

*Purification of exhaust gases
and waste liquids with
Ecopure[®]-VAR-Systems*

*Economic system solutions for the
chemical and pharmaceutical industry*



Exhaust gas purification with Ecopure®-VAR



Dürr Environmental Systems has developed a wide range of air purification (abatement) technologies under the trade name Ecopure® that are applied in many different industrial sectors. Ecopure®-VAR systems have proved efficient for the treatment of exhaust air in the chemical, petrochemical and pharmaceutical industry.

The know-how of Dürr Environmental Systems in the oxidation of exhaust gases and waste liquids (VAR) is based on many years of experience. The first Ecopure®-VAR system was commissioned for Hüls as far back as 1977.

Further systems for renowned customers such as BASF, Bayer and Ciba-Geigy followed. In the meantime Dürr Environmental Systems has supplied well over 2000 exhaust air and exhaust gas oxidiser systems.

Thanks to longstanding experience and consistent quality management according to DIN ISO 9001, Dürr Environmental Systems can offer competent solutions to customers' problems in compliance with the current or future legislation in individual countries.



Combustion chamber and steam boiler of a system for oxidation of CHCs

Problem to be solved

In the light of increasingly stringent limits (e.g. the Federal Immission Act 17.BImSchV in Germany or EPA (1990) in the UK), the safe and complete oxidation of exhaust gases and liquid residues requires special equipment that is characterised by a combination of different process measures. Besides the technical measures needed to ensure efficient combustion and safety to a high degree, increasing importance has to be attached to a high level of purity of the treated flue gas.

Suitable methods are applied for the removal of inorganic residual products such as halogenated compounds and sulphurous substances from the flue gas. If nitrogen compounds are contained in the exhaust gases or liquid residues, then several denox methods can be applied. For dioxin and furan removal there are also several possible methods. The Ecopure-VAR modular abatement system allows for the flexible combination of these methods.

Applications

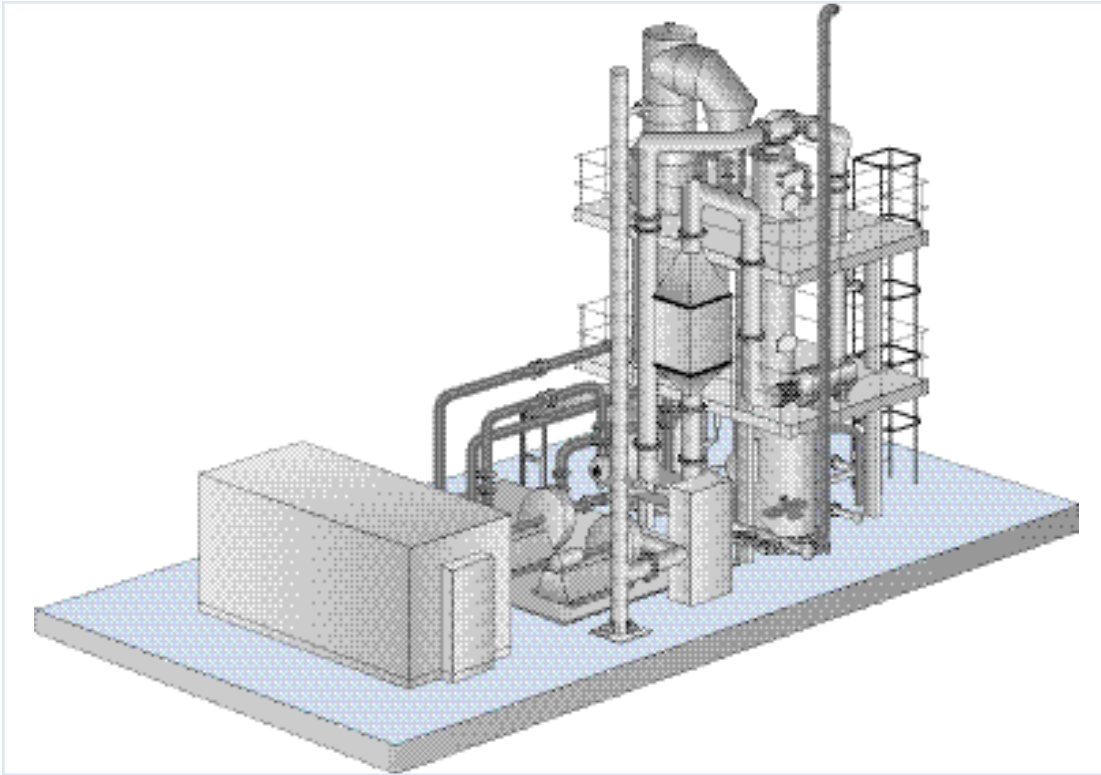
The following fluid streams can be treated with a VAR-unit:

