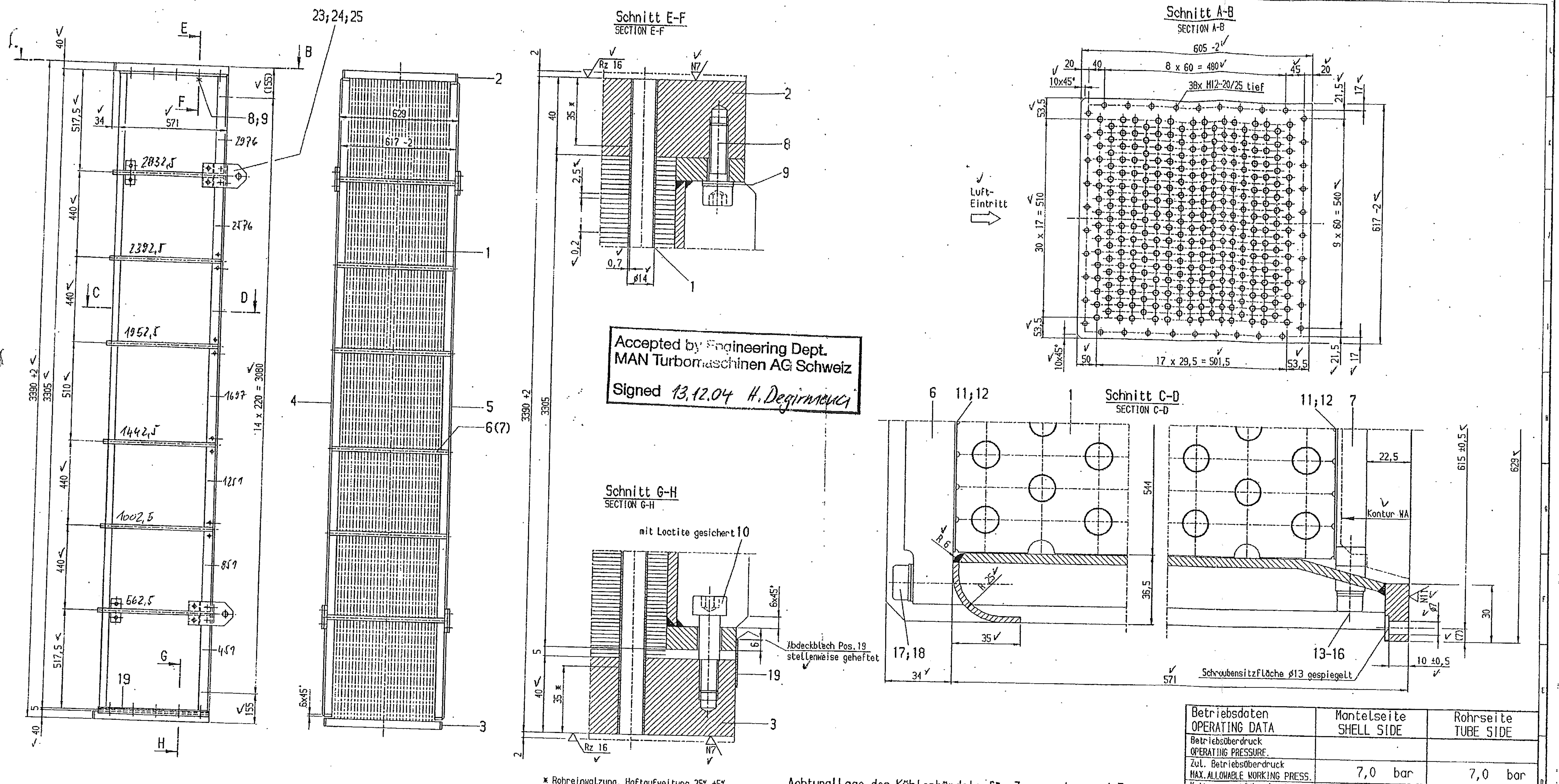


Accepted by Engineering Dept.
MAN Turbomaschinen AG Schweiz
Signed 13.12.04 H. Degirmenci

