



ECONOPLATE BARE PLATE HEAT EXCHANGERS

**INSTALLATION, OPERATION & MAINTENANCE
DOCUMENTATION**

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1. To the owner

1.1 Preface

These operating instructions are your guide to the installation, operation and maintenance of Stokvis gasketed Plate Heat Exchangers (PHE). We advise you to study these instructions carefully and to make them accessible to staff entrusted with the installation, operation and maintenance of the PHE. This manual will be of no value to you if it is locked away at a time when your personnel need it.

Stokvis accepts no responsibility or liability for damage caused by incorrect installation, operation or maintenance or by failure to observe these instructions.

In all correspondence with Stokvis concerning your heat exchanger, please quote the serial number, plate heat exchanger type and year of construction.

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1.2 Intended purpose

These operating instructions are generally applicable to all PHE's manufactured and supplied by Stokvis. Each heat exchanger is also delivered with a compact IOM manual with written design limitations.

Stokvis wishes to point out that this PHE has been specially designed and manufactured for the customer-specified operating conditions concerning pressure, temperature, flow rates, thermal properties and composition of the media flowing through the PHE. Sudden pressure surges exceeding these operating conditions, e.g. when starting and stopping the PHE in an abrupt way, may cause damage and must be avoided. Stokvis accepts no liability for the serviceability of the PHE under operating conditions deviating from those specified.

If a change in the specified operating conditions becomes necessary, Stokvis must be consulted. The PHE may only be operated under revised conditions after Stokvis has fully assessed the changed conditions and issued written approval of such.

2. Health and safety precautions

Any work on the heat exchanger should be carried out in full compliance with the applicable Site and Statutory Safety Regulations.

2.1 General advice / dangers

- If people may be injured by product leakage, install a protection shroud (splash guard). If the PHE is equipped with a protection shroud, this must NOT be removed as long as the PHE is under pressure.
- Shutdown should take place slowly. Make sure the unit is NOT under pressure and is empty before starting service and maintenance.
- Cool the heat exchanger before starting work. If possible, allow the heat exchanger to stand and cool overnight.
- When handling heat exchanger plates, always use gloves to prevent injuries to the hands - the plate edges are sharp!
- Make sure that the workroom is sufficiently ventilated when gluing gaskets on to the heat transfer plates.



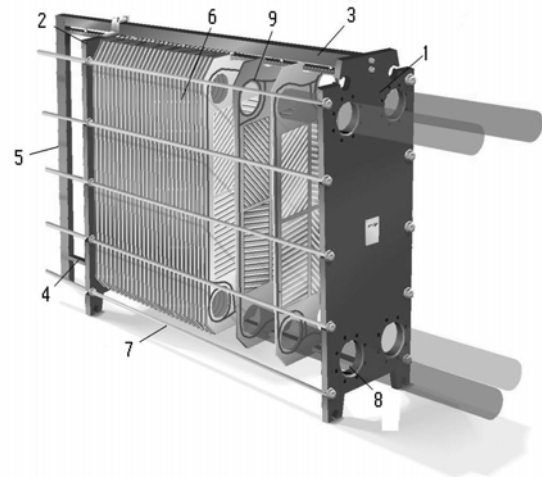
3. General description

3.1 General description

The Plate Heat Exchanger (PHE) consists of Fixed and Moving Cover Plates, Carrying and Guiding Bars, End Support, corrugated and gasketed Heat Transfer Plates, Tightening Bolts/Nuts, and Connection Ports. The corrugated plates are held in between the fixed and moveable cover and are compressed by the tightening bolts. Optional protection shrouds are available on request. The heat exchanger's construction enables it to be easily opened for inspection, cleaning and extension.

Plates are manufactured in standard sizes in virtually any material that can be cold formed. The size, number and arrangement of the plates are contingent upon the duty to be performed. Accordingly, the units are custom designed for each application.

Elastomer gaskets are glued in the gasket groove around the heat transfer surface and the portholes. The gaskets are double around the portholes to prevent leakage between the media. In the event of gasket failure the medium runs straight out of the exchanger. When the unit is tightened, the gasket seals the structure and in conjunction with the portholes, allows fluids to flow in alternate channels and almost always flow counter-currently. The thin fluid interspace coupled with the corrugated plate design induces turbulence that produces extremely high heat transfer coefficients.



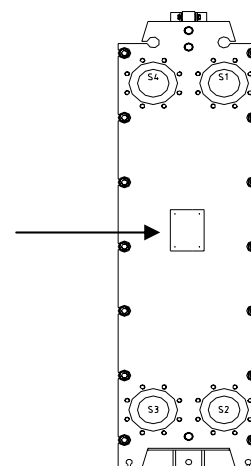
1. Fixed Cover Plate
2. Movable Cover Plate
3. Carrying Bar
4. Guiding Bar
5. End Support
6. Heat Transfer Plates
7. Tightening Bolts and Nuts
8. Connection/ Nozzle Ports
9. Gaskets

3.2 Identification of unit

Each PHE is provided with a machine (name) plate attached to the fixed cover. It gives details of:

- Plate heat exchanger type
- Serial number
- Year of construction
- Permitted working pressure range (bar)
- Permitted working temperature range (°C)
- Channel arrangement
- Volume (litres)
- Connection location
- Test pressure (bar)
- Weight empty/full (kg)

In all correspondence with Stokvis concerning your PHE, always quote the serial number, plate heat exchanger type and year of construction. Those details can be found on the machine (name) plate.



4. Main components and their function

The plates and gaskets are the main components of your PHE. Always use original Stokvis parts to guarantee the performance and lifetime.

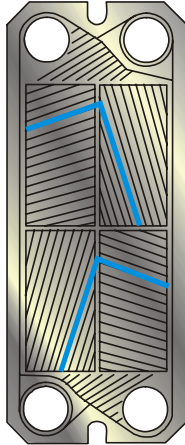
4.1 Plates

Stokvis offers one of the world's largest ranges of gasketed plate heat exchangers. Our plate menu consists of:

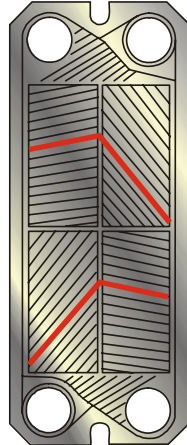
4.1.1 Ultra Flex (GX) plates

With the gasket groove in the plate's neutral plane the GX plate can be rotated about its x-axis as well as its y-axis, thus flow channels are formed with differing thermal characteristics.

Every plate size is available with two different angle combinations thus forming six different flow channels for every plate size. This enables exact matching to every application.



GX Low-theta plate



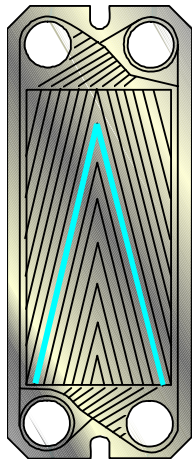
GX High-theta plate

The GX heat transfer plates are made with two different arrowhead angles: one obtuse high-theta plate (higher turbulence, higher heat transfer and higher resistance to flow), and one acute low-theta plate (lower turbulence, lower heat transfer and lower resistance to flow).

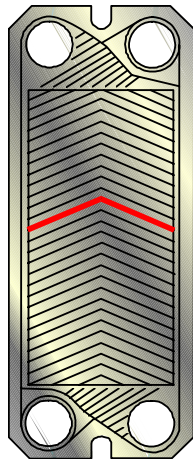
The GX series of plates are based on a **diagonal** flow pattern and have a gasket groove in the neutral plane. Parallel flow pattern can be offered on request, but may affect performance.

4.1.2 Conventional (GC and GL) plates

Conventional herringbone (chevron) pattern complement Stokvis's range of Ultraflex (GX) plates



GC - Low Theta Plate



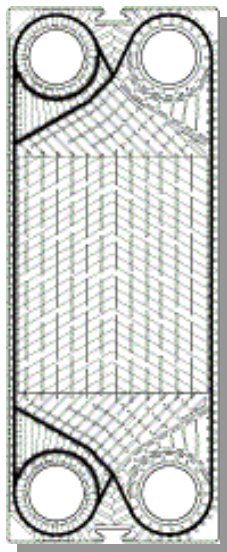
GC - High Theta Plate

The GC and GL heat transfer plates are made with two different arrowhead angles: one obtuse high-theta plate (higher turbulence, higher heat transfer and higher resistance to flow), and one acute low-theta plate (lower turbulence, lower heat transfer and lower resistance to flow).

The GC series of plates is based on a **parallel** flow pattern and has the gasket groove in the bottom plane.

The GL series of plates are available in both **diagonal** and **parallel** execution and has the gasket groove in the neutral plane.