- Exhaust gases with fluctuating flow rates and pollutant concentrations high enough to be within the explosive range
- Exhaust gases containing halogenated compounds, nitrogen, and sulphur. This group also includes all toxic and carcinogenic substances
- Exhaust gases with an oxygen content of 0 - 21 vol. %
- Residual liquids and waste solvents, plus waste water containing dissolved or emulsified organic and/or inorganic substances that are difficult to remove. Waste and residual liquids containing salts and/or a salt-binding substances.
- Exhaust gases burning only with a back-up flame, self-burning lean gases and self-burning rich gases



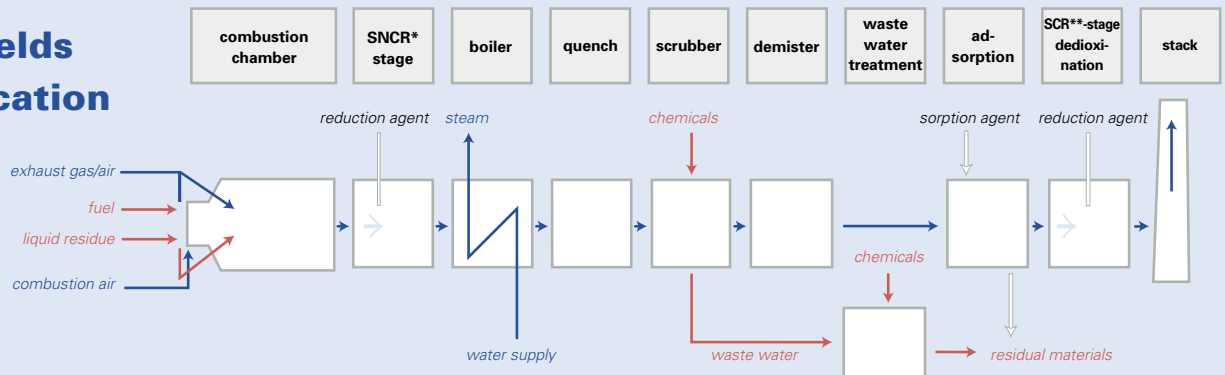
Turnkey system for purification of explosive exhaust gases

VAR - the possible combination of components



3 dimensional isometric VAR planning.

VAR - Fields of application



	combustion chamber	SNCR* stage	boiler	quench	scrubber	demister	waste water treatment	ad-sorption	SCR** stage dedioxination	stack
Organic solvents	X		X							
Halogenated compounds	X		X	X	X	X	X	X	X	
Compounds containing nitrogen	X	X	X							X
Sulphurous compounds	X		X	X	X	X	X	X		
Heavy metals, e.g. mercury	X		X	X	X	X	X	X		
Other liquids containing salts	X		X	X	X	X	X	X		
Liquids containing particles (ash)	X		X	X	X	X	X	X		

*SNCR = selective non-catalytic reduction

**SCR = selective catalytic reduction

The individual components of an Ecopure®-VAR system



View of a two-stage burner system

Burner system

The burner system consists of

- main burner
- possible additional injection or feed-in units such as lances
- complete regulation train and the MCR-package
- plus all auxiliaries such as pumps or combustion air fans.