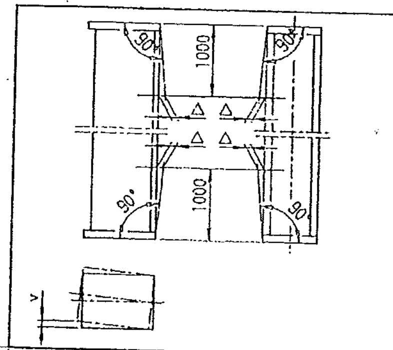
* Rohreinwalzung, Haftaufweitung 25% ±5%

Achtung! Lage des Kühlerbündels für Zusammenbau und Transport ist die Lufteintrittseite

Betriebsdaten OPERATING DATA	Mantelseite SHELL SIDE	Rohrseite TUBE SIDE
Betriebsüberdruck OPERATING PRESSURE		
Zul. Betriebsüberdruck MAX. ALLOWABLE WORKING PRESS.	7,0 bar	7,0 bar
Kaltwasserprüfüberdruck COLD WATER TEST GAUGE PRESS.		✓ 10,5 barg
Ein-und Austrittstemperatur INLET-OUTLET TEMPERATURE		
Zul. Betriebstemperatur MAX. ALLOWABLE WORKING TEMP.	135 °C	50 °C
Inhalt CONTENTS	l	120 l
Medium MEDIUM	Luft AIR	Kühlturmwasser COOLINGTOWER WATER

Einbaulage FIXATION	hängend VERTICAL
Austauschfläche SURFACE	669 m^2
Rohranzahl NUMBER OF TUBES	282 ✓
Gewicht WEIGHT	ca. 860 kg

GEA Auftr.-Nr.	MAN Best.-Nr.	Kennwort
27089/10	720511	Nanying 2004
29025/10	724915	Kosair 2004
29026/10	724916	Chengde 2004



Anforderungen an die Ausführung der Dichtflächen

1.) Planebenheit mit dem Lineal und über die Ecken mit dem H-Lineal messen. Maximal zulässige kurzwellige Abweichungen bis 0,05mm ; ✓ Langwelligkeit siehe Rechtwinkligkeit unter Pkt. 3.)

2.) Vorgeschriebene Oberflächenbeschaffenheit = N7 und max. zulässige Rauhtiefe R_t = 16µm ✓

3.) Max. zulässige Rechtwinkligkeit der Dichtflächen zum Rohrbündel △ = 0,5mm Abweichung pro Meter, vom Rohrboden aus mit einem Winkel ✓ von mindestens 1m Schenkellänge gemessen

4.) Max. zulässige Verwindung des Kühlerbündels ✓ v = 0,5mm pro Meter Kühlerlänge

REQUIREMENTS ON THE DESIGN OF SEALING SURFACES

1) PLANENESS TO BE MEASURED BY MEANS OF A STRAIGHTEDGE AND ABOVE THE CORNERS BY MEANS OF A SPECIAL FINE STRAIGHTEDGE. MAX. ALLOWABLE SHORT-WAVE DEVIATIONS UP TO 0,05mm ; LONG-WAVE LENGTH SEE RECTANGULARITY POINT 3)

2) PRESCRIBED SURFACE FINISH = N7 AND MAX. ALLOWABLE PEAK-TO-VALLEY HEIGHT R_t = 16µm

3) MAX. ALLOWABLE RECTANGULARITY OF SEALING SURFACES TO THE TUBE BUNDLE △ = 0,5mm TOLERANCE PER METER MEASURED FROM TUBE SHEET WITH AN ANGLE OF A MIN. LEG LENGTH OF 1m

4) MAX. ALLOWABLE TWISTING OF COOLER BUNDLE v = 0,5mm PER METER OF COOLER LENGTH

Rev.	Änderung / Modification	Name	Date	Gepr. / Chk
5				
4				
3				
2				
1	neuer Auftrag 29025 und 29026	Kleib.	11.04	Krauss

