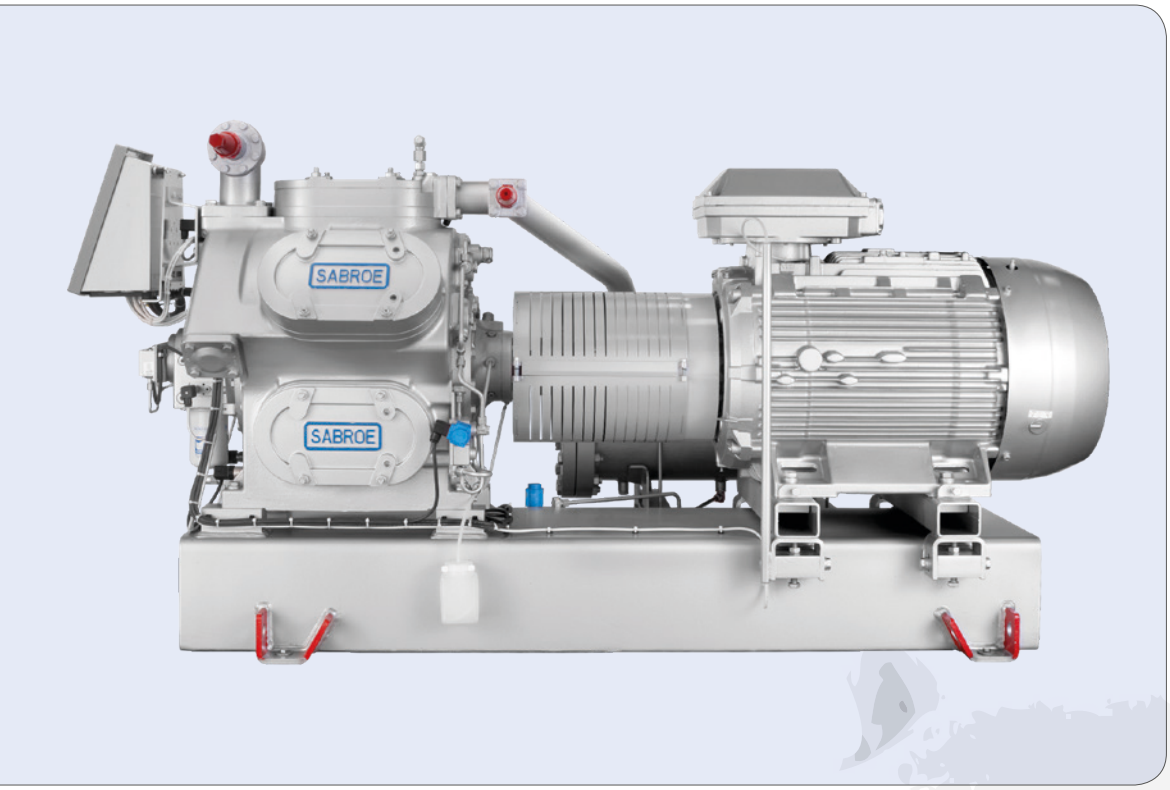
Operating manual

en

SMC/TSMC 100 Mk 4 LL & Mk 5 (including ATEX) Reciprocating compressor units



SABROE

Johnson Controls

Manual for SMC and TSMC Mk 4 LL & Mk 5

Compressor type	☐ SMC ☐ TSMC ☐ S ☐ L ☐ E ☐ 104 ☐ 106 ☐ 108 ☐ 112 ☐ 116
Compressor no.	
Refrigerant	☐ R717 ☐ R22 ☐ R134a ☐ R404A ☐ R507 Other _____
Control	☐ Unisab III ☐ None ☐ Other
Compressor cooling	☐ Thermopump
	☐ Water-cooled top and side covers
	☐ Air-cooled top and side covers
	☐ Air-cooled top covers and water-cooled side covers
	☐ Air-cooled top and side covers + oil cooling (refrigerant-cooled)
Drive type	☐ Fixed speed ☐ Variable speed (VSD)
Ex-execution (ATEX)	☐ T3 ☐ T4 Other _____
Oil return on parallel systems	☐
Oil separator	☐ SABROE OVUR ☐ SABROE OHUR
Intermediate cooling system	☐ With internal intermediate cooling system ☐ With external intermediate cooling system

<table>
<tr><td rowspan="12">Safety valve:
Data for calculation of downstream line according to EN 13136</td><td colspan="3">Vessel data</td></tr>
<tr><td>Type</td><td>External surface [m²]</td><td>Design pressure [bar]</td></tr>
<tr><td>Condenser</td><td></td><td></td></tr>
<tr><td>Evaporator</td><td></td><td></td></tr>
<tr><td>Liquid separator</td><td></td><td></td></tr>
<tr><td>Oil separator</td><td></td><td></td></tr>
<tr><td>Oil cooler</td><td></td><td></td></tr>
<tr><td>Economiser</td><td></td><td></td></tr>
<tr><td>Desuperheater</td><td></td><td></td></tr>
<tr><td>Subcooler</td><td></td><td></td></tr>
<tr><td>Other</td><td></td><td></td></tr>
<tr><td colspan="3">Pressure loss, if any, from safety valve to customer connection (based on design pressure) [bar] _____</td></tr>
<tr><td colspan="3">Safety valve type:
Back-pressure dependent ❑
Back-pressure independent ❑</td></tr>
</table>

Contents

1. Introduction

The SABROE® reciprocating compressor and unit can be configured with various types of equipment depending on its function and requirements. Some of the equipment may be described in this manual even though it is not featured on your particular unit.

This manual describes:

- dangers resulting from failure to comply with safety precautions when operating the equipment and performing maintenance tasks
- how to start, operate and stop the equipment safely
- how to act when problems occur during operation
- scheduled maintenance tasks for the equipment and when/how to carry them out safely
- components with ATEX-related specifications.

This manual is primarily intended for operators and service engineers.

It is important that the operating personnel familiarise themselves with the contents of this manual in order to ensure proper and efficient operation. Johnson Controls Denmark is not liable for damage occurring during the warranty period where this is attributable to incorrect operation.

All compressor intervention within the warranty period must be performed by competent personnel only. If not, the warranty no longer applies.

This manual does not describe:

- Control systems. A specific operating manual is delivered with the compressor.
- Safety when handling refrigerants and oils.
- Installation.
- Service and repair, including spare parts lists.

For further information, see www.sabroe.com

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1.1 Amendments to the manual

2019.09 Version 6
• The copies of the declarations of conformity (Unit and ATEX) are now only contained in the printed manual delivered with the unit and the pdf version uploaded with the order specific documentation. • Various minor corrections.
2018.09 Version 5
• The regular service schedule, Table 13, and the 'Annual service' section have been updated. • New unit and compressor drawings, showing single-beam. • New noise data tables showing 1500 and 1800 rpm. • Updated versions of declarations of conformity: Unit and ATEX.
2018.01 Version 4
• The manual now covers SMC/TSMC Mk 4 LL as well as Mk 5.
2017.12 Version 3
• Name plates with EurAsian Conformity mark (EAC) have been added. • 'Requirements for competent persons' section has been added. • 'F-gas regulation' section has been updated. • Updated versions of declarations of conformity: Unit and ATEX. • And more.

The original version of this manual is the English language version. If there are any discrepancies or conflicts between the English and any other version that has been translated into another language, the English version will prevail.