The burner system must form a functional unit with the combustion chamber. There are 2 possible solutions:

The one-stage system

Here all fluids such as exhaust gases, residual and waste liquids, back-up fuel, injection air or steam and combustion air are fed into the burner flanged in the centre of the chamber's face end. The technology required here is to match the combustion air to the different combustibles, as these have different calorific values. Cooling of the flame must be avoided when low calorific substances are being treated by the VAR system.

As the regulation ranges of the individual fluids usually overlap each other, the burner is faced with a large overall regulation range. When the exhaust gases or liquids have a corrosive effect, then the high quality burner may be required to be manufactured from high quality materials. The advantage of a combustion pro-

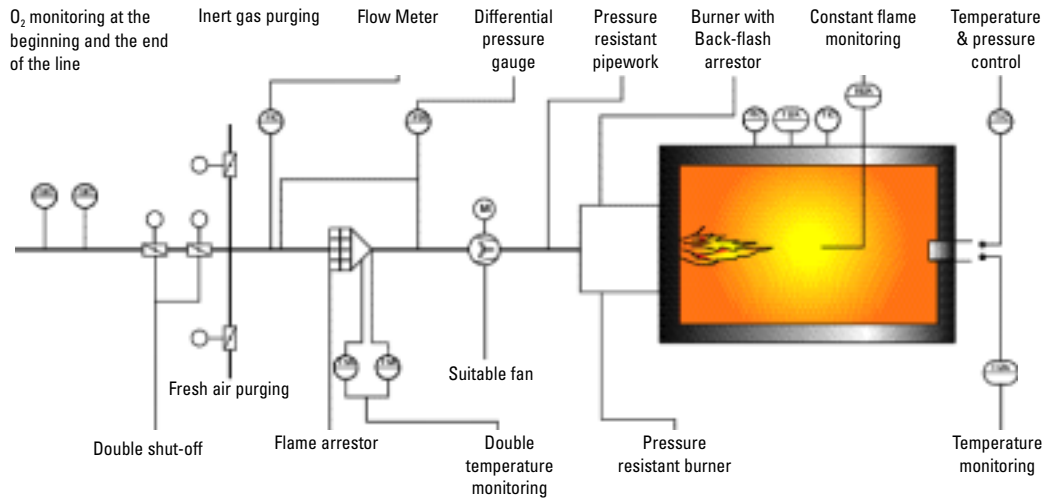
cess in one stage is that it only requires a very simple combustion chamber.

The two-stage system

If a primary and a secondary combustion and flame zone are required, the chamber must be provided with a "pre-combustion chamber". The primary burner is only required to be of simple design. A normal burner can be used as the primary burner.

The regulation range and the possible corrosive effects of the individual fluid stream no longer determine the design of the main burner. For injection into the secondary zone, tangential injection is often employed to ensure a good mixing effect with the flue gases from the primary section.

The decision has to be taken for every individual case as to whether combustion is to be one- or two-stage.



Example of a VAR-system for the combustion of explosive exhaust gas

Safety equipment

Here, mainly primary measures are necessary for protection against explosion, i.e. measures against the presence of explosive exhaust gases. If these measures are not feasible, then secondary anti-explosion measures have to be applied.

- Static arrestors (deflagration and detonation arrestors)
- Liquid-type arrestors
- Introduction of exhaust gases into the combustion chamber without backflash risks
- Analytic monitoring (by dilution with air or addition of an inert gas, the formation of an explosive gas mixture is avoided)

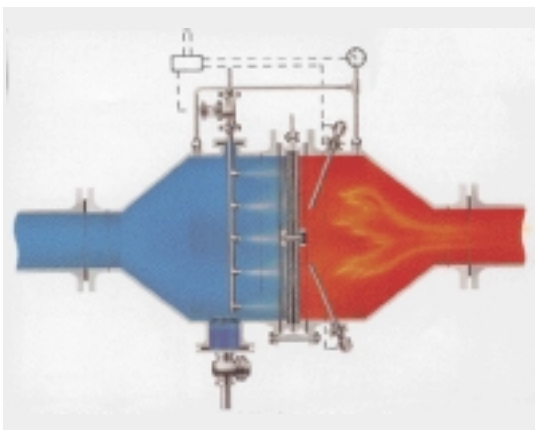
gas and low calorific value liquids are introduced into the flame in a turbulent manner with the flue gases of the primary zone. The secondary zone also consists of a mixing zone and a reaction zone. Directly after the flame there is still a high level of CO, that does not oxidise to CO₂ until it reaches the secondary reaction or final combustion zone. For this reason, VAR-units have to have long residence times (1 - 2 sec). This can be minimised by optimising the turbulence.