2004	Tag / Date	Name		
Gez. Prep.	07.06.	Kleib.	A.-Nr. Order No.	siehe Tabelle
Gepr. Chk.	08.06.	Maney	Besteller Customer	MAN Turbomaschinen AG
Gen. Appr.	08.06.	Krauss	Kennwort Code	siehe Tabelle
			Material Nr.	10083002

GEA Maschinenkühltechnik GmbH
Unternehmensbereich Wärmetechnik

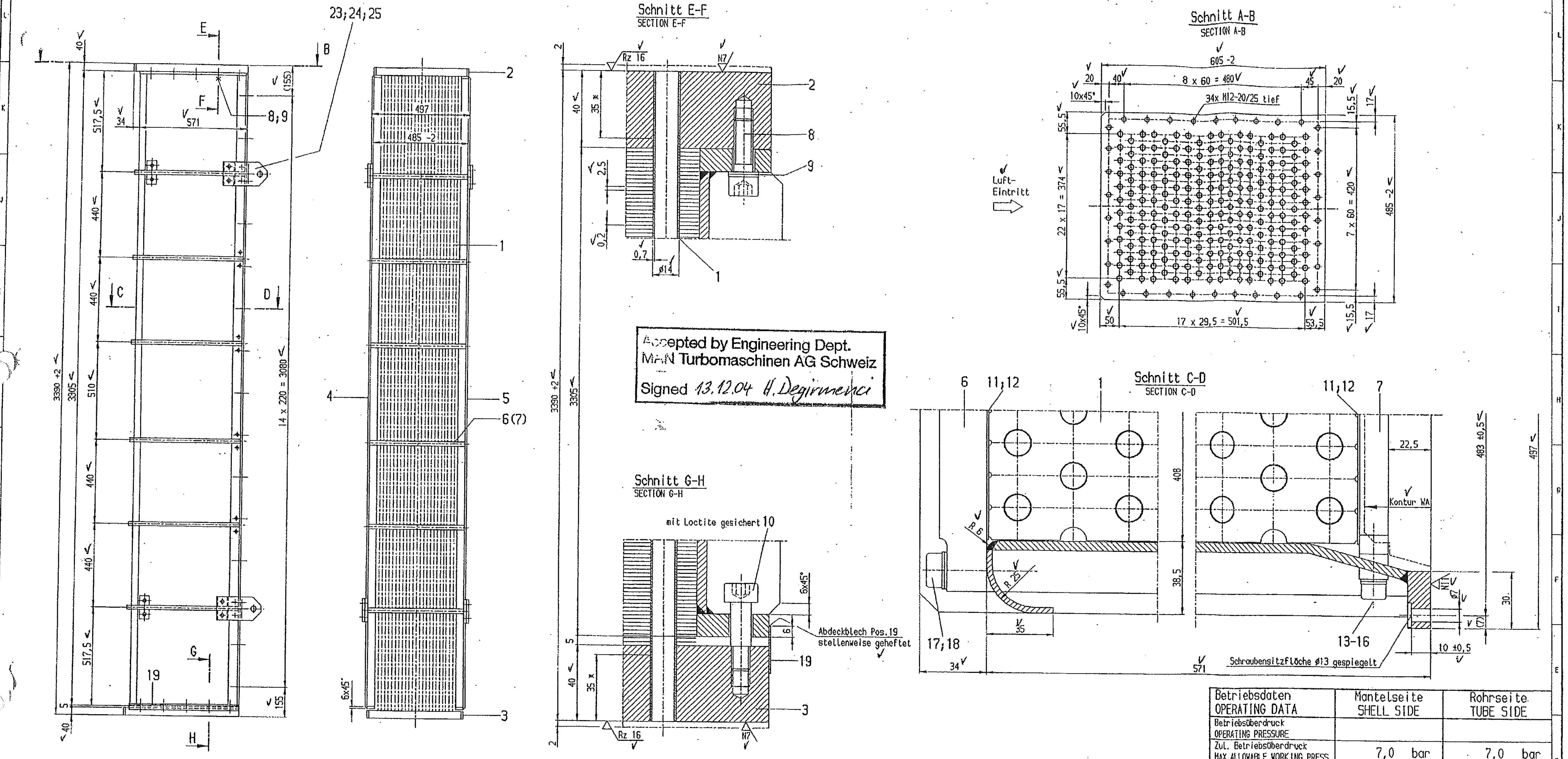
Kühlerbündel RIK 80/1.Stufe

COOLER BUNDLE RIK 80/STAGE 1 ✓

Typ: 16-15/3300-18L-S141-34S253 ✓

Maßstab / Scale: 1:10, 1:5, 1:1

GEA-Zeichn.Nr. / GEA-Drwg.No.: WED10000039557 — Rev. 1

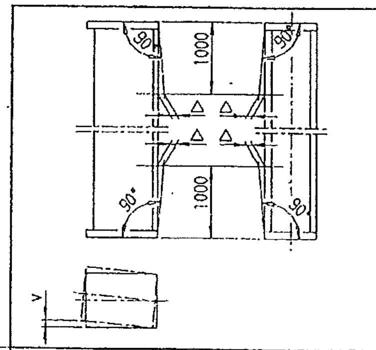


* Rohreinwalzung, Haftaufweitung 25% ±5%

Achtung! Lage des Kühlerbündels für Zusammenbau und Transport ist die Lufteintrittseite

Betriebsdaten OPERATING DATA	Mantelseite SHELL SIDE	Rohrseite TUBE SIDE
Betriebsüberdruck OPERATING PRESSURE		
Zul. Betriebsüberdruck MAX.ALLOWABLE WORKING PRESS.	7,0 bar	7,0 bar
Kaltwasserprüfüberdruck COLD WATER TEST GAUGE PRESS.		10,5 barg
Ein-und Austrittstemperatur INLET-OUTLET TEMPERATURE		
Zul. Betriebstemperatur MAX.ALLOWABLE WORKING TEMP.	135 °C	50 °C
Inhalt CONTENTS	l	90 l
Medium MEDIUM	Luft AIR	Kühlturmwasser COOLINGTOWER WATER

Einbaulage FIXATION	hängend VERTICAL
Austauschfläche SURFACE	498 m²
Rohranzahl NUMBER OF TUBES	210
Gewicht WEIGHT	ca.720 kg



Anforderungen an die Ausführung der Dichtflächen

