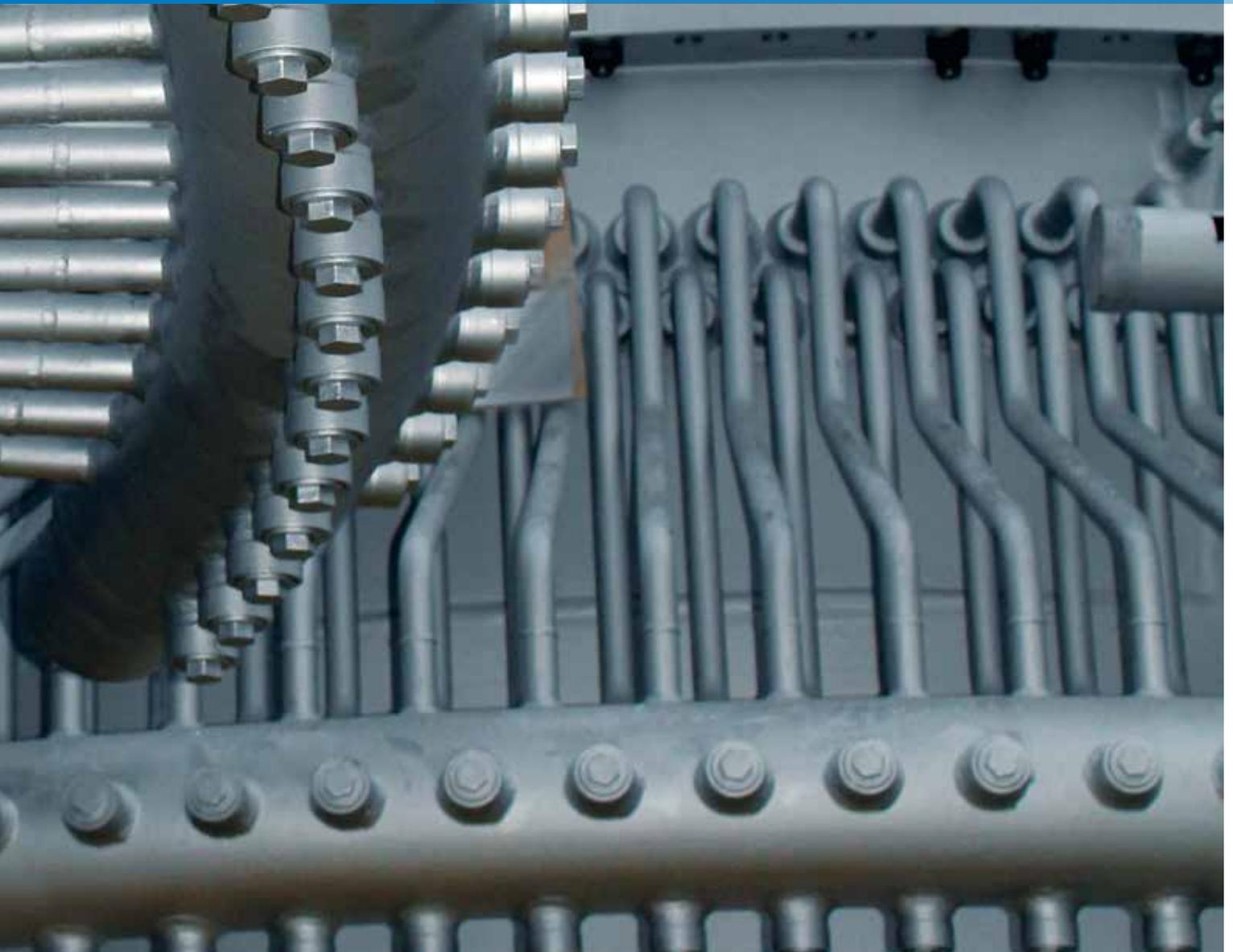


BORSIG

BORSIG
PROCESS HEAT
EXCHANGER
GMBH

WASTE HEAT BOILERS FOR NITRIC ACID, CAPROLACTAM AND FORMALDEHYDE PLANTS



ABOUT BORSIG PROCESS HEAT EXCHANGER GMBH

BORSIG Process Heat Exchanger GmbH, a member of the BORSIG Group, is the international leading manufacturer of pressure vessels and heat exchangers for cooling gases at very high temperatures (up to 1,500 °C) and high pressure (up to 35,000 kPa) for the chemical and petrochemical industries. These pressure vessels and heat exchangers are used for process stages in plants for the production of basic chemicals where they are installed directly at the downstream end of the cracking furnaces and/or reactors. BORSIG technology is also used in innovative coal gasification processes.