1.2 Safety precaution definitions used in this manual

Danger!

Indicates an imminently hazardous situation which, if not avoided, will result in death or serious injury.

Warning!

Indicates a potentially hazardous situation or practice which, if not avoided, will result in death or serious injury.

Caution!

Indicates a potentially hazardous situation or practice which, if not avoided, will result in damage to equipment and/or minor injury.

Note: Indicates an operating procedure, practice, or portion thereof, which is essential to highlight.

1.3 Requirements for competent persons

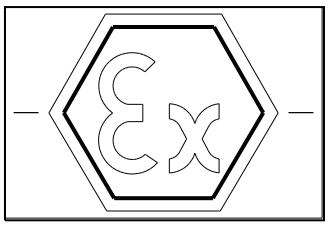
- Personnel working on the unit must be competent in accordance with national safety rules and regulations relating to flammable refrigerants or according to EN 13313.
- Maintenance work must be performed according to EN 378 or ISO 5149 supported by evidence of appropriate training.
- Assign only competent personnel instructed in safety and all machine functions to operate or service the compressor/unit according to EN 13313.
- Operators and maintenance personnel must carefully read, understand and fully comply with all alarms and instructions.

2. Safety

2.1 Application of the compressor

To prevent unintentional application of the compressor, which could injure personnel or damage equipment, the following must be observed:

- The compressor must only be used as a refrigeration compressor and within the operating limits specified in the manuals or in a written agreement with Johnson Controls Denmark.
- Compressor types SMC 100 and TSMC 100 in an S or L execution can as standard compressors be used with various refrigerants. Please see the relevant operating limits diagrams in the *Engineering manual*.
- Compressor types SMC 100 and TSMC 100 in E executions are as standard compressors used with R717 only.
- The compressors can be used with other refrigerants, but only following a written agreement with Johnson Controls Denmark.
- Johnson Controls Denmark further accept no liability of any kind for damage to compressor unit and plant parts caused by torsional oscillation or the like which is attributable to built-in VSD solutions initiated by the customer after delivery.
- SMC 100 and TSMC 100 compressors in S, L or E executions may be used at a max. discharge design pressure of 25 bar.
- **ATEX**: The compressor is approved for application in potentially explosive atmospheres provided it is fitted with explosion-proof equipment. If it is ATEX approved, there will be an EX name plate fixed on the unit. Please note that special non-sparking tools must be used for all maintenance work on the compressor.



The compressor must not be used:

- to evacuate the refrigeration plant of air and moisture
- to put the refrigeration plant under air pressure in view of a pressure testing
- as an air compressor.

Warning!

Johnson Controls Denmark is not liable for injuries to personnel or damage to equipment resulting from using the equipment for other purposes than the ones stated above.

2.2 Application of combustion engines

According to EN 378/ISO 5149, no other machinery should be installed in a refrigeration machine room. Some refrigerant types may, to a certain extent, be absorbed by the fuel in a combustion engine, and when the contaminated fuel reaches the fuel pumps, the refrigerant will "flash out" (separate) and react on the increased temperature and pressure by creating acids, which will

destroy the pumps. However, check with the local authorities as exemptions to this rule may be granted.

Warning!

Johnson Controls Denmark is not liable for injuries to personnel or damage to equipment resulting from using the equipment for other purposes than the ones stated above.

2.3 Identification

2.3.1 Identification of equipment

All equipment from Johnson Controls Denmark can be identified by one or several name plates positioned as illustrated in the following drawings:

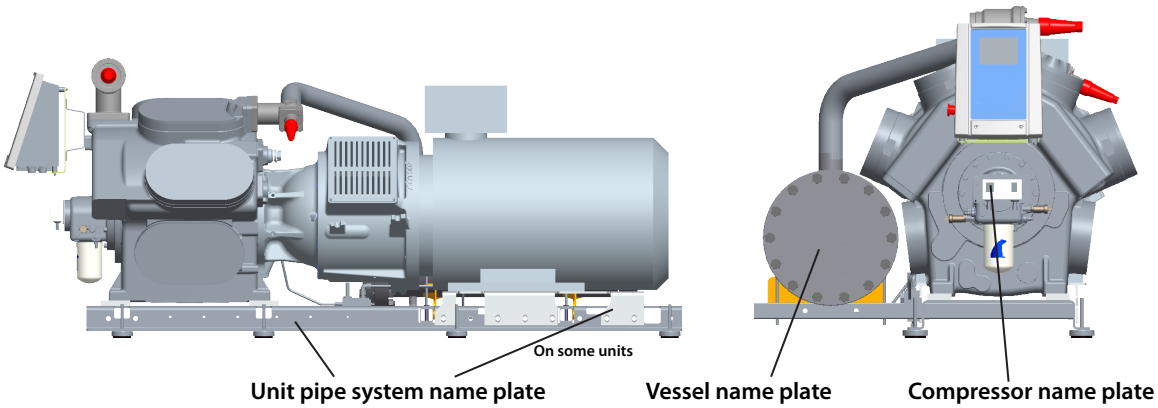


Fig. 1: Identification of name plates

2.3.2 Unit/pipe system name plate

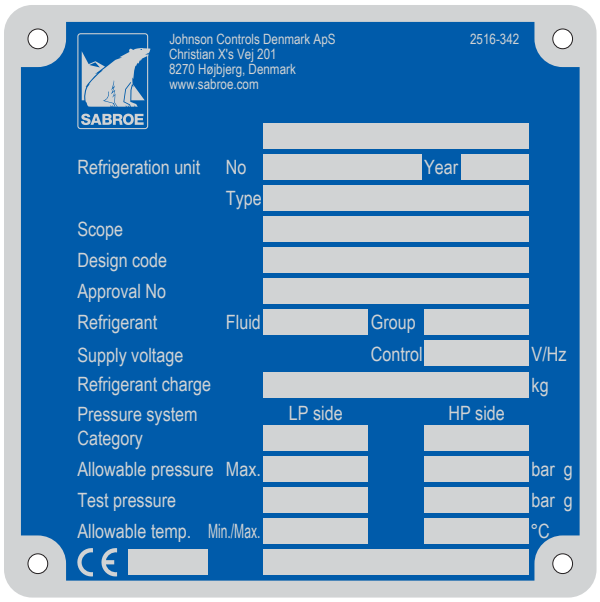


Fig. 2: Name plate for standard unit

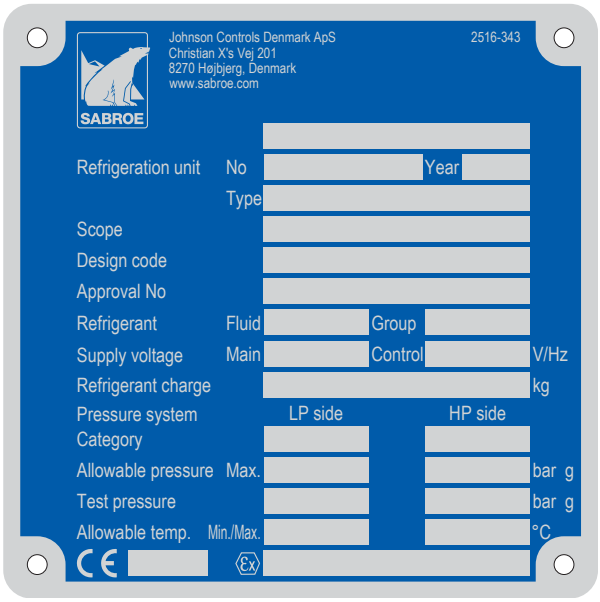


Fig. 3: Name plate for ATEX unit

Fig. 4: Name plate for unit with EurAsian Conformity mark (EAC)

