Vessel manual

en

ECSQ
Cascade cooler

SABROE
BY JOHNSON CONTROLS

Johnson Controls

Introduction

Sabroe cascade coolers meet the requirements of the European Pressure Equipment Directive (PED) and most maritime classification societies. The heat exchanger is suitable for several purposes mainly as a cascade cooler for coupling refrigerant circuits with different refrigerants e.g. CO_2/NH_3. Furthermore, the heat exchanger can be used as an intermediate cooler in refrigerant circuits using the same refrigerant if total separation of the circuits or condensing of different compatible gasses is required.

Due to a unique inner design and state-of-the-art construction and production technology, the heat exchanger features include small outside measures, reduced refrigerant charging, high efficiency and increased safety against mixing of different refrigerants. This ensures economical and environmentally sound operation. By using a Windows computer programme it is easy to find the most appropriate size.

Description and function

Description

The heat exchanger is a flooded evaporator for condensing gasses on the tube side. Evaporation takes place on the shell side. The integrated liquid separator protects the connected compressor against liquid hammering. Some of the heat exchanger types offer an extra volume in the separator part. This volume can be used as a low pressure receiver for liquid refrigerant.

In refrigerant circuits with two different refrigerants, e.g. CO_2 on the low pressure side and NH_3 on the high pressure side, the heat exchanger can transfer the heat from the low pressure side of the plant to the high pressure side, and keep the two different refrigerants completely separated.

Complete separation of several refrigerant circuits may also be appropriate in circuits with only one refrigerant but several types of oil e.g. in heat pumps.

The heat exchanger is primarily intended for condensation of CO_2 or NH_3 and evaporation of NH_3. However, the heat exchanger can be used as a cascade cooler with most compatible refrigerants.

The heat exchanger is made of low alloy carbon steel. The tube plates are connected with 10/8 mm steel pipes. The pipes form the heat transferring surface. The end covers can be either welded or flanged removable ones.

There are two types of tube plates to choose from: a single tube plate solution or a double tube plate solution. For heat exchangers with double tube plate, there is a small cavity between the tube side and the shell side. This prevents the refrigerant on the shell side and the refrigerant on the tube side from mixing. In case of leakage, the refrigerants will first flow into this cavity and out through the leaking channel. All channels must always be open to atmospheric pressure. A leak detector can be connected to indicate when repair work is required.

The tube side inlets and outlets are positioned in the end covers. One-pass types have inlet in one end cover and outlet in the bottom of the other while the inlet and outlet on the two-pass types are positioned in the same cover. Optionally the two-pass version can be made with an extra outlet for the condensate in the bottom of the return cover.

Heat exchangers must be installed horizontally to allow the condensed fluids to be drained from the tubes.

Function

The condensing gas flows from the covers to the tube bundle. The small pipes ensure a compact design and reduced refrigerant charging. One or more vertical channels are made in the tube bundle. By means of extra refrigerant circulation, these channels ensure a high heat transferring coefficient and thus an even more compact design and lower charge.

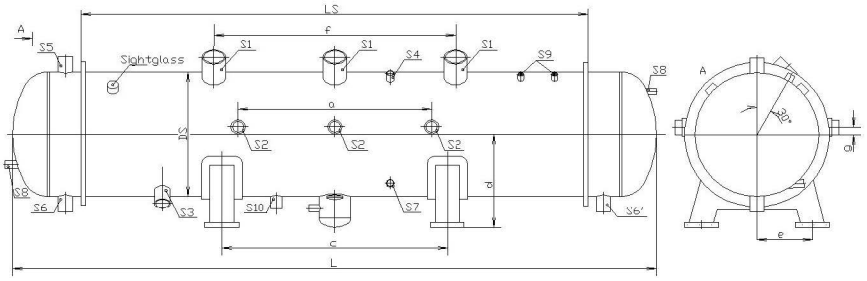
The tube bundle does not fill up the complete shell as the upper part of the shell functions as a vertical liquid separator. The even gas suction is ensured with a suction manifold just like the liquid injection is carried out through a manifold.

If non-miscible oil is used, there is an oil collector positioned at the bottom of the evaporator which will hold the oil carry-over of approximately one week. In case of automatic oil return or miscible oil, the collector may be replaced by a connection for automatic oil return system or oil rectifier.

Connections for safety valve, purging etc. are positioned on top of the shell.

Connections for removal of non-condensing gasses are positioned on the inlet and outlet covers.

