AIG UPGRADE FOR GREATER EFFICIENCY, LOWER NOx

Selective Catalytic Reduction (SCR) is a mature technology for removing nitrogen oxides (NOx) from combustion emissions. SCR does this by injecting a reducing agent—ammonia or urea—into the emission stream, which is then passed over a catalyst.

A series of reactions reduces the NOx to diatomic nitrogen (N_2) and water. (See Fig.2) SCR has been around since the 1950s but did not come into widespread use until the environmental damage caused by NOx emissions, such as acid rain, triggered regulations that required them to be more and more stringently controlled. This process in turn has driven continual, mostly incremental improvements to the basic technology.

CECO Peerless has made significant advances in SCR Technologies. One of these, described below, is their advanced Ammonia Injection Grid that both improves efficiency and lowers installation and operating costs.

Figure 1: Exterior of an exhaust duct showing the Ammonia Injection Grid

The Peerless EDGE AIG™

Beyond the catalyst used and the right temperature range, the key to effective SCR is the Ammonia Injection Grid (AIG)—the system of stainless-steel pipes or lances that inject the reagent into the emission stream through orifices spaced along their length (see Fig. 1). The goal is to mix the reagent with the NOx-laden effluent so thoroughly that 100% of the NOx is reduced, while maintaining or even improving the overall efficiency of the larger system.

$$4NO + 4NH_3 + O_2 \rightarrow 4N_2 + 6H_2O$$

$$2NO_2 + 4NH_3 + O_2 \rightarrow 3N_2 + 6H_2O$$

$$NO + NO_2 + 2NH_3 \rightarrow 2N_2 + 3H_2O$$

Figure 2: Main SCR Reactions

Although the actual chemistry of SCR is quite simple (see Fig.1), bringing about effective reduction is not. Grid design is critical and must be approached as part of the larger system that includes the duct, the catalyst array, and the stack. Peerless engineers take the results from lab tests of reagent spray from a lance and, in a patented process, use the data in models built with Computational Fluid Dynamics (CFD) to optimize key design features for the project. These design features help determine how well the reagent and the effluent are mixed in the reactor before passing over the catalyst. They include the spacing of the lances in the array and of the injection orifices in the lances, the pressure at each point in the grid, the dynamics of the resulting turbulence in the flow, and so on. (see Fig. 3)

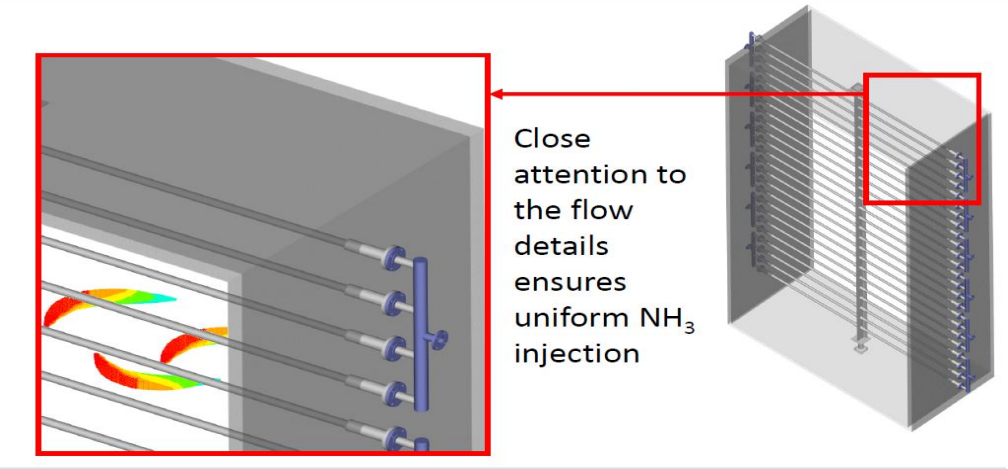


Figure 3: CFD model image of flow from AIG lances

CFD-based model-building and testing have led to the most important innovations in the Peerless EDGE AIG design. These are changes to three other aspects of the grid: how the injection orifices are created; their angle in relation to the exhaust stream; and the shape of the lance.

- In most AIG designs, the injection orifices are drilled. This tends to leave residual burr from the drilling in the pipe that can end up back in the orifices, partly blocking them; and the roughened orifice surface from the drilling will over time also trap material such as dust or ammonium bisulfate crystals, again potentially causing blockage. The injection orifices in Peerless EDGE lances are precision bored, which means no drilling residue and an opening as smooth as the lance interior.
- The injection orifices in traditional AIG lances are along the top and bottom of the pipe. This also tends to cause blockage over time, as debris borne by the exhaust gas or within the delivery piping to the AIG can foul the lances and partially or completely plug the orifices. The orifices in Peerless EDGE lances are horizontal, avoiding this problem.
- Finally, and most important, the traditional lance is circular in section. Peerless EDGE lances are square in section, placed in “diamond” formation (rotated through 45 degrees). This design together with the horizontally positioned orifices greatly improves the turbulence that makes for complete mixing of reagent and exhaust. (See Figs. 2 and 3.)

