# SCR Catalyst Management: Lessons Learned

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More than 13,000 MWe of Italian power generation capacity have been retrofitted by SCR technology since middle '90s. SCR denoxing reactors are in operation on all large coal and orimulsion fired power plants. Many oil and gas fired power plants have been equipped with SCR technology too, even if they use depends on performances of primary technologies.

Enel Produzione Spa, the largest Italian utility, has 22 fossil fired units (from 240 to 660 MW each) equipped with SCR. Denoxing reactors are installed in high-dust configuration (apart one unit in tail-end configuration) and approx. 6,800 $m^3$ of catalysts from different suppliers are in operation.

| Power Station | Unit N° | MW | Main fuel (as 01/2002) | Catalyst Ttype | Catalyst Manufacturer | Configuration | DeNOx Reactors | Catalyst Layers | Volume ($m^3$) | DeNOx Commissioning |
|---|---|---|---|---|---|---|---|---|---|---|
| Brindisi Sud | 1 | 660 | coal-orimulsion | plate | Hitachi | High-dust | 2 | 2 | 578 | 06/1998 |
| Brindisi Sud | 2 | 660 | coal-orimulsion | plate | Hitachi | High-dust | 2 | 2 | 578 | 07/1998 |
| Brindisi Sud | 3 | 660 | coal-orimulsion | plate | Hitachi | High-dust | 2 | 3 | 868 | 05/1998 |
| Brindisi Sud | 4 | 660 | coal-orimulsion | plate | Hitachi | High-dust | 2 | 3 | 868 | 06/1999 |
| Fusina | 3 | 320 | coal | honeycomb | KW Huls | High-dust | 2 | 3 | 304 | 11/1997 |
| Fusina | 4 | 320 | coal | honeycomb | KW Huls | High-dust | 2 | 3 | 304 | 05/1998 |
| Montalto di Castro | 1 | 660 | natural gas | honeycomb | Frauenthal | High-dust | 2 | 3 | 276 | 06/1996 |
| Montalto di Castro | 2 | 660 | natural gas | honeycomb | Frauenthal | High-dust | 2 | 3 | 276 | 12/1996 |
| Montalto di Castro | 3 | 660 | natural gas | honeycomb | Frauenthal | High-dust | 2 | 3 | 276 | 05/1998 |
| Montalto di Castro | 4 | 660 | natural gas | honeycomb | Frauenthal | High-dust | 2 | 3 | 276 | 10/1998 |
| Rossano Calabro | 1 | 320 | natural gas | plate | Hitachi | High-dust | 2 | 3 | 242 | 01/1998 |
| Rossano Calabro | 2 | 320 | natural gas | plate | Hitachi | High-dust | 2 | 3 | 242 | 03/1999 |
| Rossano Calabro | 3 | 320 | natural gas | plate | Hitachi | High-dust | 2 | 3 | 242 | 11/1999 |
| Rossano Calabro | 4 | 320 | natural gas | plate | Hitachi | High-dust | 2 | 3 | 242 | 04/1999 |
| Spezia | 3 | 600 | coal | honeycomb | Frauenthal | High-dust | 1 | 3 | 535 | 10/2001 |
| Sulcis | 3 | 240 | coal | honeycomb | Frauenthal | Tail-end | 1 | 2 | 180 | 09/2000 |
| Termini Imerese | 4 | 320 | natural gas | honeycomb | Siemens | High-dust | 2 | 3 | 132 | 12/1999 |
| Termini Imerese | 5 | 320 | natural gas | honeycomb | Siemens | High-dust | 2 | 3 | 132 | 12/1999 |
| Torrevaldaliga Nord | 1 | 660 | oil | honeycomb | Frauenthal | High-dust | 2 | 3 | 240 | 11/1998 |
| Torrevaldaliga Nord | 2 | 660 | oil | honeycomb | Frauenthal | High-dust | 2 | 3 | 240 | 12/1998 |
| Torrevaldaliga Nord | 3 | 660 | oil | honeycomb | Frauenthal | High-dust | 2 | 3 | 240 | 03/1998 |
| Torrevaldaliga Nord | 4 | 660 | oil | honeycomb | Frauenthal | High-dust | 2 | 3 | 240 | 12/1997 |
| total | 22 | 11,320 | | | | | | | 7,511+ | |

Catalysts are the core of the SCR technology. They are typically formed as plates or honeycombs and they are grouped in modules sizing about 2x1x1 $m^3$. Many chemical reactions take place on the catalyst. Oxidation of $SO_2$ to $SO_3$ is surely the most dangerous reaction in burning fuels containing sulfur. $SO_3$ can reacts with ammonia giving sulfates and bi-sulfates that can damage downstream systems.

