Catalytic waste gas and exhaust air purification
EWK Environmental Engineering has been manufacturing systems for the purification of air and waste gas for decades. In the past few years the catalytic waste gas purification method has gained more and more importance in this context.

As a result of years of tests and developments we now use the SCR (selective catalytic reduction) method successfully for the reduction of pollutants in

- process exhaust air
- combustion waste gases.

The burning of **biological fuels**, (wood, straw, biogas etc.) as well as **fossil fuels** (heating oil, natural gas, heavy oil, coal) and **industrial waste** (solvent, sewage sludge, explosive, refuse and industrial residue etc.) generates large amounts of the following substances even in the most advanced furnaces:

- nitric oxide \( \text{NO}_x \)
- carbon monoxide \( \text{CO} \)
- hydrocarbon \( \text{C}_m\text{H}_n \)
- dioxin/furan \( \text{PCDD/PCDF} \)

With the SCR catalyst technology these air pollutants can be precipitated to a large degree and modified to \( \text{N}_2, \text{CO}_2 \) and \( \text{H}_2\text{O} \).

### Chemical Reactions

#### NO\(_x\) reaction with ammonia \( \text{NH}_3 \)

<table>
<thead>
<tr>
<th>Reaction Type</th>
<th>Reaction</th>
<th>Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>for ( \text{NO} )</td>
<td>( 4 \text{ NO} + 4 \text{ NH}_3 + \text{O}_2 )</td>
<td>( 4 \text{ N}_2 + 6 \text{ H}_2\text{O} )</td>
</tr>
<tr>
<td>for ( \text{NO}_2 )</td>
<td>( 6 \text{ NO}_2 + 8 \text{ NH}_3 + \text{O}_2 )</td>
<td>( 7 \text{ N}_2 + 12 \text{ H}_2\text{O} + \text{O}_2 )</td>
</tr>
</tbody>
</table>

#### NO\(_x\) reaction with urea \( (\text{NH}_2)_2\text{CO} \)

<table>
<thead>
<tr>
<th>Reaction Type</th>
<th>Reaction</th>
<th>Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>for ( \text{NO} )</td>
<td>( 4 \text{ NO} + 2 (\text{NH}_2)_2\text{CO} + 2 \text{H}_2\text{O} + \text{O}_2 )</td>
<td>( 4 \text{ N}_2 + 6 \text{ H}_2\text{O} + 2 \text{CO}_2 )</td>
</tr>
<tr>
<td>for ( \text{NO}_2 )</td>
<td>( 6 \text{ NO}_2 + 4 (\text{NH}_2)_2\text{CO} + 4 \text{H}_2\text{O} )</td>
<td>( 7 \text{ N}_2 + 12 \text{ H}_2\text{O} + 4 \text{CO}_2 )</td>
</tr>
</tbody>
</table>

#### SO\(_2\) secondary reaction

<table>
<thead>
<tr>
<th>Reaction</th>
<th>Equation</th>
<th>Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>( 2 \text{ SO}_2 + \text{O}_2 )</td>
<td>( \text{SO}_3 + \text{NH}_3 + \text{H}_2\text{O} )</td>
<td>( \text{NH}_4\text{HSO}_4 )</td>
</tr>
<tr>
<td>( \text{SO}_3 + 2 \text{ NH}_3 + \text{H}_2\text{O} )</td>
<td></td>
<td>( (\text{NH}_4)_2\text{SO}_2 )</td>
</tr>
</tbody>
</table>

#### CO reaction

<table>
<thead>
<tr>
<th>Reaction</th>
<th>Equation</th>
<th>Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>( 2 \text{ CO} + \text{O}_2 )</td>
<td>( \text{C}_m\text{H}_n + \text{O}_2 )</td>
<td>( \text{CO}_2 + \text{H}_2\text{O} )</td>
</tr>
</tbody>
</table>

#### C\(_m\)H\(_n\) reaction

<table>
<thead>
<tr>
<th>Reaction</th>
<th>Equation</th>
<th>Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \text{C}_m\text{H}_n )</td>
<td>( \text{CO} )</td>
<td>( \text{CO}_2 + \text{H}_2\text{O} )</td>
</tr>
</tbody>
</table>
The different methods

Reduction catalysts

**NO\textsubscript{x}**

The combustion in furnaces, motors and turbines generates large amounts of toxic nitrogen oxides (NO\textsubscript{x}), depending on temperature and fuel-bound nitrogen. With the help of a reduction solution in the form of monatomic nitrogen compounds (urea, ammonia) NO\textsubscript{x} can be converted (reduced) to harmless nitrogen and water vapor. For that purpose an urea solution is sprayed into the crude gas flow and thermolyzed to NH\textsubscript{3}. In the static mixer NO\textsubscript{x} is thoroughly mixed with the NH\textsubscript{3}. The reduction of NO\textsubscript{x} to N\textsubscript{2} and H\textsubscript{2}O occurs in the DeNO\textsubscript{x} catalyzer. Honeycomb catalysts made of homogenous ceramic base material with integrated active catalytic material are commonly used.

Oxidation catalysts

Flammable, partially toxic and odour-intensive waste gases can be burned (oxidized) by thermal or catalytic methods. A suitable catalyzer allows an almost complete combustion at significantly lower temperatures. The catalyst supports the chemical reaction of the gases without additives and without changing itself.

