

# SCR Systems

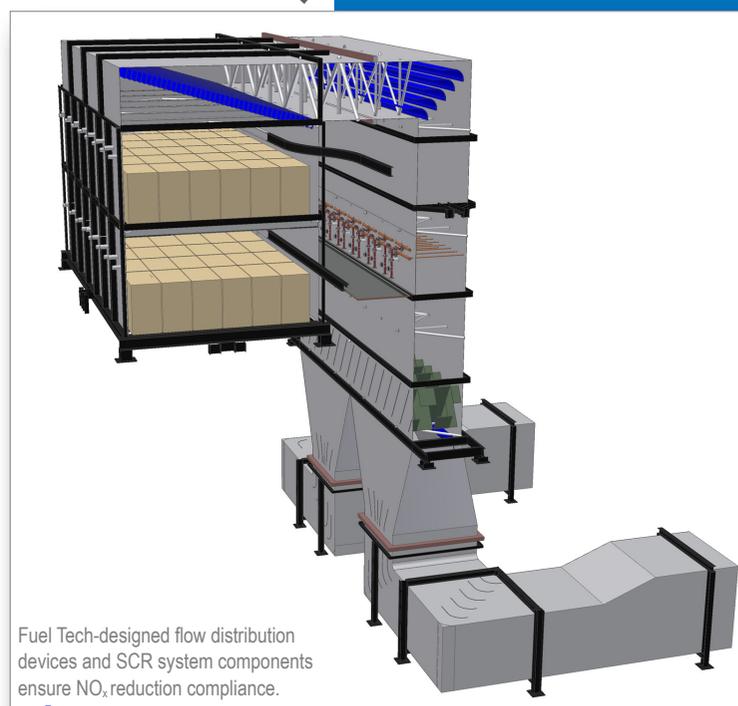
## Industrial Applications

Selective Catalytic Reduction (SCR) is a well-established means of controlling NO<sub>x</sub> emissions for industrial sources that cannot meet permit levels through combustion controls alone. Fuel Tech has extensive SCR design experience and understands “real world” plant operations, and has been applying this know-how on a wide range of SCR applications around the world. These projects include boilers, incinerators, reformers and many other types of heat recovery equipment firing coal, gas, oil, and a variety of process gases and waste fuels.

Our application review starts with an analysis of the fuel and flue gas properties, performance targets, and site constraints – this critical information is used to support the process optimization as well as the catalyst selection and arrangement. Customer drawings are used to develop a preliminary arrangement of the reactor and integrate the SCR into the new or existing duct layout.

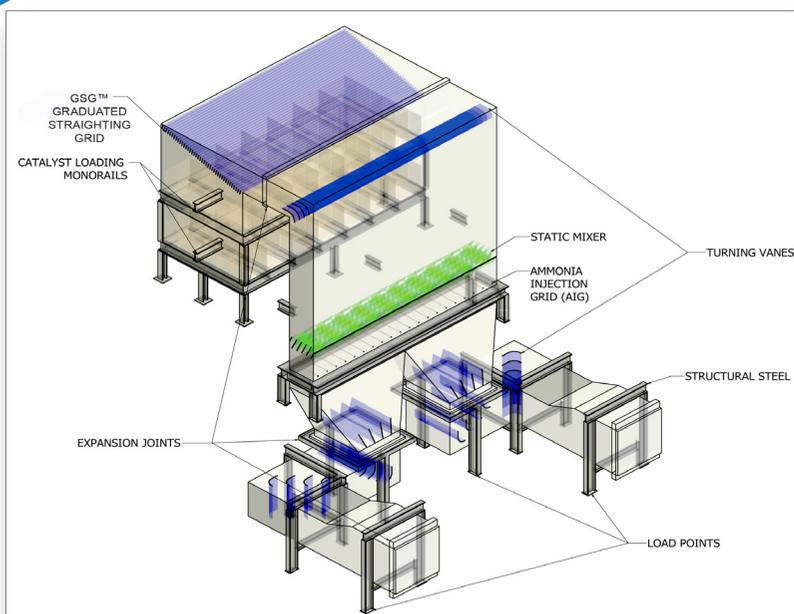
In some cases, standalone SCR is not the only solution. We offer a full range of NO<sub>x</sub> reduction technologies – combustion and post-combustion – that can be integrated to deliver a more cost-effective solution while limiting balance-of-plant impacts. These integrated I-NO<sub>x</sub><sup>™</sup> NO<sub>x</sub> reduction technologies may be applied as a retrofit solution for existing units or may be incorporated into compliance plans for a Greenfield application, in some cases facilitating NO<sub>x</sub> reduction in excess of 80%. This wide range of capabilities allows us to approach each application as a solutions provider rather than an equipment supplier, for effective NO<sub>x</sub> control from the point of combustion to the stack.

