

# Five-fold way to NO<sub>x</sub> nirvana

A layered approach to NO<sub>x</sub> reduction can achieve up to 90 per cent lower NO<sub>x</sub> emissions from coal plants – but at much lower cost than the alternatives.

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**T**he five layers proposed consist of: burner modifications; over-fire air; NO<sub>x</sub> tempering; SNCR (selective non-catalytic reduction); and amine injection.

Taken together these measures can deliver very large NO<sub>x</sub> reductions, but without the enormous capital expense of installing SCR (selective catalytic reduction).

In North America, the approach is proving to be a very cost-effective way of complying with Environmental Protection Agency (EPA) and state mandated NO<sub>x</sub> regulations, typically saving up to 40-70 per cent in total installed cost when compared with alternative technologies such as SCR or new low-NO<sub>x</sub> burners.

The layered approach entails significantly lower downtime, usually one week, as compared with six to eight weeks for alternative technologies such as SCR. In addition, capital and operating costs are lower.

The main elements of the five layers are summarised below.

## Layer 1: burner modifications

These achieve up to 70 per cent NO<sub>x</sub> reduction. The main steps include:

*Air Distribution Analysis (ADA).* Air Distribution Analysis is a fast, accurate and cost-effective technique for balancing secondary air between burners.

The technique uses actual data taken from burners, rather than information inferred from downstream data or drawn from simulated conditions. Massive airflow balancing datasets are collected from inside the burner throat, at the critical fuel-air interface, to create definitive diagnostic performance results. Typically over 2400 individual data readings are taken for each burner. As a result, the technique provides reliable, accurate results to ±1.5 per cent. Results identify airflow differences between burners, differences within the burner itself and the precise nature and location of any inefficient windbox air distribution for each unit.

*Fuel balancing.* Balancing the fuel flow from burner-to-burner coupled with airflow balancing (using ADA) ensures that the minimum furnace excess oxygen level is achieved. Fuel balancing and reduced furnace excess oxygen are beneficial to unit heat rate, boiler thermal efficiency, superheater temperature profiles, flame stability as well as NO<sub>x</sub> reduction.

For coal firing, a RotorProbe and Dirty Air Pitot tube are used to measure the existing

burner primary air and coal flow deviations. The RotorProbe is an effective measurement technique for recording coal flow distribution deviations and “roping” in the coal pipe runs, prior to the burner. This enables recommendations to be made on changes to existing pipe orifices to correct the fuel distribution by plus or minus 10 per cent. Alternatively, to limit outage time, balancing dampers can be supplied for each coal pipe, which facilitates the on-line adjustment of the fuel balance. The balance of fuel and air is confirmed by measuring LOI, percentage of oxygen and CO across a sampling grid at the boiler or economiser outlet flue. A coal distribution device can also be provided to eliminate the coal “roping” in the burner.

*CFD modelling.* CFD combustion modelling is used to verify the baseline burner NO<sub>x</sub> and CO emissions and to design the burner modifications. The final burner configuration, including the flame stabiliser, is modelled to ensure complete burnout of the fuel with low CO and NO<sub>x</sub> emissions. The difference between the baseline and modified burner emissions determines the percentage NO<sub>x</sub> reduction from the burner modifications.

*Flame stabiliser.* A flame stabiliser is added to each burner to stabilise the combustion process and allow the unit to be operated at lower excess O<sub>2</sub>. In addition, it radially and circumferentially stages the secondary air zone of the burners to reduce NO<sub>x</sub> emissions. This design creates the minimum swirl necessary to maintain a stable fire. The remaining secondary air is injected in a low- or non-swirl mode outside the primary combustion zone. The application of the flame stabiliser allows the air doors to be set in a full open or nearly full open position, removing any inconsistencies between burners caused by the air doors. The quantity of air is effectively controlled in the primary combustion zone where the majority of the NO<sub>x</sub> emissions are formed. To enhance the NO<sub>x</sub> reduction capabilities of the burner modifications, the flame stabiliser is designed with internal air/fuel staging. This sets up fuel rich and lean zones downstream of the stabiliser in the primary combustion zone. The result is additional staging, flame stability and, lower NO<sub>x</sub> emissions.

## Layer 2: overfire air

Advanced OFA ports can reduce NO<sub>x</sub> emissions by an additional 25 per cent. The OFA

system diverts secondary air to ports above the top burner rows. The ports are designed to inject air at the proper velocity to complete combustion prior to the furnace exit.

## Layer 3: NO<sub>x</sub> tempering

NO<sub>x</sub> tempering technology is another layer that can be added to incrementally reduce NO<sub>x</sub> by a further 30 per cent. This technology injects micronised water droplets into high NO<sub>x</sub> production zones in the near burner region.

## Layer 4: SNCR

SNCR can achieve a further 40 per cent increment in the NO<sub>x</sub> reduction. An aqueous solution containing a reagent (urea-based with chemical enhancers) is injected into the lean fuel zone above the furnace. The reagent reacts chemically with the NO<sub>x</sub> in the combustion gas to form nitrogen.

## Layer 5: Absolute Compliance

The fifth and final layer, RJM's Absolute Compliance (RJM-AC) technology, can provide a further 30-60 per cent reduction. This layer consists of amine reagent injection in the primary combustion zone. Thanks to combustion turbulence the reagent is well dispersed and targets specific zones where optimum chemical kinetics achieve high NO<sub>x</sub> reduction.

The RJM-AC layer evolved from Rich Reagent Injection (RRI) technology, which was developed by the Electric Power Research Institute and a Utah-based modelling company called Reaction Engineering International (REI).

RRI technology was successfully demonstrated in 2001 by RJM, REI and EPRI on cyclone furnaces at Conectiv's BL England power station in the USA, where an 80 per cent reduction in NO<sub>x</sub> emissions was achieved. The technology is now used by RJM under licence from REI for its Absolute Compliance layer.

One of the key benefits of the Absolute Compliance system is that its running costs are low compared with SCR systems as there is no catalyst to replace. In addition, installation outage times are very much lower than for an SCR system.

RJM has yet to install its Absolute Compliance system in a commercial application but the company is in an advanced stage of negotiation with several utilities in the USA on use of the technology.

