## Question 71: In your experience, what factors affect NOx emissions for a partial-burn FCC with a CO boiler? How do you achieve 50 ppm CO emissions while simultaneously minimizing NOx emissions through the stack?

**PAT BERNHAGEN** (Amec Foster Wheeler)

Combustor-or incinerator-style CO boilers can produce lower NOx 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 NOx 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 NOx in some fashion in either COB type, or the only recourse is post-combustion NOx reduction. There are two types of NOx 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 NOx 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 NOx formed in the FCC regenerator is nitrogen present in the coke, that when burned, produces NOx. The majority of this NOx is converted to N2(nitrogen gas), catalyzed by the CO and carbon in the bed. In partial-burn units, the limited availability of O2results in a partial oxidation of coke nitrogen, leading to the formation of reduced nitrogen species such as NH3(ammonia) and HCN, and lower concentrations of NOx, than in full-burn units. The reduced nitrogen species from a partial-burn FCC regenerator (collectively referred to as NOx precursors) are then converted to NOx during subsequent combustion in the CO boiler downstream of the regenerator.

In addition to the NOx precursors leaving the regenerator, the auxiliary fuel burners at the CO boiler can also create thermal NOx. The amount of thermal NOx formed in these burners is a function of burner design features and combustion air inlet configurations which promote localized high combustion temperatures. Low-NOx or ultra-low-NOx burners (LNBs or ULNBs) can be installed in CO boiler applications to reduce the thermal NOx that is being created in the auxiliary fuel burners, but they generally will not have any impact on the NOx that is generated from the combustion of NOx precursors in the CO gas from the regenerator (fuel NOx). The only way to reduce fuel NOx is to reduce the NOx 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.

In addition to LNB or ULNB to reduce thermal NOx created in the CO boiler, post-combustion NOx 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 NOx 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 NOx), CO boiler configuration and operating conditions, and other equipment issues specific to each unit. A comparative evaluation of NOx 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 that the temperature where thermal NOx is formed, which effectively decouples CO emissions from NOx emissions from properly designed and operated CO boilers.

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