We offer our clients unique, experience-based know-how focused on the design, operation and maintenance of SCRs, which includes more than 55,000 MWs of SCR system design. Our services are targeted to minimize SCR system operating costs, diagnose operating problems, enhance overall performance and assist end users in implementing the most comprehensive SCR services programs encompassing all aspects of SCR system operation and performance analysis. Our approach does not adhere to traditional catalyst management or owner/catalyst supplier contractual concepts. We partner with owners and operators to ensure that NO<sub>x</sub> removal objectives are achieved at the lowest cost without impacting the operating reliability of the units.



Fuel Tech-designed flow distribution devices and SCR system components ensure NO<sub>x</sub> reduction compliance.

- **Single Source Responsibility - from application analysis through implementation**
- **In-house CFD and Experimental Modeling**
- **55,000+ MW experience of SCR process design**
- **Guaranteed NO<sub>x</sub> Reduction Performance**



Fuel Tech designs and supplies SCR systems for a variety of industrial processes.

**We combine our experience, design expertise and know-how to produce the best possible SCR design.**

Maximizing SCR performance and minimizing its impact on plant operations requires a thorough understanding of each application. The front end of this solution approach takes advantage of our proven combustion systems including Low NO<sub>x</sub> Burners (LNBs), burner modifications, and Overfire Air (OFA) systems. These combustion solutions are augmented by our post combustion NO<sub>x</sub> control processes which include urea- and ammonia-based selective non-catalytic reduction (SNCR) and urea (or ammonia) based SCR systems. The key to our approach is the custom integration of these technologies as needed to achieve a specific NO<sub>x</sub> emission rate target while minimizing the capital investment.

When the duct configuration can be altered to provide appropriate flue gas velocities and NO<sub>x</sub> has been reduced sufficiently via the upstream controls, incremental SCR

NO<sub>x</sub> reduction performance as high as 70% can be achieved across a single layer of catalyst. Use of a single layer has been proven to oxidize more than 90% of the mercury in the flue gas for capture by a flue gas desulphurization (FGD) scrubber.

When the SCR performance goals can be met with a single catalyst layer, our SCR systems provide the added benefit of a lower SO<sub>2</sub> to SO<sub>3</sub> conversion rate and therefore the risk of ammonium sulfate/bisulfate formation in the air preheater. This low conversion rate allows for a broader operating load range and enhanced fuel flexibility. In addition, reducing the catalyst volume results in lower system pressure drop and requires less outage time for the replacement.

We combine in-house computational fluid dynamics (CFD) and experimental modeling to develop an optimum SCR reactor and adjoining duct configuration. We then apply advanced flow correction and control devices to promote consistent flue gas velocities and temperatures as well as excellent NH<sub>3</sub> to NO<sub>x</sub> distribution across the face of the catalyst for efficient SCR performance. We also work with all of the industry-leading catalyst suppliers to source the appropriate catalyst type and formulation for each application.

CFD and experimental modeling are used together in an iterative process to arrive at the optimum SCR reactor configuration. Using this combined approach we are able to recommend optimal arrangements of duct configuration and flow correction devices in order to maintain appropriate flue gas velocities, temperature distribution, fly ash distribution, and NH<sub>3</sub> to NO<sub>x</sub> distribution within the SCR system. We provide our clients with the sizing, design, and configuration of all corrective devices including: turning vanes, large particle ash (LPA) screens, ammonia injection grid (AIG), and GSG™ Graduated Straightening Grid to ensure trouble-free operation, minimize ash buildup in the reactor, and maximize catalyst life.

# Optimizing the design is a critical step in ensuring SCR performance goals are met.

## GSG™ Graduated Straightening Grid



In lieu of using large turning vanes along with straightening grids placed immediately upstream of the catalyst; our patented GSG technology combines the turning vanes and straightening grid into a

single sloped grid, that has proven to be an extremely robust solution to the challenge of effective flow correction. The GSG is much less sensitive to fluctuations in upstream flow distributions than the traditional approach. The catalyst performance is maintained and the catalyst itself is protected even when the unit is not running at the design operating conditions, such as when an economizer bypass is in service.

## Static Mixer



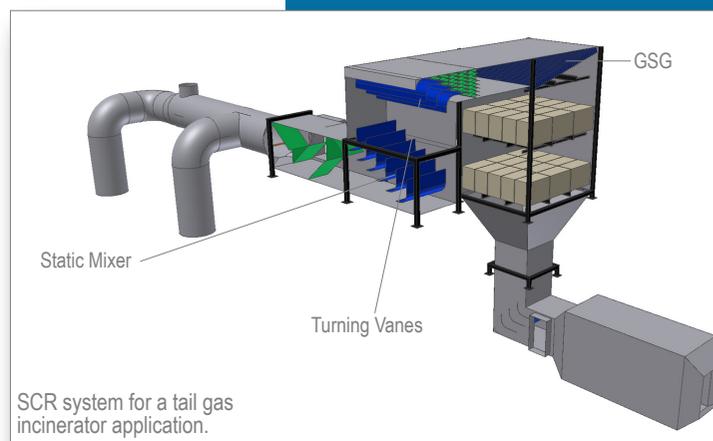
Static mixers are used in a wide variety of applications, particularly for SCR process applications in which the consistency of flue gas velocity, temperature and  $\text{NH}_3$  to  $\text{NO}_x$  distribution at the catalyst face can greatly impact system performance. The most common application of static mixers is in SCR systems, where these devices are used to address temperature, velocity and  $\text{NO}_x$  maldistributions ahead of an AIG. Static mixing devices

are also used to improve the distribution of  $\text{NH}_3$  downstream of the AIG. Other applications include the mixing of sorbents for mercury control and mixing of chemical components to optimize reactions.