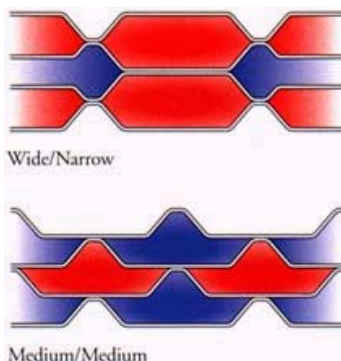
4.1.3 Wide Gap (GF) plates



Stokvis Wide Gap plates are suitable for applications with liquids containing fibres or solids which would cause extensive clogging and downtime for cleaning on a conventional plate.

Stokvis's Wide Gap plates have a draw depth two to five times greater than conventional plates, which permits unrestricted passage of coarse particles for fluids containing fibres. This allows the plates to be extremely effective in applications which involve viscous fluids, solids and slurries.

The GF series of plates is based on a **parallel** flow pattern and have gasket groove in the neutral plane.



Stokvis's new generation Wide Gap plates can be arranged in two different configurations.

Wide/Narrow when one of the fluids contains large particles that require wide gap channels or Medium/Medium when both fluids require additions flow area.

Both configurations are accomplished with single plate geometry. Max plate gap is 12 / 4 mm for Wide/Narrow configuration and 8 / 8 mm for Medium/Medium configuration.

4.1.4 Semi Welded (GW) plates

Semi-welded plate heat exchangers are especially designed for use with ammonia and other aggressive media. These exchangers feature asymmetrical and symmetrical plates laser-welded together to form a sealed channel to ensure safe, reliable operation.

The semi-welded plate pack consists of a number of plate pairs (also referred to as elements). We can create three different elements from the GW-80 plates with different thermal characteristics. A plate pack normally consists of a start plate (single C or F plate) + elements + end plate (single D plate).

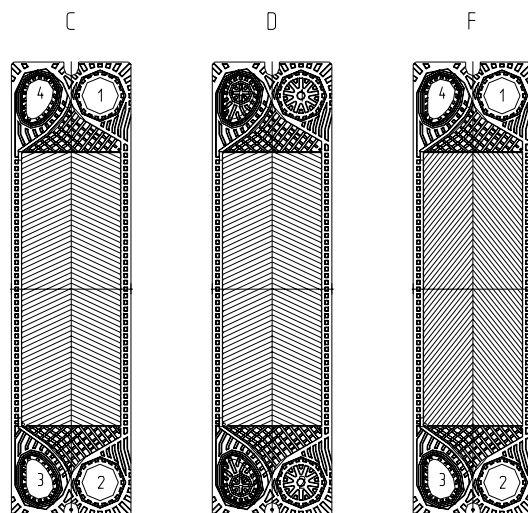
The GW series of plates is based on a **parallel** flow pattern.

GW-81

Two asymmetric C plates welded together with the **narrow** channel inside the element. The element is marked in the upper corner with letter **O**. Standard element for ammonia application (Direct Expansion).

GW-83

Two symmetric F plates welded together. The element is marked in the upper corner with letter **S**. Standard element for ammonia application (Thermosiphon system).



4.1.5 Plate material identification numbering of heat transfer plates

A five-digit number is stamped into the long edge of each plate when it is pressed. This number is used for material traceability.

The first digit Year of manufacture

The second digit Quality of material

The last 4 digits Running number for each Heat/charge.

Example 811031:

Second Digit	Material
0	AISI 304 / 1.4301
1	AISI 316 / 1.4401
3	654 SMO / 1.4652
4	254 SMO / 1.4547
5	Titanium Gr. 1 / 3.7025
6	Titanium Gr. 11 / 3.7225
7	Hastelloy C-276 / 2.4819
8	Hastelloy G-30
9	Other materials

Plate is made of AISI 316 / 1.4401 material and is manufactured in 2008. The last four digits 1031 refer to a certain material / mill certificate.

4.2 Gasket glue

4.2.1 Suitable gasket glue

Stokvis uses one-component synthetic glue to bond the gasket to the plate. The advantages are:

- The gasket will not fall off when the unit is opened.
- It is not generally necessary to clean the gasket groove before re-gluing.
- Maintenance at site is made easier.
- The gasket is easy to remove and replace.

Only certain synthetic glues may be used for gluing gaskets, namely:

Bostik 1782
3M EC 1099
Bond Spray 77
Castrol Pliobond 20/30

Do not use other types of glue; they may contain chlorine or other substances, which attack the plate material.

As export regulations for chemicals are very strict, we recommend that you buy glue from a location close to the installation site.

4.2.2 Glue consumption

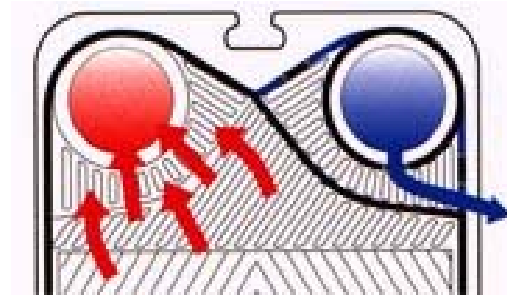
The number of gaskets that can be glued from one bottle (1 litre) of Pliobond 20 can be approximated as follows:

Model	Number of Gaskets / litre	Model	Number of Gaskets / litre
GW-081/083	70	GX-100	36
GC-012	150	GX-140	28
GC-028	100	GX-180	30
GC-009/GC-030	100	GX/GL-085	32
GX-007/GC-008	100	GX/GL-145	28
GX-012/GL-013	100	GX/GL-205	24
GC-016	100	GX/GL-265	20
GX-018	70	GX/GL-325	16
GX/GC-026	60	GL-230	22
GX-042/GC-044	40	GL-330	18
GX-051/GC-051/054	34	GL-430	14
GX-064	36	GF-057	40
GX-091	30	GF-097	36
GX-118	26	GF-187	30
GX/GC-060	40	GF-145	28
		GF-205	24

4.3 Gaskets

The plate gaskets are moulded in one piece. The material is normally an elastomer selected to suit the actual combination of temperature, chemical environment, working pressure and other prevailing conditions.

The medias are separated from each other with a double-gasket guidance system. In the event of gasket failure the media will flow through the leakage grooves so that the leakage immediately becomes apparent, as illustrated.



4.3.1 Gasket material identification

Identification marking is fashioned into the gasket at the time of moulding. It comprises of a material colour code, year/month stamping and a gasket mould reference number.

Material Colour Code

The elastomer gaskets are available in various materials. All gaskets are marked with a code colour to be able to identify the gasket material. The colour marks shall be at least in one end of the gasket, at the bleed port part – between the ring and diagonal part of the gasket.

Material	Code	Colour Code	Max. Temperature
Nitrile S (S=Sulphur cured)	NBR(S)	No marking	110°C
Nitrile P (P=peroxide cured)	NBR(P)	3 blue stripes	140°C
Nitrile P – FDA Partial	FDA NBR	1 blue stripe	140°C
Nitrile P – Low temperature	NBR LT	1 blue + 1 yellow stripe	120°C
Hydrogenated Nitrile P	HNBR	2 blue stripes	150°C
EPDM P (P=peroxide cured)	EPDM(P)	1 grey stripe	170°C
EPDM Hard - 86IRHD	EPDM XH	4 grey stripe	170°C
EPDM P – FDA Partial	FDA EPDM	3 grey stripe	170°C
FKM GB (Fluor G /Viton GB)	FKM GB	1 purple stripes	180°C
FKM B (Viton B)	FKM B	2 purple stripes	160°C
FKM GF (Viton GF)	FKM GF	3 purple stripes	160°C
IIR (R.C. Butyl)	RCB	1 yellow stripe	110°C
Neoprene (Chloroprene)	CR	1 green stripe	80°C
PTFE encapsulated NBR	PTFE/NBR	No marking on outside	120°C
PTFE encapsulated EPDM	PTFE/EPDM	No marking on outside	120°C

The temperatures given are maximum values and may be reduced depending on the medium for your specific application, maximum operating temperature and maximum operating pressure.

Arrhenius correlation: For every 10 degrees higher operating temperature the life time of the elastomer gasket is reduced by 50%.

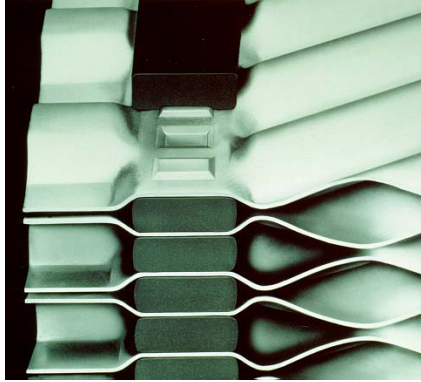
Year/Month of Manufacture

The marking shall be written in digits on the gasket: YYMM. Example 0805 is manufactured in May 2008.