Connections and dimensions



Connection	Designation	Size	Quantity	Remarks
S1	Suction nozzle	See table	See table	
S2	Injection nozzle	See table	See table	
S3	Oil rectifier	See table	See table	Not for R717 on shell side
S4	Level regulation	DN25	1	
S5	Inlet condensation	See table	1	
S6	Outlet condensation	See table	(1)	S6 only for two-pass type
S6’	Outlet condensation	See table	1	Optional for two-pass type
S7	Level regulation	DN25	1	
S8	Purge nozzle	DN25	See table	
S9	Safety and other	Specify on order	2	
S10		See table	1	Nozzle not in use

Oil sump only for use with R717 on shell side.

ECSQ	LS	a	c	f
xx20	2000	-	1300	-
xx30	3000	1200	2300	1300
xx40	4000	1700	3250	1800
xx50	5000	2200	4000	2300
xx60	6000	2700	5000	2800
ECSQ	**DS**	**d**	**e**	
40	419	435	225	
50	508	525	280	
60	610	630	320	
70	700	669	375	
80	813	735	425	
90	914	760	480	
A0	1016	835	504	

Name	Type	S1		S2		S5	S3		S6'	S6	g	L
		DN	pcs	DN	pcs	DN	DN	pcs			mm	mm
ECSQ	4020A2	50	1	25	1	25	25	1	40	50	-10	2719
ECSQ	4020B2	50	1	32	1	32	25	1	40	50	13	2728
ECSQ	4030A2	40	2	25	2	32	25	2	50	65	-10	3740
ECSQ	4030B2	50	2	25	2	40	25	2	50	65	10	3746
ECSQ	5020A2	65	1	32	1	40	25	1	50	65	54	2867
ECSQ	5020B2	65	1	40	1	40	25	1	50	65	56	2867
ECSQ	5020C2	80	1	40	1	40	25	1	50	65	56	2867
ECSQ	5030A2	50	2	32	2	40	25	2	50	65	54	3867
ECSQ	5030B2	65	2	32	2	50	25	2	65	80	54	3895
ECSQ	5030C2	65	2	32	2	50	25	2	65	80	54	3895
ECSQ	5030D2	80	2	40	2	65	25	2	65	100	83	3910
ECSQ	5040A2	65	2	32	2	50	25	2	65	80	54	4895
ECSQ	5040B2	65	2	40	2	50	25	2	65	100	56	4895
ECSQ	5040C2	80	2	40	2	65	25	2	65	100	56	4910
ECSQ	6020A2	65	1	40	1	40	25	1	50	65	121	3029
ECSQ	6020B2	80	1	50	1	50	25	1	65	80	127	3057
ECSQ	6020C2	100	1	50	1	50	25	1	65	80	127	3057
ECSQ	6020D2	100	1	65	1	65	25	1	65	100	107	3073
ECSQ	6030A2	65	2	32	2	50	25	2	65	80	118	4057
ECSQ	6030B2	65	2	40	2	65	25	2	65	100	121	4073
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ECSQ	6050A2	80	2	50	2	65	25	2	80	100	127	6086
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ECSQ	7050C2	125	2	65	2	100	25	2	100	125	165	6304
ECSQ	7060A2	100	2	65	2	80	25	2	100	125	165	7279
ECSQ	7060B2	125	2	65	2	100	25	2	100	125	165	7304
ECSQ	7060C2	125	2	80	2	100	25	2	100	150	173	7304
ECSQ	8030A2	80	2	50	2	80	25	2	80	100	178	4406
ECSQ	8030B2	100	2	50	2	80	25	2	100	125	178	4432
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ECSQ	8040C2	125	2	65	2	100	25	2	100	125	186	5457
ECSQ	8040D2	125	2	80	2	125	25	2	125	150	142	5508
ECSQ	8050A2	100	2	65	2	100	25	2	100	125	186	6457
ECSQ	8050B2	125	2	65	2	100	25	2	100	150	186	6457
ECSQ	8050C2	125	2	80	2	125	25	2	125	150	193	6508

Name	Type	S1		S2		S5	S3		S6’	S6	g	L
		DN	pcs	DN	pcs	DN	DN	pcs			mm	mm
ECSQ	8060A2	125	2	65	2	100	25	2	100	125	186	7457
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ECSQ	9040B2	125	2	65	2	100	25	2	100	150	207	5559
ECSQ	9040C2	125	2	80	2	125	25	2	125	150	214	5609
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ECSQ	6050B1	100	2	50	2	80	25	2	100	-	127	5850