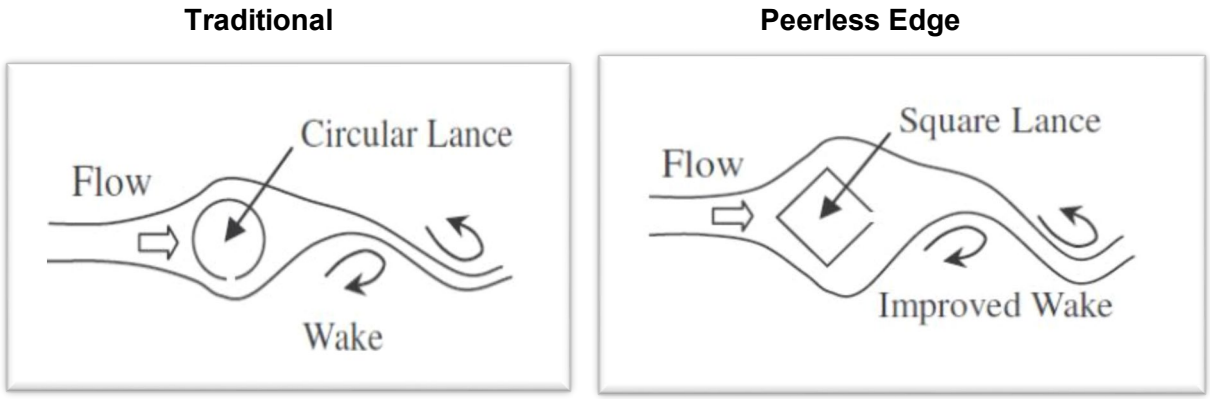
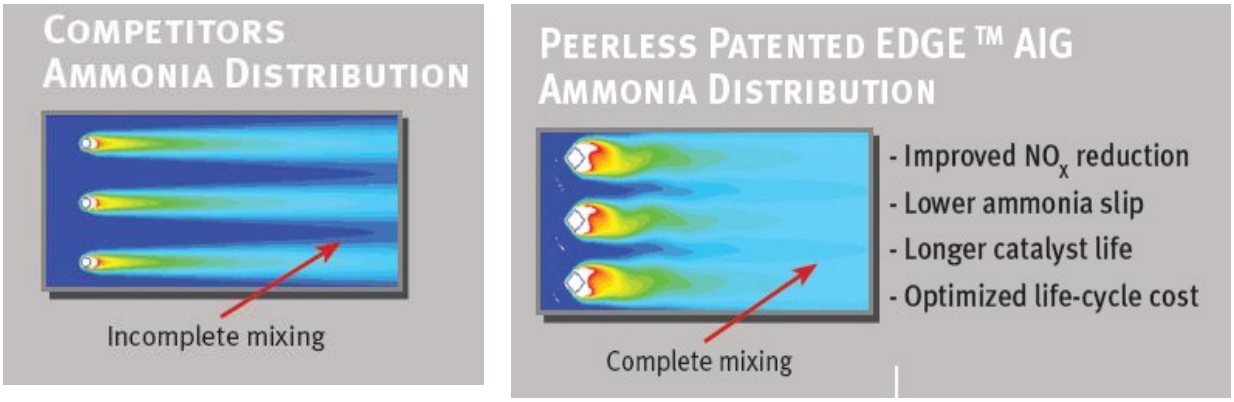


Figure 4: Traditional vs. Peerless Edge Lance Design and Wake

Together, these features provide a further advantage. The traditional AIG requires about 8 feet of mixing distance between the grid and the catalyst. The Peerless EDGE AIG halves that distance to 4 feet, allowing a more compact reactor—and achieves much more complete mixing into the bargain. This saves ductwork costs for new installations and offers an efficient way to perform retrofit installations in compact areas.

The Peerless EDGE AIG also reduces “ammonia slip”—the amount of unreacted (and therefore wasted) ammonia that reaches downstream components, risking the formation of ammonium crystals that shorten catalyst life and contaminating the final exhaust stream.

Figure 5: Reagent-Exhaust Mixing in Traditional and Peerless Edge AIGs



Peerless Edge: An Advanced Approach to a Proven Technology

To summarize, Peerless EDGE AIG has multiple advantages over traditional systems. Improved ammonia distribution and optimized reagent use allow more thorough mixing of exhaust gas and reagent. This in turn means minimal ammonia slip and up to 96% NOx emission reduction (to as little as 2 ppm). The superior design also means that mixing requires a shorter distance. The AIG lances last longer and require less maintenance and fewer replacements, as does the catalyst. Catalyst performance and volume are optimized. Together with modular design for quicker installation, all these improvements translate to lower capital cost and lower operating

expense. And to the communities and the environment around the plant, better SCR means cleaner air.

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Peerless-Aarding Background

In 2015, CECO Environmental's Aarding and Peerless brands combined to form a new global leader in custom emissions management solutions for natural-gas power and petrochemical processing plants: **Peerless-Aarding**. Peerless-Aarding's customized solutions are based on a proven track record in the design, engineering, and manufacturing of gas turbine exhaust systems, De-NOx solutions like SCR, dampers, and expansion joints. This operating history dates back to 1933.

Our customers are gas turbine manufacturers (OEM), boiler suppliers, power producers, EPC contractors, and end users. Whether a problem can be solved from our standard product line or requires a custom solution, we take control from design to installation, even for complex turn-key retrofit projects.

About CECO Environmental

CECO Environmental is a global leader in air quality and fluid handling serving the energy, industrial, and other niche markets. Providing innovative technology and application expertise, CECO helps companies grow their business with safe, clean, and more efficient solutions that help protect our shared environment. In regions around the world, CECO works to improve air quality, optimize the energy value chain, and provide custom-engineered solutions for applications including oil and gas, power generation, water and wastewater, battery production, poly silicon fabrication, chemical and petrochemical processing, along with a range of others. CECO is listed on Nasdaq under the ticker symbol "CECE". For more information, please visit www.cecoenviro.com.

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