The unit name plate is positioned on the frame and contains this information:

Refrigeration unit No.	Identification no. (serial no.)
Year	Year of manufacturing.
Type	Manufacturer's type designation.
Scope	For EC PED/EAC approval: 'Unit & Piping' means that the CE/EAC mark applies to the complete unit including the piping system. 'Piping' means that the CE/EAC mark applies to the piping system only, and it is the sole responsibility of the owner to ensure and declare that the complete unit is in conformity with the provisions of all relevant rules.
Design code	Design code used for the unit and piping system.
Approval no.	If the unit/manufacture has been approved by a 3rd party/notified body.
Refrigerant - Fluid	Refrigerant of the unit. Refrigerant designation according to ISO 817.
Refrigerant - Group	For EC PED approval: Fluid group 1 or 2 according to the PED directive.
Supply voltage - Control	Supply voltage and frequency of the control system.
Refrigerant charge	Weight of the refrigerant charge on the unit. This is only stated if the unit includes an evaporator and/or a condenser.
Pressure system	The low-pressure side of the unit piping system is referred to as the LP side. The high-pressure side of the unit piping system is referred to as the HP side.
Category	For EC PED approval: The maximum category of the piping system (CAT 1, 2 or 3) or of the assembly unit and piping (CAT 3 or 4).
Allowable pressure, max.	The max. pressure (pressure relative to atmospheric pressure) that the unit/piping system has been designed for in terms of pressure strength design. The maximum practical operation pressure is lower than the maximum allowable pressure depending on the operating conditions and safety equipment settings.
Test pressure	The test pressure that the unit/piping system has been strength tested with.
Allowable temperature, min./max.	The minimum and maximum temperatures that the unit/piping system has been designed for at the indicated maximum allowable pressures.
CE xxxx	The CE mark appears on the name plate for EC PED approval only. The four digits make up the registration no. of the notified body/ 3rd party in charge.
Ex	If the unit is designed in accordance with the EC ATEX directive, there is an Ex mark on the name plate.
EAC	The EurAsian Conformity mark (EAC) indicates that the unit is in compliance with all relevant technical regulations of the Eurasian Customs Union.

Note: Main supply voltage can be found on the motor and/or electrical panel name plate.

2.3.3 Compressor name plates

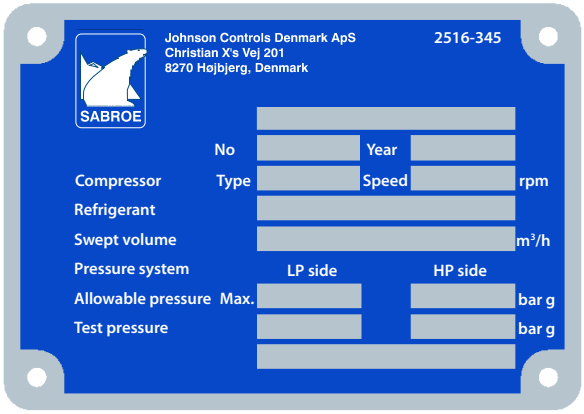


Fig. 5: Name plate for standard compressor

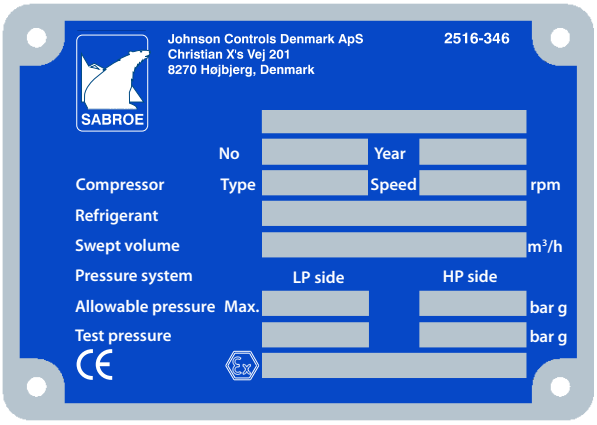


Fig. 6: Name plate for ATEX compressor

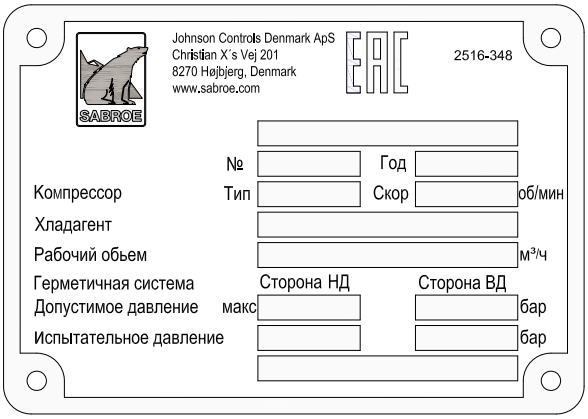


Fig. 7: Name plate for compressor with EurAsian Conformity mark (EAC)

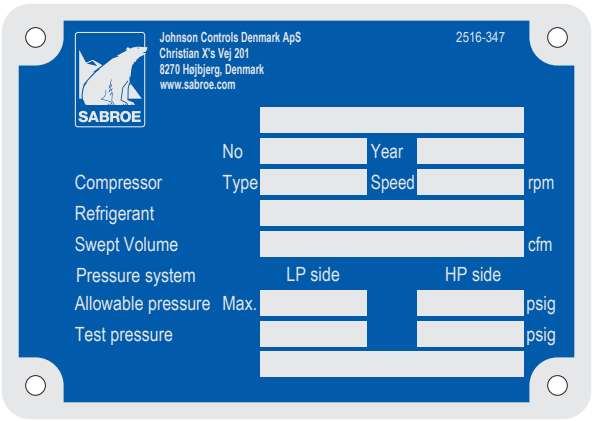


Fig. 8: Name plate for compressor to the USA

The compressor name plate is positioned on the compressor and contains this information:

Compressor no.	Identification no. (serial no).
Year	Year of manufacturing.
Type	Manufacturer's type designation.
Refrigerant	Allowable refrigerant or refrigerants for the compressor. (The actual refrigerant for the unit is stated on the unit name plate).
Speed	Specific rotational speed. Specific rotational speed is used for calculating swept volume. For the actual allowed operating speed, please refer to the operating limits and Matchmaster's calculation on the actual operating condition.
Swept volume	Swept volume of the compressor at nominal speed.
Pressure system	The low-pressure side of the compressor is referred to as the LP side. The high-pressure side of the compressor is referred to as the HP side.
Allowable pressure, max.	The max. pressure (pressure relative to atmospheric pressure) that the compressor has been designed for in terms of pressure strength design. The maximum practical operation pressure is lower than the maximum allowable pressure, depending on the operating conditions and safety equipment settings.
Test pressure	The test pressure the compressor has been strength tested with.
CE and Ex	The CE and Ex marks indicate that the compressor has been designed in accordance with the EC ATEX directive.
EAC	The EurAsian Conformity mark (EAC) indicates that the compressor is in compliance with all relevant technical regulations of the Eurasian Customs Union.

