



Bare Brazed Plate Heat Exchangers

Installation, Operation & Maintenance Manual

INSTALLATION AND MAINTENANCE MANUAL FOR CBEs

GENERAL INFORMATION

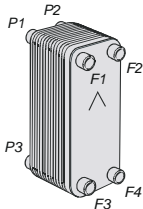
Depending on material combinations, pressure ratings and functions, there are several different types of Compact Brazed Heat Exchangers (CBEs). The standard materials are stainless steel, vacuum-brazed with a pure copper or nickel-based filler.

The basic materials of construction indicate the type of fluids that CBEs can be used with. Typical examples are: synthetic or mineral oil, organic solvents, water (not seawater), glycol mixtures (ethylene and propylene glycol), refrigerants (e.g. HCFC). Please note that if natural refrigerants (e.g. ammonia) are employed, CBEs with nickel-based brazing material must be used.

The front plate of the CBE is marked with an arrow. Either of an adhesive sticker type or embossed in the cover plate. The purpose of this marker is to indicate the front side of the CBE and the location of the inner and outer circuits/channels. With the arrow pointing up, the left side (Port F1, F3) is the inner circuit and the right side (Port F2, F4) is the outer circuit.

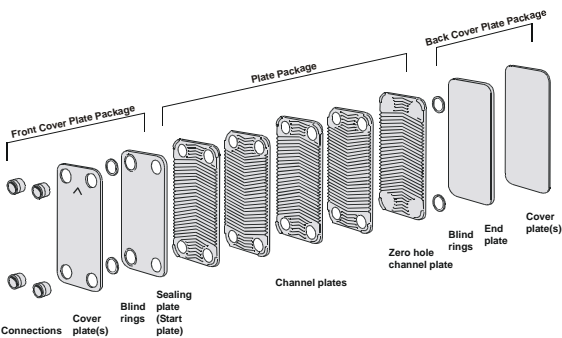
The outer circuit has a slightly lower pressure drop as it contains one more channel.

Ports F1/F2/F3/F4 are situated on the front of the heat exchanger. Ports P1/P2/P3/P4 are situated on the back. Note the order in which they appear.



CONSTRUCTION

The CBE is in principle built up by a plate package of corrugated channel plates between front and rear cover-plate packages. The cover plate packages consist of sealing plates, blind rings and cover plates. The connections can be customized to meet specific market and application requirements. During the vacuum-brazing process, a brazed joint is formed at every contact point between two plates. The design creates a heat exchanger that consists of two separate circuits.



Sealing plates are used to seal off the space between the cover plate and the first and last channel plate. The number of cover plates varies, e.g. with the type and size of CBE and its respective pressure rating.

Some CBEs have a blind ring for the purpose of sealing off the space between the channel plate and the cover plate. In some CBEs the blind rings are integrated in the cover plate and first/last channel plates.

Material Combinations

There are different types of CBE product categories depending on material combinations and design pressures. We define them as standard CBEs, All-stainless CBEs, Mo-steel CBEs and High-Pressure CBEs. The standard plate materials are stainless steel, **S**, of AISI 316 type (1.4401 or 2343), vacuum-brazed with a pure copper filler, **C**, or a nickel-based filler, **N**. Carbon steel can be used to some extent, e.g. for certain types of connections. For demanding applications, the plates can be made of SMO 254, a stainless steel with a higher content of molybdenum, **M**. There are CBEs available for standard pressure rating, **S**, or high pressure rating, **H**. The material and pressure denominations are shown below.

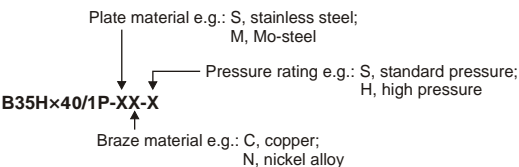
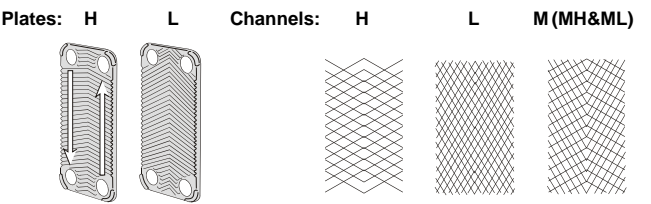


Table 1: Examples of CBEs with various material and design pressures

CBE Categories	Denomination	Explanation
Standard CBEs	B25H/1P-SC-S	B25 with stainless steel plates brazed with copper. Standard pressure rating.
High Pressure CBEs	B25H/1P-SC-H	B25 with stainless steel plates brazed with copper. High pressure rating.
All-stainless CBEs	B25H/1P-SN-S	B25 with stainless steel plates brazed with nickel alloy. Standard pressure.
Mo-steel CBEs	B25H/1P-MC-S	B25 with Mo-steel plates brazed with copper. Standard pressure rating.

