Demonstration of SNCR Trim on a 185 MW Tangential Design Coal-Fired Utility Boiler

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Summary

Limitations on NOx emissions from electric utility boilers have not only taken the form of commmand and control rules, but also tonnage caps during the ozone season that are defined for a given utility system or geographic area. In either case, operating scenarios often arise that justify application of a low capital cost technology that can provide incremental NOx reductions over defined operating periods or load ranges. SNCR Trim is one such approach. In order to minimize capital costs, SNCR Trim utilizes a single level of low-energy injectors that rely primarily upon droplet momentum and bulk furnace turbulence for mixing and that are optimized to provide NOx reductions over a limited load range.

The purpose of the subject demonstration was to quantify the level of NOx reductions that are achievable over the targetted load range, while maintaining acceptable levels of ammonia slip. A three-step approach was implemented for the demonstration:

1. High velocity thermocouple (HVT) testing of the boiler to define flue gas temperature and emission profiles as a function of location over the load range of interest
2. Numerical modeling to define the optimal reagent injection parameters, and to predict the impact of various injection parameters on SNCR performance
3. Short-term demonstration of defined optimum injection strategy using temporary reagent storage and handling, and injection equipment

The demonstration was conducted on a 185 MW tangential design boiler firing a low sulfur (0.9 percent) coal. An assessment of unit operating characteristics indicated that the unit cycled between steady full load operation during daylight hours of the ozone season and minimum load operation overnight. This mode of operation is ideally suited to SNCR Trim, with system operation started when the unit ramps up to full load in the morning, and turned off as the unit ramps down in the evening. Field tests indicated that full load furnace exit gas temperatures were on the order of 2250 F, with local carbon monoxide (CO) levels ranging between 0 – 1,300 ppmv. CO levels at the point of reagent injection are important as they impact the optimum temperature for the SNCR process. Numerical modeling provided a mechanism to predict the SNCR system performance under various reagent injection scenarios. In regards to the SNCR process, the model predicted: (1) the distribution of gas temperature, species concentrations, and flow patterns entering the region of reagent injection; (2) the reagent spray droplet injection, active reagent release into the gas phase, and subsequent mixing and chemical reaction with the flue gas, (3) the subsequent time-temperature decay of the flue gas as it entered the convective pass, and (4) impacts stemming from the limited residence time within the SNCR temperature window. Objectives for the demonstration were to: (1) achieve NOx emissions approaching 0.15 lb/MBtu from baseline levels of 0.22 lb/MBtu, and (2) maintain ammonia slip levels less than 5 ppmv.

Short-term results at full load indicated that NOx reductions of 35% were achievable at normalized stoichiometric ratios (NSR) of one, although ammonia slip levels were found to range between 6 – 12 ppmv. Tests over a range of NSR values indicated that NOx reductions on the order of 30% would be achievable at conditions that maintained ammonia slip levels at

less than 5 ppmv. A 30% NOx reduction resulted in an absolute NOx level of nominally 0.15 lb/MBtu. The primary parameters impacting NOx reduction and ammonia slip were load and NSR. Other parameters evaluated included dilution water flow rate, number of injectors in service, and injector orientation, all of which exhibited second order effects on performance in terms of NOx reduction versus ammonia slip. Detailed measurement of the NOx reduction at the economizer exit showed that the highest levels of NOx reduction occurred in the region of the furnace near the injectors, a trend also observed in the numerical modeling. Thus, SNCR performance within a fixed range of ammonia slip was mixing limited, as one might anticipate from the use of a single level of low-energy injectors. Field test results also support this assessment in which the NOx reductions were found to quickly level off as the NSR levels were increased. Further increases in NSR beyond a value of 1.3 resulted in no further NOx reductions, while ammonia slip levels increased markedly. In summary, the SNCR Trim approach was found to be able to provide significant incremental NOx reductions while being able to minimize the associated capital costs.