hundreds of commercially installed SNCR systems on a wide range of boiler configurations including: dry bottom wall fired and tangentially fired units, wet bottom units, stokers, and fluidized bed units. These units fire a variety of fuels such as coal, oil, gas, biomass, and waste. Other applications include thermal incinerators, municipal and hazardous solid waste combustion units, cement kilns, process heaters, and glass furnaces.

Emission Stream Characteristics:

a. **Combustion Unit Size:** In the United States, SNCR has been applied to boilers and other combustion units ranging in size from 50 to 6,000 MMBtu/hr (5 to 600MW/hr) (EPA, 2002). Until recently, it was difficult to get high levels of NOx reduction on units greater than 3,000 MMBtu (300 MW) due to limitations in mixing. Improvements in SNCR injection and control systems have resulted in high NO_X reductions (> 60%) on utility boilers greater than 6,000 MMBtu/hr (600MW). (ICAC, 2000).

b. **Temperature:** The NO_X reduction reaction occurs at temperatures between 1600°F to 2100°F (870°C to 1150°C) (EPA, 2002). Proprietary chemicals, referred to as enhancers or additives, can be added to the reagent to lower the temperature range at which the NO_X reduction reactions occur.

c. **Pollutant Loading:** SNCR tends to be less effective at lower levels of uncontrolled NO_X. Typical uncontrolled NO_X levels vary from 200 ppm to 400 ppm (NESCAUM, 2000). SNCR is better suited for applications with high levels of PM in the waste gas stream than SCR.

d. **Other Considerations:** Ammonia slip refers to emissions of unreacted ammonia that result from incomplete reaction of the NO_X and the reagent. Ammonia slip may cause: 1) formation of ammonium sulfates, which can plug or corrode downstream components, 2) ammonia absorption into fly ash, which may affect disposal or reuse of the ash, and 3) increased plume visibility. In the U.S., permitted ammonia slip levels are typically 2 to 10 ppm (EPA, 2002). Ammonia slip at these levels do not result in plume formation or pose human health hazards. Process optimization after installation can lower slip levels.

Nitrous Oxide (N_2O) is a by-product formed during SNCR. Urea based reduction generates more N_2O than ammonia-based systems. At most, 10% of the NO_X reduced in urea-based SNCR is converted to N_2O. Nitrous oxide does not contribute to ground level ozone or acid formation. (ICAC,2000)

Emission Stream Pretreatment Requirements: None

Cost Information: All costs are in year 1999 dollars. (NESCAUM, 2000; ICAC, 2000; and EPA, 2002)

The difficulty of SNCR retrofit on existing large coal-fired boilers is considered to be minimal. However, the difficulty significantly increases for smaller boilers and packaged units. The primary concern is adequate wall space within the boiler for installation of injectors. Movement and/or removal of existing watertubes and asbestos from the boiler housing may be required. In addition, adequate space adjacent to the boiler must be available for distribution system equipment and for performing maintenance. This may require modifications to ductwork and other boiler equipment.

A typical breakdown of annual costs for industrial boilers will be 15% to 35% for capital recovery and 65% to-85% for operating expense (ICAC,2000). Since SNCR is an operating expense-driven technology, its cost varies directly with NO_X reduction requirements and reagent usage. Optimization of the injection system after start up can reduce reagent usage and, subsequently, operating costs. Recent improvements in SNCR injection systems have also lowered operating costs.

There is a wide range of cost effectiveness for SNCR due to the different boiler configurations and site-specific conditions, even within a given industry. Cost effectiveness is impacted primarily by uncontrolled NO_X level, required emissions reduction, unit size and thermal efficiency, economic life of the unit, and degree of retrofit difficulty. The cost effectiveness of SNCR is less sensitive to capacity factor than SCR. Control of NO_X is often only required during the ozone season, typically June through August. Since SNCR costs are a function of operating costs, SNCR is an effective control option for seasonal NO_X reductions.

Costs are presented below for industrial boilers greater than 100 MMBtu/hr.

a. Capital Cost: 900 to 2,500 $/MMBtu/hr (9,000 to 25,000 $/MW)

b. O&M Cost: 100 to 500 $/MMBtu/hr (1,000 to 5,000 $/MW)

c. Annualized Cost: 300 to 1000 $/MMBtu/hr (3,000 to 10,000 $/MW)

d. Cost per Ton of Pollutant Removed:

Annual Control: 400 to 2,500 $/ton of NO_X removed
Seasonal Control: 2,000 to 3,000 $/ton of NO_X removed

Theory of Operation:

SNCR is based on the chemical reduction of the NO_X molecule into molecular nitrogen (N_2) and water vapor (H_2O). A nitrogen based reducing agent (reagent), such as ammonia or urea, is injected into the post combustion flue gas. The reduction reaction with NO_x is favored over other chemical reaction processes at temperatures ranging between 1600°F and 2100°F (870°C to 1150°C), therefore, it is considered a selective chemical process (EPA, 2002).

Both ammonia and urea are used as reagents. Urea-based systems have advantages over ammonia based systems. Urea is non-toxic, less volatile liquid that can be stored and handled more safely. Urea solution droplets can penetrate farther into the flue gas when injected into the boiler, enhancing the mixing with the flue gas which is difficult in large boilers. However, urea is more expensive than ammonia. The Normalized Stoichiometric Ratio (NSR) defines the ratio of reagent to NO_x required to achieve the targeted NO_x reduction. In practice, more than the theoretical amount of reagent needs to be injected into the boiler flue gas to obtain a specific level of NO_x reduction.

In the SNCR process, the combustion unit acts as the reactor chamber. The reagent is generally injected within the boiler superheater and reheater radiant and convective regions, where the combustion gas temperature is at the required temperature range. The injection system is designed to promote mixing of the reagent with the flue gas. The number and location of injection points is determined by the temperature profiles and flow patterns within the combustion unit.

Certain application are more suited for SNCR due to the combustion unit design. Units with furnace exit temperatures of 1550°F to 1950°F (840°C to 1065°C), residence times of greater than one second, and high levels of uncontrolled NO_x are good candidates.

During low-load operation, the location of the optimum temperature region shifts upstream within the boiler. Additional injection points are required to accommodate operations at low loads. Enhancers can be added to the reagent to lower the temperature range at which the NO_x reduction reaction occurs. The use of enhancers reduces the need for additional injection locations.

Advantages:

- Capital and operating costs are among the lowest of all NO_x reduction methods.
- Retrofit of SNCR is relatively simple and requires little downtime for large and medium size units.
- Cost effective for seasonal or variable load applications.
- Waste gas streams with high levels of PM are acceptable.
- Can be applied with combustion controls to provide higher NO_x reductions.

Disadvantages:

- The waste gas stream must be within a specified temperature range.
- Not applicable to sources with low NO_x concentrations such as gas turbines.
- Lower NO_x reductions than Selective Catalytic Reduction (SCR).
- May require downstream equipment cleaning.
- Results in ammonia in the waste gas stream which may impact plume visibility, and resale or disposal of ash.

References:

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