2.3.4 Labelling of explosion-proof equipment

ATEX:

The compressor area of application is indicated next to the Ex-sign on the name plate.

 **II 2 G T3/T4**

II	**Material group:** II indicates that the equipment is suitable for use in industrial areas above ground.
2	**Material category:** 2 indicates that the equipment is suitable for use in areas with possible occurrence of explosive gasses.
G	**Hazardous environment:** G indicates that the equipment is suitable for use in potentially explosive gas, vapour and fog atmospheres.
T3/T4	**Temperature class:** indicates the surface temperatures that may occur on the compressor.

Warning!

On ATEX-executions, the limits in Table 1 *must always be respected.*

Temp. class	Max. surface temp.	Max. oil temperature shaft seal	Min. ignition temp. oil
T1	450°C	430°C	500°C
T2	300°C	280°C	350°C
T3	200°C	180°C	250°C
T4	135°C	115°C	185°C
T5	100°C	80°C	150°C
T6	85°C	65°C	135°C

Table 1: ATEX temperature classes - reciprocating compressors

2.3.5 Vessel name plate

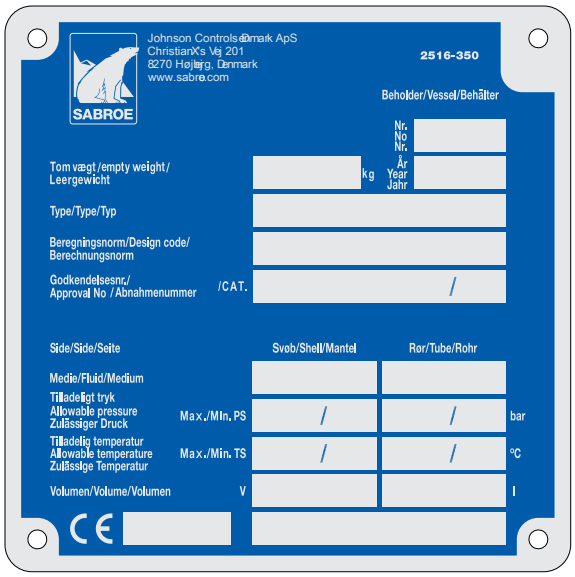


Fig. 9: Name plate for vessel

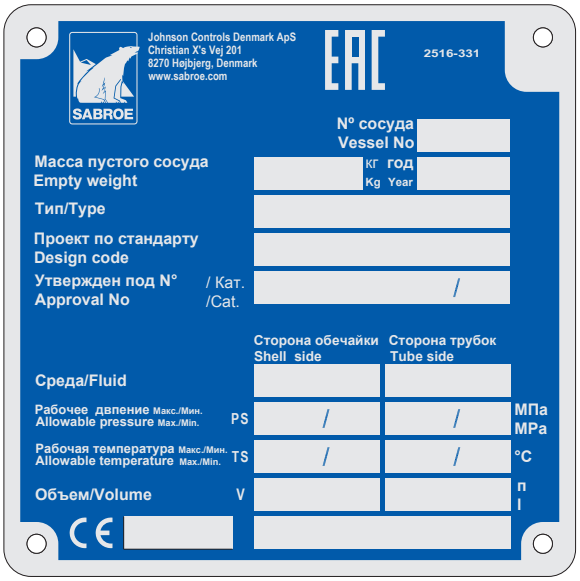


Fig. 10: Name plate for vessel with EurAsian Conformity mark (EAC)

The pressure vessel name plate is positioned on the shell of the vessel and contains this information:

Vessel no.	Identification no. (serial no.)
Empty weight	The empty weight of the vessel in kg.
Year	Year of manufacturing.
Type	Manufacturer's type designation.
Design code	Design code used for the pressure vessel.
Approval no./CAT	The approval no. of the vessel issued by the relevant 3rd party/ notified body. For EC PED approval: CAT (Category 1, 2, 3 or 4) according to the PED directive.
Side	For heat exchangers only. Refers to the columns 'Shell side' and 'Tube side'.
Fluid	Designation of the primary refrigerant(s) and the secondary refrigerant(s). For EC PED approval: Designation of the refrigerant(s) and/or the highest fluid group (Group 1 or 2) according to the PED directive.
Allowable pressure, PS	The min. and max. pressures (pressure relative to atmospheric pressure) that the vessel or vessel part has been designed for.
Allowable temperature, TS	The min. and max. temperatures that the vessel or vessel part has been designed for.
Volume	The volume of the vessel or vessel part.
CE xxxx	The CE mark appears on the name plate for EC PED approval. The four digits make up the registration no. of the notified body/ 3rd party in charge.
EAC	The EurAsian Conformity mark (EAC) indicates that the vessel is in compliance with all relevant technical regulations of the Eurasian Customs Union.

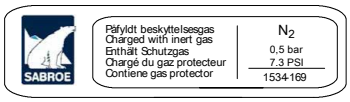
Note: Depending on the supplier of the pressure vessel/heat exchanger, the layout and content of the vessel name plate may differ from the SABROE name plate above.

2.4 Safety precautions

2.4.1 Signs

All signs which may be found on your equipment are shown below. The number of signs, however, **may vary** from one product to another.

Risk of electric shock 	**High voltage/ High pressure** 	**High surface temperature (about 70°C)** 	**The compressor may be top-heavy** 
Internal overpressure 	**Hazardous substance** 	**Cold surfaces** 	**Dangerous noise level, use hearing protectors** 
Do not step on surface 	**No open flame** 	**Flammable gas** 	**The unit IS filled with refrigerant R290** 

Internal protection  Compressor blocks and units are usually delivered **without** refrigerant and oil. To protect the compressors against internal corrosion, they are delivered evacuated of all atmospheric air and charged with dry Nitrogen (N_2) to an overpressure of **0.5 bar [7.3 PSI]**. In such cases, a yellow sign is affixed to a visible spot on the compressor.	**Pacemaker users keep out**  The magnetic field on the rotor may affect pacemakers. The motor rotor contains a powerful magnetic field. This field may affect digital devices such as watches and mobile phones. Assembly or maintenance of the rotor must not be carried out by people with pacemakers or any other implanted medical electronic device.	 The VSD contains capacitors capable of storing electrical energy, meaning that there is a risk of electric shock within 15 minutes after the drive has been turned off.

2.4.2 Emergency stop

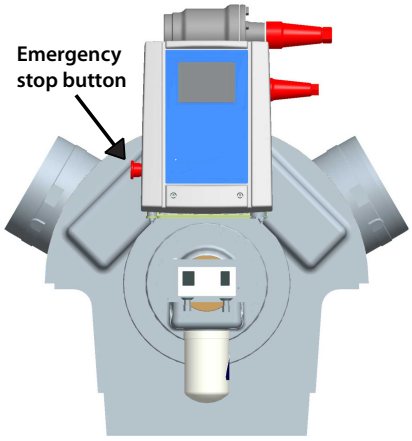


Fig. 11: Emergency stop button on the reciprocating compressor unit with Unisab III control system

The compressor control system **must** be equipped with an emergency device.

If the compressor is delivered with a Unisab control system, the emergency device is integrated in the control system.

The emergency device must be made in such a way that it remains in its stopped position after a stop command and until it is deliberately set back. The emergency device must not be able to block without releasing a stop command.

