Shell and Tube
Heat Exchangers for
Electric & Hybrid Marine Propulsion

BOWMAN®

100 YEARS OF HEAT TRANSFER TECHNOLOGY

Bowman Marine Heat Exchangers.
The efficient, reliable cooling solution for

Electric and hybrid

Bowman shell and tube heat exchangers are now a proven solution for cooling electric and hybrid marine propulsion systems and charging stations.

For over 80 years, Bowman heat exchangers have provided cooling solutions for the marine industry.

Now, as the industry moves towards renewable energy power systems, Bowman is again at the forefront, providing reliable, high quality heat exchangers for electric and hybrid marine propulsion.

Electric Propulsion

Cooling applications include: the battery pack and on-board charger (where fitted), AC-DC converter, DC-DC converter, electric drive motor, plus battery charging stations.

Hybrid Propulsion

Cooling applications include: the Hybrid Control Unit, the combined Electric Motor/Generator, plus cooling for the engine jacket water and lubrication systems (please see our Marine Cooling brochure for more information on engine and transmission cooling).

Comprehensive Range

In addition to Bowman's standard marine heat exchangers, the company has developed a new titanium range. Designed specifically for electric and hybrid marine applications, the units offer design, performance and commercial benefits compared to models of similar specification.

Shell and Tube Design

Easily removable end covers enable the tube stack to be quickly withdrawn, making cleaning and maintenance simple and straightforward.

Fully Floating Tube Stack

The precision engineered, fully floating tube stack minimises thermal stresses and provides efficient heat transfer, with low pressure drop.

Compact Design

The compact design of Bowman heat exchangers enables them to be integrated more easily in to the cooling circuit.

Extensive Range

With over 40 models in the standard marine range, plus 15 more in the titanium range, Bowman have heat exchangers providing heat dissipation from 3kW to 701kW.

Advanced Engineering

3D CAD models are available for all heat exchangers.

Premium Quality

All heat exchangers are UK manufactured, using high quality components for long operational life.

Product Support

Bowman heat exchangers are supported with comprehensive technical data, a comprehensive replacement parts programme and a global network of distributors.

propulsion systems

Product Selection and Integration

Although all systems require different levels of heat dissipation, the following guidelines can be applied to establish the typical size of the heat exchanger required:

An electric motor will commonly lose 6% of the rated power in the form of heat. Therefore, a 100kW motor may need a cooler capable of transferring 6kW of thermal energy. The associated components including transformers, inverters, chargers etc will typically require an additional 3% of the motor power to be dissipated. Additional cooling may also be required for the batteries.

These figures should only be used to estimate the size of cooler required and where possible the correct heat exchanger should be selected by Bowman who can perform thermal calculations considering the heat dissipation requirements, fluids, temperatures and flow rates of the equipment which has been specified. See below for more information.

Selection Guidance

Electric and Hybrid systems are often designed to operate with sea water temperatures of 30°C plus, making selecting the right heat exchanger critical. Whilst the tables on pages 4 and 8 list typical performance examples at given temperatures and flow rates, they are intended as a general guide only. However, by supplying the following information, we can provide a computer aided product selection, to recommend the most appropriate heat exchanger for your requirements:

Coolant type and concentration
Heat to be dissipated (in kW)
Required coolant outlet temperature (in °C)
Coolant flow (in l/min)
Seawater temperature (in °C)

Electric and Hybrid Marine Heat Exchangers Standard Range

Bowman's standard marine heat exchanger range is proven worldwide in a wide range of electric and hybrid marine installations.

The table below is intended to provide a general guide to their typical performance when used with;

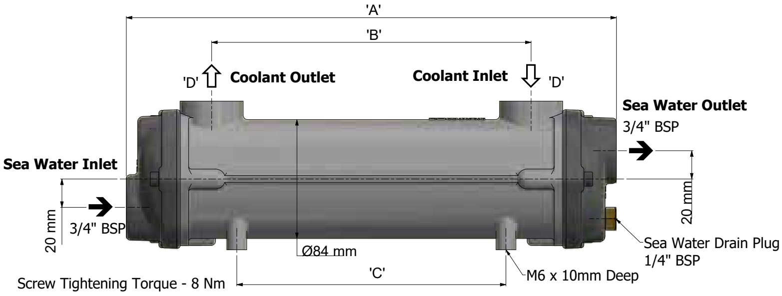
Coolant type: 50/50 water/glycol

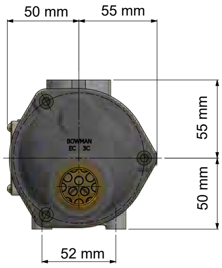
Coolant outlet temperature: 40^{0}C

Seawater inlet temperature: 30^{0}C

Type	Heat Dissipated	Coolant Flow	Sea Water Flow	Internal Coolant Volume	Internal Sea Water Volume
	kW	l/min	l/min	Litre	Litre
EC 80-3875-1	3	40	40	0.26	0.31
EC100-3875-2	7	50	50	0.49	0.44
EC120-3875-3	11	50	50	0.74	0.57
EC140-3875-4	15	50	50	0.97	0.71
EC160-3875-5	19	50	50	1.30	0.91
FC 80-3876-1	11	80	80	0.75	0.65
FC100-3876-2	16	80	80	1.10	0.84
FC120-3876-3	22	80	80	1.50	1.06
FC140-3876-4	29	80	80	2.00	1.35
FC160-3876-5	37	80	80	2.60	1.68
FG 80-3877-1	24	120	120	1.64	1.26
FG100-3877-2	32	120	120	2.40	1.56
FG120-3877-3	43	120	120	3.00	1.96
FG140-3877-4	53	120	120	3.90	2.42
FG160-3877-5	65	120	120	5.00	2.97
GL140-3878-2	50	200	200	3.60	3.10
GL180-3878-3	66	200	200	4.80	3.80
GL240-3878-4	82	200	200	6.30	4.60
GL320-3878-5	100	200	200	8.00	5.50
GL400-3878-6	121	200	200	10.00	6.60
GL480-3878-7	136	200	200	12.20	7.70
GK190-3879-3	98	300	300	7.00	6.30
GK250-3879-4	125	300	300	9.00	7.50
GK320-3879-5	153	300	300	11.60	9.00
GK400-3879-6	181	300	300	14.60	10.60
GK480-3879-7	206	300	300	17.40	12.30
GK600-3879-8	238	300	300	22.10	14.70
JK190-3881-3	121	400	400	9.70	8.80
JK250-3881-4	157	400	400	12.50	10.40
JK320-3881-5	195	400	400	16.10	12.50
JK400-3881-6	233	400	400	20.30	14.70
JK480-3881-7	267	400	400	24.20	17.10
JK600-3881-8	306	400	400	30.70	20.40
PK190-3880-3	117	650	650	13.60	16.00
PK250-3880-4	238	650	650	17.70	18.60
PK320-3880-5	303	650	650	22.60	21.80
PK400-3880-6	367	650	650	28.50	25.30
PK480-3880-7	424	650	650	34.00	29.00
PK600-3880-8	501	650	650	42.50	34.40
RK400-5882-6	524	900	900	43.40	37.90
RK600-5882-8	701	900	900	65.20	50.10

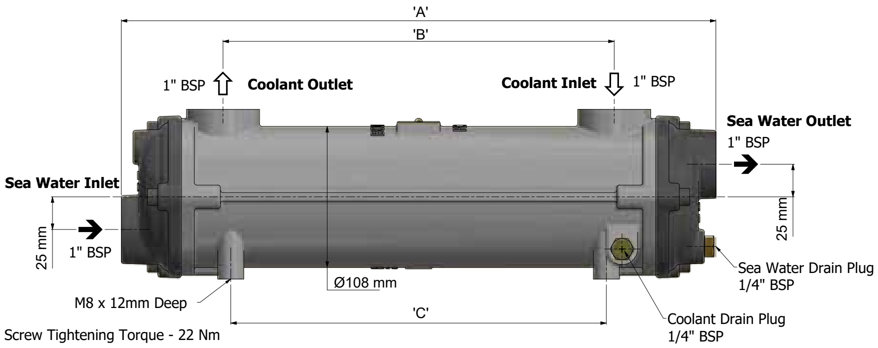
EC Range

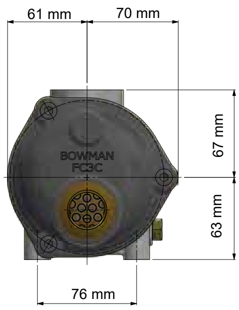




Type	Weight	A	B	C	D
	kg	mm	mm	mm	BSP
EC 80-3875-1	2.4	174	60	60	1/2"
EC 100-3875-2	3.2	260	140	104	3/4"
EC 120-3875-3	3.8	346	226	190	3/4"
EC 140-3875-4	4.8	444	324	288	3/4"
EC 160-3875-5	5.7	572	452	416	3/4"