Name	Type	S1		S2		S5	S3		S6’	S6	g	L
		DN	pcs	DN	pcs	DN	DN	pcs			mm	mm
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ECSQ	7040B1	100	2	50	2	80	25	2	125	-	157	4996
ECSQ	7040C1	100	2	65	2	80	25	2	125	-	165	4996
ECSQ	7050A1	100	2	50	2	80	25	2	125	-	157	5996
ECSQ	7050B1	100	2	65	2	100	25	2	125	-	165	5996
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ECSQ	8040A1	100	2	50	2	80	25	2	125	-	178	5113
ECSQ	8040B1	100	2	65	2	100	25	2	125	-	186	5113
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ECSQ	A060A1	150	2	80	2	125	25	2	150	-	238	7401
ECSQ	A060B1	200	2	100	2	150	25	2	200	-	253	7451
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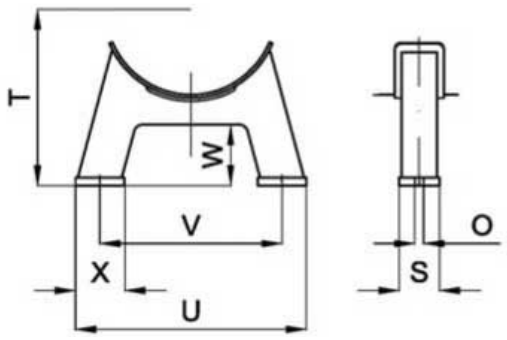
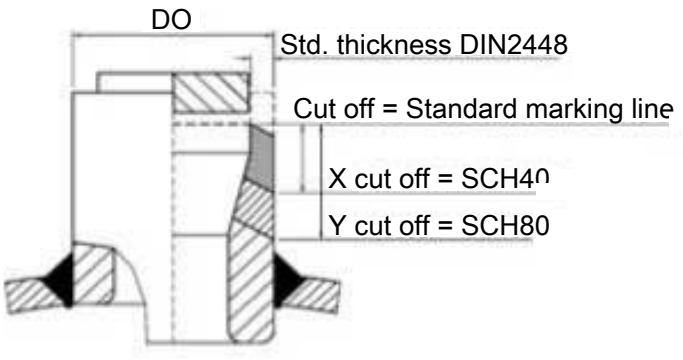
All data preliminary. To be confirmed on order.

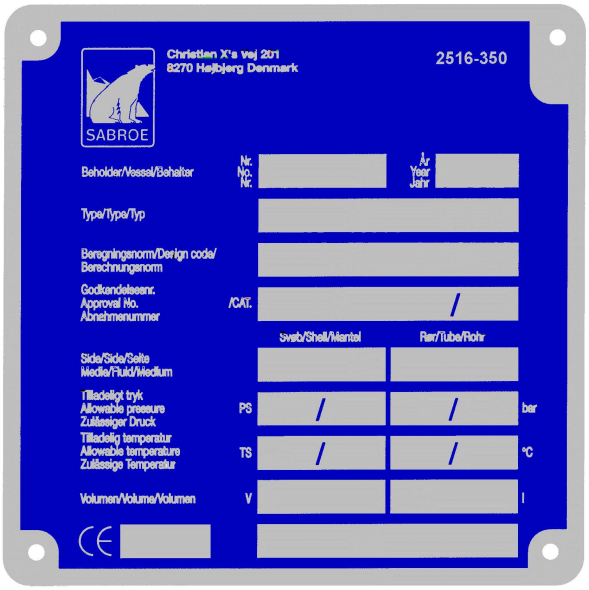


Diameter size		16	21	27	32	41	50	60	70	80	90	A0
Length	S	80	80	80	100	100	120	120	120	150	150	175
Height	T	225	250	280	350	435	525	630	669	735	760	835
Depth	U	278	328	384	449	569	680	816	925	1025	1131	1237
Bolts	V	178	228	284	329	449	560	641	750	850	960	1007
Free height	W	100	100	100	130	150	180	205	205	205	205	205
Depth foot	X	100	100	100	120	120	120	175	175	175	175	230
Bolt holes	O	25	25	25	25	25	25	25	25	25	25	25



Connection nominal diameter		Connection external diameter	Standard connection thickness	Connection possibilities	
DN	inch	OD	DIN2448	ANSI SCH40 x cut off	ANSI SCH80 x cut off
15	1/2	21.3	2.3	7	11
20	3/4	26.9	2.3	7	11
25	1	33.7	2.6	8	13
32	1 1/4	42.4	2.6	9	14
40	1 1/2	48.3	2.6	9	15
50	2	60.3	2.9	9	16
65	2 1/2	76.1	2.9	20	22
80	3	88.9	3.2	14	23
100	4	114.3	3.6	15	25
125	5	139.7	4.0	15	27
150	6	168.3	4.5	15	31
200	8	219.1	6.3	15	31

Name plate



Shipping

The heat exchanger must be blanked off and primed on delivery. The primer is not intended for outdoor storage. If the heat exchanger is not put into immediate service, take precautions against corrosion or contamination.