1.) Planebenheit mit dem Lineal und über die Ecken mit dem H-Lineal messen. Maximal zulässige kurzwellige Abweichungen bis 0,05mm ; Langwelligkeit siehe Rechtwinkligkeit unter Pkt. 3.)

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4) MAX. ALLOWABLE TWISTING OF COOLER BUNDLE v = 0.5mm PER METER OF COOLER LENGTH

Rev.	Änderung / Modification	Name	Date	Gepr. / Chk
5				
4				
3				
2				
1				

2004	Tag Date	Name	
			Material Nr. 10036392
Gez. Prep.	05.11.	Kleib.	A.-Nr. Order No. 29025/20 29026/20
Gepr. Chk.			Customer Code MAN Turbomaschinen AG
Gen. Appr.	30-40	Krauss	Kennwort Code Kosoir 2004 Chengde 2004
			MAN Best.-Nr. 724915/724916

GEA Maschinenkühltechnik GmbH
Unternehmensbereich Wärmetechnik

Benennung	Maßstab Scale	GEA-Zeichn.Nr. / GEA-Drwg.No.	Rev.
Kühlerbündel RIK 80/2.+3.Stufe COOLER BUNDLE RIK 80/STAGE 2+3 Typ: 12-11/3300-18L-5141-34S253	1:10 1:5 1:1	WED10000042332	0

DESCRIPTION, SERVICE AND MAINTENANCE MANUAL

Object:	Pressure Gas Cooler
Project:	Name Location
Customer Purch.-Ord.-No.:	xxx
Manufacturer:	GEA Maschinenkühltechnik GmbH Postfach (P. O. Box) 230 165 D-44638 Herne
Manufacturer Order No.:	xxxxx

Table of Contents

1. General

The GEA Pressure Gas Cooler is a fin tube heat exchanger. The hot gas overflows the finned surface of the heat exchanger bundle. By that the heat is exchanged to the coolant flowing through the tubes.