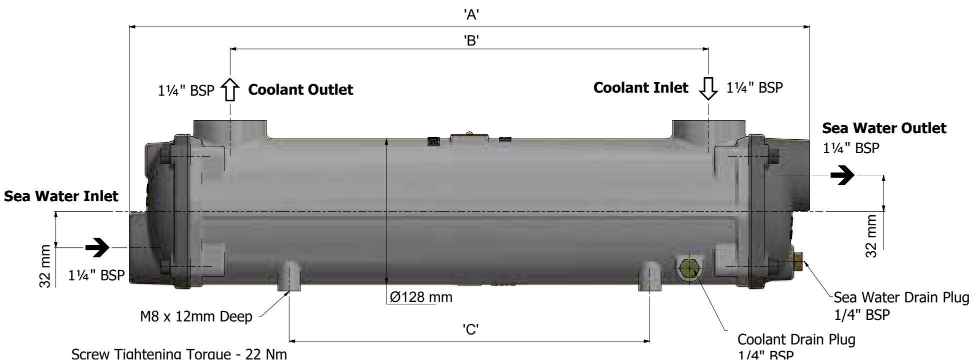
FC Range

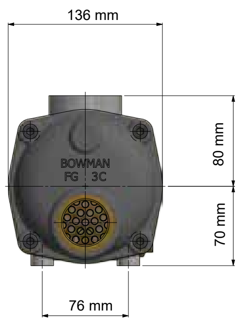




Type	Weight	A	B	C
	kg	mm	mm	mm
FC 80-3876-1	5.5	272	116	104
FC 100-3876-2	6.3	358	202	190
FC 120 -3876-3	7.3	456	300	288
FC 140-3876-4	9.4	584	428	288
FC 160-3876-5	11.0	730	574	434

FG Range



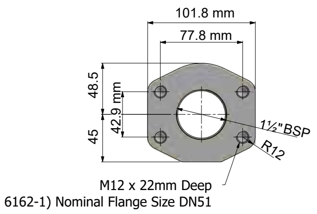


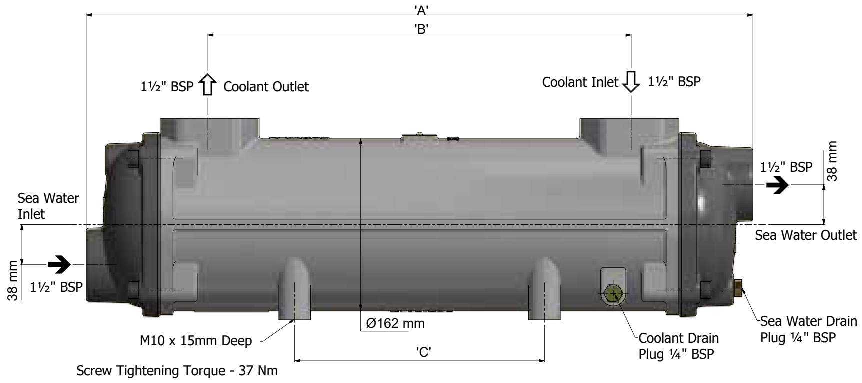
Type	Weight	A	B	C
	kg	mm	mm	mm
FG 80-3877-1	8.5	374	196	92
FG 100-3877-2	10.0	472	294	190
FG 120-3877-3	12.0	600	422	318
FG 140-3877-4	14.5	746	568	464
FG 160-3877-5	17.5	924	746	642

Maximum working coolant pressure 20 bar.
Maximum working sea water pressure 16 bar.

Maximum working coolant temperature 110°C.

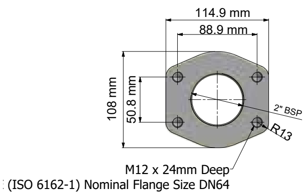
GL Range

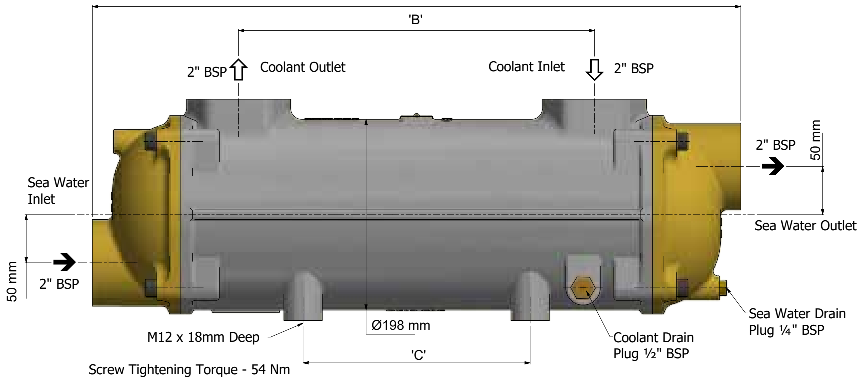


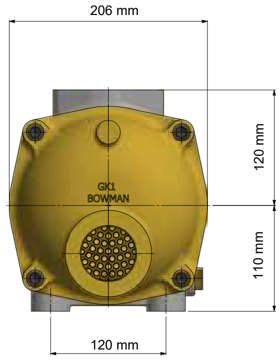


Type	Weight	A	B	C
	kg	mm	mm	mm
GL 140-3878-2	18	502	272	108
GL 180-3878-3	21	630	400	236
GL 240-3878-4	25	776	546	382
GL 320-3878-5	30	954	724	560
GL 400-3878-6	36	1156	926	762
GL 480-3878-7	42	1360	1130	966

GK Range

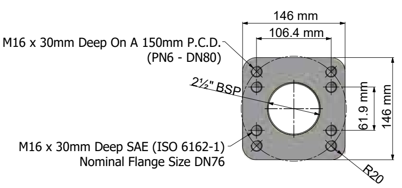


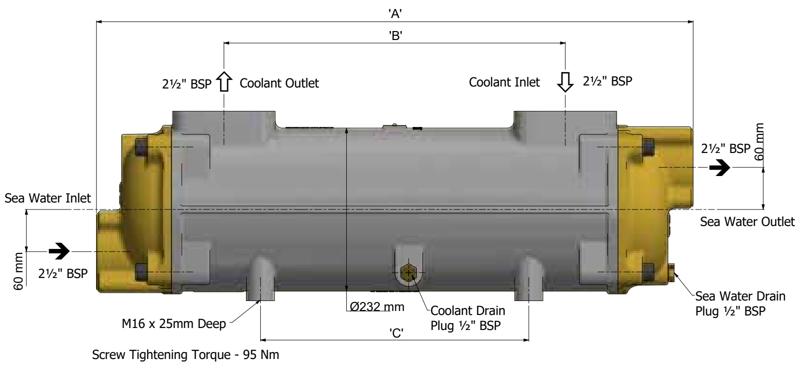


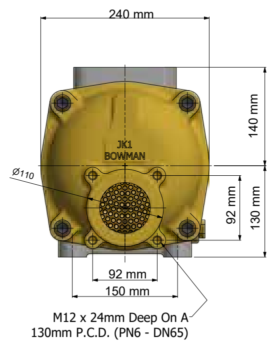


Type	Weight	A	B	C
	kg	mm	mm	mm
GK 190-3879-3	34	674	370	236
GK 250-3879-4	39	820	516	382
GK 320-3879-5	46	998	694	560
GK 400-3879-6	54	1200	896	762
GK 480-3879-7	62	1404	1100	966
GK 600-3879-8	74	1708	1404	1270

JK Range



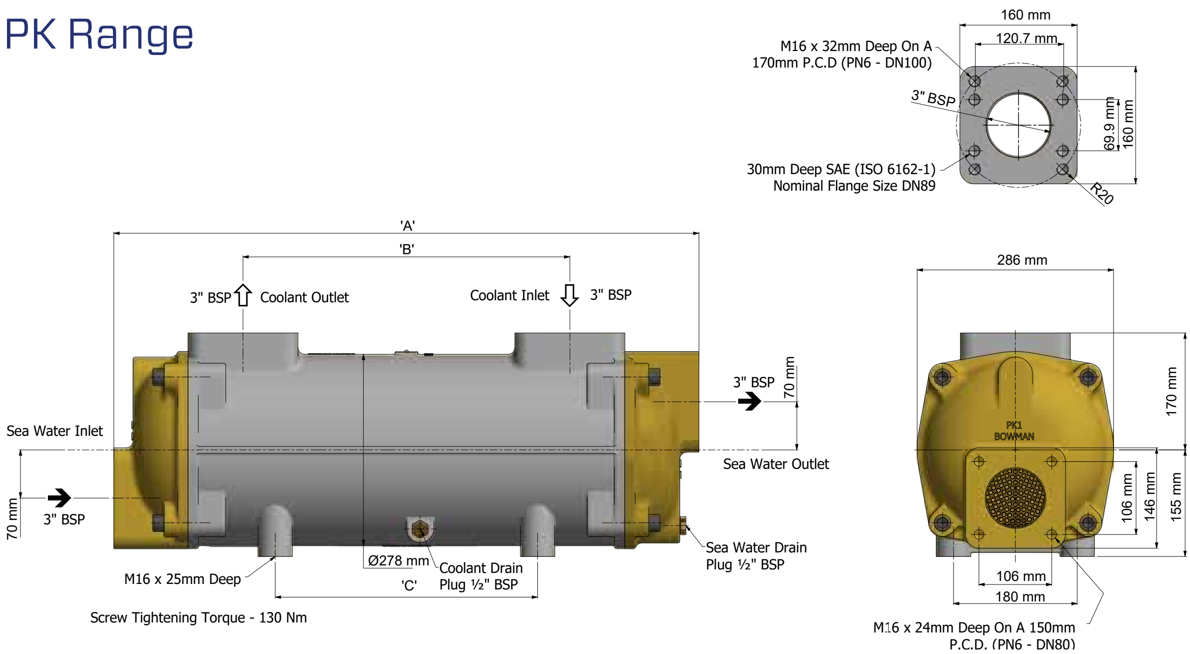




Type	Weight	A	B	C
	kg	mm	mm	mm
JK 190-3881-3	58	704	340	236
JK 250-3881-4	66	850	486	382
JK 320-3881-5	78	1028	664	560
JK 400-3881-6	92	1230	866	762
JK 480-3881-7	105	1434	1070	966
JK 600-3881-8	126	1738	1374	1270