Mould Number

The marking states which mould the gasket was manufactured in.

4.3.2 Gaskets for GX and GL plates

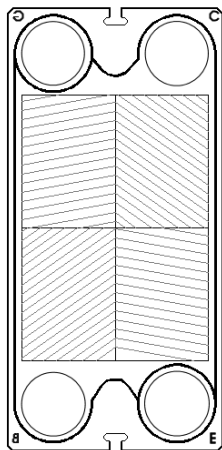


GX and GL heat exchanger plates differ from conventional plates, because the gasket groove lies in the plate's neutral plane. Each plate is glued with one full thickness gasket on the front side, except the last plate, which also has an additional half-thickness gasket on the back side. The first plate is only glued with a half-thickness gasket on the front side.

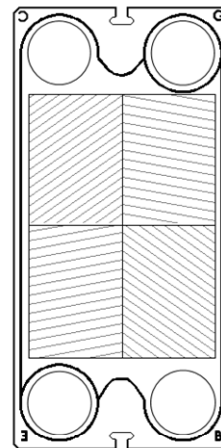
One complete set of gaskets consists of two (2) half thickness gaskets and x full thickness gaskets, x = number of plates -1.

It is important to follow the gluing instruction from the plate sequencing specification sheet, see Section 5.1. Gaskets are always viewed as being glued to the front face of a plate.

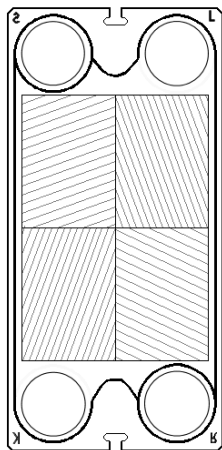
Examples of glued GX plates



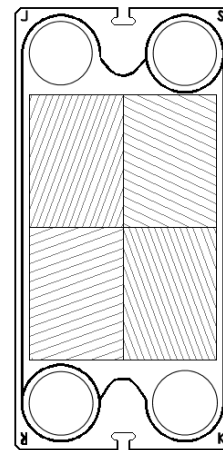
*GX High Theta Plate glued RC
Letter C up to the right, the ring down to the right*



*GX High Theta Plate glued LG
Letter G up to the right, the ring down to the left*



*GX Low Theta Plate glued RL
Letter L up to the right, the ring down to the right*



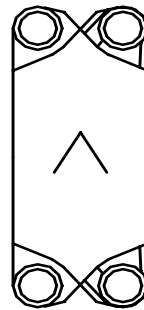
*GX Low Theta Plate glued LS
Letter S up to the right, the ring down to the left*

4.3.3 Gaskets for GC and GF plates

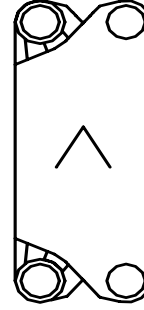
This range of plates has the gasket groove in the plate's bottom plane. Each plate is glued with one full thickness gasket on the front side. The first plate is glued with a full thickness gasket that has rings at all port holes.

One complete set of gaskets comprises of one (1) four ring gasket and x full thickness gaskets, x = number of plates - 1.

It's important to follow the gluing instruction from the plate sequencing specification sheet, see Section 5.1. Gaskets are always viewed as being glued to the front face of a plate.



Four ring gasket

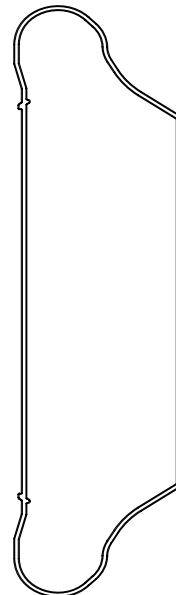


LU. The rings are to the Left and chevron is pointing Up.

4.3.4 Gaskets for GW plates

Plate pairs (also referred to as elements) are welded together to form a sealed channel. In order to close off and seal two of the four portholes in the element, a laser weld is extended diagonally in front of the two vertically aligned ports. Refrigerant (or corrosive fluids), which enters the sealed channel through the inlet port, flows inside the element. Special designed, double ring gaskets are placed on either side of the inlet and outlet ports, thereby creating a seal around the ports. Perimeter gaskets (also referred to as Parallel Gasket) are placed on either side of the element, creating a sealed envelope to contain the process fluid. The process fluid flows between the elements in the gasketed channel.

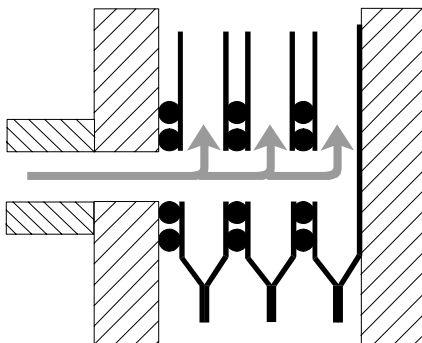
It's important to follow the gluing instruction from the plate sequencing specification sheet, see Section 5.1.



Parallel gasket



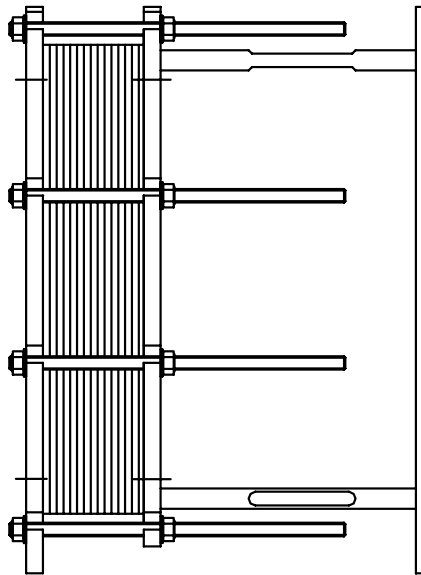
Ring gasket



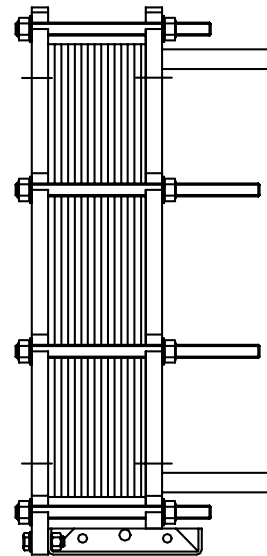
Specially designed ring gaskets are placed on either side of the inlet and outlet ports, thereby creating a safe high-resistant seal around the ports.

4.4 Frames

Stokvis PHE's are supplied with two frame designs, either with or without end support.



P frame with end support



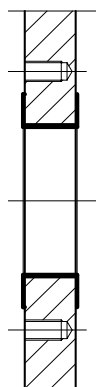
PI frame without end support

The frame type of your unit is displayed in the 'Model' box on the machine (name) plate located on the Fixed Cover Plate of your unit e.g.: GX-85 P = Frame type PHE-85 with end support capable of 16 bar design acc. to PED.

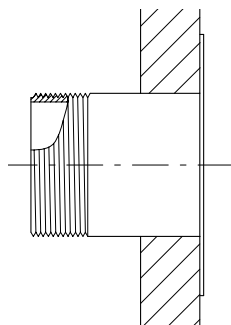
PED Design pressure (bar)	With end support	Without end support
6	T	TI
10	N	NI
16	P	PI
25	S	SI

4.5 Connections

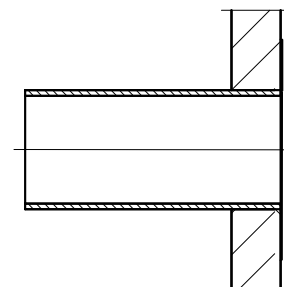
The connections are positioned either on the fixed cover alone or on the fixed cover and the moveable cover. Stokvis offer a range of different connection types like studded ports, threaded connections, weld connections, welding neck flanges and many more. The three most common connections are illustrated below.



Studded connection with Port liner



Threaded connection



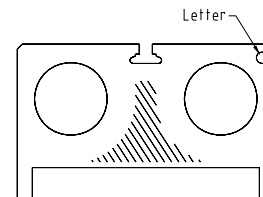
Weld connection

5. Plate sequencing and Working principle

5.1 Plate sequencing specification

Each heat exchanger is supplied with a Plate Sequencing specification sheet. The sheet gives detailed information of unit, location of connections and plate specification. The plate sequencing specification assists in determining the proper sequence and the orientation of the plates in the unit.

For the GX and GF units the code is an embossed letter, see picture.
Assembly code UP or DOWN is reflected in GC, GL and GW units as the arrow direction of the chevron pattern on the plate.