For all the described measures, further emergency measures have to be included in the process control system.

The selected combustion chamber temperature is normally between 900 - 1200°C, the upper range being suitable, for example, for chlorinated compounds. For simple exhaust gas problems, temperatures of 800°C are sufficient. Between 700 and 800°C the CO-content in the pure or flue gas drops drastically from a maximum to little more than 0. On the other hand, from 800°C upwards NO_x-formation increases more strongly. If no component in the exhaust gas or in the residue

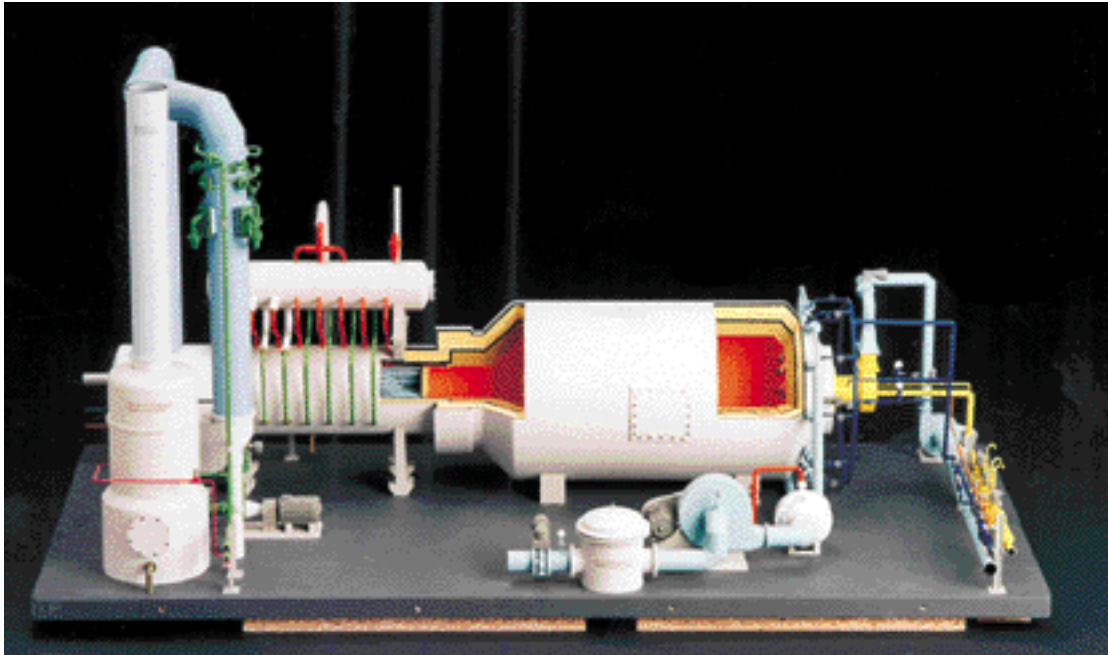
Combustion chamber

With a back-up flame and a rich gas or a residual liquid and/or waste liquid with a high calorific value, a primary flame zone as hot as possible is created in the front section of the chamber, directly before the burner. In the secondary zone the lean



Deflagration arrester

According to present state-of-the-art standards, the number of independent safety systems depends on the defined explosive zone. The following safety equipment is applied as anti-explosion protection between combustion chamber and the production plant from which source the exhaust gases to be treated:



Model of a VAR system with view inside combustion chamber

liquid dictates the operating temperatures, then the selected temperature usually represents a compromise between CO- and NOx-formation.