It should only be possible to set back the emergency stop by a deliberate act, and this must not start the compressor. It should only make it possible to restart it.

Additional requirements for the emergency device

- It must be operated by means of an easily recognisable and visible manual handle with easy access.
- It must be able to stop any dangerous situation as quickly as possible without this causing any additional danger.

2.4.3 Safety during maintenance and service

- Personnel must be qualified according to national safety rules and regulations and perform the maintenance work according to EN 378.
- Read chapter *2. Safety* in this manual before opening the compressor and other parts of the refrigeration plant.
- It is recommended to remove all main fuses. Switch off all electric components on the compressor/unit before starting the dismantling/servicing process, and lock the main switch.
- Make sure that the motor cannot start up inadvertently.
- Make sure that there is no over-pressure and no refrigerant in the part to be dismantled. Close all necessary stop valves.
- Use the prescribed tools, and check that they are properly maintained and in good working condition. In explosion-proof areas, use tools suited for this specific purpose.
- Use only Johnson Controls Denmark original spare parts; other parts may impair the safety of the compressor/unit.
- When performing maintenance, the main switch must be locked.

- Use gloves and protective goggles and make sure to have a gas mask close at hand. Also use electrical protection equipment and tools suited for electrical operation purposes.
- When dismantling the top covers, pay attention to the considerable spring force beneath the covers. When the screws are loosened, the cover must lift itself from the frame.

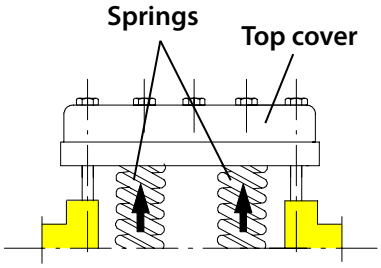


Fig. 12: Springs and top cover

- Before dismantling the side covers, empty the crankcase of its oil content.
- Check that the heating rod in the crankcase is de-energised.

ATEX:

- All parts should be electrically conductive to avoid sparking when static electricity builds up.
- Materials should only contain a limited percentage of light metals.
- Original parts supplied by Johnson Controls Denmark must not be replaced by unspecified parts that are not ATEX approved.

Warning!

On ATEX-executions, the limits in Table 2 *must always be respected.*

Temp. class	Max. surface temp.	Max. oil temperature shaft seal	Min. ignition temp. oil
T1	450°C	430°C	500°C
T2	300°C	280°C	350°C
T3	200°C	180°C	250°C
T4	135°C	115°C	185°C
T5	100°C	80°C	150°C
T6	85°C	65°C	135°C

Table 2: ATEX temperature classes - reciprocating compressors

2.4.4 Electrical installations

ATEX:

On ATEX-executions, all electrical installations supplied with the compressor are in conformity with the ATEX directive. If the installations are expanded or additional equipment is mounted, this must also be in conformity with the ATEX directive.

For equipment not supplied by Johnson Controls Denmark, it is the contractor who is responsible for ensuring that the equipment is in conformity with the ATEX directive.

Specifically, the contractor is responsible for equalising potential differences on the compressor.

2.4.5 General precautions

These precautions should be used as a supplement to the safety precautions and warnings included in:

- All other manuals pertaining to the compressor/unit
- Local, plant and shop safety rules and codes
- National safety rules and regulations.

Read and understand all safety instructions before setting up, operating or servicing/performing maintenance on the compressor/unit. Assign only competent personnel instructed in safety and all machine functions to operate or service the compressor/unit.

Operators and maintenance personnel must carefully read, understand and fully comply with all alarm and instruction plates mounted on the compressor/unit.

- Observe the safety warnings.
- Use ear protection when operating the compressor/unit.
- Use safety equipment. Wear appropriate gloves as well as eye and face protection when working with parts containing refrigerant and/or lubricating oil.
- Use proper electrical safety protection.

Note: These instructions only provide general information. The owner of the refrigeration plant is responsible for ensuring that all codes, regulations and industry standards are complied with.

2.4.6 During operation

Warning!

All safety features, disengagement and interlocks must be in place and function correctly before the equipment is put into operation. Never by-pass or wire around any safety device.

Ventilation

Before operating the unit always check, where relevant, the function of the ventilation system and refrigerant detectors used in the area where the compressor/unit is located (machine room).

Rotating parts

Warning!

Safety guards, shields, barriers, covers and protective devices must not be removed while the compressor/unit is operating.

Vibration and noise

During operation, pay attention to the compressor unit process. Excessive vibrations, unusual sounds, etc. may indicate problems requiring your immediate attention.

Pressure

Danger!

A compressor/unit comprises a pressurised system. Never loosen threaded joints while the system is under pressure, and never open pressurised system parts.

Note: Whenever a relief valve/safety valve has been activated, we recommend recalibrating it. This must be carried out by competent personnel only. See also EN 378 and existing national legislation.

2.4.7 Cooling water system

Warning!

The recirculation water system may contain chemicals or biological contaminants, including legionella, which can be harmful if inhaled or ingested. Water systems should only be operated with an effective biological treatment programme.

2.4.8 Lubricating oils

Compressor oils include the following oil types:

Code design	Oil types
M	Mineral oil, naphtenic base
A	Synthetic oils based on alkylated aromatics (alkyl-benzene)
AP	Synthetic oils blended from alkyl-benzene and poly-alfa-olefin base stocks
S	Semi synthetic oils (hydro-treated mineral oil on paraffinic base)
PAO	Synthetic oils based on poly-alfa-olefin
POE	Synthetic oils based on polyol esters
PAG	Synthetic oils based on polyalkylene glycols

See the SABROE oil recommendation for the recommended type of oil.

Warning!

When charging oil, follow the safety instructions given by the oil supplier (MSDS: Material Safety Data Sheet). Always avoid direct contact with the oil as this may cause skin allergies. Always use protective equipment, goggles and gloves, when charging oil.

When changing oil on the compressor or draining oil from the vessel of the refrigeration plant, always collect the used oil in containers marked "waste oil," and send them to an approved hazardous waste disposal site. It is not recommended to reuse oil.

2.4.9 Refrigerants

Be very careful when dealing with refrigerants. For safe handling, please refer to the safety/data sheets delivered by the refrigerant supplier.

Warning!

Be aware that large amounts of leaking (or released) refrigerant entail a risk of asphyxiation. If in direct contact with leaking liquid refrigerant, there is a high risk of injuries caused by frostbite.

2.4.10 Purging a refrigeration plant

Purging of air or other non-condensable gases is required in order to keep high system performance and avoid corrosion of the equipment, which could endanger the safety of persons and equipment.

When purging a refrigeration system, make sure to observe the following:

- Refrigerants must not be released into the atmosphere, except CO_2, which can be released slowly into the atmosphere.
- When purging an ammonia system, use an approved air purger. The purged air must pass through an open container or water for any remaining ammonia (R717) to be absorbed. The water mixture must be sent to an approved hazardous waste disposal site.
- Halocarbon refrigerants (CFC, HCFC and HFC) **cannot** be absorbed by water. An approved air purger must be fitted to the system. This must be checked regularly by use of a leak

detector. All precautionary measures practicable must be taken to prevent and minimise leakage of refrigerant from refrigeration and air conditioning systems to the atmosphere.

Note: The occurrence of air is usually an indication of poor maintenance or lack of thoroughness at installation.

