CARDINAL UNIT 1
LARGE SCALE <u>S</u>ELECTIVE <u>N</u>ON-<u>C</u>ATALYTIC <u>R</u>EDUCTION DEMONSTRATION PROJECT

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Abstract:

In late 1997, American Electric Power, Fuel Tech, and EPRI decided to perform a full-scale demonstration of a Urea-based **S**elective **N**on-**C**atalytic **R**eduction (SNCR) system. The primary objective for the project was to demonstrate that Urea-based SNCR technology can be applied to a 600MW steam generator. The specific operational goal for the project is to reduce NOx emissions by 30%, beyond the level achieved through the use of Low NOx Burners, while minimizing ammonia slip at or below 5ppm. The unit is cell-fired with baseline, (post-LNB) NOx emissions of 0.75 lb/MMBtu at full load.

Introduction:

Cardinal Unit 1 is a Babcock & Wilcox opposed-wall cell fired dry bottom pulverized coal boiler which began service in February, 1967. A consortium of EPRI member utilities, AEP, the Ohio Coal Development Office within the Ohio Department of Development, the U.S. Department of Energy, and FuelTech worked together to complete the project. The project is significant in that it is one of the largest domestic installations of the kind burning a relatively high sulfur coal.

The SNCR process is a post-combustion NOx reduction method that reduces NOx through the controlled injection of reagent, in this case urea, into the combustion products of fossil-fired boilers. Conceptually, the SNCR process is simple. A nitrogen-based reagent, is injected into and mixed with the combustion products. The chemical reacts selectively in the presence of oxygen to reduce the oxides of nitrogen (NOx) primarily to molecular nitrogen (N2) and water (H2O). The reaction between urea and NOx occurs within a specific range of temperature, known as the temperature window. If the temperature is too low, reaction rates are too slow and byproduct emissions can become excessive. At high temperatures, NOx reduction and chemical utilization are low. This optimum temperature window is specific to each application. In addition to temperature, residence time within the temperature window, flue gas velocity and directions, and baseline NOx affect the process performance.

Summary of Parametric Testing:

Parametric testing to optimize the SNCR system was performed by both Fuel Tech, Inc. and FERCO. The testing was completed across the applicable load range of 620 MWg (100% MCR) to 340 MWg (55% MCR) and the preliminary control tables for automatic operation were completed.

To avoid air heater fouling, ammonia slips were carefully measured, the pressure drop across the air heaters monitored, and the testing proceeded conservatively to limit ammonia slip. Throughout the entire testing, the air heater pressure drop at the tested loads remained relatively constant, indicating no evidence of air pre-heater fouling.

The testing at full load was performed first to determine the proper configuration of the upper furnace injection zone (Zone 2) and the multiple nozzle lances (Zone 3). The boiler and SNCR system operating parameters, NOx, CO, O2, NH_3 and other flue gas species were measured and recorded. Spray patterns were adjusted to evaluate the effectiveness of injection at relatively low chemical flow rates. The resulting chemical utilization and ammonia slip were used to determine the optimum strategy for treatment at higher chemical flow rates.

At full load, the maximum NOx reduction of 31% was achieved with 5 ppm slip, based on the recorded CEMS data. The level of achievable NOx reduction at full load varied with the apparent baseline NOx and the upper furnace temperature. For example, NOx reduction decreased to ~25% when the upper furnace temperature approached or exceeded 2600 °F (100 F° higher than typical.) Subsequent soot blowing lowered the temperature and improved the NOx reduction.

Higher reductions were achieved at reduced loads. More than 34% reduction was achieved at 450 MWg (75% MCR) with less than 5 ppm slip. At minimum load (340 MWg) as much as 42% reduction was achieved, also with less than 5 ppm ammonia slip. Lower upper furnace temperature and higher residence time than at full load improved the process performance at these reduced loads.

Summary of Long Term Testing:

The Long Term testing was completed between September 20 and November 19, 1999. During this time period the unit was held at various load points during the day. This was done to verify that the SNCR system would perform adequately at the full, intermediate, and minimum load points, in addition to providing stable operating conditions during which specific data could be gathered. When not held at the various load points the unit was under normal dispatch conditions. The system successfully provided approximately 30% reduction in NOx emissions across the load range while maintaining slip near 5ppm.

The most significant balance of plant concern was air heater pluggage due to ammonium bisulphate formation. The air heater differential was monitored throughout the long term testing and was observed to increase by approximately 1.5" w.c. We continued to monitor the air heater differential after the SNCR was taken out of service and the differential was observed to decline somewhat. This is thought to be a function of the scouring action of the flyash.

Conclusion:

Few difficulties were experienced during the systems operation. Two of the six MNL's developed leaks in their cooling water jackets as a result of a manufacturing defect, not related to the operation of the system. Each device was taken out of service, weld repaired, and returned to operation.

The system has been able to obtain a fair level of NOx reduction as installed. Overall, the unit experienced very few operational problems. This technology combined with Low NOx Burners can obtain a significant reduction in emissions at a comparatively lower installed cost than for other post combustion controls.

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