Only lift the heat exchanger when it is empty, and make sure it is not subjected to strokes or bumps during transport. When lifting the heat exchanger before it is built into the unit, always use straps around the shell.

The weight is stated in the technical data.

A shipping description can be made when the heat exchanger is built together with the unit.

Installation

The site and personal protection must be in accordance with EN 378-3 or national requirements.

Check the heat exchanger immediately upon receipt for any damage occurred during transport. If the heat exchanger is damaged, the unit must not be installed and started. When placing the heat exchanger, make sure to leave enough room for inspection, maintenance, escape and emergency.

Foundations must be sufficiently robust as their purpose is to provide permanent support without settling and to absorb any normal vibrations from outside causes.

The heat exchanger is equipped with support for horizontal installation. Please note that for some of the cascade cooler types an inclination towards the condensate outlet nozzle is required (See section).

Blanked off branches must be cut off at the cutting groove depending on metal thickness on adjoining tubes. Make sure that no impurities get into the heat exchanger during installation.

Do not remove protective plugs and covers until immediately before installation.

The entire system must be clean before starting operation. Under certain conditions, it may be required to use strainers in the piping.

When fitting the tube connections, make sure that stress in the heat exchanger during test, start-up, operation and standstill does not exceed the allowable values. Vibrations must be minimised possibly by means of a vibration damper.

Apart from branch connections, saddle plates and supports, welding must not be carried out on the heat exchanger.

The heat exchanger must be secured against exceeding the allowable pressures and temperatures.

Maximum temperature difference (shell-tube) is 20K during normal operation.

All outer surfaces must have a corrosion-resistant surface coating to allow the heat exchanger to be installed in certain environments without it causing corrosion.

Hot surfaces must be marked "Hot".

Safety equipment

Before the heat exchanger is put into operation, it must be provided with safety equipment. The manufacturer of the refrigeration plant is responsible for the safety equipment as it is not included in the heat exchanger delivery.

Start-up and operation

Before start-up, make sure that all connections are tight.

To avoid accidents or personal injury, the person responsible for the plant must make sure that the operating staff is duly trained and instructed before the refrigeration plant is started. The instruction should be based on the unit instruction manuals and should include instructions in construction, supervision, operation and maintenance of the system as well as the handling of used refrigerant.

Evacuation and charging with refrigerant must be carried out in accordance with the description in the unit instruction manual.

Before operation, the refrigeration plant must be leak tested and inspected by an authorised person.

Local safety and health regulations must be observed.

The authorised person makes a certificate which must be kept by the user.

Under no circumstances must the heat exchanger operate at temperatures or pressures higher than the ones indicated in the design specification. Excessive operation can cause stress and severely damage the heat exchanger tube bundle. During operation, the system must be completely filled with the operating fluid on boat side.

Start-up operation

Because the heat exchanger is equipped with a fixed tube sheet, fluids must be introduced in a manner that minimises differential expansion between the shell and tubes.

Shutdown operation

Because the heat exchanger is equipped with a fixed tube sheet, fluids must be shut down in a manner that minimises differential expansion between the shell and tubes.

Temperature shocks

The heat exchanger should not be subjected to abrupt temperature fluctuations. Hot fluids must not suddenly be introduced when the unit is cold nor must cold fluids suddenly be introduced when the unit is hot.

Maintenance

Only qualified personnel must carry out inspection.

Operating experience will determine how often inspection of the heat exchanger is needed. It depends on the operating conditions. Johnson Controls Denmark recommends inspection to be carried out in monthly intervals during the running-in period. After a running-in period of six months, a maintenance plan must be made. Johnson Controls Denmark recommends inspection to be carried out every third month as a minimum.

Do not dismount or tighten connections when the equipment is under pressure.

Periodic inspection during the service life of the heat exchanger must meet the requirements of national legislation or EN 378-2. Correspondingly, a visual inspection of connections, outer surfaces, bases, the vibration damper and safety equipment must be carried out.

If corrosion, erosion or other weaknesses in the heat exchanger are found, the heat exchanger must be inspected by a qualified authorised third party, who will provide the necessary permission to continue using the heat exchanger. If repair is requested, approved personnel together with a qualified third party and Johnson Controls Denmark will carry this out. If permission to continue using the heat exchanger is not granted, the heat exchanger must be scrapped.