Our comprehensive know-how is based on more than 180 years of company history. The resulting competence, the perfectly trained specialists and our awareness of quality are the basis for the reliability of our products. This symbiosis is the source of our innovative power which is reflected by our unique manufacturing program.

State-of-the-art technology, excellent employees and innovative engineering allow us to always offer our customers the perfect solution. Our products and our service have made and still make us a competent and reliable partner to numerous companies across the world.

Our product range:

- Waste heat recovery systems (ammonia plants, methanol plants, hydrogen plants, coal gasification plants, gas-to-liquid plants, nitric acid plants, caprolactam plants, formaldehyde plants, partial oxidation of oil and gas)
- Transfer line exchangers in ethylene plants
- Scraped surface exchangers for lube oil plants and special applications

BORSIG linear quencher (BLW) for ethylene cracking



Process gas waste heat system



INTRODUCTION

Waste heat boilers with direct integrated reactors are used within the production process of nitric acid, caprolactam and formaldehyde.

The feed gas is transferred to the reactor and reacts at the installed catalysators to the intermediate or final product. The heat that develops/originates during this process is regained by the directly downstream waste heat boiler.



Wall tubing



Catalyst basket

Reactor/waste heat boiler for formaldehyde production

Installation of lower tubesheet for a fire-tube boiler



WASTE HEAT BOILERS DOWNSTREAM OF AMMONIA COMBUSTION IN NITRIC ACID AND CAPROLACTAM PLANTS

The catalytic oxidation of ammonia is a base reaction for the production of nitric acid as well as for the production of caprolactam. Thus the types of waste heat boilers as described in the following are used in both production processes.

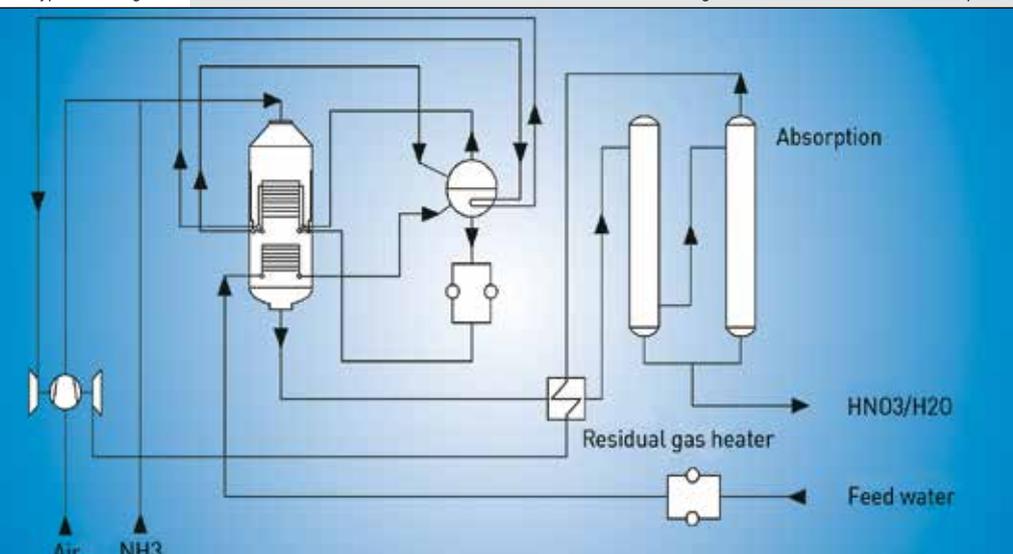
The catalyst used is a finely woven platinum gauze containing about 15% rhodium. The oxidation is an exothermic process heating the gas to a temperature around 900°C.