CBE Plates and Channel Types

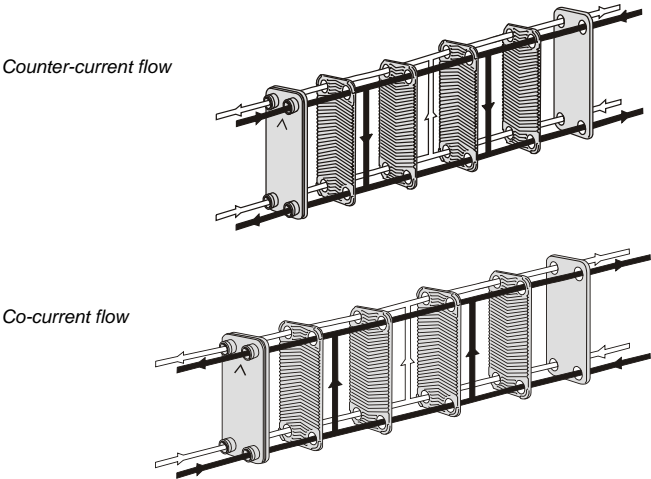
Some CBEs are available with different types of channel plates where the herringbone pattern varies. The chevrons can be obtuse (creating a high theta plate, H) or acute (creating a low theta plate, L).



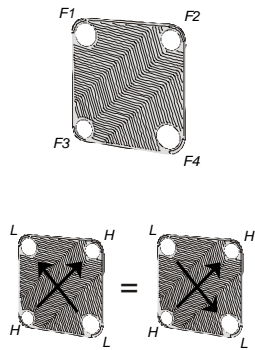
By mixing high and low theta plates, the thermal characteristics of the CBE can be modified. For example one can have a CBE with the same pressure drop on both sides despite different flow rates.

FLOW CONFIGURATIONS

The fluids can pass through the heat exchanger in different ways. For parallel-flow CBEs, there are two different flow configurations: co-current or counter-current.



For cross-flow CBEs, e.g. the B60, there are two types of plates which are combinable in only one way. This CBE has a cross-flow configuration, instead of the parallel flow normally found in CBEs. Note that ports F1 and F4 make up the outer circuit and ports F2 and F3 the inner circuit.

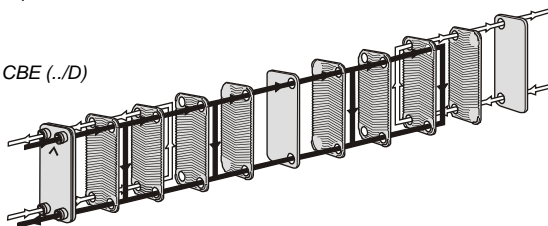


When using the B60 exchanger in single-phase applications, you get the same result with these two different installations. However in a condenser it is very important that the gas inlet is port F1 and the outlet F4.

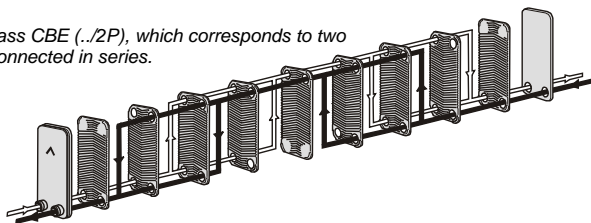
Different versions available

There are several different versions of the channel plate packages. Below are a couple of examples.

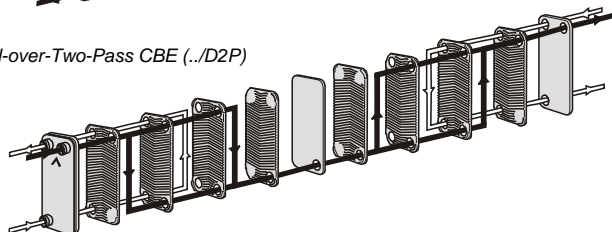
Dual-Circuit CBE (.../D)



Two-Pass CBE (.../2P), which corresponds to two units connected in series.