Internal cleaning during normal operation is not needed.

The gasket and gasket surface must be thoroughly cleaned and free of scratches and other defects. Make sure that the gasket is properly positioned before re-tightening.

Spare parts and replacement parts

Spare parts and replacement parts can be ordered directly from Johnson Controls Denmark. When ordering parts, please provide the name of the needed part as well as the heat exchanger serial number, type, size and other information from the name plate.

Environmentally correct removal

The heat exchanger does not contain environmentally damaging material such as asbestos, mercury or heavy metals.

All parts of the heat exchanger can be re-used after being scrapped.

- Refrigerant and oil must be drained off before destruction
- All steel materials can be used again after remelting
- During the re-melting process, coating will disappear without damaging the environment

Weight, charging and volume

		R717	R744	R717		Shell side	Tube side	Weight *	Evapo-rator
Name	Type	Charge	Charge	Receiv-er volume	Liquid height above tubes	Volume	Volume	Empty	Capaci-ty **
		dm^3	dm^3	dm^3	mm	dm^3	dm^3	kg	kW
ECSQ	4020A	36	13	0	5	208	82	759	79
ECSQ	4020B	43	16	0	5	200	87	780	101
ECSQ	4030A	54	19	0	5	313	95	909	117
ECSQ	4030B	64	24	0	5	300	103	944	150
ECSQ	5020A	53	20	0	5	332	141	1263	124
ECSQ	5020B	63	25	0	5	319	149	1294	158
ECSQ	5020C	71	30	0	5	307	156	1321	187
ECSQ	5030A	79	30	0	5	498	156	1481	184
ECSQ	5030B	94	38	0	5	478	174	1540	234
ECSQ	5030C	107	45	0	5	461	185	1581	278
ECSQ	5030D	135	58	0	5	428	211	1670	361
ECSQ	5040A	105	40	0	5	664	177	1715	241
ECSQ	5040B	125	51	0	5	637	199	1788	308
ECSQ	5040C	143	59	0	5	614	213	1848	366
ECSQ	6020A	72	29	162	47	484	233	1681	178
ECSQ	6020B	88	37	120	47	465	253	1738	227
ECSQ	6020C	103	44	84	47	448	264	1778	270
ECSQ	6020D	131	57	0	5	417	291	1860	350
ECSQ	6030A	108	43	243	47	726	263	1942	265
ECSQ	6030B	133	55	180	47	697	289	2020	336
ECSQ	6030C	154	65	126	47	673	308	2088	397
ECSQ	6030D	196	83	0	5	625	338	2211	516
ECSQ	6040A	144	58	324	47	968	293	2204	347
ECSQ	6040B	177	73	240	47	929	321	2316	445
ECSQ	6040C	206	85	168	47	897	342	2402	526
ECSQ	6040D	262	113	0	5	834	396	2578	684
ECSQ	6050A	180	71	405	47	1210	318	2478	429
ECSQ	6050B	221	90	300	47	1162	349	2619	547
ECSQ	6050C	257	109	210	47	1121	389	2729	653
ECSQ	7030A	146	59	342	65	960	348	2577	361
ECSQ	7030B	181	74	261	65	921	378	2680	461
ECSQ	7030C	211	87	189	65	888	400	2773	542
ECSQ	7030D	269	115	0	5	824	459	2942	705
ECSQ	7040A	194	77	456	65	1280	383	2936	474
ECSQ	7040B	241	100	348	65	1228	435	3099	604
ECSQ	7040C	282	118	252	65	1184	464	3217	725
ECSQ	7050A	243	99	570	65	1600	432	3335	587
ECSQ	7050B	302	124	435	65	1535	474	3511	747
ECSQ	7050C	352	145	315	65	1479	510	3658	881
ECSQ	7060A	291	117	684	65	1920	463	3698	698
ECSQ	7060B	362	147	522	65	1842	513	3907	890
ECSQ	7060C	423	175	378	65	1775	566	4101	1051
ECSQ	8030A	192	77	462	75	1295	498	3210	469
ECSQ	8030B	240	100	351	75	1244	556	3367	598
ECSQ	8030C	280	116	255	75	1201	584	3478	712
ECSQ	8030D	358	148	0	5	1117	637	3686	925