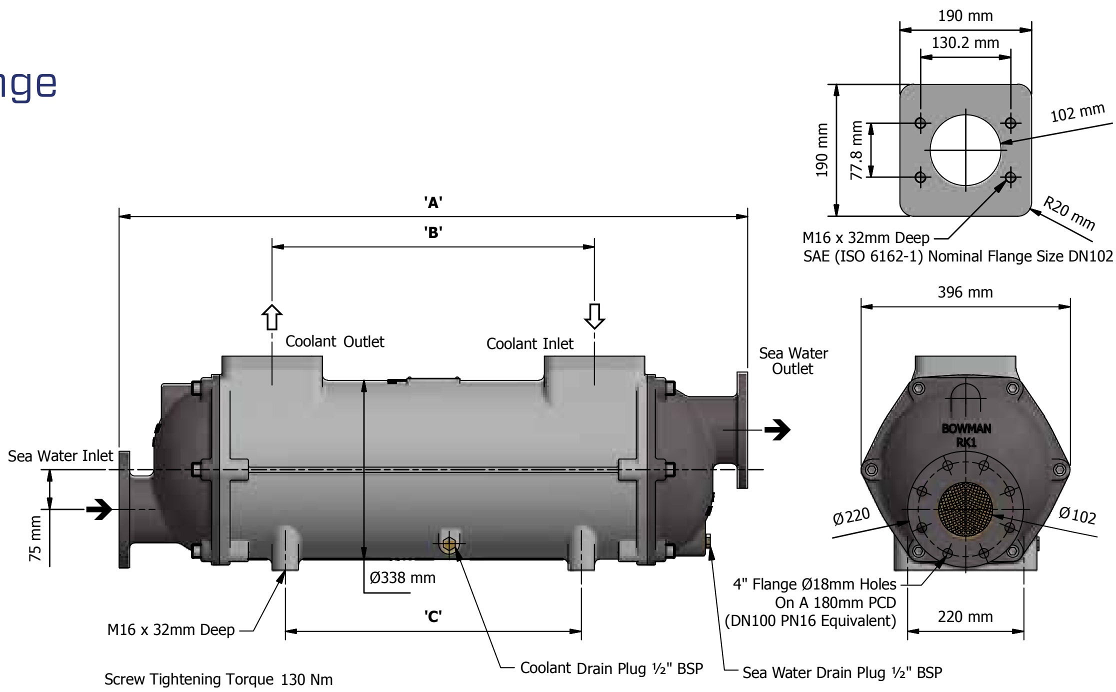
Maximum working coolant pressure 20 bar.
Maximum working sea water pressure 16 bar.
Maximum working coolant temperature 110°C.

PK Range



Type	Weight	A	B	C
	kg	mm	mm	mm
PK 190-3880-3	81	754	330	236
PK 250-3880-4	94	900	476	382
PK 320-3880-5	110	1078	654	560
PK 400-3880-6	125	1280	856	762
PK 480-3880-7	140	1484	1060	966
PK 600-3880-8	158	1788	1364	1270

RK Range



Type	Weight	A	B	C
	kg	mm	mm	mm
RK 400-5882-6	186	1392	812	762
RK 600-5882-8	246	1900	1320	1270

Maximum working coolant pressure	20 bar.	Maximum working coolant temperature	110°C.
Maximum working sea water pressure	16 bar.		

Electric and Hybrid Marine Heat Exchangers Titanium Range

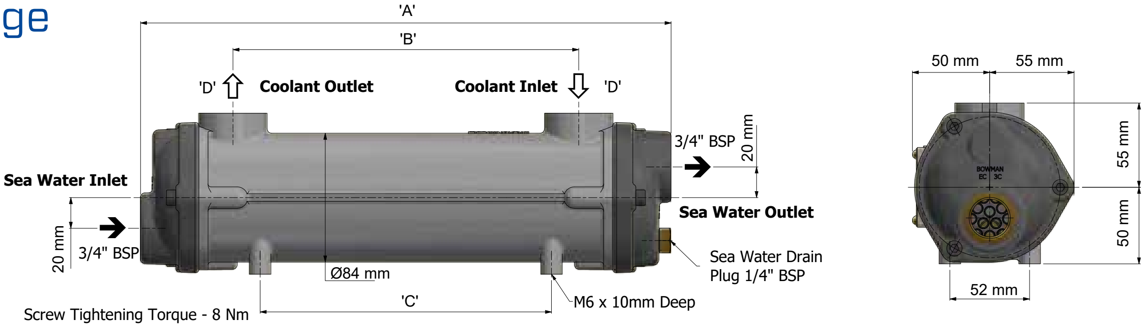
Bowman's titanium heat exchanger range has been developed for electric and hybrid marine applications and combines performance and light weight in an attractive commercial package.

The table below is intended to provide a general guide to their typical performance, when used with;

Coolant: 50/50 water/glycol
Coolant outlet temperature: 40°C
Seawater inlet temperature: 30°C

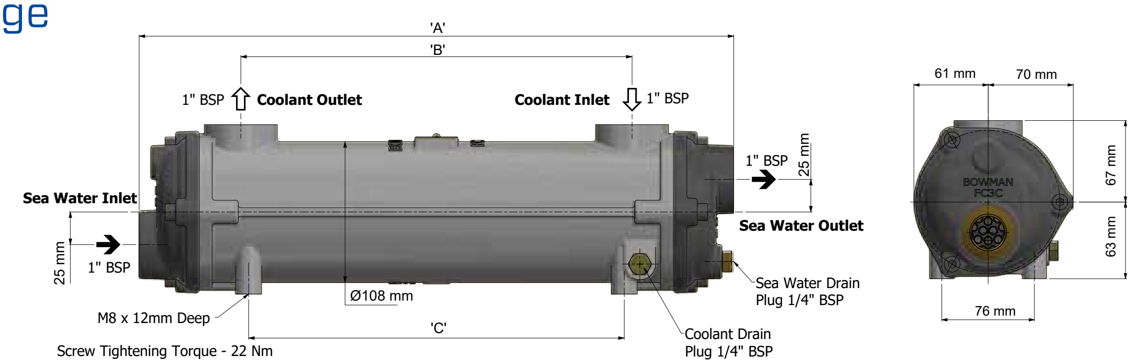
Type	Heat Dissipated	Coolant Flow	Sea Water Flow	Internal Coolant Volume	Internal Sea Water Volume
	kW	l/min	l/min	Litre	Litre
EC 80-5204-1	3	40	40	0.17	0.27
EC100-5204-2	7	50	50	0.41	0.39
EC120-5204-3	11	50	50	0.63	0.52
EC140-5204-4	15	50	50	0.89	0.66
EC160-5204-5	19	50	50	1.22	0.84
FC 80-5205-1	11	80	80	0.70	0.63
FC100-5205-2	16	80	80	0.97	0.83
FC120-5205-3	22	80	80	1.37	1.04
FC140-5205-4	29	80	80	1.90	1.30
FC160-5205-5	37	80	80	2.50	1.62
FG 80-5206-1	24	120	120	1.41	1.21
FG100-5206-2	32	120	120	2.00	1.50
FG120-5206-3	43	120	120	2.80	1.88
FG140-5206-4	53	120	120	3.68	2.31
FG160-5206-5	65	120	120	4.97	2.84

EC Range



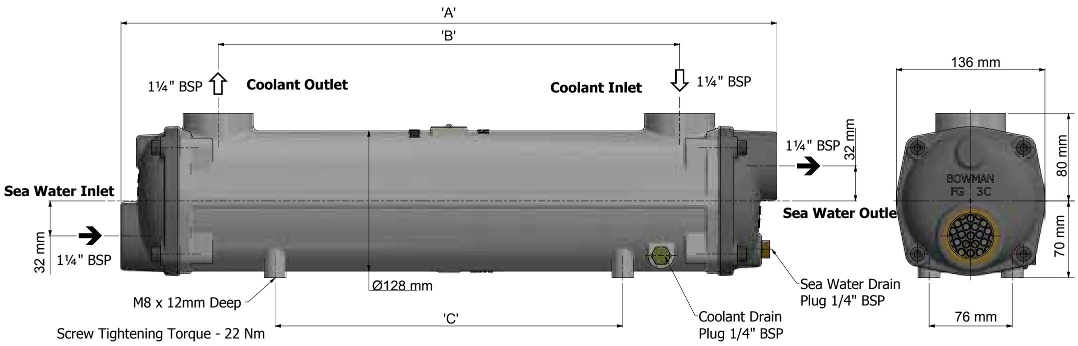
Type	Weight	A	B	C	D
	kg	mm	mm	mm	BSP
EC 80-5204-1	1.5	174	60	60	1/2"
EC 100-5204-2	2.1	260	140	104	3/4"
EC 120-5204-3	2.6	346	226	190	3/4"
EC 140-5204-4	3.2	444	324	288	3/4"
EC 160-5204-5	3.8	572	452	416	3/4"

FC Range



Type	Weight	A	B	C
	kg	mm	mm	mm
FC 80-5205-1	3.5	272	116	104
FC 100-5205-2	4.2	358	202	190
FC 120-5205-3	5.2	456	300	288
FC 140-5205-4	6.5	584	428	288
FC 160-5205-5	8.0	730	574	434

FG Range



Type	Weight	A	B	C
	kg	mm	mm	mm
FG 80-5206-1	5.7	374	196	92
FG 100-5206-2	7.0	472	294	190
FG 120-5206-3	8.4	600	422	318
FG 140-5206-4	10.4	746	568	464
FG 160-5206-5	12.6	924	746	642

Maximum working coolant pressure 20 bar.
Maximum working sea water pressure 16 bar.
Maximum working coolant temperature 110°C.

