First Commercial Installation of Amine Enhanced Fuel Lean Gas Reburn On Units 1 an2 at Public Service Electric & Gas Mercer Station

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The first commercial full-scale installation of the Fuel Tech Amine Enhanced Fuel Lean Gas Reburn (AEFLGR™) Process has been completed at PSE&G's Mercer Generating Station. Both of the 324 net MW coal-fired units at the station have existing SNCR systems which were upgraded to AEFLGR™ capability. Fuel Lean Gas Reburn (FLGR™) is the injection of natural gas, at 3-10% of the gross heat input, via turbulent jets into the upper furnace of fossil fuel boilers for NO_x reduction while maintaining an overall fuel lean furnace. AEFLGR™ is the co-injection of natural gas with amine-containing compounds such as urea. Both technologies are licensed by the Gas Research Institute (GRI). The co-injection of natural gas with urea will enhance the NO_x reduction potential of the natural gas. Maintaining an overall fuel lean furnace environment eliminates the need for downstream completion air and helps prevent excessive carbon monoxide emissions.

As part of an initial full scale demonstration of the technology, an Amine Enhanced Fuel Lean Gas Reburn system was installed on Mercer Station Furnace 22 in December of 1997. Optimization testing began in January of 1998. Mercer Station was chosen as the demonstration site because it has years of commercial operating experience with the $NO_xOUT^®$ urea-based selective non-catalytic reduction (SNCR) system.

The AEFLGR™ process represents a synergistic combination of the Fuel Lean Gas Reburn™ (FLGR) process developed with GRI support by ESA and the urea-based $NO_xOUT^®$ process commercialized by Fuel Tech. The injection of amine enhanced natural gas in the proper temperature window results in chemical reactions that reduce NO to molecular nitrogen within this window. The process relies on using controlled velocity turbulent jets for dispersing the chemical additives in the furnace. The amount of natural gas is controlled so as to maintain an overall fuel lean stoichiometry in the upper furnace.

Using natural gas as a carrier for the amine reagent widens the acceptable reaction temperature window in comparison to the SNCR process, allows amine injection at higher temperatures without amine oxidation to NO, and improves the kinetic rates of the critical chemical reduction mechanisms. The natural gas creates a locally reducing environment for the amine chemistry that raises the acceptable temperature window and prevents the oxidation reactions. Completion of the reactions at higher temperatures also decreases the chances of ammonia "slip", a byproduct of both SNCR and selective catalytic reduction (SCR) processes.

Beginning in the 1999 ozone season, the station required deeper NO_x reductions than those obtained with the existing SNCR system. PSE&G's economic analysis showed that AEFLGR™ Process would which had demonstrated 50 to 65% NOx reduction would provide very cost-effective NO_x reductions at essentially the same $/ton of NOx removal cost. Both the low capital costs (no completion air addition) and low operating costs (low gas and urea feed rates) made AEFLGR™ technology attractive to PSE&G.

Based on the results of the 1998 AEFLGR™ demonstration on Mercer Furnace 22, PSE&G installed AEFLGR™ on both Mercer units for NO_x control during the "ozone season" beginning May 1, 1999. To maintain NO_x reduction capability during the entire year, the AEFLGR™ system can be operated in "AEFLGR™ Mode" (gas/urea co-injection) or "SNCR Mode" (urea injection only). The dual operating modes allow the PSE&G system to economically meet the New Jersey NO_x budget rule during the "ozone season" as well as the annual NO_x limit under Title IV. Fuel Tech and Energy Systems Associates jointly developed the injector and process design and performed start-up and optimization testing.

The design of the commercial AEFLGR™ system was developed jointly by Fuel Tech and ESA with input from PSE&G engineering and plant personnel. Plant operating requirements guided the integration of AEFLGR™ with the existing SNCR and boiler control systems. The commercial goals of the AEFLGR™ process were:

- 60% average NO_x reduction throughout the boiler operating load range as measured at low, mid and high load operation,
- less than 10% natural gas heat input,
- urea NSR of 1.25 or less,
- maximum ammonia slip of 5ppm @ 7% O_2, and,
- maximum carbon monoxide (CO) emissions below 100 ppm @ 7% O_2.

The original NO_xOUT® SNCR system consisted of four levels of injectors located at levels 5, 6, 7 and 8 of each furnace; each furnace injection level can be operated independently from the plant DCS based on the operating conditions of the unit. Each level consists of four (4) injectors spaced between the water tube division walls in the upper furnace, so they are in line with each burner column.

Based on the 1998 demonstration program, it was determined that level 5 and level 6 injection locations would be utilized for AEFLGR™ injection. Automatic retraction mechanisms were redesigned for these levels to accommodate the AEFLGR™ gas injectors during the ozone season and the standard NO_xOUT® SNCR injectors during the non-ozone season. The AEFLGR™ system was designed to operate with each level of gas and urea injection operating at the same time for each furnace, with independent control capability for individual furnace injection levels (zones) and individual injectors.

Levels 7 and 8 continued as SNCR injectors as part of an integrated system with the AEFLGR™ injectors at levels 5 and 6. This maintains some NO_x reduction capability without gas use while operating in AEFLGR™ Mode and allows more operational flexibility with the AEFLGR™ system.

Minimizing CO emissions to levels that are acceptable is one of the key parameters that can limit the performance of the AEFLGR™ process on a unit where existing CO permit limits are relatively low. A CO control strategy was developed that would maintain CO emissions below the permit limit while maximizing the NO_x reduction possible with AEFLGR™.

CO instrumentation was added to each furnace at the ID fan outlet to trim gas flow to the two center AEFLGR™ injectors at level 6 only when needed for CO control. Individual control valves on each gas injector allow selective trimming of gas flow instead of reducing gas flow to an entire zone or furnace. CO feedback is used to trim gas flow to only two of eight AEFLGR™ injectors in a furnace, maximizing gas injection and the resultant NO_x reduction while maintaining CO emissions within the permit limits.

The AEFLGR™ system operates automatically from 60 MW net through full load. Injectors automatically insert and retract with load changes as needed based on the optimization testing. Gas and urea flow rates at each level in service follow boiler load, and the economizer outlet excess oxygen level is controlled to the appropriate level based on the quantity of natural gas injected. The units have a tight carbon monoxide (CO) emissions limit of 100 ppm (corrected to 7% excess O_2) at full load, so the gas flow controls have feedback from individual furnace CO instrumentation to control gas flow to selected injectors and thereby control CO to 50-100 ppm.

The commercial AEFLGR™ systems at Mercer Station operated automatically through out the 1999 Ozone Season providing approximately 50% to 65% NO_x reductions with an average 60% over the operating load range of the units. There are no adverse operational impacts from the AEFLGR™ system since optimization of the Mercer units. Steam temperatures are well controlled with little or no increase in spray flows. There are no problems with slag tapping from the wet bottom furnace. Stack opacity is maintained and ammonia “slip” is 5 ppm or less (corrected to 7% excess oxygen). Finally, CO emissions are controlled below 100 ppm (corrected to 7% excess oxygen).