Note: Ammonia systems should be purged on a regular basis to avoid atmospheric air and other non-condensable gases.

2.4.11 F-gas regulation (fluorinated greenhouse gases)

In the European F-gas regulation, No 517/2014, about reduction of harmful gases in the atmosphere, the European Parliament (EU) has established guidelines for the regulation of certain fluorinated greenhouse gases. The following is an extract from the guidelines and is relevant for end users and operators.

Fluorinated refrigerants are included in the category of greenhouse gases and therefore fall under the F-gas regulation. The table below lists a few of the relevant refrigerants and their respective GWP (Global Warming Potential) according to the F-gas regulation. The so-called "HFOs" and natural refrigerants do not fall under the scope of the regulation.

Refrigerant	GWP (Global Warming Potential)
R134a	1300
R407C	1650
R404A	3785
R507	3850

Requirements of the F-gas regulation include:

- Bans and limitations
- Labelling
- Leakage test
- Recovery of refrigerant
- Certification of personnel
- Record keeping.

Bans on GWP

R404A/R507A and other refrigerants with a GWP over 2500 are banned from new stationary systems after 2020. Existing systems can be serviced with reclaimed refrigerant until 2030, provided that proper-quality refrigerant is available. Read the local regulations.

Labelling

The unit must be fitted with a label (name plate). Refrigerant type, charge in kg and CO_2Equivalent (CO_2eq) must be stated on the plate.

Leakage test

It is the operator's responsibility to ensure that the unit is checked for leakages by a competent person. For units charged with fluorinated greenhouse gases, the following conditions apply depending on type of plant and amount of charge:

- for equipment that contains fluorinated greenhouse gases in quantities of 5 tonnes of CO_2eq or more, but of less than 50 tonnes of CO_2eq: at least every 12 months; or where a leakage detection system is installed, at least every 24 months
- for equipment that contains fluorinated greenhouse gases in quantities of 50 tonnes of CO_2eq or more, but of less than 500 tonnes of CO_2eq: at least every six months or, where a leakage detection system is installed, at least every 12 months
- for equipment that contains fluorinated greenhouse gases in quantities of 500 tonnes of CO_2eq or more: at least every three months or, where a leakage detection system is installed, at least every six months.

The equipment must be checked for leakage within one month after a leak has been repaired to ensure that the repair has been effective.

Recovery of refrigerant

Operators are responsible for putting in place arrangements for the proper recovery of fluorinated greenhouse gases by competent personnel to ensure recycling, reclamation or destruction.

Certification of personnel

According to directive 303/2008, it is mandatory for the member states to establish certification and training programs for personnel involved in leakage inspections and the recovery, recycling, reclamation and destruction of fluorinated gases.

Record keeping

For all units containing fluorinated greenhouse gases in quantities of more than 5 tonnes of CO_2eq, records must be kept indicating the quantity and type of product, quantities added for recharges and the quantity recovered during servicing, maintenance and final disposal. Other relevant information is also requested, such as identification of the servicing company or technician, as well as dates and results of the checks.

For further information, please see the F-gas regulation in full.

2.4.12 Transmission safety

Coupling

The coupling guard for directly driven compressors is not designed to resist unintended load. Therefore, do not step on it or load it in any way during operation. The guard is marked with a sign.

⚠ Warning!

When mounting the coupling guard, make sure that it is not in contact with any rotating parts. After 20 hours, check to see if tightening-up is required. Check the coupling guard for correct tightening, cracks or other defects every 5000 hours.

⚠ Warning!

Do not start the compressor until the coupling guard is mounted correctly. Before performing any kind of work on the coupling, make sure that the compressor motor cannot start up inadvertently. When performing service where the motor is dismantled from the base frame, follow the instructions for coupling alignment in the Installation instructions chapter in the Engineering manual.

Note: These instructions only provide general information. The owner of the refrigeration plant is responsible for ensuring that all codes, regulations and industry standards are complied with.

2.5 Sound measurement and noise data

2.5.1 Noise data

Noise data is stated in:

SWL: A-weighted **s**ound po**w**er **l**evel
SPL: A-weighted **s**ound **p**ressure **l**evel, in free field over reflecting plane (1 m distance).

- Noise data is based on measurements according to ISO 9614-2.
- The stated SPL values are calculated using the formula 8.3 in ISO 3744.
- The stated values are for a complete unit operating in 100% capacity.

2.5.2 Noise data for SMC and TSMC

Single-stage

SWL and SPL values are measured at the stated conditions.

Single-stage, SMC

Evaporating temperature, TE	-10°C [14°F]
Condensing temperature, TC	+35°C [95°F]
Refrigerant	R717
Speed	**1500 rpm**

Compressor block	SWL	SPL
SMC 104 S	95	79
SMC 106 S	96	81
SMC 108 S	97	82
SMC 112 S	99	82
SMC 116 S	100	83
SMC 104 L	96	80
SMC 106 L	97	82
SMC 108 L	98	83
SMC 112 L	100	83
SMC 116 L	101	84
SMC 104 E	96	80
SMC 106 E	97	82
SMC 108 E	98	83
SMC 112 E	100	83
SMC 116 E	101	84

Table 3: Noise data for SMC, 1500 rpm

Evaporating temperature, TE	-10°C [14°F]
Condensing temperature, TC	+35°C [95°F]
Refrigerant	R717
Speed	**1800 rpm**

Compressor block	SWL	SPL
SMC 104 S	97	82
SMC 106 S	99	83
SMC 108 S	100	84
SMC 112 S	101	84
SMC 116 S	102	86
SMC 104 L	98	83
SMC 106 L	100	84
SMC 108 L	101	85
SMC 112 L	102	85
SMC 116 L	103	87

Table 4: Noise data for SMC, 1800 rpm

Two-stage, TSMC

Evaporating temperature, TE	-40°C [-40°F]
Condensing temperature, TC	+35°C [95°F]
Refrigerant	R717
Speed	**1500 rpm**

Compressor block	SWL	SPL
TSMC 108 S	95	80
TSMC 116 S	98	81
TSMC 108 L	96	81
TSMC 116 L	99	82
TSMC 108 E	96	83
TSMC 116 E	99	83

Table 5: Noise data for TSMC, 1500 rpm

Evaporating temperature, TE	-40°C [-40°F]
Condensing temperature, TC	+35°C [95°F]
Refrigerant	R717
Speed	**1800 rpm**

Compressor block	SWL	SPL
TSMC 108 S	98	82
TSMC 116 S	100	83
TSMC 108 L	99	83
TSMC 116 L	101	85

Table 6: Noise data for TSMC, 1800 rpm

Noise data for other operating conditions can be provided by Johnson Controls Denmark on request.

Note:

- The actual SPL value on site will be between the stated SPL and SWL depending on the acoustic environment in the machine room.

- In a typical machine room without any noise absorbing materials, the actual SPL will be approximately 14 dBA higher than the stated SPL (free field value).
- Checking the actual SPL must therefore always be accompanied by measurements of the acoustic environment of the machine room. Alternatively, ISO 9614-2 could be followed at the installation site to obtain SWL comparable values.
- Be aware of local/national requirements for the use of ear protection. Generally, it is recommended to use ear protection in machine rooms.

3. Operating instructions

3.1 Safety precautions

Danger!

A number of safety precautions, which must be read before operating the unit, are presented in the following. General safety instructions/regulations must be studied carefully. Failure to do so may result in personal injury or even death. Moreover, equipment may be damaged or destroyed.