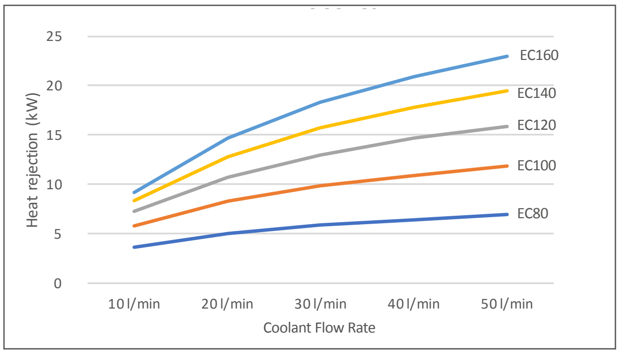
Heat Transfer

Coolant flow rates can significantly affect the performance of a heat exchanger and usually vary from one electrical system to another. Whilst general performance figures are provided on pages 4 and 8, referral to the tables below is also recommended, to check the flow rates of the system the heat exchanger will be cooling.

Please note, these figures have been generated using fixed seawater flow rates and the temperature of the coolant entering the heat exchanger, so the figures should only be used as a guide. If exact figures - as outlined on page 3 – are known, please contact the sales team who can provide a computer aided product selection, to recommend the most appropriate heat exchanger.

EC Series

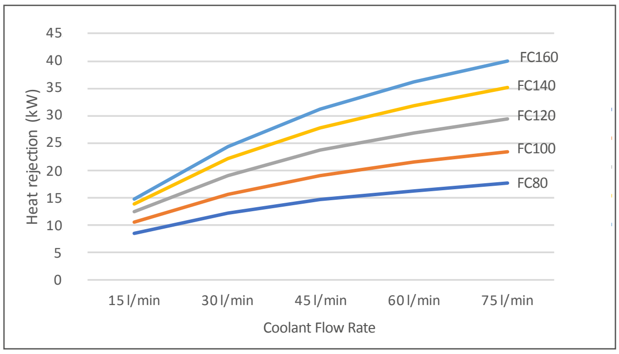
	Coolant Flow Rate				
Model	10 l/min	20 l/min	30 l/min	40 l/min	50 l/min
EC80	3.7	5.0	5.9	6.5	7.0
EC100	5.8	8.3	9.9	11.0	11.9
EC120	7.3	10.8	13.0	14.6	15.9
EC140	8.4	12.8	15.8	17.9	19.5
EC160	9.2	14.6	18.3	20.9	23.0



Figures based upon: Coolant type: 50/50 water/glycol. Seawater inlet temperature: 30 deg C at 50 l/min. Coolant inlet temperature: 50 deg C

FC Series

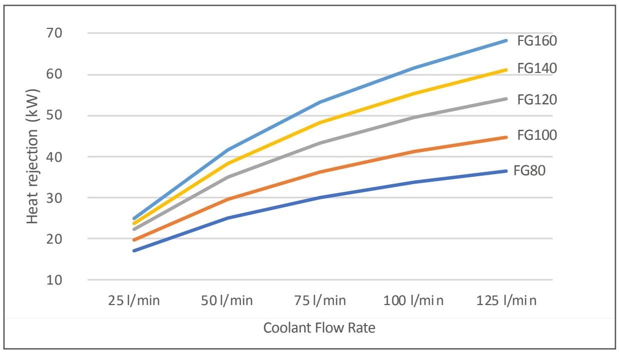
	Coolant Flow Rate				
Model	15 l/min	30 l/min	45 l/min	60 l/min	75 l/min
FC80	8.5	12.2	14.6	16.3	17.7
FC100	10.5	15.7	19.0	21.5	23.4
FC120	12.5	19.2	23.6	26.8	29.4
FC140	13.9	22.1	27.8	31.9	35.1
FC160	14.7	24.4	31.1	36.1	39.9



Figures based upon: Coolant type: 50/50 water/glycol. Seawater inlet temperature: 30 deg C at 80 l/min. Coolant inlet temperature: 50 deg C

FG Series

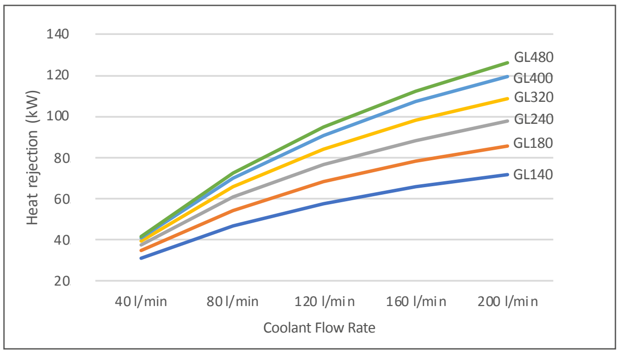
	Coolant Flow Rate				
Model	25 l/min	50 l/min	75 l/min	100 l/min	125 l/min
FG80	17.0	24.9	30.0	33.6	36.4
FG100	19.7	29.7	36.2	41.0	44.6
FG120	22.3	34.9	43.2	49.3	54.0
FG140	23.7	38.3	48.2	55.4	61.0
FG160	24.9	41.5	53.1	61.6	68.2



Figures based upon: Coolant type: 50/50 water/glycol. Seawater inlet temperature: 30 deg C at 120 l/min. Coolant inlet temperature: 50 deg C

GL Series

	Coolant Flow Rate				
Model	40 l/min	80 l/min	120 l/min	160 l/min	200 l/min
GL140	31.0	47.0	57.6	65.5	71.6
GL180	34.7	54.5	67.9	77.8	85.5
GL240	37.4	60.6	76.5	88.4	97.7
GL320	39.3	65.5	83.9	97.7	108.6
GL400	40.9	70.0	91.0	106.9	119.3
GL480	41.5	72.4	95.1	112.4	126.1



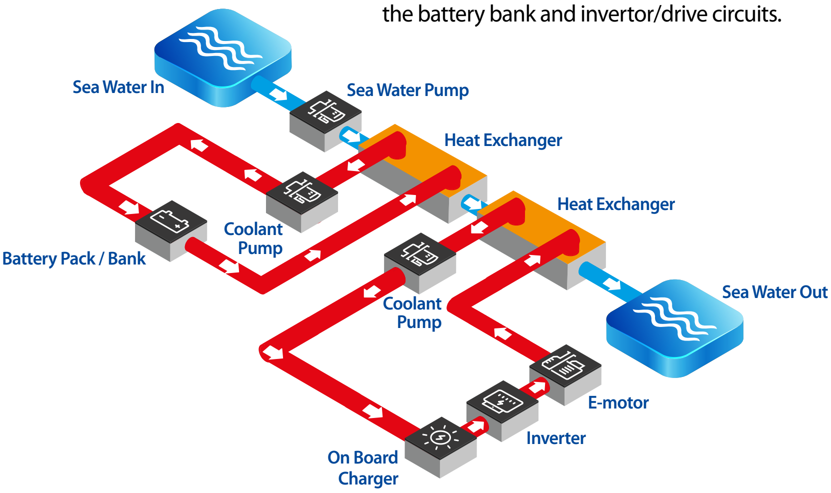
Figures based upon: Coolant type: 50/50 water/glycol. Seawater inlet temperature: 30 deg C at 200 l/min. Coolant inlet temperature: 50 deg C

Installation Examples

Below are some examples of typical installations where Bowman heat exchangers are used to cool electric powered marine propulsions systems.
They are provided for general information and not intended as installation recommendations.