## Ammonia Injection Grid (AIG)



AIGs are used to feed aqueous or anhydrous ammonia to the catalyst to ensure proper coverage to react with  $\text{NO}_x$  within the catalyst. Proper mixing of flue gas constituents and temperatures along with proper flow and velocity profiles to maximize  $\text{NO}_x$  reduction and to minimize ammonia slip emissions.



## Single Source Responsibility

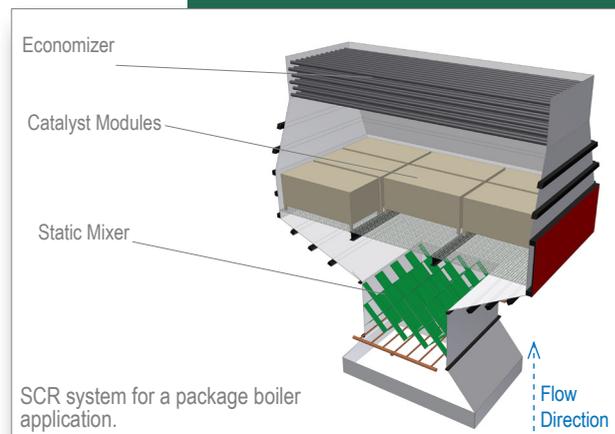
### Application Analysis

- Fuels and Fuel Blends
- Firing Arrangement
- Performance Expectation

### System Design

- CFD Modeling
- Experimental Modeling

### Performance Guarantees



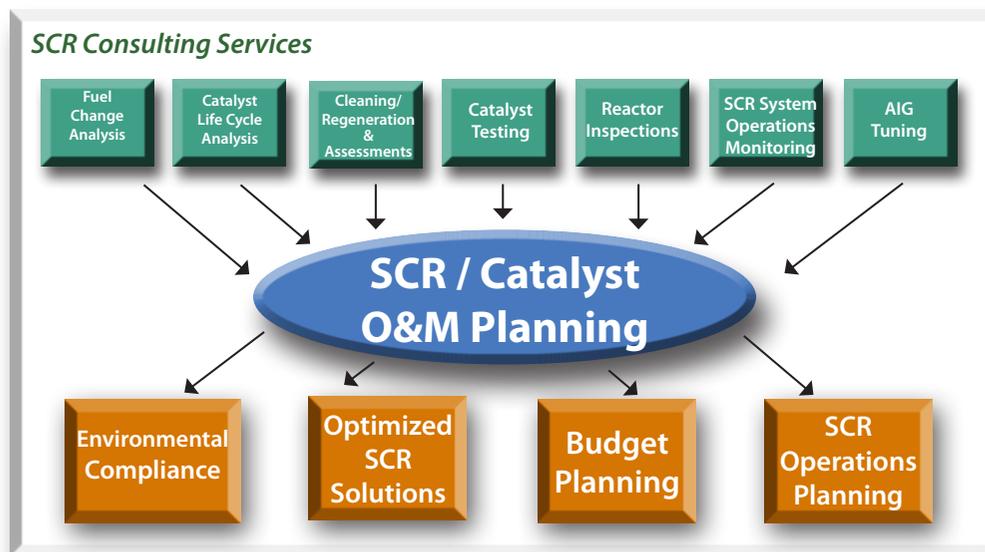
**Industrial SCR systems include design, engineering, procurement, delivery, and startup of any combination of the following:**

- **Combustion modifications SNCR Systems**
- **Modeling and Process Design**
- **Performance Guarantees**
- **Static Mixer**
- **LPA Screen**
- **GSG™ Graduated Straightening Grid**
- **AIG**
- **Catalyst Specification**
- **SCR Reactor Design**
- **System startup, optimization, and training services**
- **SCR and Catalyst Management Services**

***Fuel Tech's extensive experience and financial status allow us to offer single source responsibility - from application analysis through implementation.***

Our experience includes more than 100 LNB and OFA systems, 600+ SNCR and SCR systems, SCR design consulting support covering more than 55,000 MWs, and over 20,000 MWs of AIG Grid Tunings. Fuel Tech has many tools to provide the most efficient design for our systems.

Our comprehensive program of services regarding catalyst management and SCR system performance enhancements is one of a kind in the industry. The program is not simply focused on catalyst management, but encompasses overall SCR system management. Cost effective and reliable operation of the SCR systems for the owner's fleet is of the utmost importance to Fuel Tech. The consulting services associated with Fuel Tech's programs are designed to compliment and supplement the performance guarantees and warranties provided by Catalyst OEMs, along with any other suppliers.



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