Example 1. Hanging specification for GXD-085 with 421 titanium plates and NBR(p) gaskets

Plate Sequence	Plate Type	Plate Materials	Plate Thickness	Gasket Material	Piercing	Gluing	Hanging
1	GX-085	Titanium / 3.7025	0.5	NBR(P)	L1234	RL Start *	K ***
2, 4 .. 418, 420	GX-085	Titanium / 3.7025	0.5	NBR(P)	L1234	LS	R ***
3, 5 .. 417, 419	GX-085	Titanium / 3.7025	0.5	NBR(P)	L1234	RL	K ***
421	GX-085	Titanium / 3.7025	0.5	NBR(P)	H0000	RC End **	B ***

Note: Plate 1 is the Plate adjacent to the Fixed Cover Plate

* The start plate (Plate 1) has a half gasket assembly on the front side.

** The back plate (Plate 421) has a full thickness gasket on the front side and a half thickness gasket on the back side.

*** Thus when correctly glued and assembled and viewed from the Fixed Cover End of the unit the embossed letter coding at the TOP RIGHT HAND CORNER of the Heat Transfer Plates should read as below:

According to the assembly instructions, the plates should be hung as follows:

Plate 1	K
Plate 2,4 .. 418, 420	R
Plate 3,5 .. 417, 419	K
Plate 421	B

Example 2. Hanging specification for GCP-051 with 50 AISI316 plates and EPDM(p) gaskets

Plate Sequence	Plate Type	Plate Materials	Plate Thickness	Gasket Material	Piercing	Gluing	Hanging
1	GC-051	AISI 316 / 1.4401	0.5	EPDM(P)	L1234	LU Start	LU
2, 4 .. 46, 48	GC-051	AISI 316 / 1.4401	0.5	EPDM(P)	L1234	LU	RD
3, 5 .. 47, 49	GC-051	AISI 316 / 1.4401	0.5	EPDM(P)	L1234	LU	LU
50	GC-051	AISI 316 / 1.4401	0.5	EPDM(P)	H0000	LU End	RD

Note: Plate 1 is the Plate adjacent to the Fixed Cover Plate

According to the assembly instructions, the plates should be hanged as follows:

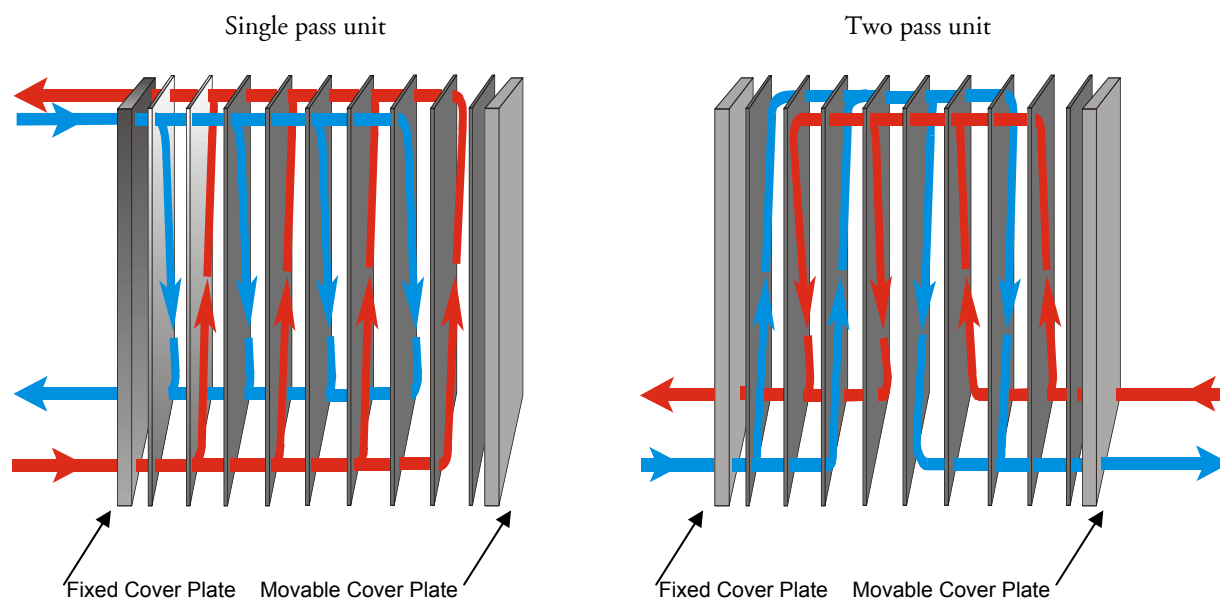
Plate 1	Arrow Up
Plate 2	Arrow Down
Plate 3	Arrow Up
Plate 4 ...	Arrow Down ...

5.2 Working principle

A series of pressed plates with portholes form a plate pack of flow channels. The heat exchange media flow through these plates in alternate channels.

Usually single-pass plate heat exchangers are used. They are distinguished by the 100% counter-flow of the two media. All of the feed and discharge pipes are connected to the fixed cover plate. This is a particularly maintenance friendly installation.

Close temperature differences between the media may demand multi-pass plate heat exchangers. The connection pipes are then attached both to the fixed and movable cover plate.

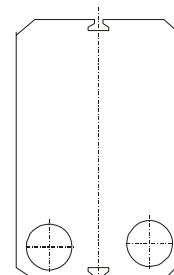


5.3 Partition plates and draining of multi-pass unit

Multi-pass units may require factory installed drains/vents, i.e. additional nozzles on the cover plates.

The blank ports in the turning plate for two-pass grouping and the first turning plate for three-pass grouping are provided with holes, 3 mm diameter for small units and 6 mm diameter for large units.

Larger plate heat exchangers like GX-051/064/091/118, GX-060/100/140/180, GX/GL-085/145/203/265/325, GL-230/330/430, GF-057/097/187/145/205 and GC-060 require a partition plate after every turning plate to prevent deformation of the blank ports in multi-pass grouped heat exchangers.



Note. On multi-pass units, which are sized for close temperature approach these drain/vent holes are situated on the bottom/top of the partition plates and can be opened with a screw. This execution is due to the small amount of bypassing that otherwise would occur.

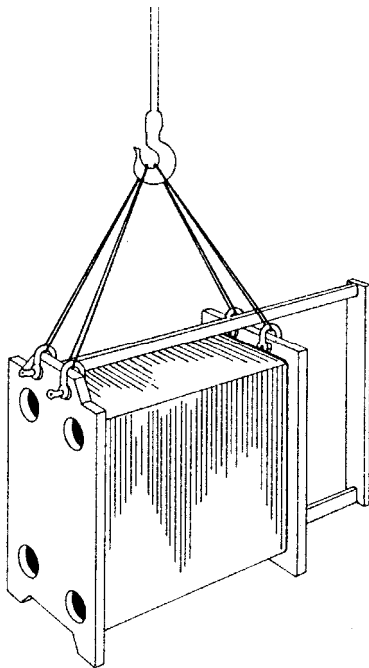
6. Installation

Unless otherwise agreed, Stokvis delivers the plate heat exchangers ready to be put in service upon arrival. Stokvis's plate heat exchangers are always pressure tested at the factory before delivery.

6.1 Unpacking

Stokvis PHE's (with optional protection shroud and/or thermal insulation) are strapped/mounted to a steel or wooden pallet. Other optional items, if supplied, are packed either inside the box or separately. All items should be checked against packing lists. Should any parts be missing or damaged, please notify your Stokvis representative.

6.2 Lifting and handling



The PHE is usually delivered fully assembled, either lying down on the fixed cover or standing upright on a steel or wooden pallet. The pallet can be lifted by a forklift from beneath and transported.

If supplied lying down, the PHE must be erected as follows:

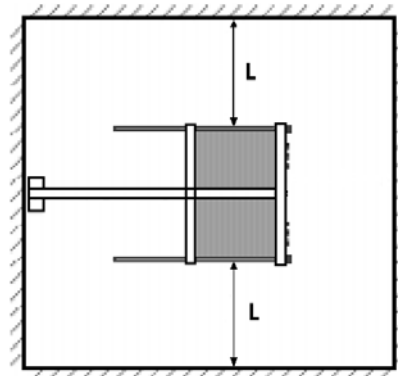
1. Release and remove all fastening screws and elements on the planks.
2. Attach a sling to one of the tightening bolts on either side of the PHE. Do not use steel ropes or chains!
3. Slowly lift the PHE from the planks over its centre of gravity.
4. Slowly lower the PHE onto the feet of the fixed plate whilst at the same time manoeuvring the PHE into its final position at the installation site.
5. Remove the slings and other aids and anchor the PHE to the ground.

The unpacked PHE must not be lifted by the carrying bar or the connections. Use only the lifting holes provided, see figure.