Dual-over-Two-Pass CBE (.../D2P)



DESIGN CONDITIONS AND APPROVALS

The standard pressure rating for CBEs, i.e. maximum operating pressure, is 31 bar (3.1 MPa, 450 psi). The standard maximum operating temperature is 225°C (437°F) for copper-brazed CBEs, and 350°C (660°F) for All-stainless CBEs (nickel-based filler). However, as temperature and pressure are closely coupled, there is a possibility to increase the pressure if the temperature is reduced. For details, please check the label and other technical documentation.

CBEs are approved by a number of independent bodies, e.g.

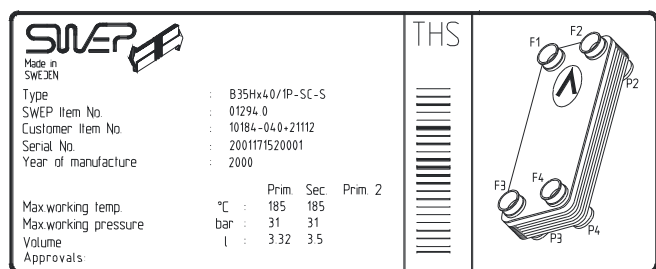
- Canada, Canadian Standard Association (CSA)
- Japan, The High Pressure Gas Safety Institute of Japan (KHK)
- USA, Underwriters Laboratories (UL)
- Europe, Pressure Equipment Directive (PED)

We also have design approvals, e.g. from: Lloyds Register, Great Britain; Det Norske Veritas (DNV), Norway; American Bureau of Shipping (ABS), USA; Korean Register of Shipping (KR), Korea; Registro Italiano Navale (RINA), Italy.

For operating conditions concerning the European approval PED, please see Appendix, TableA. For more details on the respective approvals, please contact Stokvis.

LABELING SYSTEM AND OPERATING CONDITIONS

All CBEs are equipped with an adhesive label which includes vital information about the unit, e.g. type of heat exchanger (which indicates the basic CBE execution and material combination) and item number. The label also includes the serial number which is described below. The Operating Conditions; state the maximum operating temperature and pressure as per the respective approving organization.



2 00 11 715 2 0001

- Number in series
- Number of circuits
- Product code
- Month 11, i.e. November
- Year 00, i.e. 2000
- Production Entity

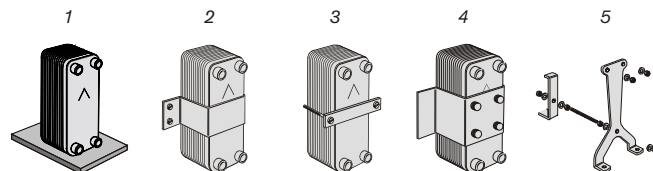
The engraved Serial Number provides information about where and when the CBE was produced.

MOUNTING

Never expose the unit to pulsations or excessive cyclic pressure or temperature changes. It is also important that no vibrations are transferred to the heat exchanger. If there is a risk of this, install vibration absorbers. For large connection diameters, we advise you to use an expanding device in the pipeline. It is also suggested that e.g. a rubber mounting strip should be used as a buffer between the CBE and the mounting clamp.

In single-phase applications, e.g. water-to-water or water-to-oil, the mounting direction has little or no effect on the performance of the heat exchanger, but in two-phase applications, the orientation of the heat exchanger becomes very important. In two-phase applications, CBEs should be mounted vertically, with the arrow on the front plate pointing upwards.

Several mounting suggestions for CBEs are shown below. Mounting stud bolts, in different versions and locations, are available on the CBEs as an option.



1. Supported from the bottom
2. Sheet metal bracket (rubber insert between bracket and exchanger)
3. Crossbar and bolts (rubber insert between the crossbar and exchanger)
4. Equipped with mounting stud bolts on the front or back cover plate
5. Support legs are available for some CBEs

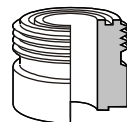
For smaller CBEs it is also possible to mount the unit by simply suspending it from the pipes/connections.

CONNECTIONS

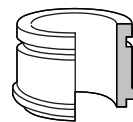
All connections are brazed to the heat exchanger in the general vacuum brazing cycle, a process which gives a very strong seal between the connection and the cover plate. However, take care not to join the counterpart with such force that the connection is damaged.

Depending on the application, there are a lot of options available for the connections, different versions and locations, e.g. Compac flanges, SAE flanges, Rotolock, Victualic, threaded connections and welding connections. It is important to have the right international or local standard of connection, as they not always are compatible.