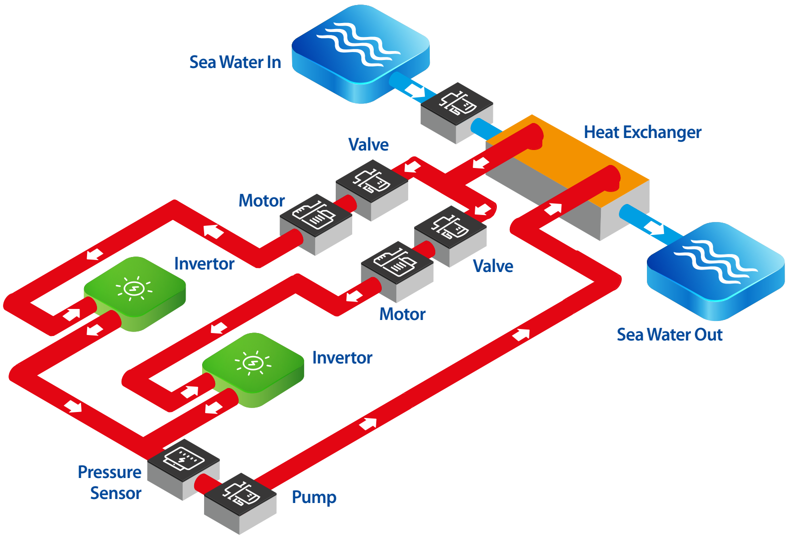
Cooling System

Two heat exchangers, installed in series, control the differing cooling requirements for the battery bank and invertor/drive circuits.



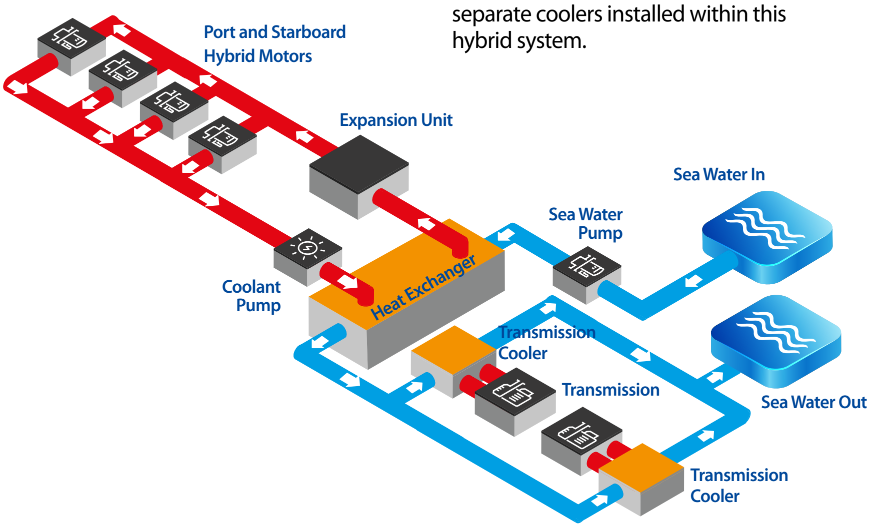
Cooling System

A single heat exchanger is used to cool the dual invertor/drive circuits in this installation.



Hybrid Control Unit

A single heat exchanger cools both the hybrid motors and invertors, plus two separate coolers installed within this hybrid system.



Installation

For maximum heat transfer, Bowman heat exchangers must be installed in a counterflow arrangement, where the seawater flows in the opposite direction to the coolant – see installation examples opposite.

For more information, download the installation guide from www.ej-bowman.com

Seal Options

Bowman heat exchangers are supplied with Nitrile seals as standard. However, for applications where coolant escape could harm the marine life, either Ethylene Propylene or Viton seals can be provided as an option at additional cost. To specify this option, a suffix should be added to the oil cooler type number when ordering, as follows:
EP – Ethylene Propylene; or VT - Viton

Warranty

Bowman heat exchangers are guaranteed against manufacturing and material defects for 12 months from the date of delivery.

Replacement Parts

Replacement parts are available for all Bowman heat exchangers. These include end covers and fixings, 'O' rings, seals, tube stacks and bodies.

Servicing the unit

Removing the end cover retaining screws enables the tube stack to be withdrawn for routine maintenance. On reassembly, new 'O' rings should be used to ensure a watertight seal.

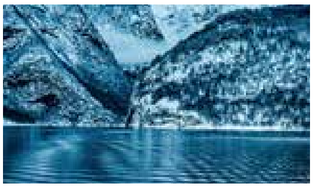
A world of applications

Bowman heat exchangers can be found cooling traditional marine propulsion systems, hydraulic control systems throughout the world. They are renowned for excellent heat transfer, plus long operational life, in even the most demanding applications.

Now Bowman heat exchangers have become the go to solution for electric and hybrid marine propulsion systems.

Electric Propulsion

This leading European manufacture of electric propulsion systems specifies Bowman for cooling its larger, 100 kW plus propulsion products.



Battery Cooling

In Scandinavia, a superfast charging system, used to re-charge commercial ferry batteries, is being cooled by Bowman heat exchangers, preventing the heat loads generated from damaging the batteries.

Passenger Ferries

In Thailand, a fleet of electric ferries are reducing pollution along Bangkok's waterways. Four Bowman heat exchangers are installed in each ferry to control heat generated in the propulsion system.

All Bowman marine heat exchangers are produced to the highest quality in our UK manufacturing facility. With 100 years' experience producing efficient heat transfer solutions, you can have complete confidence when you specify Bowman marine heat exchangers.

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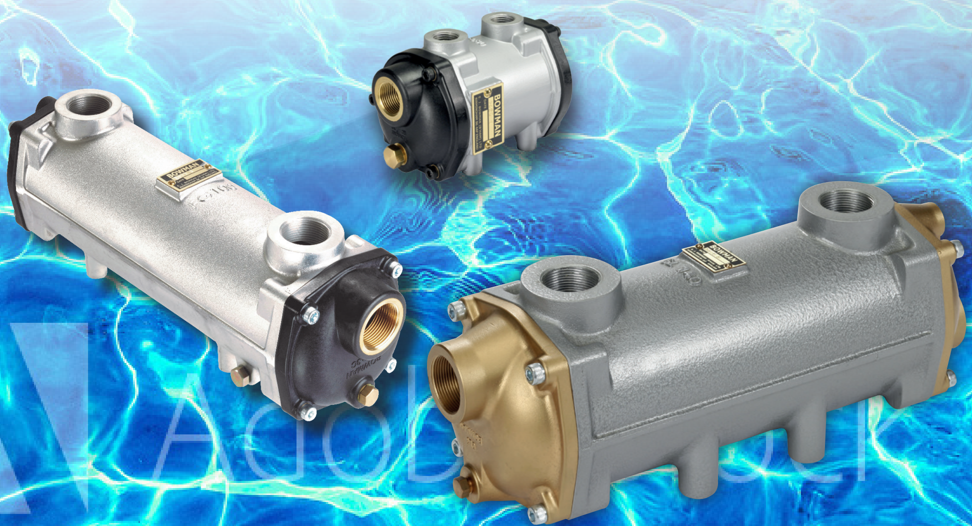
BOWMAN®
100 YEARS OF HEAT TRANSFER TECHNOLOGY

FM38224

Installation, Operation & Maintenance Guide

MARINE HEAT EXCHANGERS FOR ELECTRIC AND HYBRID PROPULSION



BOWMAN®

100 YEARS OF HEAT TRANSFER TECHNOLOGY

Contents

Introduction

Thank you for purchasing a high quality Bowman marine heat exchanger.

Bowman® has been manufacturing marine heat exchangers for over 60 years and our products are renowned for their quality, heat transfer performance and durability.

Please read this 'installation, Operation & Maintenance Guide' carefully before installation to ensure your heat exchanger operates efficiently and reliably.

Please keep this guide for future reference to ensure the long term performance of your Bowman heat exchanger.

Should you require advice or assistance, please contact your Bowman stockist or distributor. Further copies of this 'installation, Operation & Maintenance Guide' can be downloaded from our website **www.ej-bowman.com**

1. Safety

1.1 Hazards when handling the heat exchanger

BOWMAN® heat exchangers are constructed to current practice and recognised safety standards. Hazards may still arise from operation, such as:

- Injury of the operator or
- Third parties or
- Damage to the heat exchanger or
- Damage to property and equipment

Any person involved with the installation, commissioning, operation, maintenance or repair of the heat exchanger must be:

- Physically and mentally capable of performing such work
- Appropriately qualified
- Comply completely with the installation instructions

The heat exchanger must only be used for its intended purpose.
In the event of breakdowns which may compromise safety, a qualified person must always be contacted.

1.2 Safety Instructions

The following symbols are used in these operating instructions:

Danger

This symbol indicates an immediate danger to health.
Failure to comply with this instruction may result in severe injury.

Caution

This symbol indicates a possible danger to health.
Failure to comply with this instruction may result in severe injury.

Take Care

This symbol indicates a possible risk to health.
Failure to comply with this instruction may result in injury or damage to property.

This symbol indicates important information about correct handling of the equipment
Failure to comply with this instruction may cause damage to the heat exchanger and/or its surroundings.