3.2 Ventilation

Before operating the unit, always check the function of the ventilation system used in the area where the compressor unit is located (machine room).

Danger!

Pay close attention to the fact that large amounts of escaping (or released) refrigerant entail risk of suffocation. Safety sheets explaining the risks associated with the relevant refrigerant should be supplied by the supplier of the plant.

Danger!

Body contact with leaking liquid refrigerant entails high risk of injuries caused by intense cold. The safety sheets supplied by the supplier of the plant also explain the risks generally associated with refrigerants.

3.3 Pressure

Danger!

A compressor unit comprises a pressurised system. Never loosen threaded joints (such as a union nut) while the system is under pressure, and never open pressurised system parts.

Note: Whenever a by-pass valve/safety valve has been activated, we recommend recalibrating it. This must be carried out by competent personnel only. See also EN 378 and existing national legislation.

3.4 Hot and cold surfaces

Warning!

A compressor unit contains both hot and cold system parts. Always wear and use appropriate safety equipment.

Never use your hands or other parts of your body to search for leaks.

3.5 Compressor control and alarm functions

Standard reciprocating compressors can be equipped with either an analogue reading and regulating system or a Unisab reading, safety and regulating system.

3.6 Alarms and warnings

Analogue system

Analogue reading and regulating systems always require an external control board for the regulation of capacity. The board can be equipped with alarms.

The safety system consists of the following components:

KP1: Low pressure cut-out

Stops the compressor at too low pressure in the refrigeration system.

KP 5: Intermediate pressure cut-out

(TSMC compressors only)
Stops the compressor at too high intermediate pressure.

KP7 ABS High pressure cut-out

As standard equipped with a high pressure cut-out adjusted to stop the compressor if the discharge pressure rises to a pressure higher than 0.9 x the compressor design pressure (PS) or 2 bar below the setting pressure of the by-pass valve, whichever is the lower value.

MP 55: Oil differential cut-out

Stops the compressor at too low oil pressure in the lubricating system.

External oil filter differential pressure warning (mechanical)

The red button on the differential pressure device pops out when the differential pressure exceeds 2.5 bar.

Fig. 13

KP 98: Discharge pipe thermostat

Stops the compressor at too high discharge gas temperature.

KP 98: Oil thermostat

Stops the compressor at too high oil temperature.

The safety equipment stops the compressor if the maximum or minimum values are exceeded. If this happens, correct the error before restarting the plant. To prevent accidents the plant cannot be started before the function of the safety cut-out has been activated. Cut-outs and thermostats are not factory-set on delivery, but must be set during the initial phase. Insert the set values in *Table 8: Pressure and temperature settings for compressor type SMC/TSMC* . Always check the set values before starting the plant.

Note: Set values should be changed by competent personnel only.

3.7 Unisab reading, safety and capacity regulating system

The Unisab III control system is described in a separate manual that will be delivered with all units equipped with Unisab III.

3.8 Heating element

To keep the compressor lubricating oil warm during a period of standstill, a heating element is built into the oil reservoir. Before start-up, the heating element must be switched on for 6-8 hours to ensure that only a minimum of refrigerant remains in the oil. If there is too much refrigerant in the oil, the oil loses its lubricating properties, and, in reciprocating compressors, there is a great risk of the oil foaming vigorously when the compressor starts because of the falling suction pressure.

Warning!

The heating element must not be switched on if the oil level in the reservoir is below minimum in the sight glass. Normally, it must be turned off when the compressor is in operation.

Remember to turn off the heating element before draining the oil through the compressor service valve and before opening the reciprocating compressor crankcase for inspection.

ATEX:

On ATEX-executions, the heating element(s) are ATEX-approved. Heating elements from Johnson Controls Denmark have a thermostat with manual reset. If the thermostat drops out, only competent personnel should reactivate it.