The process operates under a pressure of about 500 kPa. The heat of the process gas is recovered by cooling the gas down to 200°C, generating steam and superheating it. Superheated steam temperatures up to 500°C can be obtained. The steam pressures are usually between 4000 and 8000 kPa.

Various designs have been developed and built to cover a wide variety of applications. Main criteria for choosing the type of waste heat boiler are the gas throughput of the plant, the steam parameters required and the integration of the combustion elements into the process as a whole.

A summary of the main designs and special features is given on pages 4 and 5.

Typical arrangement of a waste heat boiler (illustrated as a water-tube boiler with integrated economizer in a nitric acid plant)



Burner head



WASTE HEAT BOILERS DOWNSTREAM OF DEHYDRATION OF METHANOL IN FORMALDEHYDE PLANTS

For the production of formaldehyde the dehydration of methanol to formaldehyde is the basic catalytic reaction. The general design of the corresponding waste heat boilers is similar to the boilers described for the nitric acid plants.

In this application silver gauzes are used as catalyst, the gas is heated to a temperature of 600° to 700°C.



Upper head for waste heat boiler for formaldehyde plants

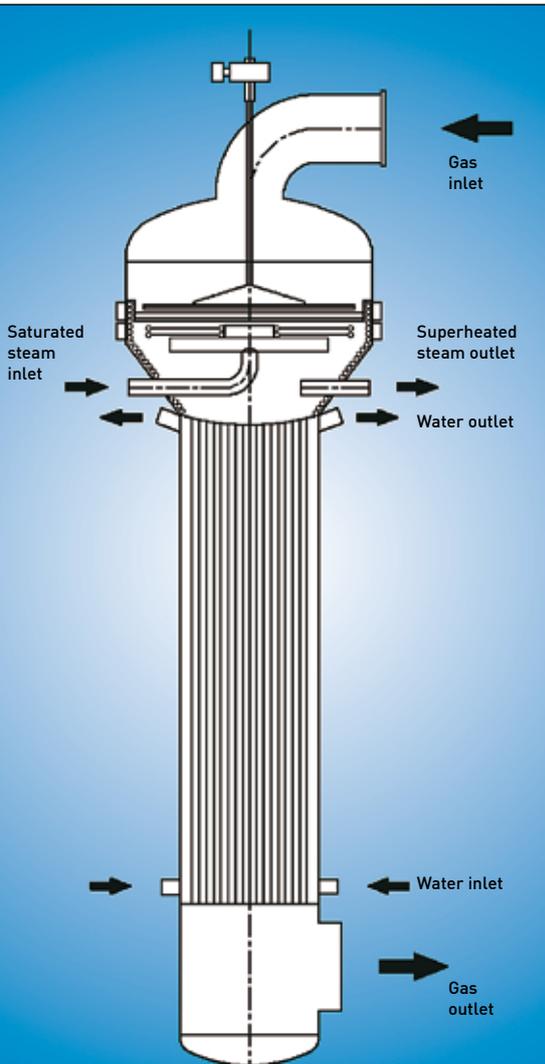
Final assembly of a LaMont type boiler



Waste heat boiler for a formaldehyde plant ready for shipment

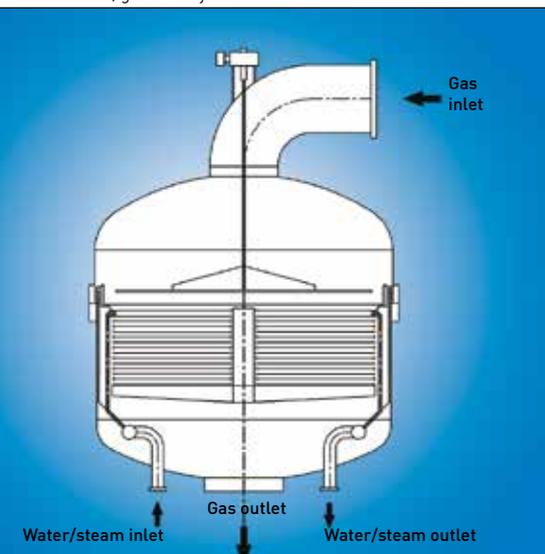


BASIC DESIGN



Fire-tube boiler with natural circulation, general layout

Water-tube boiler with internally located distributors and headers, general layout