1.3 Approved use

BOWMAN® heat exchangers are only approved for cooling water/water with glycol mixture (closed system). Any other use, unless sanctioned by **BOWMAN®** is not approved. **BOWMAN®** declines all liability for damage associated or arising from such use:

Caution

The maximum permissible operating pressures must not exceed:

Titanium heat exchanger range
Water/glycol side: 4 bar
Cooling water side: 4 bar

Cupro-Nickel heat exchanger range
Water/glycol side: 16 bar
Cooling water side: 16 bar

The maximum permissible operating temperature must not exceed:
Titanium heat exchanger range
Water/glycol side: 95 °C
Cooling water side: 95 °C

Cupro-Nickel heat exchanger range
Water/glycol side: 110°C
Cooling Water side: 110°C

This applies to EC-RK three pass threaded connections only – for other versions please contact Bowman for guidance.

1.4 Potential Hazards

Danger

Ensure the maximum permissible operating pressures are not exceeded.
NB: Before the heat exchanger is disconnected it must be allowed to cool and be depressurized. The supply and return from the cooler should be isolated to minimise fluid loss.

2. Installation

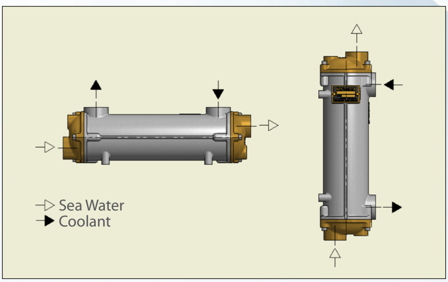
2.1 Transport / storage

Take Care

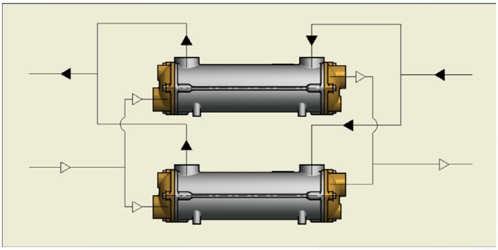
The heat exchanger must be drained prior to transportation. Once drained and dry, the heat exchanger must only be stored indoors in a non-aggressive atmosphere. The connections should be capped to avoid ingress of dirt and contaminants.

2.2 Fitting

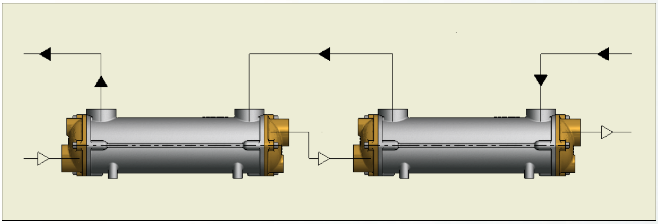
Before fitting, the heat exchanger should be checked for visible signs of damage. The heat exchanger should be connected in counterflow so that the fluids flow in opposite directions, as shown in the illustration below:



Multiple units can be connected in parallel.



Or in series:



2.3 Connecting the heat exchanger

Shut off all drainage valves in the flow and return pipes in both circuits.

Take Care

When fitting into the pipe work care must be taken to ensure that no debris has been introduced into the heat exchanger.

Unsupported lengths of pipework should be avoided so as not to subject the heat exchanger to excessive loads.

Water side pipework diameter should not reduce to less than the connection size within a distance of 1m from the heat exchanger.

Measures should be taken to isolate the heat exchanger from excessive vibration. Rigid mounting of the heat exchanger should be avoided.

Taper fittings are not recommended as these can split the shell and end cover castings if over tightened.

The correct length of fitting should be used as too long a fitting will damage the tubestack.

Pipework materials must be compatible with the heat exchanger materials. Stainless steel sea water pipes and fittings should not be used adjacent to the heat exchanger.

If the sea water supply is taken from ships main, ensure that the recommended flow rate cannot be exceeded. This will normally mean that an orifice plate must be fitted in the pipe work, at least 1m before the heat exchanger, with the orifice size calculated to ensure that the maximum sea water flow rate cannot be exceeded. See section 2.5 for further information.

If these precautions are not taken, it is possible that the sea water flow rate through the heat exchanger may be several times the recommended maximum which will lead to rapid failure.

2.4 Marine Installation-recommendations

No heat exchanger manufacturer can guarantee that their products will have an indefinite life and for this reason, we suggest that the cooling system is designed to minimise any damage caused by a leaking heat exchanger. This can be achieved as follows:

1. The coolant pressure should be higher than the sea water pressure, so that in the event of a leak occurring, the coolant will not be contaminated.
2. When the propulsion system is not being used, the heat exchanger should be isolated from sea water pressure.
3. The sea water outlet pipe from the heat exchanger should have a free run to waste.
4. Stainless steel sea water pipes and fittings should not be used adjacent to the heat exchanger.
5. **Important note for cupro-nickel tubes** during commisioning, shutdown and standby periods, if the heat exchanger has not been used over 4-6 day period, it should be drained, cleaned and kept dry. Where this procedure is not possible, drain the stagnant water and refill the heat exchanger with clean sea or fresh water, which should be replaced with oxygenated sea water every 2-3 days to avoid further decomposition.

2.5 Orifice Plates

If the sea water supply is taken from a ship's main, it is important to ensure that the recommended flow cannot be exceeded.

This will normally mean that an orifice plate must be fitted in the pipework at least 1m before the heat exchanger, with the orifice size calculated to ensure that the maximum sea water flow rate cannot be exceeded.

The correct orifice diameter can be determined from the table below.

Three Pass Bowman Heat Exchangers		Orifice diameter in mm for max. sea water flow									
Heat exchanger	Max. Sea water flow l/min	1 bar	2 bar	3 bar	4 bar	5 bar	6 bar	7 bar	8 bar	9 bar	10 bar
EC	50	11	9.5	8.5	8	7.5	7.2	6.8	6.7	6.5	6.3
FC	80	14	12	11	10	9.5	9	8.7	8.4	8.2	8
FG	110	17	14	13	12	11	10	10	9.8	9.6	9.3
GL	200	23	19	17	16	15	14	14	13	13	13
GK	300	28	23	21	19	18	17	17	16	16	15
JK	400	32	27	24	22	21	20	20	19	18	18
PK	500	41	34	31	28	27	26	25	24	23	23
RK	900	48	40	36	34	32	30	29	28	27	26

2.6 Composite end cover water pipe installation

For heat exchangers supplied with composite end covers, it is recommended that a bonded seal is used in conjunction with the fitting and tightened to the appropriate torque figure given below to ensure sufficient sealing.

Size	Torque (Nm)
EC range (3/4" BSP)	10
FC range (1" BSP)	15
FG range (1 ¼" BSP)	20
GL range (1 ½" BSP)	25

3. Operation

3.1 Maximum water flow rates

Take Care

The following tables give maximum flow rates through the tube stack for either single, two or three pass configuration, using either sea or fresh water.

Sea Water Application (Maximum 2 m/s)

Type	3-Pass	2-Pass	1-Pass
	Max Recommended Flowrate (l/min)	Max Recommended Flowrate (l/min)	Max Recommended Flowrate (l/min)
EC range	50	80	170
FC range	80	120	230
FG range	110	170	320
GL range	200	290	560
GK range	300	450	900
JK range	400	600	1200
PK range	650	1000	2000
RK range	900	1400	2800

3.2 Minimum water flow rates

The following tables give minimum flow rates through the tube stack for either single two or three pass configuration, using either sea or fresh water.

Type	3-Pass	2-Pass	1-Pass
	Max Recommended Flowrate (l/min)	Max Recommended Flowrate (l/min)	Max Recommended Flowrate (l/min)
EC range	27	42	84
FC range	47	70	140
FG range	65	95	190
GL range	115	170	340
GK range	160	250	500
JK range	240	350	700
PK range	350	530	1060
RK range	510	780	1560

3.3 General information

The heat exchanger should be pressurised on the coolant (shell) side such that it is at a higher pressure than the sea water (tube) side. This will ensure that should a leak occur it will be detected by a reduction in the coolant level and the coolant will not be contaminated. A differential pressure of 2 bar would be sufficient. It is essential that the following instructions are followed to prevent corrosion/erosion of the heat exchanger:

a) Always maintain the water pH to within correct levels. The ideal water pH should be kept within 7.4 to 7.6. On no account should it be below 7.2 or above 7.8. It is accepted that sea water can have a pH of 8.

b) Minimum water velocity of 1m/s should be used to avoid under deposit corrosion.

c) Ensure compliance with water quality and maximum permissible pressure requirements.

d) Air must be adequately vented from both circuits.

e) Stagnant water should not be allowed to accumulate in the heat exchanger. If it is not in use for any period of time the water should be drained off.

4. Commissioning

Commissioning of the heat exchanger should not be undertaken until this document been fully read and understood. Both circuits of the heat exchanger must be closed prior to commissioning.

Danger

Adequate provision should be made to ensure that correct operating/service equipment along with personal protection equipment (PPE) in accordance with current standards/legislation is used prior to the commencement of any working. Cooling water should be introduced to the heat exchanger prior to the gradual introduction of hot coolant. Both circuits should be vented initially and again when operating temperatures and pressures are reached. The system should be checked for leaks.

Take Care

Copper-nickel alloys have a very good resistance to seawater corrosion due to the formation of a thin protective film on the surface of the metal. This film starts to develop over the first few days after the metal has been in contact with clean, oxygenated seawater, and requires a further 3 months to develop fully. This is the most important part of the process to ensure long term corrosion resistance behaviour of copper nickel. The protective surface film of cuprous oxide is indicated by either a brown, greenish brown or blackish brown thin film layer. The process of ensuring that copper alloy receives an effective oxide coating prior to service is known as "conditioning" which is a very important stage for the alloy. Ferrous sulphate can be used if commissioning in clean sea water is not possible. Schedule cleaning may help to reduce the risk possibly with non-metallic brushes. Please refer to Copper Alliance web page for more information: www.copper.org.