		R717	R744	R717		Shell side	Tube side	Weight *	Evapo-rator
Name	Type	Charge	Charge	Receiv-er volume	Liquid height above tubes	Volume	Volume	Empty	Capaci-ty **
		dm^3	dm^3	dm^3	mm	dm^3	dm^3	kg	kW
ECSQ	8040A	256	104	616	75	1727	563	3674	616
ECSQ	8040B	319	130	468	75	1659	606	3853	785
ECSQ	8040C	373	152	340	75	1601	644	4016	933
ECSQ	8040D	477	200	0	5	1489	742	4316	1213
ECSQ	8050A	320	127	770	75	2159	602	4114	764
ECSQ	8050B	399	163	585	75	2074	671	4367	980
ECSQ	8050C	467	193	425	75	2001	730	4573	1156
ECSQ	8060A	384	151	924	75	2590	642	4571	907
ECSQ	8060B	479	195	702	75	2489	734	4872	1156
ECSQ	8060C	560	229	510	75	2401	790	5104	1367
ECSQ	9030A	245	99	582	85	1633	666	4299	593
ECSQ	9030B	307	124	441	85	1568	707	4455	761
ECSQ	9030C	359	145	321	85	1513	742	4597	898
ECSQ	9030D	460	191	0	5	1407	844	4867	1168
ECSQ	9040A	327	129	776	85	2177	716	4862	785
ECSQ	9040B	409	166	588	85	2091	789	5102	1003
ECSQ	9040C	479	196	428	85	2018	852	5302	1179
ECSQ	9050A	409	159	970	85	2722	766	5438	970
ECSQ	9050B	511	206	735	85	2614	868	5770	1238
ECSQ	9050C	599	241	535	85	2522	927	5997	1456
ECSQ	9060A	491	194	1164	85	3266	850	6046	1156
ECSQ	9060B	613	244	882	85	3137	932	6426	1460
ECSQ	9060C	718	291	642	85	3026	1035	6710	1746
ECSQ	A040A	409	159	964	94	2705	952	6875	962
ECSQ	A040B	512	205	728	94	2598	1062	7186	1238
ECSQ	A040C	600	240	532	94	2507	1120	7400	1460
ECSQ	A050A	511	201	1205	94	3381	1056	7590	1191
ECSQ	A050B	640	252	910	94	3248	1141	7958	1518
ECSQ	A050C	750	302	665	94	3134	1253	8278	1812
ECSQ	A060A	613	239	1446	94	4057	1118	8298	1421
ECSQ	A060B	768	305	1092	94	3898	1259	8759	1812
ECSQ	A060C	901	360	798	94	3761	1369	9114	2153

*) Two-pass version with flanged end covers.

**) Qnom: R717 shell side evaporation at -10°C, R744 tube side condensation at -5°C.

All data preliminary. To be confirmed on order.

Operating limits

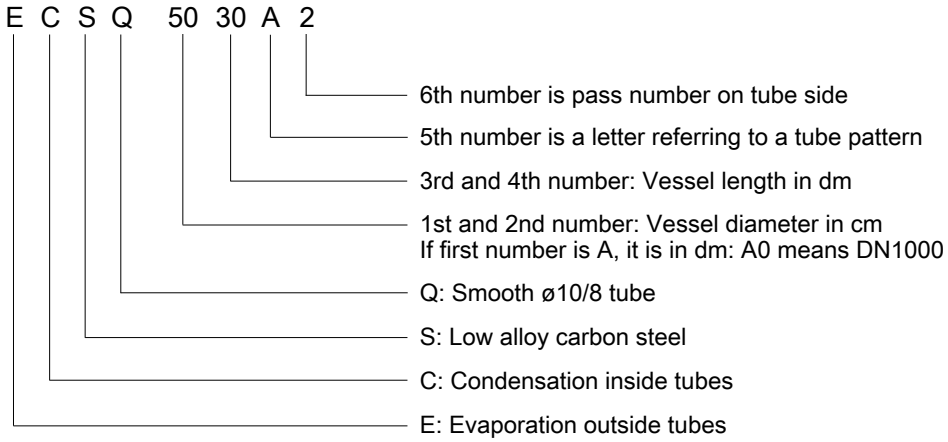
Design temperature:	
Shell side (max./min.)	50/-40 °C
Tube side (max./min.)	100/-40 °C
Typical LMTD area:	4 to 10K
Operating pressure:	
Shell side (max./min.)	21/-1 barg
Tube side (max./min.)	40/-1 barg
Velocity:	
Recommended min. velocity on tube side (inlet):	4 m/s
Fouling:	
Ammonia (R717) condensing inside tubes	0.0001 m2K/W
Other refrigerants condensing inside tubes	0 m2K/W

Selecting a heat exchanger

The heat exchanger is made in different lengths and diameters to cover a wide capacity range. Calculation of capacity is carried out by the Windows programme, COMP1.