Flue gas cooler

The hot flue gases can be cooled by being passed through a heat exchanger allowing, in addition to the treatment of flue gases and liquids, energy costs to be saved. This is only possible when sufficient thermal energy is available which can be utilised in the form of steam, water, thermal oil or air. When these systems already exist as factory facilities, a parallel link to the factory network can be made, in order to complement the existing heat generators. Waste heat boilers or air/air heat exchangers are often used as flue gas coolers.

Flue gas quench / flue gas scrubber

If the flue gas contains non-combustible inorganic pollutants, such as HCl whose emission is also limited by law, an additional flue gas removal stage becomes necessary. In order to minimise the cost of this stage, the temperature of the flue gas is firstly lowered by evaporation cooling in a quench stage.

The flue gas scrubber stage or absorber units are often installed in several stages and utilise designs such as floor columns, packed bed towers or jet scrubbers. In many cases, the absorbed substance is neutralised directly in the scrubber tower. In order to reduce water loss, a water cascade system can be installed between the scrubber stages.

Besides the removal of pollutants with waste water, an integration of material recovery concepts is also possible in the secondary purification process. The possibilities to this effect

must be examined in each individual case. For example where acid substances are involved, the flue gas scrubber can be part of an acid recovery system.

Combustion chamber and fume tube boiler of a CHC oxidiser





Example of a flue gas scrubber downstream of a exhaust gas and liquid oxidiser system

Flue gas denox stage

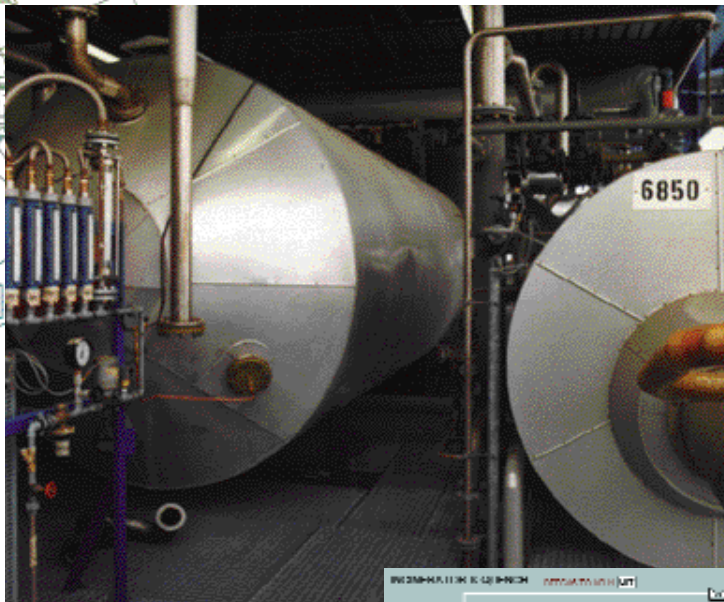
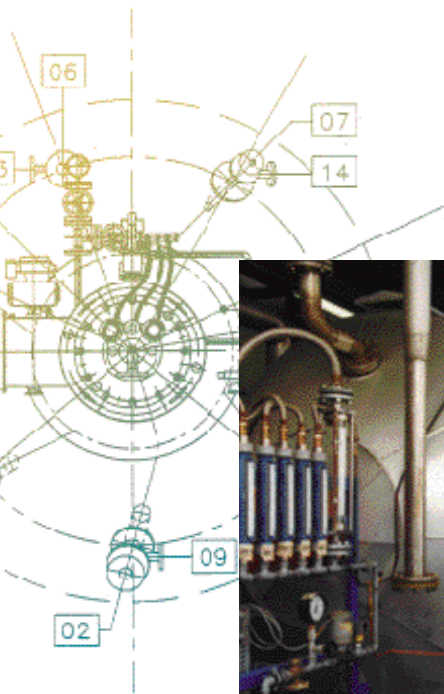
Two different methods are applied for reduction of nitrogen oxides from the combustion process.