5. Maintenance / Repair

5.1 Winter shutdown in areas exposed to frost

Care should be taken to prevent frost damage from a winter shutdown in conditions exposed to frost. We recommend draining the heat exchanger or removing it completely from the installation for the duration of the shutdown period.

5.2 General maintenance

While the unit is in operation, weekly inspection of the heat exchanger and its connections should be made for leaks and externally visible damage. **BOWMAN®** recommend that the tubestack should be cleaned and inspected annually and the o rings should be renewed at this time. Removal of the screws around the periphery of each end cover will allow the end covers and seals to be removed. The tubestack can then be withdrawn from either end of the body.

5.3 Cleaning

Whilst we strongly recommend that mechanical and chemical cleaning of the heat exchanger is carried out only by specialised companies, below are some general guidelines that may be useful;

a) Removing the end covers allows access to the tube stack, which can be removed from the body.

b) Wash the tube plates and tubes using a hand held hose or lance. An industrial steam cleaner can also be used if available.

c) Tube brushes can be used to clean through each tube to aid removing stubborn deposits. Small diameter rods and brushes for tube cleaning are available from companies such as Rico Industrial Services www.ricoservices.co.uk

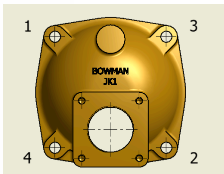
d) Detergents or chemicals suitable for use with the tube material* can be used if fouling is severe. Allow time for the detergent or chemical cleaner to work, before hosing down with plenty of water. **Please refer to the spare parts list for details of the tube materials.*

e) The tube stack should be flushed through with clean water to remove all traces of cleaning chemicals/detergents. If necessary, the cleaning fluid should be neutralised.

f) **When refitting the end covers after cleaning, new 'O' seals must be used**

5.4 End cover screw tightening sequence

End covers must be refitted in their original orientation and tightened to the torque figures below.



Cooler Series	Screw Size	Torque (Nm)	Cooler Series	Screw Size	Torque (Nm)
EC	M6	8	GK	M12	54
FC	M8	22	JK	M16	95
FG	M8	22	PK	M16	130
GL	M10	37	RK	M16	130

6. Potential Service Problems

6.1 Tube failures

The majority of problems facing an heat exchanger are those of corrosion or erosion on the water side. Three common types of failure are:

a) Impingement attack (or erosion corrosion)

This is caused by water containing air bubbles flowing at high speed through the tubes. The impingement of rapidly moving water may also lead to a breakdown of the protective copper oxide film on the tubes thus allowing corrosion/erosion. This is worse with water containing sand or grit in the absence of a filter. The effect of these conditions would be pockmarking and pin holing of the tubes. The maximum and minimum water flow rates must be followed (see Table 3.1 and 3.2)

b) Oxide corrosion

This is caused by water containing organic matter such as that found in polluted estuaries. Usually this water produces hydrogen sulphide, which is very corrosive and can cause failure of the tubes, particularly if stagnant water are present or also excessive water flows are used.

c) Pitting

This problem is caused by very aggressive sea water in the tubes, especially in partially filled heat exchangers where the sea is stagnant. Low sea water flow rates (anything <1m/s) can create a high temperature rise on the sea water side. Under these conditions deposits may build or settle in the tube, allowing pitting corrosion to take place under the deposits.

This is only a brief introduction to corrosion problems. The subject is complex and the purpose of these notes is to outline in very general terms what may occur under extreme conditions.

6.2 Fault finding

Symptoms	Possible Causes	Remedy
Increase in temperature on shell side or excessive pressure loss	Sludging, tube scaling or build up of both resulting in an insulating film covering the tubes	The complete heat exchanger should be thoroughly cleaned
Pressure loss is as expected, but the temperature of the coolant rises	Film, scale or restrictions on the inside of the tubes	The complete heat exchanger should be thoroughly cleaned
Coolant leaking into the cooling water circuit or vice versa	Split or perforated tubes	Tubes should be blocked with hard wooden plugs as a temporary measure & the tubestack replaced asap
Inadequate performance	Flow rate too low Unit connected in parallel flow	Check flow rates & increase if necessary Reconnect in counterflow as per section 2.2

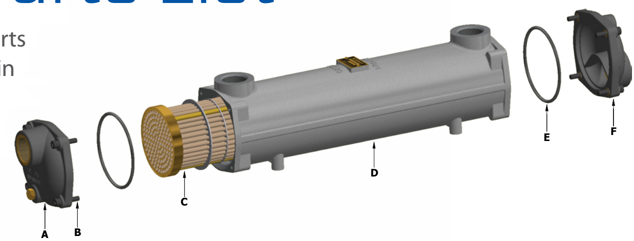
7. Warranty

All **BOWMAN**® Heat exchangers are guaranteed against manufacturing and material defects for a period of twelve months from the date of delivery.

BOWMAN® should be contacted immediately if a unit is received damaged. No attempt should be made to repair a faulty unit as this will invalidate the warranty.
For full warranty terms, please see the **BOWMAN**® Conditions of Sale. A copy of which is available on request or via download from the website: **www.ej-bowman.com**

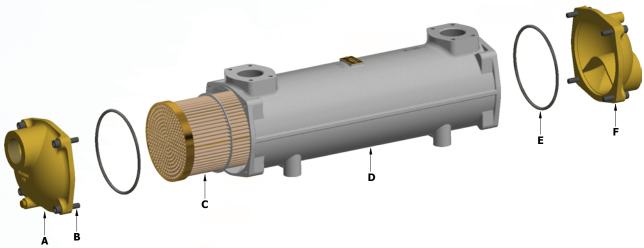
8. Spare Parts List

A comprehensive stock of spare parts is available for all models, as listed in the tables below and overleaf.



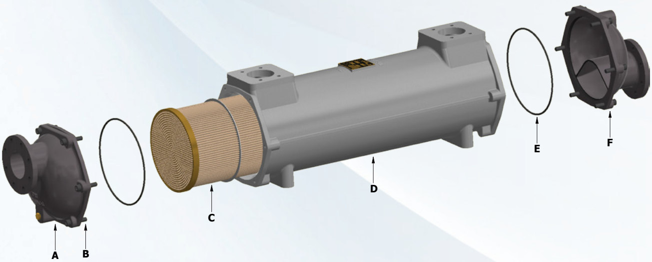
STANDARD RANGE

Type	End Covers Drain (A)	Screws (B)	Tubestack (C)	Body (D)	O Seals (E)	End Covers Non Drain (F)
EC-80-3875-1	EC3C-5480-DR	HS06X30DP	785-1TN1A	EC21-978-AL2	AN12NT	EC3C-5480
EC-100-3875-2	EC3C-5480-DR	HS06X30DP	785-2TN1A	EC10-783-2AL	AN12NT	EC3C-5480
EC-120-3875-3	EC3C-5480-DR	HS06X30DP	785-3TN1A	EC12-783-3AL	AN12NT	EC3C-5480
EC-140-3875-4	EC3C-5480-DR	HS06X30DP	785-4TN1A	EC14-783-4AL	AN12NT	EC3C-5480
EC-160-3875-5	EC3C-5480-DR	HS06X30DP	785-5TN1A	EC16-783-5AL	AN12NT	EC3C-5480
FC80-3876-1	FC3C-5481-DR	HS08X35DP	1530-1TN1A	FC8-1200-1AL	OS46NT	FC3C-5481
FC100-3876-2	FC3C-5481-DR	HS08X35DP	1530-2TN1A	FC10-1200-2AL	OS46NT	FC3C-5481
FC120-3876-3	FC3C-5481-DR	HS08X35DP	1530-3TN1A	FC12-1200-3AL	OS46NT	FC3C-5481
FC140-3876-4	FC3C-5481-DR	HS08X35DP	1530-4TN1A	FC14-1200-4AL	OS46NT	FC3C-5481
FC160-3876-5	FC3C-5481-DR	HS08X35DP	1530-5TN1A	FC16-1200-5AL	OS46NT	FC3C-5481
FG80-3877-1	FG3C-5482-DR	HS08X35DP	1959-1TN1A	FG8-1650-1AL	OS52NT	FG3C-5482
FG100-3877-2	FG3C-5482-DR	HS08X35DP	1959-2TN1A	FG10-1650-2AL	OS52NT	FG3C-5482
FG120-3877-3	FG3C-5482-DR	HS08X35DP	1959-3TN1A	FG12-1650-3AL	OS52NT	FG3C-5482
FG140-3877-4	FG3C-5482-DR	HS08X35DP	1959-4TN1A	FG14-1650-4AL	OS52NT	FG3C-5482
FG160-3877-5	FG3C-5482-DR	HS08X35DP	1959-5TN1A	FG16-1650-5AL	OS52NT	FG3C-5482
GL140-3878-2	GL3C-5483-DR	HS10X40DP	1798-2TN1A	GL15-3136NF-2AL6	OS63NT	GL3C-5483
GL180-3878-3	GL3C-5483-DR	HS10X40DP	1798-3TN1A	GL19-3136NF-3AL6	OS63NT	GL3C-5483
GL240-3878-4	GL3C-5483-DR	HS10X40DP	1798-4TN1A	GL25-3136NF-4AL6	OS63NT	GL3C-5483
GL320-3878-5	GL3C-5483-DR	HS10X40DP	1798-5TN1A	GL33-3136NF-5AL6	OS63NT	GL3C-5483
GL400-3878-6	GL3C-5483-DR	HS10X40DP	1798-6TN1A	GL41-3136NF-6AL6	OS63NT	GL3C-5483
GL480-3878-7	GL3C-5483-DR	HS10X40DP	1798-7TN1A	GL49-3136NF-7AL6	OS63NT	GL3C-5483