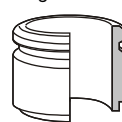
Rotolock Connections



Victualic Connections



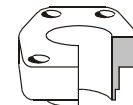
Welding Connections



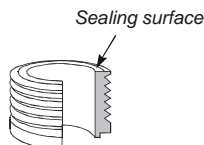
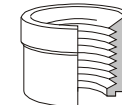
Flanges of DIN Type, Compac® flanges



Flanges of SAE Type



SAE O-Ring Connections



Sealing surface

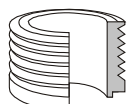
Some connections are equipped with a special plastic cap to protect the threads and sealing surface of the connection and to prevent dirt and dust from entering the CBE. This plastic cap should be removed with care, in order not to damage the thread, sealing surface or any other part of the connection. Use a screwdriver, pliers or knife.

Some connections have an external heel. The purpose of the heel is to simplify the pressure and leakage testing of the CBE in production.

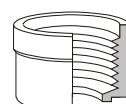
Threaded connections

Threaded connections can be female or male of well-known standards such as, ISO-G, NPT and ISO 7/1. The exterior can also be hexagonal which is shown below.

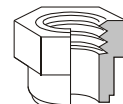
Externally Threaded Connections (Male)



Internally Threaded Connections (Female) of Standard Type



Internally Threaded Connections (Female) with a Hexagonal Exterior



Soldering Connections



The soldering connections (sweat connections) are in principle designed for pipes with dimensions in mm or inches. The measurements correspond to the internal diameter of the connections. Some of the soldering connections are universal, i.e. fit both the mm and inch pipes. These are denominated xxU, such as the 28U which fits both the 1 1/8" and 28.75 mm.

All CBEs are vacuum-brazed with either a pure copper filler or a nickel-based filler. Under normal soldering conditions (no vacuum), the temperature should not exceed 800°C (1470°F). Too much heat could change the material structure resulting in internal or external leakage at the connection. Because of this we recommend that all soldering is made with silver solder containing min. 45% silver. This type of solder has a relatively low soldering temperature and high moistening and fluidity properties.

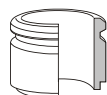
Soldering flux is used in order to remove oxides from the metal surface, and thereby its property makes the flux potentially very aggressive. Consequently, it is very important to use the correct amount of flux. Too much might lead to severe corrosion, so no flux should be allowed to enter the CBE.

Soldering Procedure

Degrease and polish the surfaces. Apply chloride flux with a brush. Insert the copper tube into the connection and braze with min. 45% silver solder. Point the flame towards the piping and braze at max. 650°C (1200°F). Avoid internal oxidation, e.g. by protecting the inside of the refrigerant side with N₂ gas.

Welding Connections

Welding is only recommended on specially designed welding connections. All our welding connections are executed with a 30° chamfer on top of the connection. Do not weld on pipes on other types of connections. The measurement in mm corresponds to the external diameter of the connection.

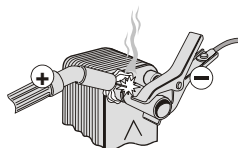


Welding Procedure

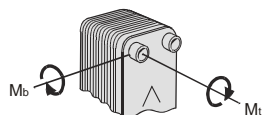
Protect the unit from excessive heating by:

- using a wet cloth around the connection.
- making a chamfer on the joining tube and connection edges as shown.

Use TIG or MIG/MAG welding. When using electrical welding circuits, connect the ground terminal to the joining tube, not to the back of the plate package. Internal oxidation can be reduced by a small nitrogen flow through the unit.



Allowable Connection Loads for Pipe Assembly Conditions

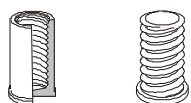


The maximum allowable connection loads given below are valid for low cycle fatigue. If high cycle fatigue is involved special analysis should be made.

Table 2: Allowable connection loads for different pipe assembly conditions

Pipe Size	Shear Force, Fs		Tension Force, Ft		Bending Moment, Mb		Torque, Mt	
	(kN)	(kp)	(kN)	(kp)	(Nm)	(kpm)	(Nm)	(kpm)
1/2"	3.5	357	2.5	255	20	2	35	3.5
3/4"	12	1224	2.5	255	20	2	115	11.5
1"	11.2	1142	4	408	45	4.5	155	16
1 1/4"	14.5	1479	6.5	663	87.5	9	265	27
1 1/2"	16.5	1683	9.5	969	155	16	350	35.5
2"	21.5	2193	13.5	1377	255	26	600	61
2 1/2"	44.5	4538	18	1836	390	40	1450	148
4"	73	7444	41	4181	1350	138.5	4050	413.5

Allowable Loads for Stud Bolt Assembly Conditions



Mounting stud bolts, in different versions and locations, are available on the CBEs as an option. These stud bolts are welded to the unit. The maximum allowable load on the stud bolts during assembly are stated below.