Depending on the case of application and the capacity, two basic types can be selected for the design of the waste heat boiler:

1. Water-tube boiler with forced circulation (LaMont type)

The applied heating surface elements are bent coils and arranged in principle in the sequence superheater, evaporator and economizer as required. A so-called protective coil is arranged upstream of the superheater coils in order to reduce the temperature stress for the tube material of the superheater in the zone with the highest gas temperature.

Where large-scale plants are concerned, the economizer is also arranged outside of the waste heat boiler. The vessel wall is protected by means of the positioning a wall tubing ahead of the direct gas heat.

2. Fire-tube boiler with natural circulation

Whereas the fire-tube boilers are concerned, the evaporator is arranged as a bundle of parallel tubes. For the superheating of the resulting saturated steam, coil-shaped heating surface elements are also arranged above the fire-tube part.

For waste heat boilers in nitric acid plants it is also possible to integrate a tail gas reheater into the boilers depending on the process requirements.

Arrangement of coils/metal jacket for LaMont type WHB



SPECIAL FEATURES OF THE BORSIG DESIGN

Water-tube boilers

In recent years, a design with internally-located headers has established itself whereas the water-tube boilers are concerned. This is advantageous from the aspects of manufacturing because the vessel can be fabricated independently of the heating surfaces. When the unit goes into operation later, this arrangement allows an uncomplicated and time-saving replacement of a complete heating surface bundle.

In order to avoid sealing problems at the vessel flange, this is provided with a buffer seal gas connection which securely prevents an escape of ammonia to the surroundings. This form of sealing of the vessel flange is protected by patent.

The heating surface bundles have a metal jacket which serves to avoid unwanted bypass flows and, subsequently, allowances for the heating surface size.

The uniform circulation of the water through the evaporator heating surfaces is ensured by means of LaMont nozzles.

Fire-tube boilers

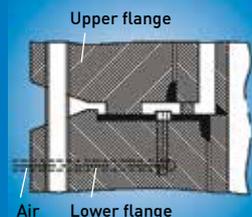
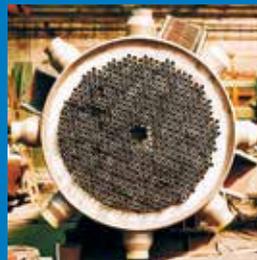
Whereas the fire-tube evaporators are concerned, a sufficient cooling of the upper tube plate is a crucial factor. This is provided with a central tube cooling for the purpose of preventing an accumulation of steam bubbles below the plate. Furthermore, the gas inlets are provided with ferrules in order to reduce the direct heat transfer to the tubesheet.

The material is selected for the water-tube as well as the fire-tube boilers in accordance with the requirements for corrosion protection.

Catalyst basket

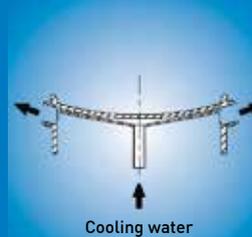
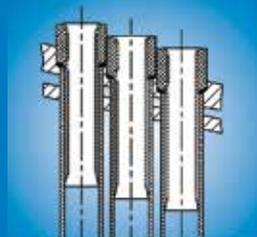


Upper tubesheet, protruding tubes



Buffer gas seal of the vessel flange

Ferrules with wire mesh for the inlet section of the fire-tubes



Central tube cooling of the upper tubesheet

EXECUTED PLANTS

Waste heat boilers for nitric acid, caprolactam and formaldehyde plants according to the design as described here have been in service for many years.

A detailed overview of the plants already in service is shown on a separate reference list. For many of these plants the scope of supply included also the steam drums and the connecting pipework in addition to the waste heat boiler itself.