6.3 Raising the PHE

It is necessary to provide enough clearance around the PHE, see figure. This facilitates access to the PHE and permits for necessary service tasks. The heat exchangers must be installed with clearance on both sides:

Clearance	Size
300 mm	GX-007, GC-008/012/028
600 mm	GX-012/018/026/042, GL-013, GC-009/016/026/030/044, GW-081/083
1000 mm	GX-051/085, GC-051/054, GL-085
1200 mm	GX-091/118/060/100/145/205, GC-060, GL-145/205/230, GF-057/097/187/145/205
1500 mm	GX/GL-265/325, GL-330/430

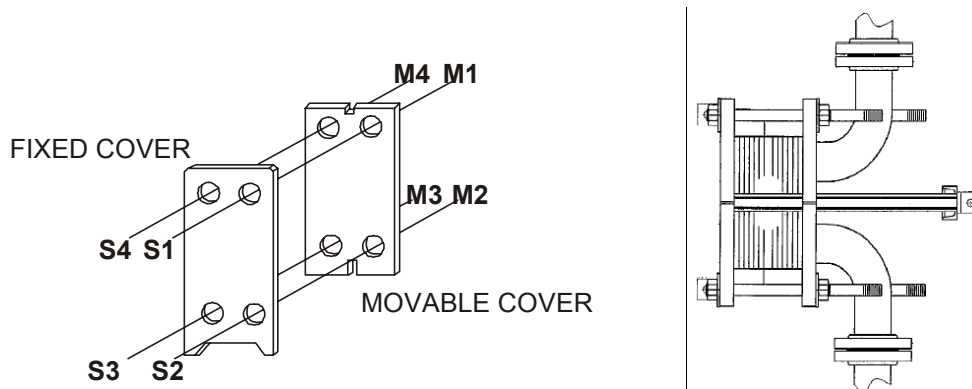


If the existing installation area is limited, the clearance dimensions may be reduced. This should only be done after consultation with Stokvis.

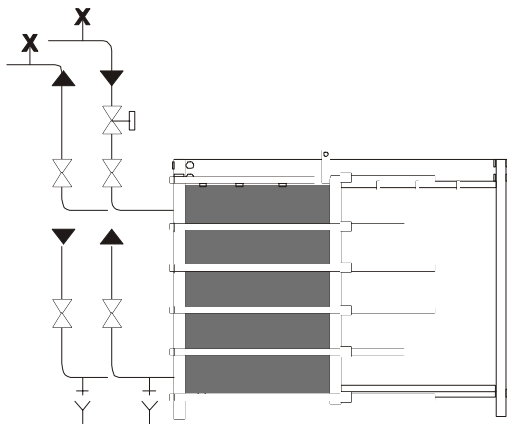
6.4 Foundation

All information necessary for the preparation of the foundation appears on the design data sheet. In some cases it may be practical to place the heat exchanges on a drip tray or a drainage box.

6.5 Installation



All connections to the heat exchanger must be provided with shut-off valves. The lower connections (S2 and S3; M2 and M3) must be provided with drain valves. The upper connections (S1 and S4; M1 and M4) must be provided with venting devices at their highest points. The hot side's regulating valve should be installed in the feed pipe between the pump and the shut-off valve.



All connections to the movable cover must be made using removable 90-degree elbows, allowing the movable cover to be pushed back for servicing.

All nozzle loading must be minimized during installation and operation.

Make sure that the pipe system connected to the PHE is secured against sudden pressure surges and temperature fluctuations.

In case of welding, the PHE must not be used as a grounding mechanism as electric arcs may occur between the heat transfer plates.

See Section 7 in this manual for Operation and Start-up.

6.6 Specialized labour

The plate heat exchanger is a simple piece of equipment and is delivered ready to be piped up. Installation and commissioning of Stokvis's plate heat exchangers does not normally require our own personnel on site. Stokvis can naturally send our service engineers to site if necessary. Detailed service contracts can be offered on request. Please contact your Stokvis representative for more information.

6.7 Special tools

No special tools are required. A ratchet spanner is all that is needed for maintenance and repair. Disassembly and re-assembly of large plate heat exchangers during maintenance operations using standard tools can be time consuming. Stokvis also offer hydraulic tightening equipment, which you may find beneficial for use with the unit where frequent servicing is necessary.

7. Operation

Always check applicable Site and Statutory Safety Regulations before you start. The heat exchanger is often one part of a complete process system, sometimes with advanced automatic controls. Always check applicable instructions for the whole process system before you start.

7.1 Filters

Stokvis recommend primary filters to be installed before the plate heat exchanger to capture fibres, debris and other coarse particles in the process fluids which can foul and clog the plate heat exchanger.

7.2 Pumps

Pumps that feed the plate heat exchanger must be provided with regulating valves. If the pumps can deliver a higher pressure than the rated pressure for the heat exchanger, safety valves must be installed. The pumps must not be allowed to suck in air.

7.3 Initial operation

Each heat exchanger is supplied with thermal design data sheet, giving details of the operating parameters, limits, capacity etc.

1. Check that the operating data does not exceed that given on the heat exchanger's machine (name) plate.
2. Check that all tightening bolts are properly tightened.
3. Check that all connection pipes are screwed tight.
4. Check that the A-dimension is correct.

7.4 Start-up

Always start with one side at a time.

1. Close the feed valve between the pump and the PHE.
2. Fully open the valve at the outlet connector, if present.
3. Open the vent valves.
4. Start the pump.
5. Slowly open the feed valve to prevent pressure surges.
6. When all the air has escaped from the PHE, close the vent valves.

Follow step 1-6 for the second side.

Hammering must be avoided, otherwise the rubber gaskets may be displaced and cause leakage.

7.5 Venting

The exchanger must be properly vented. Remaining air can cause air locks and serious scorching of the plates, reducing the heat transfer capacity and increasing the risk of corrosion.

7.6 Shut-down

Short period of time

If the PHE is to be shut-down briefly, proceed as follows:

- Slowly close the feed valves, starting with the feed line with the higher pressure.
- Switch off the pump(s).
- Close the valve in the outlet pipes, if present.

Longer period of time

For longer periods of downtime and especially when there is a risk of freezing or if the media are aggressive, the heat exchanger must be emptied and cleaned. While the unit is not in use, ease the tension on the tightening bolts so that the plates just lie against each other, but close enough to prevent any dirt entering between them. The tightening bolts should be greased.

8. Storage procedures

8.1 Storage procedures for Stokvis plate heat exchangers

When a plate heat exchanger is to be placed in storage for an extended period of time, the procedures listed below must be followed.

1. If the unit has been recently shipped from our factory and is unused, disregard statements 2, 3 and 4; follow instructions 5-10.
2. If the unit has been used and long-term storage is required, it must be completely drained. Prior to draining, remove any shroud and let the unit cool to ambient temperature. Units with plate packs arranged in one pass (all connections to the fixed cover plate) are self-draining. Simply vent at the upper nozzle location and drain from the lower nozzle for each side individually. A multi pass unit is also self draining, provided all nozzles are at the lower elevations (S2/S3/M2/M3). Other units may be self-draining if they have been fitted with separate drain and vent connections. Units that are not self-draining must have the plate pack completely loosened to drain all liquids. Before opening the plate pack, wipe off the exterior surfaces with water to make sure no fluids or debris fall into the plate pack.
3. Open the plate pack and thoroughly clean the unit internally and externally. Dry the unit by blowing air at approx. 60°C on all areas.
4. Install blind flanges with gaskets on all nozzles. Plug all other openings.
5. Coat all unpainted carbon steel components with light grease, SAE 30 oil or other rust inhibiting products.
6. Coat all bolt threads with light grease.
7. To minimize gasket compression set, the plate pack length dimension needs to be adjusted. As a guideline, the units tightening dimension should be increased by a factor 1.2 (e.g. if the A-dimension is 500 mm, the bolts should be slackened to new dimension 600 mm).
8. Protect the unit from direct sunlight, intense heat radiation or ultra violet light by loosely covering the unit with an opaque, reflecting type plastic film or similar material. Make sure air is allowed to circulate around the unit preventing condensation and other negative effects.
9. It is preferable to store the unit indoors, well protected from the weather. The temperature in the storage area should ideally be 20°C with a relative humidity of max. 70 %. Avoid storing the unit in an area where the temperature can fall below 0°C.
10. All potential sources of Ozone, such as operating electric motors, or welding equipment, should be removed from the storage area to prevent Ozone attack on the gaskets. For gasket storage, please refer to separate instruction in this manual.

8.2 Gasket storage procedure

General

If the rubber gaskets are stored under unsuitable conditions, the physical properties of the rubber material may change, resulting in a hardness change, permanent deformation, cracks or other surface damage. The changes can be caused by, for example, the oxygen in the surrounding air, Ozone, heat, light, humidity, solvents or mechanical forces. If the rubber parts are handled and stored correctly, they will maintain their properties for a longer period of time.

Storage room

The storage room should be cool, dry, free from dust and only moderately ventilated. It should also be relatively dark and protected from direct sunshine.