The core tubes are connected to the tube plates either by rolling-in or welding so that the gas-side and the coolant-side are separated air-tight.

To stabilize the heat exchanger bundle as well as to direct the gas the cooler is equipped with partition and side walls. These walls are bolted to the spacers resp. to the tube plates.

At either end of the heat exchanger bundle there are headers. One of them is equipped with one inlet and one outlet nozzle, the other one is designed as coolant return header. A various number of coolant passes can be realized by inserting the corresponding numbers of partition plates. The headers are bolted to the tube plates and gaskets are used for tightening. Furthermore the headers have vent and drain nozzles which are closed by plugs at delivery. When the pressure gas cooler is installed at site it has to be connected in that way, that the gas and the water are flowing according to the countercurrent principle.

The cooler can be installed in horizontal or vertical position.

ATTENTION

Welding on pressurized parts of the cooler is strictly prohibited! For all welding works please contact GEA! For damages caused by improper handling, operation or maintenance the manufacturer will not take over any responsibility!

The cooler shall be operated constantly and the maximum thermal load in accordance with the attached data sheet shall not be exceeded.

2. Installation and De-Installation of the Cooler

Prior to first installation, the transport covers have to be removed from the gas connection flanges and the water connection flanges. The air and water side sealing faces must be cleaned by use of turpentine to remove the corrosion inhibitor.

The gas side connections have to be bolted to the gas ducts using gaskets provided by the customer. Also the water side connections have to be bolted to the water manifold system using gaskets provided by the customer.

To avoid deformation and inadmissible stress to the cooler the connecting surfaces have to be in parallel and the tolerances have to be kept precisely.

Transports lugs are provided on the side walls for lifting and handling of the cooler. The pressure vessel is equipped with lugs or posts for easy handling.

Prior to dismantling, the cooler has to be drained on the water side. For doing so, the shut-off device of the feed piping has to be closed. If cooler installation enables draining through the drain piping the vent screw needs to be removed only. If draining cannot be done through the drain piping the shut-off device of the drain piping must be removed, too, and prior to removal of the drain and vent screws.

After removal of the connecting bolts the cooler can be dismounted.

Re-installation has to be done by using new gaskets as described above.

3. Commissioning

Prior to delivery the cooler has been tested hydraulically to be tight in the manufacturer's workshop. However, it is recommended to carry out a test with the specified test pressure before installing the cooler.

After long-term storage (≥ 3 month) as well as after extended standstill all header bolts have to be tightened again. The cooler has to be checked for leaks by carrying out a pressure test with the specified test pressure. In case of leaks the gaskets shall be replaced.

When the assembly of the cooler is completed the unit has to be filled with cooling water. The water pressure shall be limited to the minimum but to ensure proper operation of the cooler.

For cooler venting, the vent plugs at the headers have to be removed. They have to be refitted after the gas has been evacuated from the cooler completely. Venting should be repeated shortly after the cooler has been put into operation. However, venting of the entire cooling system is recommended rather than venting of the cooler only and therefore should be made preferably.

If the cooler comprises more than one (1) heat exchanger bundle each bundle must be vented separately.

After a leak test has been carried out on all plant components and the water flow has been found unobjectionable the cooler can be put into operation on the gas side.

Upon turning up the cooler to nominal load the gas temperature should be checked before and behind the cooler and the cooling water flow set to the specified value.