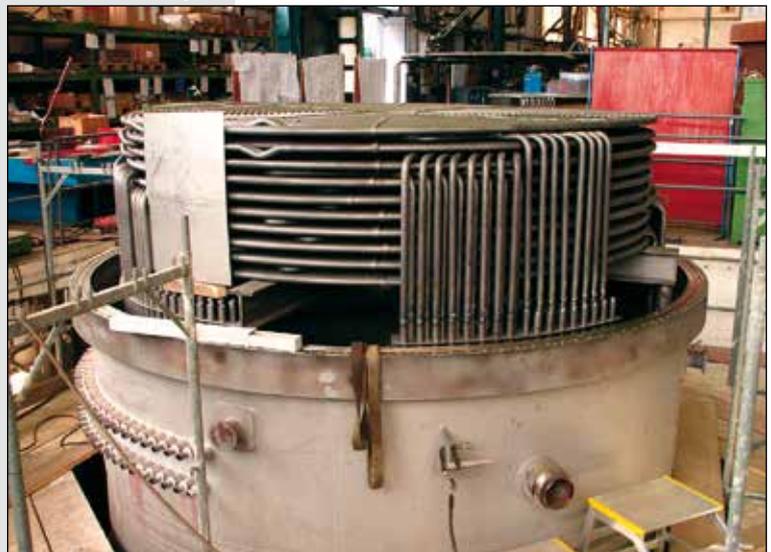
Especially for nitric acid or caprolactam plants, respectively, the spectrum with reference to operating parameters is very wide and lies within the range listed below:

Gas side	Pressure	bar]	up to 9
	Temperature	[°C]	up to 960
	Mass flow	[Nm³/h]	up to 184.000
Steam side	Pressure	[bar]	up to 72
	Temperature	[°C]	up to 500
	Mass flow	[kg/h]	up to 64.000

LaMont type waste heat boiler ready for transport



Installation of heating surface bundle



REPLACEMENT

BORSIG Process Heat Exchanger GmbH provides also the service of complete replacement jobs of waste heat boilers in nitric acid, caprolactam, formaldehyde, ammonia, methanol, hydrogen, ethylene and all other steam reforming plants.

BORSIG supervisors are specialized on replacement performances covering the detailed engineering, elaborating the shortest time frame, determining the logistic replacement sequence, mobilization of local personnel and complete supervision from shutdown to start-up of plant.



Completed metal shroud and tube bundle

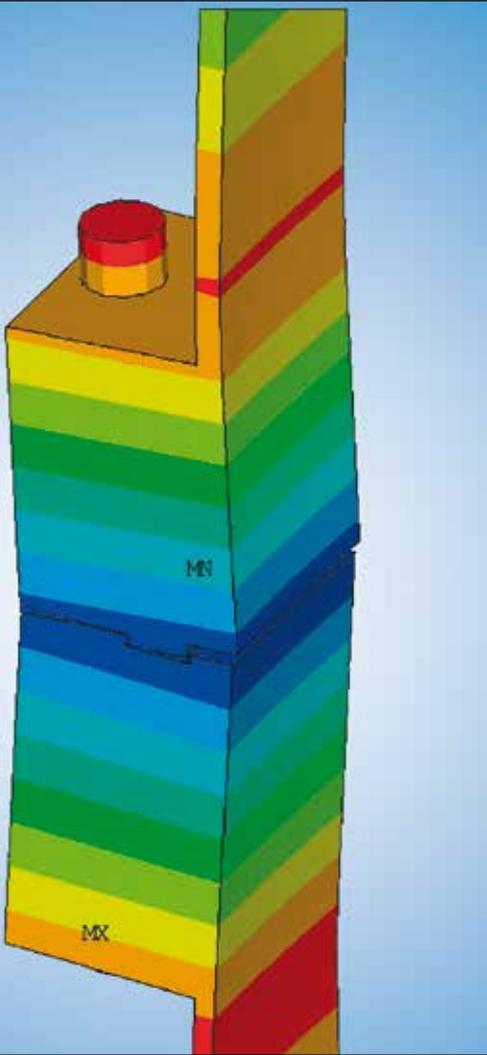
Inlet headers for LaMont waste heat boiler



Transport of a waste heat boiler for a formaldehyde plant



ENGINEERING AND MANUFACTURING FACILITIES



FEM calculation of a vessel flange connection

BORSIG Process Heat Exchanger GmbH has complete in-house engineering facilities. Thermal layout of heat exchangers and special heat transfer calculations are performed and checked with computer programs developed in-house. For highly complex tasks, the gas flow and heat transfer are calculated by means of three-dimensional CFD models (computational fluid dynamics).