Temperature

If the temperature is $>20^{\circ}\text{C}$, a gradual deterioration of the physical properties occurs. A 10°C increase in temperature can result in twice the ageing rate. Rubber gaskets that have been subjected to low temperature during freight or storage may be stiff from the cold and should be "thawed" at approx $+20^{\circ}\text{C}$ for a period of time. Precautions to avoid condensation on the gaskets should be taken.

Light

Rubber articles should be protected from light, especially direct sunshine and artificial light with high UV intensity.

Air and ozone

Ozone is a danger to the gaskets. Electrical motors or other machines that produce sparks or other electrical discharges which can produce Ozone must not be present in the storage room.

Deformation

Rubber gaskets should be stored so that they are deformed as little as possible. Mechanical forces within the rubber material can speed up the ageing rate and is the basic mechanism behind the formation of Ozone cracks, especially in NBR rubbers.

Storage times

If the above recommendations are followed, the storage time will be at least:

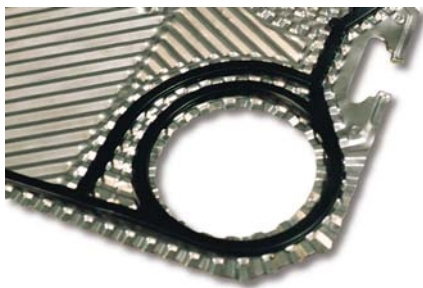
Material	Code	Shelf time
Nitrile	NBR	3 years
HNBR	HNBR	3 years
EPDM	EPDM	5 years
FKM GB (Fluor G)	FKM	5 years
FKM B (Viton B)	FKM	5 years
FKM GF (Viton GF)	FKM	5 years
IIR (R.C. Butyl)	RCB	3 years
Neoprene	CR	3 years

Remember to use gaskets on a first in, first out (FIFO) basis.

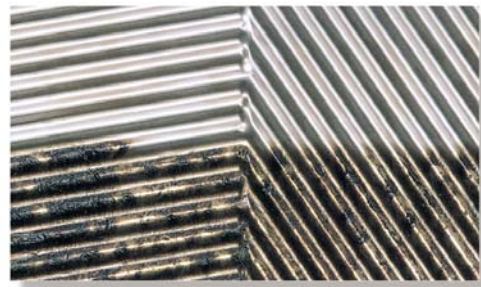
9. Maintenance

9.1 Scheduled maintenance

Unscheduled shutdowns are very expensive and mostly quite unnecessary. Fouling causes decreased performance and gaskets ageing. The heat exchanger should be emptied and cleaned on a regular basis so that the condition of the heat transfer plates and the gaskets can be checked. Each application is unique, making it very hard to predict service intervals. Stokvis has several service centres that offer reconditioning of plates. Please contact your Stokvis representative for more information.



Gaskets age. If they are replaced in time, you avoid both leakage and resulting damage.



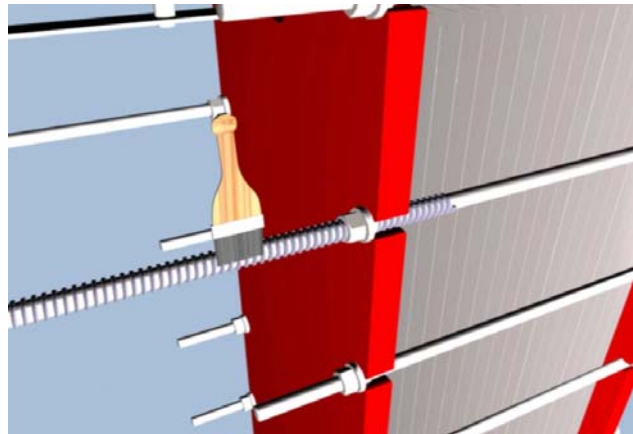
Plates get dirty. The coating affects heat transfer and reduces performance.

9.2 Lubrication

The thread of the tightening bolts must be kept lubricated with molybdenum disulphide or equivalent, particularly on the section of the thread used for opening and closing the equipment.

To improve their sliding ability, the following components should be treated with an acid free grease:

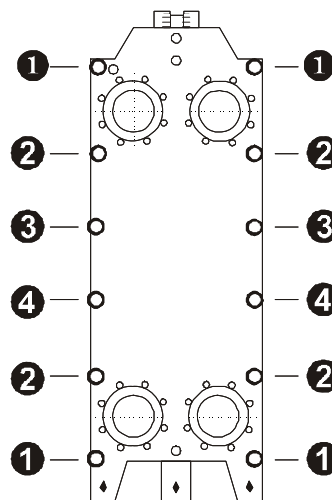
1. Sectional rails and beam surfaces to which the plates are attached and on which they are slid.
2. Pressure surfaces between tightening nut and retaining ring.
3. The bearings of the carrier roller on the movable cover plate.



9.3 Opening the heat exchanger

No special tools are required. A ratchet spanner is all that is needed for maintenance and repair.

- Shutdown should take place slowly. Make sure the unit is NOT under pressure and is empty before starting work.
- Cool the heat exchanger. If possible allow the heat exchanger to stand and cool overnight.
- Disconnect any connection to the moveable cover.
- Clean the thread of the tightening bolt.
- Apply a thin film of oil to the thread.
- We advise painting a diagonal line across the plate pack to ensure that the plates are reassembled in the right order.
- Note the current A-dimension.
- Remove Bolts 1.
- Slacken nuts 2, 3 and 4 alternatively so that the movable cover can move parallel with the frame plate.
- Remove bolts 3 and 4.
- Slacken nuts 2 alternatively.



Warning! In some applications space is limited and standard length of guiding bars and tightening bolts cannot be used. Those units are tightened with short bolts and are under compression. Special handling is required to open the units. Please read the special instruction Fbla-260.

9.4 Taking out the heat transfer plates

USE GLOVES - THE PLATE EDGES ARE SHARP!

If two or more plates have stuck together they must be separated carefully so that the gaskets are kept on the correct plate. The plates support each other in pairs. If a plate has been so damaged that it must be taken out and cannot be repaired or replaced with an identical one, the adjacent plate must also be taken out of the heat exchanger.

If the number of plates is changed, so is the A-dimension (see Section 9.11). Special plates, such as the first and last plates and turning plates in multi-pass heat exchangers, must be replaced with identical plates.

9.5 Cleaning the plates

Fouling of the plate heat exchanger is often caused by low flow velocity through the heat exchanger. Where the possibility exists to increase the flow this should be tried if the heat exchanger shows signs of reduced capacity or increased pressure drop. Severe fouling requires opening and cleaning the heat exchanger.

- The heat exchanger is opened according to Section 9.3.
- Steel wool or brushes of carbon steel must not be used, nor may stainless steel be used on titanium plates.
- In the first step the heat transfer surface is cleaned by rinsing with a powerful jet of water and scrubbing with a nylon or similar brush.
- Take care not to damage the gaskets.
- The gaskets must be wiped dry with a cloth. Solid particles adhering to the gaskets cause damage and result in leakage when the unit is put back in operation.
- The lower portion of each plate as hung in the unit should be inspected carefully and cleaned appropriately as this is the primary area where residual solid material tends to accumulate.

Do not use chlorine or chlorinated water to clean stainless steel or Nickel alloys. Chlorine is commonly used to inhibit bacteria growth in cooling water systems. Chlorine and chlorinated water can rapidly attack the above mentioned materials. For any applications where chlorination must be used with non-titanium equipment, please contact your Stokvis representative.

9.6 Plate cleaning guidelines

- Do not use hydrochloric acids, or water containing in excess of 300 ppm chlorides, with stainless steel.
- Do not use phosphoric or sulfamic acid for cleaning titanium plates.
- Limit cleaning solution concentration to 4% strength, with temperature not exceeding 60°C unless otherwise specified.

General guidelines for cleaning are tabulated below:

Type of Fouling	Suggested cleaners
Calcium Sulphate, Silicates	Citric, Nitric, Phosphoric or Sulfamic acid
Calcium Carbonate	10% Nitric acid
Alumina, Metal oxides, Silt	Citric, Nitric, Phosphoric or Sulfamic acid (To improve cleaning add detergent to acid)
Biological growth	Sodium Carbonate or Sodium Hydroxide (NaOH)
Greasy deposit	Kerosene and a soft brush. After cleaning, rinse thoroughly with water

Important! Sodium hydroxide and concentrated Nitric acid can seriously harm skin and mucous membranes. The solution must be handled with greatest care. Always wear protective goggles and protect hands with rubber gloves.

9.7 Adjusting the gaskets

A gasket that has come loose, either partly or entirely, must be glued in place. If only a short length has become detached, gluing can be carried out immediately before clamping, with the plate still hanging in the frame. If the entire gasket has become detached, the plate should be taken out of the heat exchanger.