Table 3: Allowable loads for different stud bolt assembly conditions

Stud Bolt	Diameter, dk (mm)	Tension Force, Ft (N)	Torque, Mt (Nm)
M6	5.1	1500	3
M8	6.9	2700	7
M12	10.3	6000	18

STRAINERS

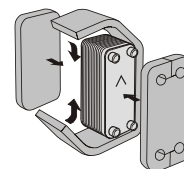
If any of the media contains particles larger than 1 mm (0.04 inch), we recommend that a strainer with a size of 16-20 mesh (number of openings per inch) is installed before the exchanger. The particles could otherwise block the channels, causing bad performance, increased pressure drop and risk of freezing. Some strainers can be ordered as CBE accessories.



INSULATIONS

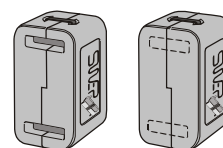
Insulation for Refrigerant Applications

CBE insulation is recommended for evaporators, condensers or district heating applications, etc. For refrigeration, use extruded insulation sheets, e.g. Armaflex or equivalent which also can be supplied



Insulation for Heating Applications

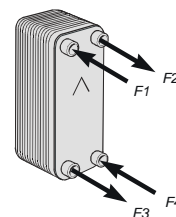
For heating applications, various types of insulation boxes can be used. The working temperature range defines which insulation is recommended. We can supply some of these insulation types as optional accessories.



INSTALLATION OF CBEs IN DIFFERENT APPLICATIONS

Single-Phase Applications

Normally, the circuit with the highest temperature and/or pressure should be connected on the left side of the heat exchanger when the arrow is pointing upwards. For example, in a typical water-to-water application, the two fluids are connected in a counter-current flow, i.e. the hot water inlet in connection F1, outlet F3, cold water inlet F4, outlet F2. This is because the right-hand side of the heat exchanger contains one channel more than the left-hand side, and the hot medium is thus surrounded by the cold medium to prevent heat loss.



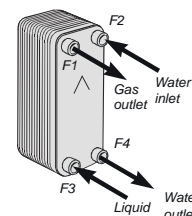
Two-Phase Applications

In all refrigerant applications it is very important that every refrigerant channel is surrounded by a water/brine channel on both sides. Normally the refrigerant side must be connected to the left-hand side and the water/brine circuit to the right-hand of the CBE. If the refrigerant is incorrectly connected, to the first and last channel instead of water/brine, the evaporation temperature will drop, with the risk of freezing and very bad performance. CBEs used as condensers or evaporators should always be fitted with adequate connections on the refrigerant side.

Evaporators; V-Type CBEs

The V-type CBEs type are equipped with a special distribution device at the refrigerant inlet, i.e. normally port F3. The purpose of the distribution device is to evenly distribute the refrigerant in the channel.

The refrigerant liquid should be connected to the lower left connection (F3) and the refrigerant gas outlet to the upper left connection (F1). The water/brine circuit inlet should be connected to the upper right connection (F2) and the outlet to the lower right connection (F4).



Expansion Valves

The expansion valve should be placed close to the inlet connection, whereas the bulb should be mounted about 500 mm from the vaporized refrigerant outlet connection. The pipe diameter between the expansion valve and the CBE should be the same as the diameter of the refrigerant liquid line.

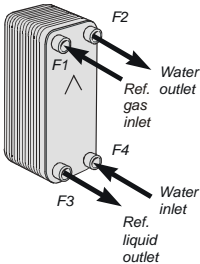
For V-type CBEs, the pressure drop in the internal distribution system must be added to the pressure drop in the expansion valve to arrive at the total pressure drop. Normally, selecting the next larger size valve will give satisfactory performance.

Freezing Protection

- a) Use a filter < 1 mm, 16 mesh (see previous chapter on Strainers).
- b) Use an antifreeze when the evaporation temperature is close to liquid-side freezing.
- c) Use a freeze protection thermostat and flow switch to guarantee a constant water flow before, during and after compressor operation.
- d) Avoid "pump-down" function.
- e) When starting up a system, wait a moment before starting the condenser (or have reduced flow through it).