Generally speaking, the most inexpensive heat exchanger is quite long and has a small diameter. In certain cases, e.g. on small ships, it may be necessary to choose a short heat exchanger with a large diameter with regard to the integrated liquid separator.

Name type explanation



How to use the heat exchanger

Connect the heat exchanger inlet (5) to the source of the condensed gas - usually the discharge pipe on low pressure compressors. The heat exchanger outlet (6) is usually connected to the liquid line of the low pressure system.

Connect the heat exchanger suction outlet (1) to the suction line of the high pressure compressor, and the injection inlet (2) to the liquid line of the high pressure system.

It is important to make sure that there is a sufficient refrigerant liquid level on the shell side. This can be controlled by a low pressure float, or by a high pressure float by means of measured refrigerant charging.

The optimal liquid level can be adjusted and controlled by observing the sight glass mounted on top of the shell. The upper row of pipes must be covered by refrigerant liquid (10-20 mm above the top of the pipes). Remember! Flooded evaporators do not require superheating.

The liquid level sensor can be connected to the level indicator connections 4 and 7.

If the liquid level is too high it may cause damage or accidents.

In case of miscible oil on the shell side, an oil rectifier must be mounted or the oil concentration must be kept below 0.5 weight % in the refrigerant.

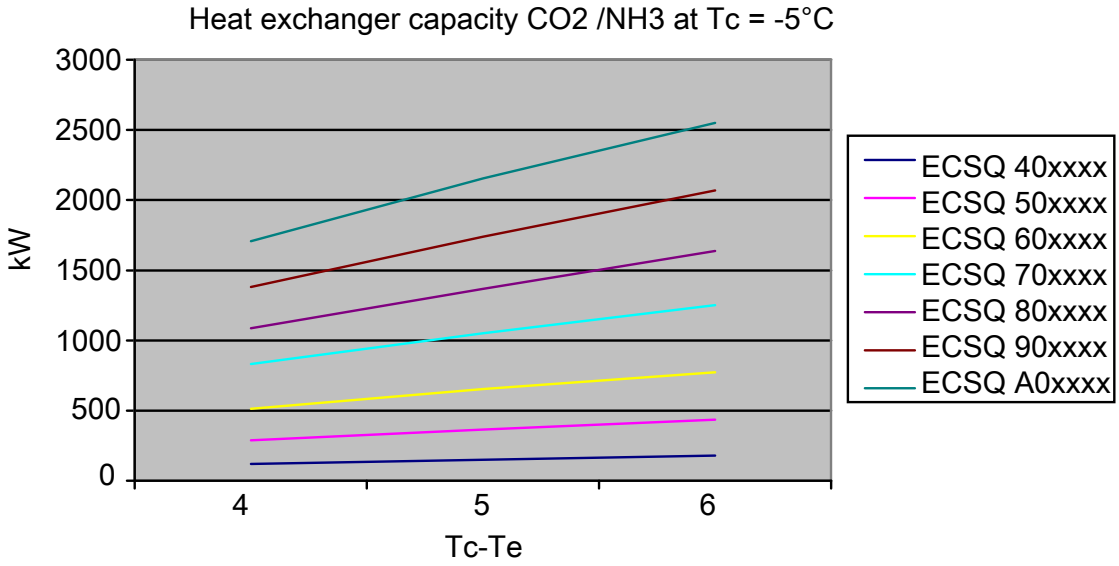
The heat exchanger is primarily intended for complete condensing of overheated or saturated gasses not containing any liquid. COMP1 calculations presuppose this condition. For other conditions, for instance part condensing or gasses containing liquid, contact the heat exchanger group.

On cascade coolers with double tube plates, a leak detector can be connected to the leak detector connections (15) on the tube plate.

Technical description

Materials		
Carbon steel low alloy		
Gaskets	Fiber	
Painting	Min. 30 my primer	
Approvals	**Authorities**	**Design codes**
PED		
Classification	LRS, DNV, GL, RINA, BV, ABS, NK	

Nominal capacity



	Diameter	Length *	Qnom **
	mm	m	kW
ECSQ 40xxxx	419	2, 3	79-150
ECSQ 50xxxx	509	2, 3, 4	124-366
ECSQ 60xxxx	610	2, 3, 4, 5	178-653
ECSQ 70xxxx	700	3, 4, 5, 6	361-1051
ECSQ 80xxxx	813	3, 4, 5, 6	469-1367
ECSQ 90xxxx	914.4	3, 4, 5, 6	593-1739
ECSQ A0xxxx	1016	4, 5, 6	962-2153