4. Cooling Water Velocity

The following water velocities shall be observed when setting the cooling water flow:

Material (Tubes)	ASTM	Min.Velocity*	Max. Velocity
CuZn28Sn (B-111C)	(B-111C44300)	1.0 m/s	2.0 m/s
CuZn20Al (SoMs769	(B-111C68700)	1.0 m/s	2.2 m/s
CuNi30Fe (CuNi70/30)	(B-111C71500)	1.0 m/s	2.5 m/s
CuNi10Fe (CuNi 90/10)	(B-111C70600)	1.0 m/s	2.2 m/s
Cu	(B-111C12200)	1.0 m/s	2.0 m/s
Steel	(A-179)	1.0 m/s	2.5 m/s

* Never operate at min. velocity for a prolonged period of time.
The nominal water flow should be maintained.

For corrosion protection it is vital that a protective layer is build-up on the water touched side of the cooler. Frequent variation of the water velocity prevents the building-up of such protective layer.
Furthermore the water velocity does not have to be kept too low, as deposits of soils would be built up.
A too high water velocity would cause erosion.
By throttling of the water flow or improper positioning of the water intake gas bubbles may form and favour corrosion. To keep the water flow (resp. the water velocity) constant also during part-load operation, control devices should be installed. Gas accumulations, if any, should be remedied by venting as per para. 3. above.

The use of a by-pass control system is suitable to fulfil these requirements. Bypassing can be done in such a way that the discharged hot cooling water is mixed with the cold water at the suction side of the pump to assure operation at almost constant gas outlet temperature. Consequently, the feed temperature of the cooling water can be controlled and the water flow resp. cooling water velocity maintaines constant in the cooler.

5. Building-up of a water side protective layer

The inherent good chemical corrosion resistance of copper alloys is due to their ability to form a resistant natural protective film.

New cooler tubes that do not have an inner protective layer yet should never be taken into operation using contaminated water, as deposits on the material surface would prevent the building-up of such protective film.

For the above reason clean fresh water is always used for the hydraulic test of the coolers. The use of contaminated water, aggressive water or water low in oxygen should also be avoided during test runs.

It is recommended to add small quantities of easily soluble ferrous sulphate ($FeSo_4 7H_2O$) to the cooling water during test runs to make sure that a good protective layer is formed. It is efficient to add about 5g/m³ cooling water during a period of 1 hour within every 24 hours. Adding of ferrous sulphate should, if possible, be repeated during normal operation until the first inspection is carried out.

An appropriate valve for adding ferrous sulphate should be provided in the piping close to the water inlet nozzle of the cooler.

<u>Start up of Cooling water-side for Building-up a Protective Layer</u>

Start-up period 2 months continuously with 1.0 to 2.0 m/s water velocity.

Deposits on the tube - inside shall be avoided as they can cause corrosion or erosion.

6. Standstill

For cooler parts made of copper and copper alloys as well as of steel and cast iron, standstill may cause damages especially as long as no protective layer is built up. On the other hand products of putrefaction such as ammonium compounds and hydrogen sulphide that can result from deposits of soil can cause corrosion underneath such deposits.

If possible, cooler operation should not be interrupted during the first 2 months after commissioning. In the case of an engine standstill, i.e. there is no water supply to the cooler, that does not take time more than 3 days, the cooler does not have to be drained if it is operated again for a longer period of time (min. 2 weeks).

Nevertheless it has to be secured, that the tubes are free from deposits. If deposits have formed the cooler has to be cleaned and flushed with clean water prior to being dried. For drying it is recommended to blow warm or dry gas through the tubes. The cooler has to be vented adequately. If the cooler is operated with sea water, brackish or saline water chloride content > 500 mg/l) water of low salinity (drinking-water quality) should be used for flushing.

In case of standstills for more than 3 days within the start-up period of 2 months and the same time deposits are likely, the cooler shall be drained, flushed and dried.

To avoid standstill corrosion after the start-up period of 2 months and in case of standstills lasting 2 weeks or more, the above described cleaning procedure shall be repeated.

In case of permanent service interruptions after the start-up period it may be necessary to limit the standstills (cooler kept undrained) to 3 days and operate the unit under conditions as recommended for the start-up period.