The competition between denoxing and $SO_2$ to $SO_3$ conversion is the main problem in catalyst design. At early stage the SCR technology showed erosion and plugging problems well recognized and solved by design optimization of the reactor (mobile guide vanes configuration, reverse of the ammonia injection vs to counter flow, etc.).

In order to keep the catalyst surface as clean as possible, in the denoxing reactors, soot blowers are usually installed. Pressure drop across the reactor is the leading parameter in soot blowers use. The frequency of their use depends on fuel: for coal and oil fired it is typically of 3 times per day, for gas fired they can be kept out of service for several days.

The amount of catalyst needed to denox a flue gas depends on the rate of denitrification and the type of fuel. For denox efficiency targeted at 80 %, the following figure can be considered: 1 to 1.2 $m^3$/MW for coal, 0.8 to 1 $m^3$/MW for oil, approx. 0.5 $m^3$/MW for gas fired station. Catalyst' costs depends on the market. They range from 8 to 10 kEuro/$m^3$. The full substitution of catalyst in a 600 MW coal fired power station can cost some 6 MEuro.

During operation catalysts decrease and finally loose their performances. So they are consumables that must be replaced by catalyst spare parts. At design levels it was usually assumed that for oil/coal fired power station 1/3 of the catalyst should be replaced each year. Very complex strategies for catalyst replacement management are known.

The catalyst life is based on catalyst deactivation processes that take place during operation. To follow the catalyst behavior during operational life, in order to be on time for replacement, eventually, catalyst samples are periodically pull out from the reactor and checked in laboratory. Special catalytic measurements are implemented for estimating the degree of degradation, its homogeneity inside the reactor, and the residual life of the catalyst.

In this context Cesi has implemented dedicated facilities and technologies to support Enel Produzione into selection and operation of SCR catalysts. Special lab rigs for NOx catalytic activities and $SO_2$ conversion rate measurements are currently used for comparing catalytic properties of different catalysts, as well to assess the degradation rate during operation. Special technologies for catalyst cleaning to allow its reinstallation has also implemented. Cleaning techniques range from simple ash suction, to air blasting, up to high pressure water blasting. In the most difficult cases sand-water blasting could be used. Sonic equipments can be used too.

The lesson learned can be summarized as in the following.

SCR denoxing technology appears to be quite easy to manage. A few problems happen in a very limited number of denoxing systems. They are primarily correlated with modification in combustion assets.

Generally, catalyst life seams to be higher than expected. This is due to both a lower required efficiency (due to joint use of combustion modifications) as well as a controlled operation. Up to now Enel Produzione did not buy for new catalysts.

Before switching the operation from coal to orimulsion fuel in a large power station, Enel Produzione did some investigations. The effect of $SO_2$ concentration on the catalyst performance were determined, showing that the catalyst was effective also with high content of $SO_2$. More than two years of operation with orimulsion flue gas showed the possibility to keep outlet $NO_x$ under the regulatory limits without any relevant problem. A significant increase of the catalyst fouling was noted during reactor inspections. In many case this fouling can be removed and the catalyst performances can be restored. The major part of this catalyst fouling was correlated to an improper addition of magnesium oxides to combat acid corrosion in to the boiler.

When problem occurs, soot blowers should be used more frequently and their proper operation must be checked possibly during each shutdown. Moreover an increased check program on catalysts based on laboratory testing must be implemented, in order to be on time for replacement and/or defining remedies. More accurate inspection programs (for soot-blowers too) as well as reactor asset measurements should be implemented too. These actions can really delay catalyst replacement and save money.

In some cases, in order to extend as much as possible the catalysts life, special monitoring guidelines have been implemented.

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