9.8 Cleaning the gasket groove

The solvent must not contain chlorine. Clean the plates from residues of the old gasket. Small patches of glue that are securely stuck to the gasket groove may remain there. They provide an excellent foundation for the new gasket. Clean the gasket groove so that it is completely free of oil and other greasy substances, using a rag and acetone or other solvent not containing chlorine compounds. Then let the plate dry off.

9.9 Gluing the gasket

Glue consumption is listed in Section 4.2.

Glue is applied with a small flat brush to those parts of the plate's gasket groove in which the gasket lies. These parts of the gasket groove are easily recognized as they differ in colour arising from previous residues of glue. The gasket is then placed into position on the plate. After drying for about 30 seconds (the time depends on the thickness of the glue film and how much the glue has been diluted), the glue holds the rubber gasket firmly in place in the gasket groove, thus facilitating mounting. The plate must then be held under light pressure with the aid of other heat transfer plates, a stiff sheet or plate of suitable weight for about half an hour.

When the glue joint has dried the gasket should be coated with talc to prevent the plates subsequently sticking to each other. The plates are then ready to be assembled into the frame.

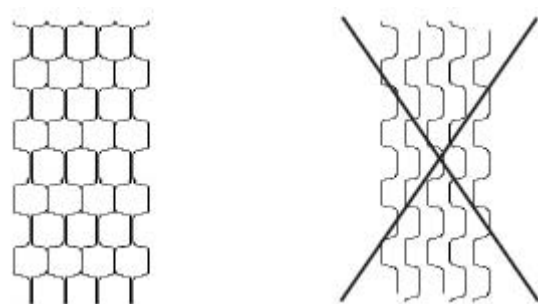
Always follow the precautionary instructions given by the manufacturer of the glue/adhesive!

9.10 Assembly

Before the heat exchanger is assembled, inspect all gaskets and surfaces that lie against the gasket. Particles that may jeopardize the integrity of the seals or damage the gasket or sealing surfaces must be removed. Note that contaminants usually collect at the lower part of the plates.

Plates that have been provided with new gaskets must be checked to make sure that the gaskets lie correctly in the gasket groove. Also check the half thickness gaskets on the first and last plates.

Use the Plate Sequencing Specification Sheet, to make certain that the plate pack is assembled correctly.

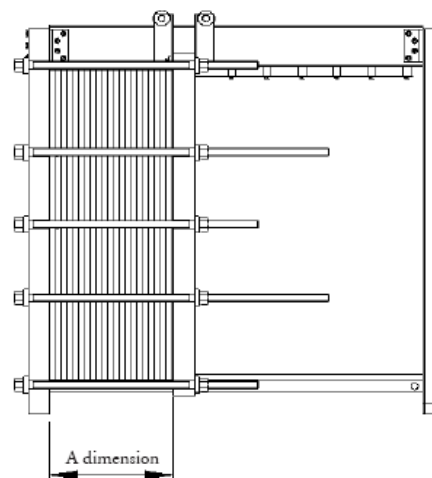


The plate edges form a regular honeycomb pattern.

9.11 Tightening the heat exchanger

The plate pack must be compressed to a specific thickness - the A-dimension. The A-dimension $\pm 3\%$ gives the inside length in millimetres between the fixed and moveable cover.

NEVER TIGHTEN THE PLATE HEAT EXCHANGER WHILE IT IS UNDER PRESSURE!



Size	Plate thickness	Draw depth	A-dimension
GX-007	0.5 mm	2.5 mm	3.0 x number of plates
GX-012/018	0.5 mm	2.9 mm	3.4 x number of plates
GX-026/042/051	0.5 mm	3.3 mm	3.8 x number of plates
GX-037/064/091/118	0.5 mm	2.9 mm	3.4 x number of plates
GX-060/100/140/180	0.5 mm	3.3 mm	3.8 x number of plates
GX-085/145/205/265/325	0.5 mm	3.3 mm	3.8 x number of plates
GL-013	0.5 mm	2.9 mm	3.4 x number of plates
GL-085/145/205/265/325	0.5 mm	3.3 mm	3.8 x number of plates
GL-230/330/430	0.5 mm	4.5 mm	5.0 x number of plates
GC-008	0.4 mm	2.1 mm	2.5 x number of plates
GC-009	0.5 mm	2.5 mm	3.0 x number of plates
GC-012/030	0.6 mm	2.5 mm	3.1 x number of plates
GC-016	0.4 mm	1.85 mm	2.25 x number of plates
GC-028	0.4 mm	2.05 mm	2.45 x number of plates
GC-026/051	0.5 mm	4.0 mm	4.5 x number of plates
GC-044	0.5 mm	1.6 mm	2.1 x number of plates
GC-054	0.4 mm	1.7 mm	2.1 x number of plates
GC-060	0.5 mm	4.4 mm	4.9 x number of plates
GF-057/097/187/145/205	0.8 mm	8.0 mm	8.8 x number of plates
GW-081/083	0.5 mm	2.4 mm	2.9 x number of plates

Example 1: A GX-026 has a total of 37 plates (0.5 mm thick).
The A-dimension is calculated as: $3.8 \times 37 = 140.6 \text{ mm} \pm 3\%$

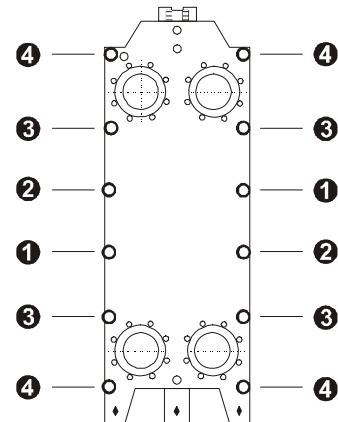
Example 2: A GX-026 has a total of 37 plates (0.6 mm thick)
The A-dimension is calculated as: $3.9 \times 37 = 144.3 \text{ mm} \pm 3\%$

NOTE! With large plate packs the A-dimension, due to tolerances in the plate thickness and depth of pressing, can deviate somewhat from values given above. With the correct A-dimension the plates lie in metallic contact with each other. Check this by examining the plate edges around the heat exchanger. Further compression can deform the plates.

Tightening sequence

The nuts must be tightened alternately. The movable cover plate must always be moved parallel to the frame at all times, and not drawn out of alignment.

- Tighten bolts 3 alternately.
- As the resistance is increased also tighten bolts 1 and 2 alternately.
- Tighten bolts 4 alternately.
- Check the A-dimension along the heat exchanger.
- The A-dimension must not vary more than 2 mm at different measuring points.



9.12 CIP (Cleaning-In-Place)

Cleaning-in-place is the preferred cleaning method for fouling applications and when especially aggressive liquids are processed in a plate heat exchanger unit. Install drain piping to avoid corrosion of the plates due to residual liquids left in the unit after an operation cycle.

To prepare the unit for cleaning, follow the procedures listed below:

1. Drain both sides of the unit. If it is impossible to drain, force liquids out of the unit with flush water.
2. Flush the unit on both sides with warm water at approximately 40°C until the effluent water is clear and free from process fluid.
3. Drain the flush water from the unit and connect CIP pump.
4. For thorough cleaning it is necessary to circulate the CIP solution from bottom to top to ensure wetting of all surfaces with cleaning solution. When cleaning multiple pass units it is necessary to reverse flow of the cleaning solution for at least half the cleaning time to wet all surfaces.
5. For optimum cleaning, use a flow rate of water and/or CIP solution that is greater than normal product rate of flow. A CIP operation will be most effective if performed on a regularly scheduled basis and before the unit is completely fouled.
6. Flush thoroughly with clean water after CIP cleaning.

Cleaning Example 1. Protein or grease deposits

1. Rinse with water immediately after using the process fluid.
2. Circulate a 2-3% caustic soda solution at 80°C for thirty minutes.
3. Flush with sufficient amount of water.
4. Circulate a 0.5% nitric acid solution at max 65°C (alternatively a 2% phosphoric acid solution at 80°) for fifteen minutes. Caution: Nitric acid attacks elastomer gaskets.
5. Flush with sufficient amount of water until the acid is completely rinsed out of the PHE and the pipe system.

Cleaning Example 2. Limescale deposits

1. Circulate a 2-3% phosphoric acid solution at 20°C for two hours.
2. Flush with sufficient amount of water until the acid is completely rinsed out of the PHE and the pipe system.

9.13 Back flushing

Often, when fibres or large particles are present, back flushing of the unit proves to be very beneficial. This is accomplished by one of the following methods:

1. Flush the unit with clean water in reverse flow to the normal operation direction.
2. Arrange piping and valves so the unit may be operated in reverse flow mode on the product side for fixed periods of time. This method is particularly well suited for steam applications.