In the case of a short standstill the cooler should be fed with water at low velocity rather than to stop the cooling water flow. This will help to avoid putrefaction products such as ammonium compounds and hydrogen sulphide getting in contact with parts of the cooler.

At standstill in winter under frost conditions the cooler has to be drained in any case to prevent deformation or heavy damages.

7. Operation Control and Performance Test

For operation control, thermometers have to be installed in the gas ducts and in the cooling water piping before and behind the cooler. It is recommended to keep records of the gas and water temperature in the machine log book periodically. Further control instruments can be provided if required.

The guarantee point of thermal power is defined as the temperature difference between cold water and cold gas under nominal operation conditions.

This temperature difference should be checked from time to time.

A considerable increase of the guaranteed temperature difference after a longer time of normal operation might be due to air accumulation in the cooler. To remedy this effect the cooler has to be vented in accordance with the procedure described in para. 3.

Should the above measure not lead to the nominal thermal performance and is no other failure noted the same time the cooler has to be cleaned.

The water side differential pressure can be considered as an indication for cooler cleaning to be necessary. It is recommended to install differential pressure gauges in the water piping before and behind the cooler. After commissioning of the cooler, the differential pressure has to be measured and recorded. From time to time the measured value is to be compared with the originally specified value. Cooler cleaning becomes necessary when the differential pressure increases significantly.

8. Cleaning

8.1 General

To achieve a long lasting operation period free from failures the cooler inner and outer heat exchanger surfaces have to be cleaned periodically. For cleaning the cooler has to be taken out of operation.

The necessary cleaning intervals are subject to the water quality the cooler is operated with as well as the operation mode.

Cleaning of the water side is not only required to maintain the thermal performance of the cooler but also to prevent pitting corrosion caused by the building-up of deposits of soil. On the other hand do deposits of soil increase the water velocity and hence erosion would occur.

For the above reasons, the cooler parts in contact with water shall be checked for corrosion damage regularly, but not later than 1 year after putting into operation.

Cleaning can be done mechanically, hydraulically or with chemical detergents.

8.2 Mechanical Cleaning (Tube inside)

Mechanical cleaning is done by use of nylon brushes fitted to a rod. The brush with rod is part of the cooler supply. Mechanical cleaning can be done when the cooler is installed or de-installed as well. For cleaning at least one of the headers has to be removed. For header removal the fastening bolts need to be removed and the water connections have to be taken off eventually. To withdraw the headers bolts have to be inserted into the special withdrawal holes at the header frame. The header bolts can be used for that as the size of the withdrawal holes is identical to those in the header frame.

The wet tubes have to be thoroughly cleaned by use of the brush and the dirt has to be flushed until no residues are left. After cleaning is completed the headers have to be refitted using new gaskets.

When re-commissioning the cooler, please proceed as per para. 3. above.

8.3 Hydraulic Cleaning

For hydraulic cleaning the cooler has to be de-installed. A high pressure jet with special nozzles is used to remove dirt out of the tubes.

Hydraulic cleaning of the cooler outside has to be done very carefully. A certain distance to the finned surface has to be kept not to damage the fins. Furthermore the water jet has to be directed strictly in parallel to the fins.

8.4 Chemical Cleaning

Chemical cleaning of the de-installed cooler can be done if neither mechanical nor hydraulic cleaning proved successful.

The entire cooler (with headers) has to be connected to an external cleaning circuit via special flanges or it has to be filled with a detergent on the water side. The cleaning time depends of the degree of contamination. Cleaning must be done again if the result is still not satisfying after one cleaning cycle.

The following detergents are recommended for use.

Detergent	Manufacturer
P3-T288	Henkel KGaA; Düsseldorf
SAF-ACID	DREW AMEROID GmbH, Hamburg
VECOM BA-S	VECOM GmbH, Hamburg

The instructions and handling guidelines provided by the detergent manufacturer always have to be observed when using the chemical.

