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**Question 71: In your experience, what factors affect NO<sub>x</sub> emissions for a partial-burn FCC with a CO boiler? How do you achieve 50 ppm CO emissions while simultaneously minimizing NO<sub>x</sub> emissions through the stack?**

**PAT BERNHAGEN** (Amec Foster Wheeler)

Combustor-or incinerator-style CO boilers can produce lower NO<sub>x</sub> emissions than direct burning CO boilers (COBs). COBs with cold planes where the CO is combusted (package boilers, as an example) require high firing rates to combust the CO to acceptable levels, thereby increasing the liberation and NO<sub>x</sub> contribution. Combustor types use the CO as fuel inside the combustor and recover the sensible heat of the combustion process. Depending on the CO content in the regenerator gas stream, the supplemental firing can be much lower than the other type of COB. Of course, nitrogen-bound compounds in the regenerator gas stream will be converted to NO<sub>x</sub> in some fashion in either COB type, or the only recourse is post-combustion NO<sub>x</sub> reduction. There are two types of NO<sub>x</sub> reduction: selective non-catalytic reduction and selective catalytic reduction systems. Both have been used on CO boilers, and each has its advantages and disadvantages due to the percent of NO<sub>x</sub> reduction, dust particles in the regenerator gas stream, and temperature window that the device operates.

**CHRIS STEVES** (Norton Engineering)

Although this has been a hotly debated topic over the past few years, most now agree that source of NO<sub>x</sub> formed in the FCC regenerator is nitrogen present in the coke, that when burned, produces NO<sub>x</sub>. The majority of this NO<sub>x</sub> is converted to N<sub>2</sub>(nitrogen gas), catalyzed by the CO and carbon in the bed. In partial-burn units, the limited availability of O<sub>2</sub> results in a partial oxidation of coke nitrogen, leading to the formation of reduced nitrogen species such as NH<sub>3</sub>(ammonia) and HCN, and lower concentrations of NO<sub>x</sub>, than in full-burn units. The reduced nitrogen species from a partial-burn FCC regenerator (collectively referred to as NO<sub>x</sub> precursors) are then converted to NO<sub>x</sub> during subsequent combustion in the CO boiler downstream of the regenerator.

In addition to the NO<sub>x</sub> precursors leaving the regenerator, the auxiliary fuel burners at the CO boiler can also create thermal NO<sub>x</sub>. The amount of thermal NO<sub>x</sub> formed in these burners is a function of burner design features and combustion air inlet configurations which promote localized high combustion temperatures. Low-NO<sub>x</sub> or ultra-low-NO<sub>x</sub> burners (LNBS or ULNBS) can be installed in CO boiler applications to reduce the thermal NO<sub>x</sub> that is being created in the auxiliary fuel burners, but they generally will not have any impact on the NO<sub>x</sub> that is generated from the combustion of NO<sub>x</sub> precursors in the CO gas from the regenerator (fuel NO<sub>x</sub>). The only way to reduce fuel NO<sub>x</sub> is to reduce the NO<sub>x</sub> precursors in the CO gas, which is a result of crude choices and how much heavy nitrogen-rich feed is being processed in the FCC.

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In addition to LNB or ULNB to reduce thermal NO<sub>x</sub> created in the CO boiler, post-combustion NO<sub>x</sub> reduction can be obtained via several commercial technologies such as:

- (1) Selective non-catalytic reduction (SNCR),
- (2) Medium-temperature selective catalytic reduction (MTSCR), and
- (3) Flue gas scrubber NO<sub>x</sub> reduction technology, such as WGS+ (wet gas scrubber) and Lot Ox.

The right system for any application will depend on FCC regenerator design, feed characteristics, emission limits (CO and NO<sub>x</sub>), CO boiler configuration and operating conditions, and other equipment issues specific to each unit. A comparative evaluation of NO<sub>x</sub> control technologies and costs is typically warranted for each application due to the significant cost differences in capital and operating costs of the technologies and, most importantly, how they are configured (singly or using multiple technologies) to meet each plant's unique requirements.

CO destruction in the CO boiler is problematic when one or more of the following conditions exist:

- (1) Flue gas temperatures leaving the combustion zone are low (less than 1250°F).
- (2) CO gas and combustion air (or hot oxygen-rich flue gas) are not adequately mixed in the combustion zone; and/or,
- (3) The auxiliary fuel burners are operated at sub-stoichiometric conditions (insufficient combustion air).

CO destruction can be achieved at temperatures significantly lower than the temperature where thermal NO<sub>x</sub> is formed, which effectively decouples CO emissions from NO<sub>x</sub> emissions from properly designed and operated CO boilers.

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