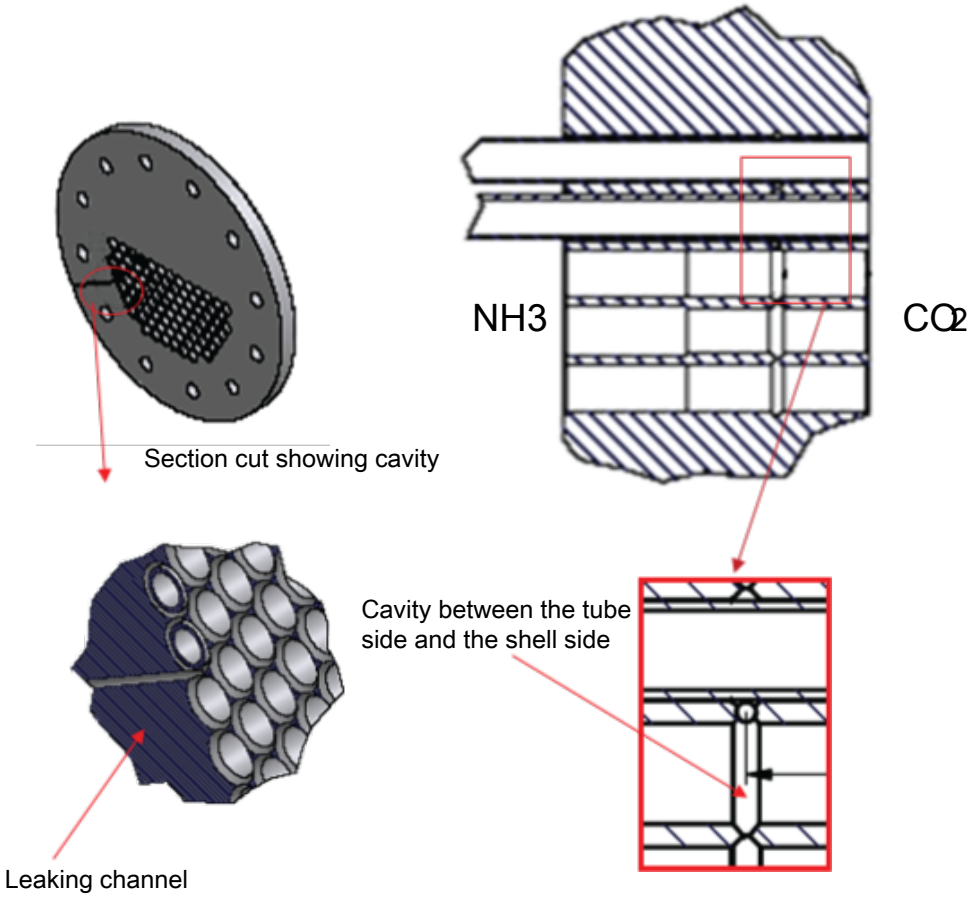
* Unit length (excluding end covers)

**Qnom: R717 shell side evaporation at -10°C, R744 tube side condensation at -5°C

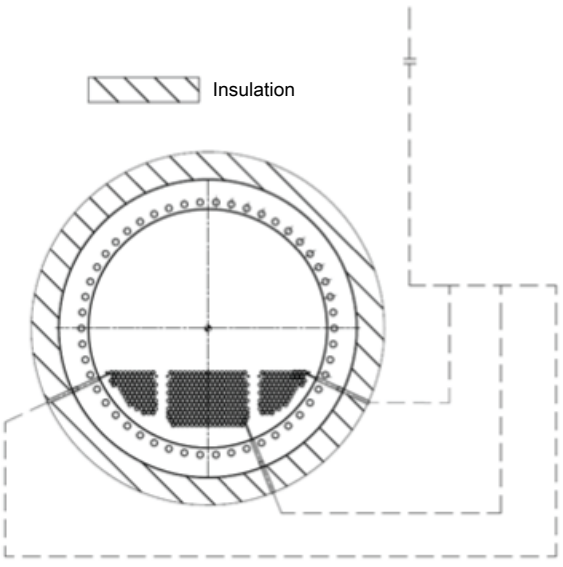
Data based on COMP1 version 18.00RC2.

ECSQ double tube sheet solution

Option: leak detection facility



In case of leaking, the refrigerants will first flow into the cavity and out through a leaking channel. All leaking channels must always be open to atmospheric pressure. A leak detector can be connected to indicate when repair work is required.



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