Selective, non-catalytic reduction (SNCR)

This process operates without a catalyst between the temperature range of 850 - 1000°C. Ammonia or urea is injected into the flue gas between the combustion chamber outlet and the subsequent flue gas cooling stage. The advantage of SNCR is the low investment cost and low space requirement. The process is applied for low and medium nitrogen oxide loads.

Selective, catalytic reduction (SCR)

The advantage of catalytic reduction is the high removal efficiency which can be as much as 95%. By addition of ammonia, the nitrogen oxides are reduced to elementary nitrogen in the subsequent catalytic stage between the temperature range of 200 - 350°C. The so-called „low dust“ arrangement is applied here, where the SCR unit is installed subsequent to the flue gas scrubber. Via a heat transfer unit or with a regenerative gas pre-heater, the flue gas has, however, to be heated up again to the required reaction temperature.



Combustion chamber with SCR

and high availability of the system, important monitoring functions are automatically self checking. The process control system is capable of determining the flexibility of the system to adapt automatically and quickly to the fluctuations in quantity, load, and available amount of oxygen.

De-dioxination stage

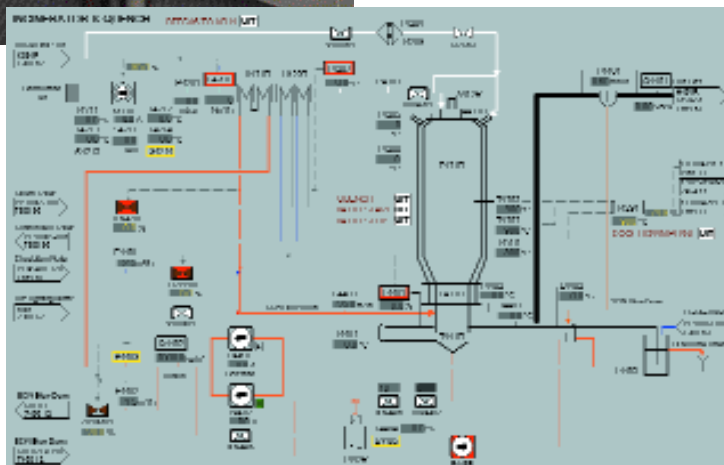
In order to achieve the PCDD/-PCDF emission limit reliably, the following processes can be applied:

Adsorber

The dioxins are adsorbed, such that the loaded adsorbent (e.g. activated carbon, open-hearth coke, porous plastic material) has to be treated in a further stage.

Catalytic destruction

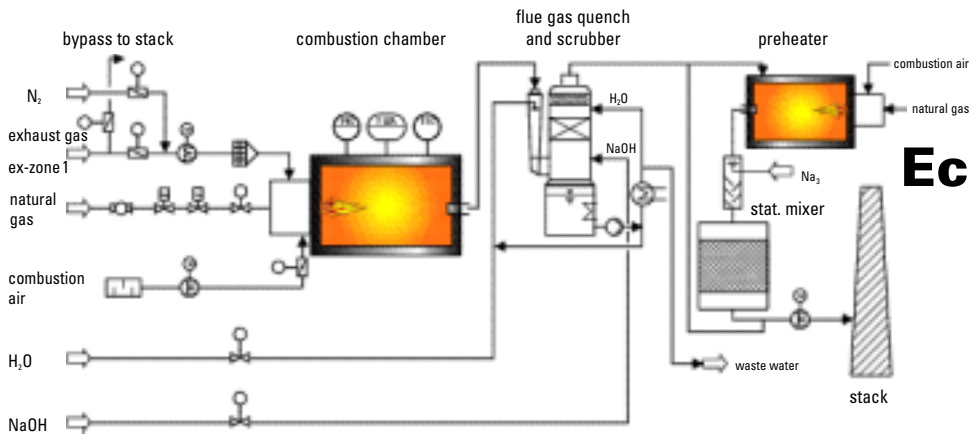
Catalysts are often used in conjunction with an SCR-denox stage. Catalytic destruction has the advantage of not producing a potential danger through the accumulation of PCDD/PCDF, and that no costly post-treatment (e.g. of contaminated adsorbent) is necessary.