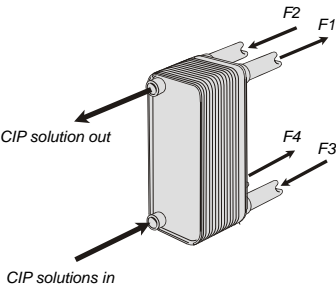
Condensers

The refrigerant (gas) should be connected to the upper left connection, F1, and the condensate to the lower left connection, F3. The water/brine circuit inlet should be connected to the lower right connection, F4, and the outlet to the upper right connection, F2.



CLEANING OF THE CBEs

Thanks to the normally very high degree of turbulence in CBEs there is a self-cleaning effect in the channels. However, in some applications the fouling tendency can be very high, e.g. when using extremely hard water at high temperatures. In such cases it is always possible to clean the exchanger by circulating a cleaning liquid (CIP - Cleaning In Place). Use a tank with weak acid, 5% phosphoric acid or, if the exchanger is frequently cleaned, 5% oxalic acid. Pump the cleaning liquid through the exchanger.



For tough installations we recommend factory-installed CIP connections/valves for easy maintenance.

For optimum cleaning, the cleaning solution flow rate should be a minimum of 1.5 times the normal flow rate, preferably in a back-flush mode. After use, do not forget to rinse the heat exchanger carefully with clean water. A solution of 1-2% sodium hydroxide (NaOH) or sodium bicarbonate (NaHCO₃) before the last rinse ensures that all acid is neutralized. Clean at regular intervals

For further information about cleaning of the CBEs, please consult our CIP information or your local supply company.

WARRANTY

we offer a 12-month warranty from the date of installation, but in no case longer than 15 months from the date of delivery. The warranty covers only manufacturing and material defects.

DISCLAIMER

CBE performance is based on installation, maintenance and operating conditions done in conformance with this manual. We cannot assume any liability for CBEs that do not meet these criteria.

For further information, please consult our technical information or your local supply company.

APPENDIX

A number of CBEs are approved by the European approval PED (Pressure Equipment Directive). For approved units the data on the table must not be exceeded at any circumstances. The heat exchangers are designed for use with fluids according to groupe1 in AFS 1999:4. For details about operating conditions for our PED approved heat exchangers, please see TableA.

Table A: Operating conditions for PED approved units.

Type of CBE	Max Working Pressure (PS)		Work. Temp. (TS)		Test Pressure (PT)		Volume/Channel (V) Litre	Channels/ circuit Max No.
	bar	PSI	°C	°F	bar	PSI		
Type 5	31/31	550/550	-160/155*	-256/311*	50/50	725/725	0,024	50
Type 8	31/31	550/550	-160/155*	-256/311*	50/50	725/725	0,041	50
Type 10	31/31	550/550	-160/155*	-256/311*	50/50	725/725	0,061	75
Type 12	31/31	550/550	-160/155*	-256/311*	50/50	725/725	0,061	75
Type 16	25/25	363/363	-160/155*	-256/311*	41/41	595/595	0,082	75
Type 15	31/31	550/550	-160/155*	-256/311*	50/50	725/725	0,062	50
Type 25	31/31	550/550	-160/155*	-256/311*	50/50	725/725	0,11	75
Type 27	31/31	550/550	-160/155*	-256/311*	50/50	725/725	0,11	75
Type 28	25/25	363/363	-160/155*	-256/311*	41/41	595/595	0,11	75
Type 35	31/31	550/550	-160/155*	-256/311*	50/50	725/725	0,18	100
Type 45	31/31	550/550	-160/155*	-256/311*	50/50	725/725	0,23	125
Type D47	31/31/31	550/550/550	-160/155*	-256/311*	50/50/50	725/725/725	0,24	100
Type 50	31/31	550/550	-160/155*	-256/311*	50/50	725/725	0,24	125
Type 56	31/31	550/550	-160/155*	-256/311*	50/50	725/725	0,21/0,30	125
Type 57	31/31	550/550	-160/155*	-256/311*	50/50	725/725	0,33	150
Type D57	31/25/31	550/363/550	-160/155*	-256/311*	50/41/50	725/595/725	0,42	155
Type D58	31/25/31	550/363/550	-160/155*	-256/311*	50/41/50	725/595/725	0,42	155
Type 60	31/31	550/550	-160/155*	-256/311*	50/50	725/725	0,22	150
Type 65	30/30	435/435	-160/155*	-256/311*	49/49	711/711	0,59	200

* Max. working temperature 225°C (437°F), for exact information see label on the heat exchanger.



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