Also scaling deposits in the cooling tubes can be removed by chemical cleaning. For removal, a 10 % HCL-acid is used and an abt. 0.5 % inhibitor (specifically suitable for the individual tube material) is added. The outside of the tubes can be cleaned with the same media by jetting or flushing. After cleaning as above, the cooler shall be flushed thoroughly, i.e. no detergent residues are allowed to be left in the cooler. This is absolutely necessary in case the cooler will not be re-commissioned immediately after cleaning. Normal cooling water can be used for flushing.

Re-commissioning shall be done as per para. 3. above.

9. Identifying and repairing of leaks

9.1 General

Tube leaks can be caused by corrosion, erosion or improper operation of the cooler.

If a leakage is observed, the defective tube must be identified. If this cannot be done by a visual inspection, a pressure test of the cooler or an individual pressure test of each tube has to be carried out. If there is ample space around the cooler and the gas side can be inspected visually the cooler does not need to be de-installed.

9.2 Pressure test of single tubes

Prior to the pressure test, both headers have to be removed. For the test rubber plugs featuring small tubes as water pass can be used. The tube to be tested is plugged at both ends and tested at low pressure applied via the gas or water supply line.

Pressure gauges can be installed in the gas or water supply line to indicate a loss of pressure. Even if there is just a very small leak the pressure loss is indicated shortly after pressure application.

If there is no pressure gauge available the tube has to be checked carefully at the outside for leaks. For that the cooler has to be de-installed eventually.

9.3 Pressure Test of Cooler with water

If the pressure test of the cooler bundle is made with water, the outer surface has to be carefully checked for leaks (wet spots at the fins). To identify wet spots clearly caused by leakages the surface should by dried with hot air prior to the test.

9.4 Pressure Test with Air under Water

If no pressure gauges are available the pressure test can be made with air under water.

Prior to the test the cooler has to be dried at the water side with hot air. Either the entire bundle or single tubes have to be closed and served with air at max. 0.5 bar(g). Then the entire bundle has to be put under water. A leak can be easily identified by the rising bubbles. Please note that after the dipping of the bundle also bubbles coming from accumulations of air at the surface will rise which do not indicate a leakage. If single tubes are tested this procedure has to be carried out for each.

9.5 Plugging of Tubes

Once a defective tube is identified it can be closed at both ends with plugs made of hard wood, rubber or plastics. Steel plugs should not be used to avoid damages at the tube sheet bores. Plugging can be made at all types of tubes.

In case that several tubes are found leaking it should be checked if the thermal performance of the cooler after the plugging will be sufficient or not.

9.6 Replacement of single tubes (Partial Re-tubing)

If the cooler bundle is made of single fin tubes, i.e. elliptical tubes with slip-on fins in rectangular shape or round tubes with wound-on fins, it is possible to replace single tubes. If a leaking tube is found in the middle of the tube bundle, the neighbouring outer tubes also have to be removed and replaced to gain access to the leaking tube. After the tubes that have to be replaced have been removed the tube sheet holes must be cleaned.

The spare tubes have an extended de-finned portion at one end. The tube has to be inserted into the tube sheet hole (long de-finned end first) and then retracted and slid into the corresponding tube hole in the second tube sheets.

9.7 Repairing by insertion of additional core tube

Replacement of single tubes is not possible at coolers equipped with the compact fin tube system. This tube system is made of a block of plate fins with the tubes inserted and expanded.

To remedy tube leaks, bare tubes of a smaller diameter than the defective original tube can be inserted. If possible the inserted tube should be expanded to ensure a very good heat transfer. If several tubes have to be repaired this way and expansion is not possible it should be checked if the thermal performance of the cooler after repair will be sufficient or not.

9.8 Pressure Test after Repair of Cooler

After repair the cooler has to be checked for tightness by a pressure test with the specified test pressure (see nameplate).

Please contact GEA Herne or one of the GEA Service Centers worldwide for spare tubes, tools and other material used for leakage repair.

10. Cooler data