Excerpt from a visual display screen

Process control system

Process control system elements such as the display of the individual process stages on a screen, and the programmed operator guide provide high operating convenience and high availability of the system. Complex regulating functions and logic functions require the use of more automated systems. For high demands



Ecopure®-VAR



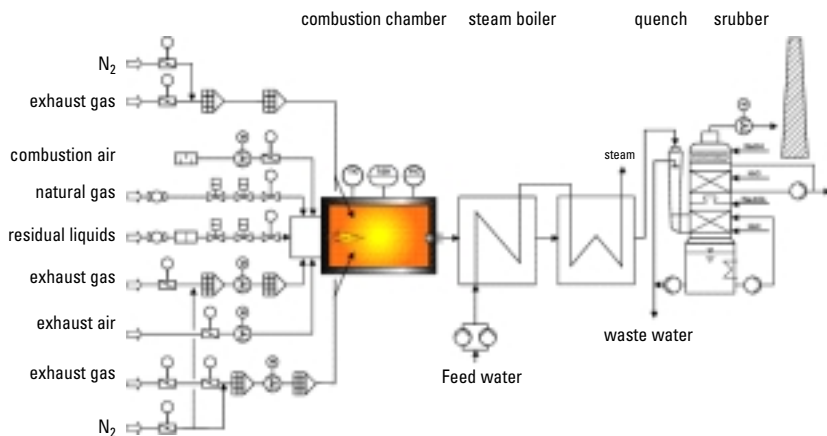
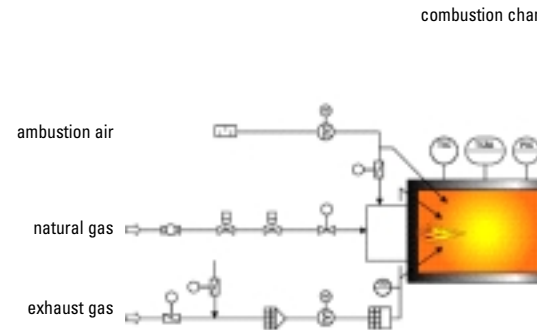
Location Germany, Frankfurt a.M.
Customer Clariant

Industrial branch: chemical industry
 Process: production of fluorinated aromated compounds
 Flue gas stream: 300 kg/h
 Pollutants: trichlorobenzene, dichlorofluorbenzene, methyl pyrrolidon, trifluorobenzene, chlorofluorobenzene, methyl fluoride, methyl chloride, nitrogen oxide
 Modules: turnkey system, combustion chamber with brickwork lining and burner, SCR (selective catalytic reduction), scrubber (selektive katalytische Reduktion), Wäscher
 Special features: combined SNCR/SCR
 Year of delivery: 2001



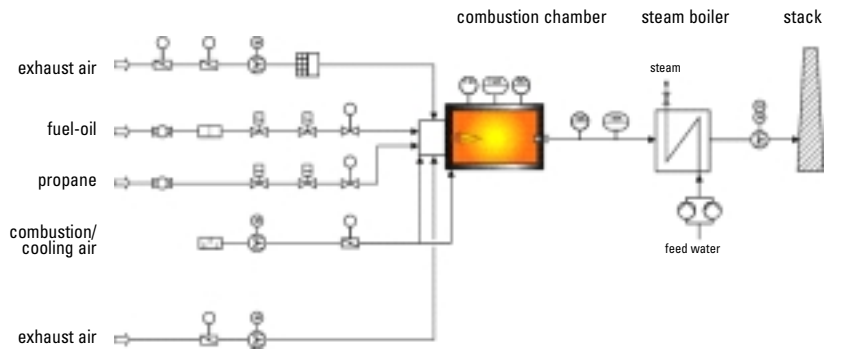
Location Germany, Ludwigshafen
Customer BASF

