NO$_x$ reduction solutions
Choose wisely with the market’s widest range of alternatives

Key benefits
- Reliable NOₓ reduction
- Full spectrum of solutions for an ideal match
- Expertise to help plants weigh costs and benefits
- Solutions with guaranteed performance
- Evaluation of potential process effects

Targeting precisely what you need
Reducing nitrogen oxide (NOₓ) successfully requires more than just buying a particular product, or injecting ammonia or urea into a system.

It’s a matter of process optimisation and evaluating your present system to explore a range of potential reduction methods. It also requires weighing costs and benefits to find the correct solutions. In other words, it’s not just about installing systems.

FLSmidth offers the entire spectrum of low NOₓ alternatives, since there can be a variety of ways to achieve the results you’re looking for. And we have the expertise to recommend exactly which is optimal for your plant.

We strive to optimise your entire system – and we do so with a professional approach that utilises the full potential NOₓ reduction capability of your existing system. We don’t automatically recommend that our clients install secondary measures like Selective Non-Catalytic Reduction (SNCR).

Reliable primary and secondary reduction solutions
Increasingly stringent regulations mean it’s more important than ever to be sure that your plant complies with the norms at any time. With FLSmidth you get proven solutions, delivered by experienced professionals with vast process knowledge.

You will benefit from our many years of experience with customised computer models that accurately predict NOₓ emissions. You’ll also appreciate our advanced test facilities, where we research and develop the market’s leading solutions. These tools are refined by experienced commissioning engineers and process engineers, data collected from the field, and a Research and Development department that continuously improves the foundation of our NOₓ reduction capabilities.

So whether your challenges require a primary or secondary reduction method, you can be sure the solution will be developed with the professionalism the industry expects from FLSmidth.

Primary methods
- Improve burning process
- Optimise automatic kiln operating control
- Optimise chemical control
- Improve raw material burnability by adjusting chemical and physical properties
- Modify existing pyro process

Secondary methods
- Install a Selective Non-Catalytic Reduction (SNCR) system
- Install alternative technology
Primary NO\textsubscript{x} reduction – the easy way

Process optimisation starts with process audit
The first step in virtually any low NO\textsubscript{x} reduction project is the process audit. The purpose of reviewing a cement plant for process optimisation is to ensure that the present system secures the lowest possible NO\textsubscript{x} emissions.

A process audit investigates the system through a review of plant measurements, operational stability, chemical study, burner optimisation and preheater design. The preheater design review can be especially important, as fuel or tertiary air are not always introduced in locations favourable for reducing NO\textsubscript{x}. Introducing raw meal correctly and operating the calciner/riser at the optimal temperatures is essential for NO\textsubscript{x} reduction by primary measures.

Once the process audit is complete, the plant and FLSmidth must agree on a course of action – including minor or major design changes – while weighing the costs and benefits of the different alternatives.

Automated control with Expert Control System (ECS)/ProcessExpert
Process optimisation/NO\textsubscript{x} reduction can also be achieved using advanced ECS/ProcessExpert automated process control.

Using a sophisticated toolbox and specialised application modules, the automated process control continuously performs complex analyses of your plant’s process conditions. This enables it to adjust the process more frequently and reliably than human operators can. The result is stable temperature control in the calciner, stable burning zone temperature in the kiln for good clinker quality, and stable cooler operation, which helps reduce NO\textsubscript{x} emissions from the pyro system.

FLSmidth also offers training of operators in the high-tech ECS™ CEMulator\textsuperscript{®} cement process simulator. This helps operators better utilise the full NO\textsubscript{x}-reducing potential of the system.

Typical steps
1. Conduct process optimisation, including audit
2. Decide course of action, weighing costs and benefits
3. Make necessary operational and design changes

Automated control ensures a timely and correct response to process changes. The result is a stable pyro system and reduced NO\textsubscript{x} emission.
Primary NO\textsubscript{x} reduction – optimise your system

The ILC sets high standards for primary reduction
Simple construction and simple operation are keywords when it comes to the FLSmidth\textsuperscript{®} In-Line Calciner (ILC). Unlike many more complicated systems, our ILC makes it easy to reduce the thermal NO\textsubscript{x} generated in the kiln and limit the formation of fuel NO\textsubscript{x} in the calciner. FLSmidth In-Line Calciners are found on some of the lowest NO\textsubscript{x}-emitting plants in the world.