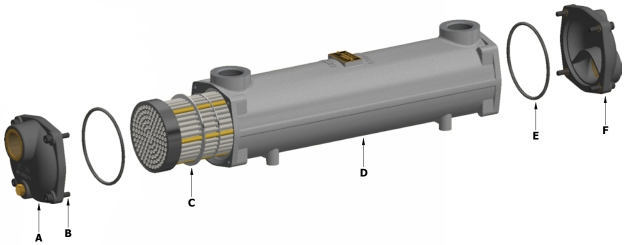
STANDARD RANGE

Type	End Covers Drain (A)	Screws (B)	Tubestack (C)	Body (D)	O Seals (E)	End Covers Non Drain (F)
GK190-3879-3	GK1-2864BR-DR	HS12X50DP	2315-3TN1A	GK19-2865NF-3AL7	OS69NT	GK1-2864BR
GK250-3879-4	GK1-2864BR-DR	HS12X50DP	2315-4TN1A	GK25-2865NF-4AL7	OS69NT	GK1-2864BR
GK320-3879-5	GK1-2864BR-DR	HS12X50DP	2315-5TN1A	GK32-2865NF-5AL7	OS69NT	GK1-2864BR
GK400-3879-6	GK1-2864BR-DR	HS12X50DP	2315-6TN1A	GK40-2865NF-6AL7	OS69NT	GK1-2864BR
GK480-3879-7	GK1-2864BR-DR	HS12X50DP	2315-7TN1A	GK48-2865NF-7AL7	OS69NT	GK1-2864BR
GK600-3879-8	GK1-2864BR-DR	HS12X50DP	2315-8TN1A	GK60-2865NF-8AL7	OS69NT	GK1-2864BR
JK190-3881-3	JK1-4353BR-DR	HS16X70DP	3334-3TN1A	JK19-3332NF-3AL8	OS74NT	JK1-4353BR
JK250-3881-4	JK1-4353BR-DR	HS16X70DP	3334-4TN1A	JK25-3332NF-4AL8	OS74NT	JK1-4353BR
JK320-3881-5	JK1-4353BR-DR	HS16X70DP	3334-5TN1A	JK32-3332NF-5AL8	OS74NT	JK1-4353BR
JK400-3881-6	JK1-4353BR-DR	HS16X70DP	3334-6TN1A	JK40-3332NF-6AL8	OS74NT	JK1-4353BR
JK480-3881-7	JK1-4353BR-DR	HS16X70DP	3334-7TN1A	JK48-3332NF-7AL8	OS74NT	JK1-4353BR
JK600-3881-8	JK1-4353BR-DR	HS16X70DP	3334-8TN1A	JK60-3332NF-8AL8	OS74NT	JK1-4353BR
PK190-3880-3	PK1-4352BR-DR	HS16X70DP	2829-3TN1A	PK19-2919NF-3AL9	OS81NT	PK1-4352BR
PK250-3880-4	PK1-4352BR-DR	HS16X70DP	2829-4TN1A	PK25-2919NF-4AL9	OS81NT	PK1-4352BR
PK320-3880-5	PK1-4352BR-DR	HS16X70DP	2829-5TN1A	PK32-2919NF-5AL9	OS81NT	PK1-4352BR
PK400-3880-6	PK1-4352BR-DR	HS16X70DP	2829-6TN1A	PK40-2919NF-6AL9	OS81NT	PK1-4352BR
PK480-3880-7	PK1-4352BR-DR	HS16X70DP	2829-7TN1A	PK48-2919NF-7AL9	OS81NT	PK1-4352BR
PK600-3880-8	PK1-4352BR-DR	HS16X70DP	2829-8TN1A	PK60-2919NF-8AL9	OS81NT	PK1-4352BR



STANDARD RANGE

Type	End Covers Drain (A)	Screws (B)	Tubestack (C)	Body (D)	O Seals (E)	End Covers Non Drain (F)
RK400-5882-6	RK1-5451CIC-DR	HS16X70DP	5455-6TN1A	RK40-5450NF-6AL0	OS453NT	RK1-5451CIC
RK600-5882-8	RK1-5451CIC-DR	HS16X70DP	5455-8TN1A	RK60-5450NF-6AL0	OS453NT	RK1-5451CIC



TITANIUM RANGE

Type	End Covers Drain (A)	Screws (B)	Tubestack (C)	Body (D)	O Seals (E)	End Covers Non Drain (F)
EC-80-5204-1	EC3C-5480-DR	HS06X30DP	5195-1T1A	EC21-978-AL2	AN12EP	EC3C-5480
EC-100-5204-2	EC3C-5480-DR	HS06X30DP	5195-2T1A	EC10-783-2AL	AN12EP	EC3C-5480
EC-120-5204-3	EC3C-5480-DR	HS06X30DP	5195-3T1A	EC12-783-3AL	AN12EP	EC3C-5480
EC-140-5204-4	EC3C-5480-DR	HS06X30DP	5195-4T1A	EC14-783-4AL	AN12EP	EC3C-5480
EC-160-5204-5	EC3C-5480-DR	HS06X30DP	5195-5T1A	EC16-783-5AL	AN12EP	EC3C-5480
FC80-5205-1	FC3C-5481-DR	HS08X35DP	5196-1T1A	FC8-1200-1AL	OS46EP	FC3C-5481
FC100-5205-2	FC3C-5481-DR	HS08X35DP	5196-2T1A	FC10-1200-2AL	OS46EP	FC3C-5481
FC120-5205-3	FC3C-5481-DR	HS08X35DP	5196-3T1A	FC12-1200-3AL	OS46EP	FC3C-5481
FC140-5205-4	FC3C-5481-DR	HS08X35DP	5196-4T1A	FC14-1200-4AL	OS46EP	FC3C-5481
FC160-5205-5	FC3C-5481-DR	HS08X35DP	5196-5T1A	FC16-1200-5AL	OS46EP	FC3C-5481
FG80-5206-1	FG3C-5482-DR	HS08X35DP	5197-1T1A	FG8-1650-1AL	OS52EP	FG3C-5482
FG100-5206-2	FG3C-5482-DR	HS08X35DP	5197-2T1A	FG10-1650-2AL	OS52EP	FG3C-5482
FG120-5206-3	FG3C-5482-DR	HS08X35DP	5197-3T1A	FG12-1650-3AL	OS52EP	FG3C-5482
FG140-5206-4	FG3C-5482-DR	HS08X35DP	5197-4T1A	FG14-1650-4AL	OS52EP	FG3C-5482
FG160-5206-5	FG3C-5482-DR	HS08X35DP	5197-5T1A	FG16-1650-5AL	OS52EP	FG3C-5482

9. CE Marking Documentation

Heat exchangers are covered by the Pressure Equipment Directive 97/23/EC which is mandatory for all EU member states.. This manual is part of the compliance and points out all essential safety requirements to be observed.

BOWMAN® Heat exchangers fall within the Sound Engineering Practice category of the Pressure Equipment Directive 2014/68/EU and as such cannot be CE marked.

10. Notes on Zinc Anodes

The use of zinc anodes in heat exchangers has been employed for some years, generally by manufacturers using admiralty brass tube or its variants. The purpose of the zinc anode, or zinc pencil as it is sometimes called, is to prevent dezincification of the brass alloy tubes. As such zinc anode acts sacrificially in favour of the tube.

There are a number of American and European manufacturers that use these anodes in their products.

BOWMAN®, do not fit zinc anodes as the tubes used in the construction of our coolers are of copper nickel alloy or titanium and as such do not require a zinc anode. It is possible that if this anode is fitted it can actually destroy the copper oxide film built up by the tube as a natural defence which can allow the tube material to be attacked.
It is usual with the copper nickel alloys to use an iron anode which allows an iron oxide film to build up inside the tube which breaks down as a sacrificial element reducing the possibility of corrosion to the heat exchanger. In **BOWMAN®** designs it is not practical to fit iron anodes as their size has to be very generous.

Therefore as an alternative a piece of black iron pipework can be placed before the heat exchanger which in itself acts as sacrificial element protecting the cooler. The Royal Navy has often used this technique and when the black iron pipework corrodes, it is simply replace with a fresh piece.

We do know that some manufacturers of heat exchangers, mostly those that are copies of better known products, often fit zinc anodes with copper nickel alloys in error.

Please use this page to record any service notes for the heat exchanger

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