**CO/C\textsubscript{m}H\textsubscript{n}**

Additional by-products of combustion or other industrial processes, carbon monoxides (CO) and hydrocarbons (C\textsubscript{m}H\textsubscript{n}), are converted in the oxidation catalyzer. In the process CO is oxidized to CO\textsubscript{2} and the hydrocarbons burned to CO\textsubscript{2} and H\textsubscript{2}O. Honeycomb catalysts made of a ceramic base material with a coating of precious metal are commonly utilized.

Dioxin/furan

Primarily in the burning of residual waste, but also in process waste gases, frequently present annular hydrocarbons can form dioxins and furans when they combine with chlorine. In an oxidation catalyzer, made of homogenous ceramic base material with integrated active catalytic material, the highly toxic pollutants are split up into harmless constituents.

Fiber filter catalyzer

To precipitate the micro dust (soot) of combustion engines fiber cartridge filters are used. Due to the catalytic coating of the fibre the soot oxidizes at temperatures between 360 - 480 °C.
Precipitation of catalytic systems for boiler and engine units

<table>
<thead>
<tr>
<th>Fuel</th>
<th>NOx</th>
<th>CO</th>
<th>CmHn</th>
<th>Dioxin/Furan</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mg/Nm³</td>
<td>mg/Nm³</td>
<td>mg/Nm³</td>
<td>ng/Nm³</td>
</tr>
<tr>
<td>Heating oil, heavy</td>
<td>800</td>
<td>80</td>
<td>40</td>
<td>-</td>
</tr>
<tr>
<td>Heating oil, extra light</td>
<td>400</td>
<td>50</td>
<td>15</td>
<td>-</td>
</tr>
<tr>
<td>Natural gas</td>
<td>250</td>
<td>30</td>
<td>10</td>
<td>-</td>
</tr>
<tr>
<td>Wood, waste, old timber</td>
<td>500</td>
<td>35</td>
<td>1000</td>
<td>100</td>
</tr>
<tr>
<td>Residual waste incineration</td>
<td>200 - 4000</td>
<td>&lt;100</td>
<td>1000 - 5000</td>
<td>&lt;100</td>
</tr>
<tr>
<td>Diesel engine</td>
<td>2000 - 4000</td>
<td>&lt;100</td>
<td>800</td>
<td>&lt;100</td>
</tr>
<tr>
<td>Natural gas engine</td>
<td>800</td>
<td>&lt;100</td>
<td>1000</td>
<td>&lt;100</td>
</tr>
<tr>
<td>Efficiency</td>
<td>90 - 98%</td>
<td>92 - 98%</td>
<td>65 - 90%</td>
<td>80 - 95%</td>
</tr>
</tbody>
</table>

Temperature ranges
Our catalyzers are marked by
- low starting temperature and wide temperature range with the middle value indicating the optimum operating level.

- NOx: 250 - 300 - 500 °C
- Dioxin/Furan: 220 - 300 - 420 °C
- CO: 180 - 260 - 600 °C
- CmHn: 120 - x - 600 °C
- C: 360 - 420 - 480 °C

For hydrocarbons the optimum operating temperature depends strongly on the pollutant composition.

Advantage
- Urea is nontoxic, transportation and storage hold no risks
- NOX conversion rates of over 98% are possible
- No or neglectable reaction by-products such as nitrous oxide, hydrocyanic acid, isocyanic acid
- All furnaces can be upgraded with SCR catalysts
- Low MSR effort required
- Low ammonia slip

Applications
- Thermal power station
- Waste incineraters
- Waste wood incineration
- Explosives incineration
- Gas/Diesel engines
- Gas turbines
- Crematories
- Solvent disposal
- Chemical/pharmaceutical industry
- Textile/paint/varnish industry
- Stainless steel pickling plants
- Various process air purifications
- Thermal residue utilization
- Cogeneration systems
- Greenhouses

Modular construction
- The reactor casing is constructed of stainless steel in a modular system with integrated insulation
- This allows an individual line-up of components depending on type and concentration of pollutant
- Single and multi-stage catalyzer layout as required
- Adjustments to structural conditions possible any time
- Compact and economical construction possible

SCR catalyst technology
is characterized by
- long life span
- high quality standard
- simple operation
- high operating safety
- low maintenance effort
- low operating costs
- wide temperature range, 120-520°C, depending on pollutant
- high conversion rate of up to 98%
- low ammonia slip
- existing systems are easily upgraded
Examples of SCR technology

Catalytic reactor with 6 rows of catalyzers for pickling plant
DeNO_x catalyst unit for diesel engine 14,300 m^3/h
Catalytic convertor for NO_x, Dioxin, CO and HC behind incineration of explosives, 28,500 m^3/h
2 Dual-DeNO_x catalyzer units for heavy oil fired boiler, 56,000 m^3/h each
Dual-DeNO_x catalyzer unit for glass smelters 304,600 m^3/h
Control panel with PLC system and dosing unit
Top: electrical control unit with PLC
Bottom: dosing unit for compressed air and reactant
Environmental protection is a tradition at EWK Environmental Engineering. Our plants, proven throughout the world in decades of operation, are the best evidence.

With this experience we develop and offer innovative technologies.

- Plant design
- Engineering
- Production
- Assembly
- Commissioning
- Maintenance/service

for:
- Electrostatic precipitators
- Fabric type filters
- Wet absorber/scrubbers
- Catalytic gas cleaning systems
- Heat recovery systems
- Water cooling towers
- System combinations

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