Flexible when it comes to fuel
Both flexible when it comes to fuel and highly reliable, our ILC achieves proven NO\textsubscript{x} reduction from high-temperature, “stage-less” combustion. This is incorporated into the standard design of the ILC preheater. It’s a simple and effective way to create low NO\textsubscript{x} emissions with only one firing location, one meal split and one tertiary air stream entering tangentially to the calciner.

Optionally, the second- or third-lowest stage cyclone material can be further split to allow for diversion of a portion of the meal directly into the upper section of the calciner. This creates a “hot zone” in the lower section of the calciner that is conducive to burning difficult fuels and increasing NO\textsubscript{x} reduction.

Highly reliable operation
Fuel is injected into the kiln riser below the area where the tertiary air enters at the base of the calciner. This so-called reduction zone, sized for a particular gas retention time, has an oxygen-deficient atmosphere that promotes NO\textsubscript{x} reduction. The optimum temperature in the zone is controlled by a material split from the second-lowest stage between the calciner and the kiln riser.

This material split is also used to control possible build-up within the kiln riser for operational stability. Above the reduction zone is the main calciner vessel, which is divided into two or more sections separated by a notch. The changes in cross-sectional areas create turbulence that ensures effective mixing of fuel, raw meal and gas, improving heat transfer and combustion.

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**Gas phase reactions**

- Tertiary air
- Coal
- Kiln NO

**Char reactions**

- N\textsubscript{2}
- NO
- N\textsubscript{2}O
- NO
- N\textsubscript{2}O

**Catalysed reactions**

- CO
- Fe\textsubscript{2}O\textsubscript{3}
- CaO
- N\textsubscript{2}
- NH\textsubscript{3}
- C\textsubscript{x}H\textsubscript{y}
- Char

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IFLSmidth\textsuperscript{®} In-Line Calciners are found on some of the lowest NO\textsubscript{x}-emitting plants in the world.

Reaction pathways occurring in an oxygen-deficient atmosphere in the lower part of the calciner.
A typical delivery in the SNCR system consists of a pump module for filling (PMF), a tank, a pump module for reductant (PMR), flow control (CMM), individual lance flow control (IM) and the lances for injecting the reductant.

A look at the SNCR system

Secondary reduction measures – superior alternatives

**SNCR systems reduce NOx up to 80%**
Primary NOx abatement techniques are not always sufficient to comply with the most stringent emission requirements. Therefore plants are increasingly considering secondary reduction methods such as the FLSmidth® Selective Non-Catalytic Reduction (SNCR) system.

A properly implemented SNCR system can reduce NOx by up to 80%. FLSmidth has a proprietary SNCR system with proven, highly efficient performance. Furthermore, the FLSmidth SNCR system combines easy operation and maintenance with safety.

**How the SNCR system works**
An SNCR system reduces NOx by injecting an aqueous ammonia (or urea) solution into the flue gas at an optimum temperature window. The NH3 converts into NH2 radicals that can react with NOx, forming atmospheric nitrogen and water. Usually the ammonia solution is injected in the outlet of the calciner, due to optimal operating temperatures here in a typical calciner system.

FLSmidth’s SNCR includes unloading pump modules, storage tank facilities, reductant pump modules, reagent flow control modules, injection modules and specially engineered spray lances with nozzles. The system can be configured to include any number of pumps, tanks and injection modules. It’s all tied together by a dedicated, comprehensive electrical and control system to ensure the best performance in a truly integrated system.

**A wide range of advantages**
- Combined with the initial audit performed by our experienced process engineers, the ammonia consumption is low – which reduces operational costs
- FLSmidth’s extensive experience with the pyro process ensures your SNCR system is highly incorporated with the kiln system for optimal operational efficiency
- Little to no ammonia slip or CO2, with a properly installed and operated SNCR system.
- FLSmidth offers the possibility of SNCR trials with our mobile SNCR test rig, to determine the optimal injection and NOx reduction
- In addition to SNCR, FLSmidth offers the possibility of reducing NOx by more than 80% with other, superior technology.