Production: Chemical industry
 Process: OC-system
 Exhaust stream: 6,000 Nm³/h
 Pollutants: halogenated hydrocarbons
 Flue gas stream: 8,000 Nm³/h
 Modules: combustion chamber with brickwork lining and burner, steam boiler, scrubber
 Year of commissioning: 1992

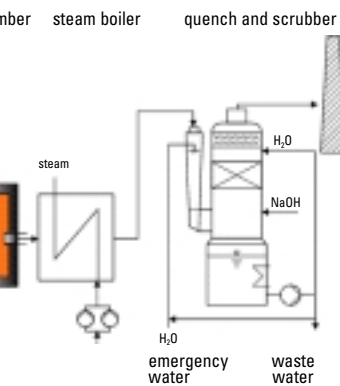


Location Switzerland, Basel
Customer Ciba Geigy

Production: Chemical industry
 Process: 2 production facilities with 180 reactors
 Exhaust streams: 5,500 Nm³/h (exhaust gas)
 Pollutants: acetone, isopropanole, toluene, cresole, et dichloro-benzol, methyl bromide, epoxy p acryl nitrile, dimethyl ether
 Flue gas stream: 7,300 Nm³/h
 Modules: air directing system with safety-equipmen combustion chamber, radiation boiler, jet venturi aerosol separator, control system
 Year of commissioning: 1991



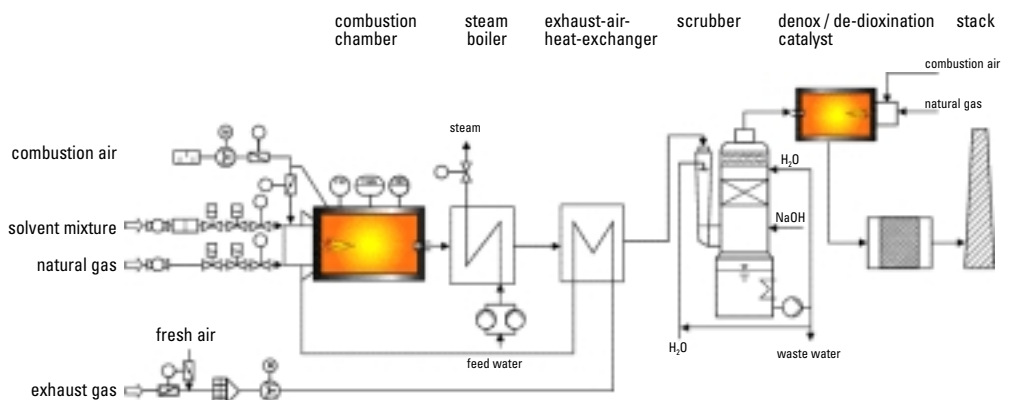
Location	Spain, Tarragona
Customer	Bayer
Production:	Chemical industry
Process:	plastic production
Exhaust streams:	5,450 Nm ³ /h
Pollutants:	200 kg/h
Residual liquids:	styrene, acryl nitrile, butadiene, sulphur gases, CHCs, sulphurous hydrocarbons
Flue gas stream:	9,000 Nm ³ /h
Modules:	turnkey project incl. construction work, combustion chamber, steam boiler, pipework, structural steelwork
Year of commissioning:	1993



methanol, acetic acid, propane, methanol,

burner, dual-fuel burner, quench, scrubber, MCR-system

Location	Austria, Linz
Customer	DSM Chemie Linz
Production:	pharmaceutical industry
Process:	pharmaceutical products
Exhaust gas and Residual liquids:	400 kg/h
Pollutants:	hydrogen, different chlorinated and bromated and sulphurous hydrocarbons
Flue gas stream:	25,000 Nm ³ /h
Modules:	Pipework with safety devices, multi-component burner, combustion chamber, steam boiler, quench with scrubber system, denox unit (SCR)
Year of commissioning:	1996



Environmental

The Dürr Environmental business unit is the innovative manufacturer of more than 2,000 air pollution control systems worldwide.

For more than 30 years Dürr's environmental technologies have formed the basis for ecological and economic emission reduction in a wide variety of branches of industry.

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