The use of filters and strainers is required in supply lines ahead of the exchanger when the streams contain significant solids or fibres. This will reduce the requirements for back flushing.

9.14 Recycling and waste disposal

Heat exchangers have no consumable items apart from the heat transfer plates and gaskets which are considered to be spare parts. The plates, gaskets and all other parts of the heat exchanger can be recycled after cleaning them from the process liquid. No parts of the heat exchangers are considered hazardous. Please check local regulation for recycling and waste disposal.

10. Trouble shooting

10.1 Rectifying a leaking PHE

10.1.1 General

Measure the A-dimension at several points around the plate pack. Compare with theoretical value and adjust if necessary, see section 9.11 for details.

To rectify a minor leak, it may be sufficient to tighten the unit a bit further. Ensure that the plate pack is not tightened below the minimum A-dimension.

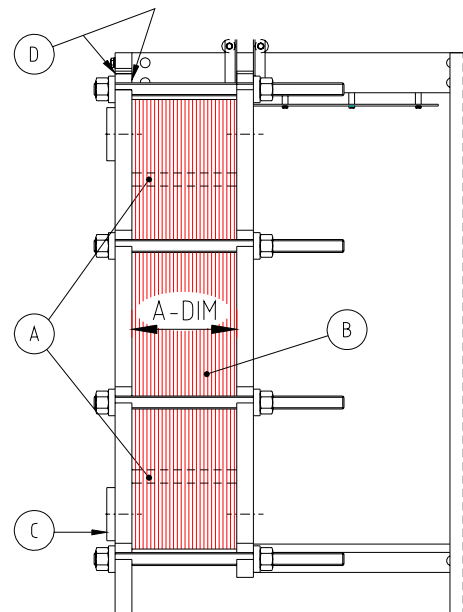
Check that the frame cover plates are parallel and not drawn out of alignment.

If a PHE is leaking, it is important to localize the leak before the unit is dismantled, otherwise it often becomes more difficult to rectify the problem.

10.1.2 Localizing the leak

The unit should be inspected thoroughly on all sides including top and bottom of the plate pack. Pinpoint all leaks by counting the number of plates from a frame cover and by accurate measurements. If possible, connection ports that are not under pressure should be inspected for leaks. There are four possible leakages:

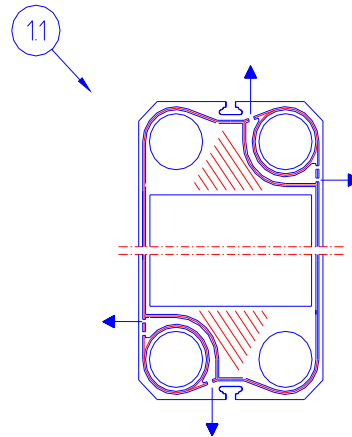
- A. Through the gasket leakage groove (from the area between ring and diagonal gasket)
- B. Through an external gasket on the side of the plate pack
- C. Internal leakage
- D. Leakage at the connections



A. Leakage through the gasket leakage groove

The most common reason for this type of leakage is gasket failure, either the ring or the diagonal gasket.

If the gaskets are in good condition and correctly located in the gasket grooves, check for possible corrosion in the areas between the ring and diagonal gasket by visual inspection or dye penetration.



B. Leakage through an external gasket

If an external leakage occurs on the side of a plate pack at any position excluding the ones described in picture 1.1 above, during operation, this may have the following causes:

- Inadmissible high pressure or temperature. Check operating pressure and temperature. Correct if necessary.
- The compression (A dimension) is incorrect. In this case, shut down the PHE and tighten gradually in its unpressurized state. Do not go below minimum A-dimension. The A-dimension must not vary by more than 2 mm at different measuring points.
- Incorrectly positioned or damaged gaskets. Check the gasket and its location in the gasket groove for foreign particles that might jeopardize the integrity of the seal. Replace damaged gaskets and if necessary correct the position of the gaskets.

C. Internal leakage

If there is an internal leak inside the PHE, the reason is probably a hole or crack in a heat transfer plate caused by corrosion or mechanical damage. To localize this type of leak, it is necessary to disconnect one of the lower connections, pressurize the other side and observe where the drops come from.

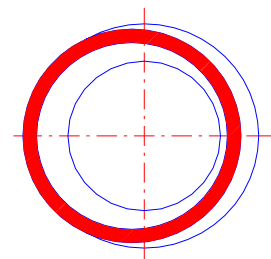
Note that it may be necessary to switch sides to find the hole or crack. Measure the distance from the frame cover to the leak to determine which plates are suspected. Remove and check these plates visually and by dye penetration to find the holes and cracks. Replace damaged heat transfer plates with new ones.

D. Leakage at the connections

If a leak occurs adjacent to a frame cover near a port, the reason could be:

- Cracks in the metal/rubber liner results in leakage between the cover plate and the liner. If this occurs on the inside of the frame cover, it is often easy to see.
- If it occurs on the outside of the frame cover, it can sometimes be difficult to see the difference between this and a leaking gasket for the connection flange.
- The ring gasket on the first heat transfer plate not sealing correctly to the liner can also cause a leak at the cover inside.

If this is due to incorrect centring of the liner/ring gasket, it can be remedied by adjusting the carrying bar. In certain cases, it may be possible to adjust the liner somewhat by moving it sideways in the cover porthole.



10.1.3 Determining which liquid is leaking

Even though both liquids in the heat exchanger may be similar and hard to distinguish (i.e. water on both sides), it may still be possible to determine which of the two liquids is leaking.

External leakage on the side of the heat exchanger

Heat exchangers assembled according to Stokvis standard, the liquid in the first channel (that is the channel formed by plate numbers 1 and 2) corresponds to connections S2 and S4.

Channel number	Corresponds to connection
Even	S1 & S3
Odd	S2 & S4

Leakage through the leakage vent

If only one side of the exchanger is pressurized, and the leak occurs through the leakage vent, the following applies for heat exchangers assembled according to Stokvis standard:

Pressurized connections	Leakage from channel with even number	Leakage from channel with odd number
S1 & S3	Diagonal gasket failure	Ring gasket failure <u>or</u> hole in plate between ring and diagonal gasket
S2 & S4	Ring gasket failure <u>or</u> hole in plate between ring and diagonal gasket	Diagonal gasket failure

10.1.4 Types of gasket failures

- Gaskets not located correctly in the gasket groove
- Gasket crushed (split). This is caused by excessive deformation of the rubber material by, for example:
 - Excessive tightening of the plate pack.
 - Swelling of the gasket material by chemical attack and/or high temperatures.
 - Gaskets squeezed between contact points due to incorrect location of the gasket in the groove.
- Gasket attacked chemically by the liquid. This can lead to the gasket being dissolved, swelled, hardened etc.
- Gasket has lost its elasticity due to heat ageing.

10.1.5 Excessive pressure and spikes

Operating a plate heat exchanger above its design pressure will result in gasket sealing problems. These problems vary depending on the type of plate heat exchanger being used but are most often indicated by protruding gaskets which will extrude between plates and be visible on the perimeter of the plate pack. Leakage may or may not be present; but in either case, steps must be taken to correct the situation. Excessive pressure must be reduced to limits within the design pressure of the unit. All regulating and throttling valves must be placed on the inlet sides of the heat exchanger. Excessive lengths of piping being stopped by valves on nozzle outlets can cause tremendous pressure on gaskets and this is to be avoided at all times. Pressure spikes can also cause extremely high pressures. Some of the causes are totally closed systems without allowance for expansion, booster-pump start-up and rapid acting control valves. When these conditions exist, they should be handled with vented closed systems, slow-acting control valves and accumulators whenever possible.

10.2 Impaired plate heat exchanger performance

If your PHE shows impaired performance in the form of high pressure drops or insufficient heat transfer, check the connection pipes and plate pack for contamination, foreign particles or other deposits. Open and clean the heat exchanger if necessary. Check that filters before the plate heat exchanger are working properly.

Impaired performance may also be caused by problems elsewhere in the system, e.g. inaccurate substance values, deviations in the volumetric flow or inadequate pump performance.

11. Warranty

Stokvis Energy Systems warrants to the original purchaser/user that all equipment or parts thereof supplied by it will be free from defects in material and workmanship only, under normal use and service, for a period of 12 months from the date of installation, but no longer than 15 months from the date of original shipment. Longer guarantee period can be offered for special projects.

Stokvis Energy Systems shall not be liable for any loss of profit, loss by reason of plant shutdown, non-operation or increased cost of operation, loss of product or material or other special or consequential loss or damages.

DISCLAIMER

The plate heat exchanger performance is based on installation, maintenance and operating conditions in conformance with this manual. Stokvis Energy Systems cannot assume any liability for plate heat exchangers that do not meet these criteria.

Please contact your Stokvis representative for further information.