The pressure vessels and heat exchangers are calculated with computer programs developed in-house and commercial software PROBAD or PVElite according to all national and international design standards:

ASME CODE Sections I and VIII (Div.1 & Div.2), ASME B31.1 and B31.3, AD-2000, TRD, EN 13445, PD 5500, CODAP, RTOD, IBR, JIS, Australian Standards, Russian Standards, China SQL and GB 150.

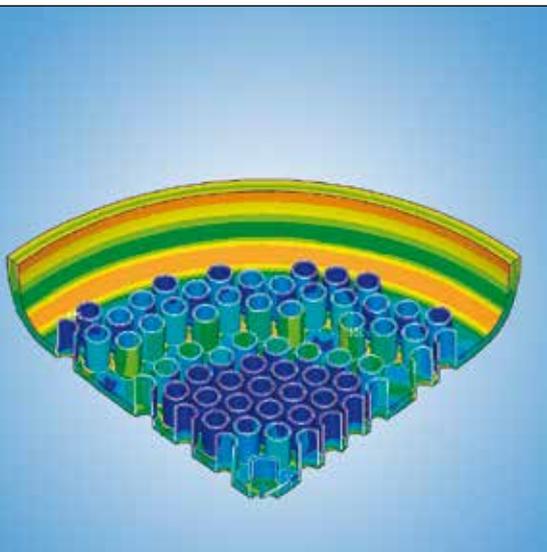
In the case of critical parts, Finite Element Analysis with software package ANSYS is carried out.

Flexibility, foundation loads and nozzle loads on interconnecting piping are calculated by software Rohr2 or CAESAR II.

BORSIG Process Heat Exchanger GmbH in Berlin owns more than 16,700 m² of indoor workshop facilities and is equipped with a 250 t crane capacity. High-tech welding technology is our core competence, such as the laser controlled welding seam guidance system for submerged narrow-gap welding, the use of robot welding systems for the GMAW welding process in the high pressure vessel manufacture, GMAW narrow gap robot systems with integrated 3D cutter systems plasma and autogenous, TIG hot wire welding, RES and SAW strip weld cladding, the automatic tube to tubesheet welding incl. inbore welding of up to 500 mm as well as qualified machining of all steel and nickel-based alloys.

The company has a direct water connection since 2008, the Borsig-Harbor, so that pressure vessels and heat exchangers of any overall size can be transported easily on the water way.

FEM calculation for a tubesheet of a fire-tube boiler



Tubesheet welding in the works area



QUALITY

Quality assurance and control activities are independent of the manufacturing process or product lines and guarantee that machined and handled materials, components, assemblies, products and service operations are executed in accordance with all specified requirements.

Quality assurance surveys the adherence to national and international specifications, statutory and contract provisions as well as the directives, standards and regulations stipulated by BORSIG Process Heat Exchanger GmbH.

In order to ensure even better interaction between quality, work safety and environmental management, the individual management systems were merged to form an Integrated Management System (IMS).

Certificates of the BORSIG Process Heat Exchanger GmbH (Extract):

- Quality Management DIN EN ISO 9001
- Environmental Management System DIN EN ISO 14001
- Occupational Safety SCC**
- ASME U, U2, R and S
- SQL licence for PR China (Pressure Vessels A1, A2)
- AD 2000 - Directives HP 0, TRD 201 and DIN EN ISO 3834-2 and DIN 18800-7, etc.

Installation of metal shroud



Waste heat boiler for formaldehyde ready for shipment



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