3.9 Valves for operation of compressor

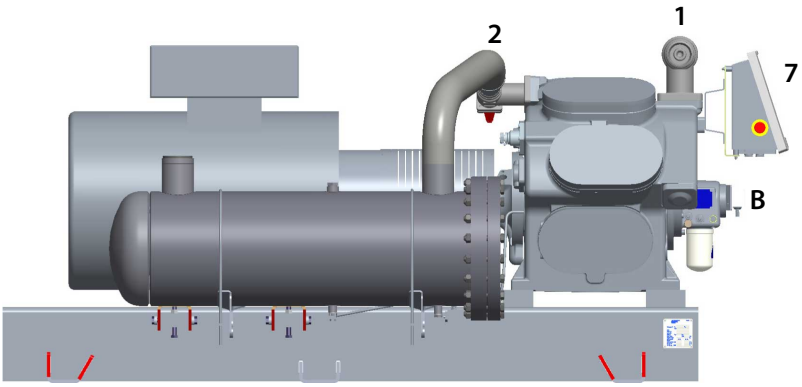


Fig. 14: SMC short block

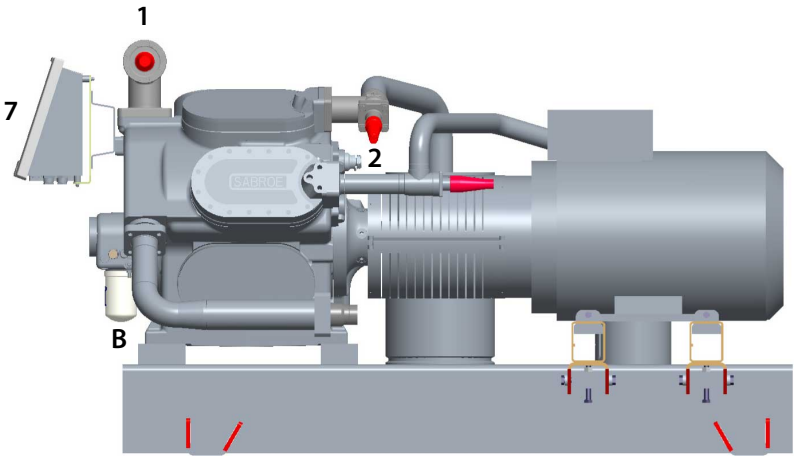


Fig. 15: TSMC short block

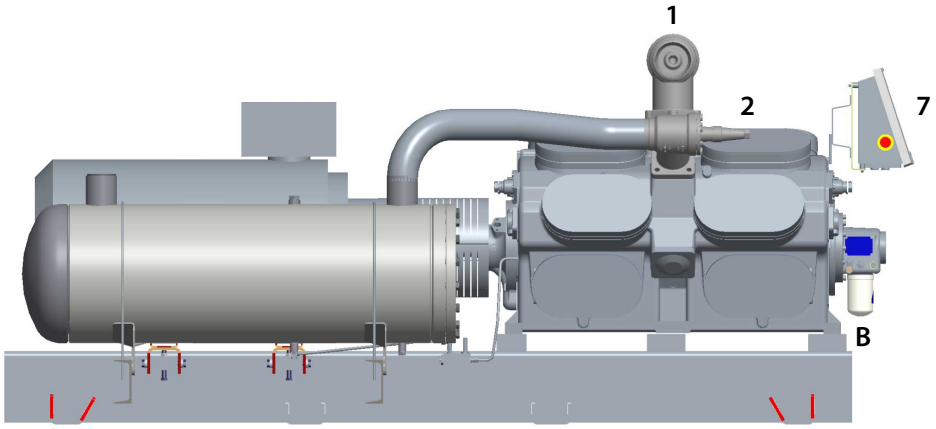


Fig. 16: SMC long block

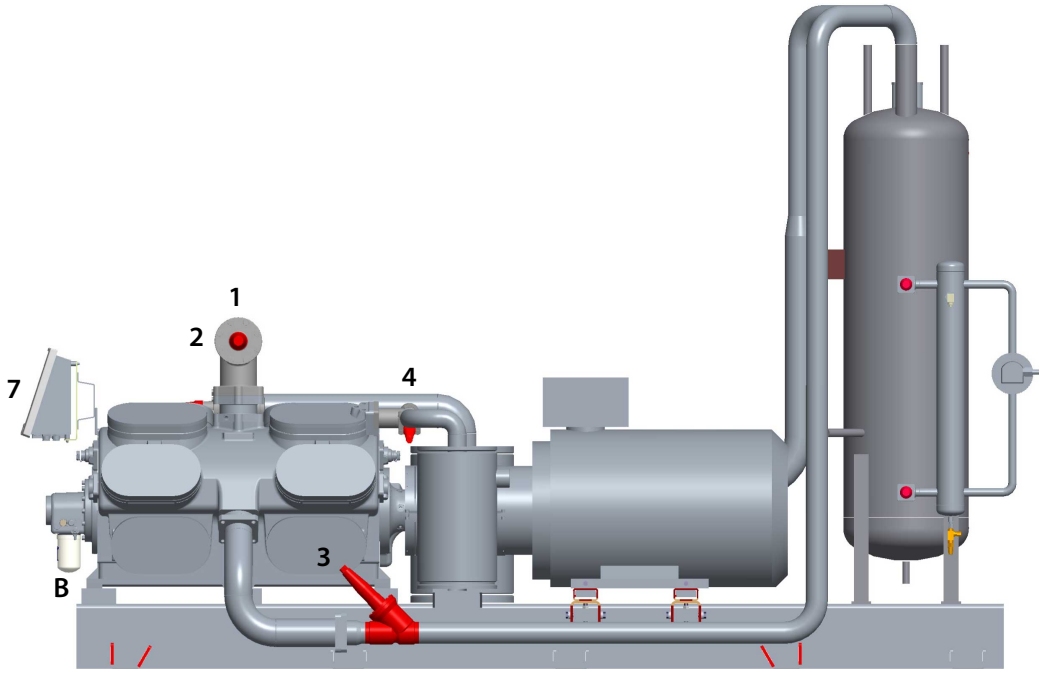


Fig. 17: TSMC long block with intermediate cooler

Pos.	Description	SMC	TSMC
1	Suction stop valve	X	X
2	Discharge stop valve, SMC Discharge stop valve, intermediate pressure TSMC	X	X
3	Suction stop valve, intermediate pressure		X
4	Discharge stop valve, high pressure		X
B	Oil purge/drain valve	X	X
7	Control equipment	X	X

3.10 Installation and first start-up procedure

Installation in terms of mechanical work (refrigeration system and piping), electrical work and installation of safety equipment must be performed in accordance with local codes/rules and/or according to EN 378-3 and EN 378-4 as minimum requirements.

The pressure loss in the downstream line from the safety valve must meet the values stated in EN 13136 to which EN 378 is referring. The data necessary to dimension the line in accordance with this standard is stated in the vessel data table for the specific unit in the beginning of this manual.

Make sure that all necessary documents are available, including declarations, certificates, identification plates, manuals, machine card, logbooks and/or other documentation required according to local rules and/or EN 378.

3.11 Preparations for starting

Check the following before starting the compressor for the first time after installation:

- that the oil level is at the middle of the sight glass. If this is not the case, recharge with oil. See section *4.12 Compressor prelubrication*.
- that the safety equipment is set correctly. All safety functions are factory-set. This is the case for both analogue control and Unisab control.
- that the heating element in the crankcase has been energised 6-8 hours before starting up the compressor.
- that the pilot voltage is switched on. Check that the emergency stop button is in ON-position (the button must be in its outermost position). If the plant does not start, check that the fuses are intact.
- that the valves are open according to Table 7.
- that direction of rotation is correct. Check this by starting the motor and turning it off again immediately.

  At **fixed speed**, check the direction of rotation before mounting the coupling intermediate part.

  At **VSD operation**, make the check with the entire coupling mounted, but run the motor for maximum 1 second. It is a good idea to have someone else help observe the direction of rotation.

Note: On delivery, the compressor is fitted with a fine-meshed filter bag in the suction filters. The filter bag filters off any small rust particles, which may penetrate the suction filters, and thus effectively ensures that no impurities are mixed with the oil. The filter bag must not be used for more than 50 hours after the first compressor start-up. This also applies to situations where modifications that may cause impurities in the suction gas are performed on the plant. After 50 hours, the filter bag and the insert must be removed and discarded. Disposal of used filter bags must be carried out according to the existing environmental legislation. Please read the Final disposal chapter.

Pos. no.	Qty.	Designation	Position during operation	Comments
1	1	Suction stop valve	Open	Open by a couple of turns only
2	1	Discharge stop valve	Open	
3	1	Air purge valve	Closed	
4	1	Oil charge valve	Closed	Marked "B" on the compressor
5	1	Stop valve - after oil separator	Open	
6	1	Stop valve - receiver	Open	
7	1	Stop valve - liquid line	Open	Open after start-up

Table 7: Positions during operation

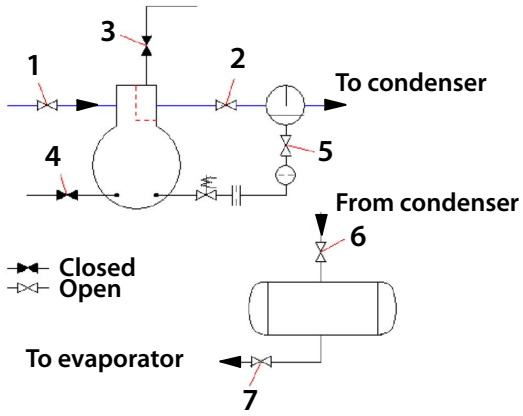


Fig. 18: Principle drawing - positions during operation

Note: There may be more valves. See dimensions and piping diagram.

3.12 Pressure and temperature settings

For SMC and TSMC compressors

Analogue control and safety system			Refrigerant						Min. setting	Max. setting
			R22	R134	R404A	R507	R717			
Safety equipment	Safety valve on compressor	HP	X	X	X	X	X	24 bar (standard)		
			X	X	X	X	X	22 bar (special)		
		IP	X	X	X	X	X	12 bar		
	High and intermediate pressure cut-out	KP5 (KP15)	X	X	X	X	X	Set to stop the compressor at a pressure 2 bar lower than the safety valve setting.		
	Low pressure cut-out	KP1 (KP15)	X	X	X	X	X	Set to a pressure with saturation temp. 5°K lower than the lowest evaporating temperature.		
	Oil pressure cut-out	MP55	X	X	X	X	X	3.5 bar		
	Discharge pipe thermostat	KP98	X	X	X			* 120°C		
							X	* 150°C		
	Oil thermostat	KP98	X	X	X	X	X	80°C		
Control equipment	Thermostat for compressor cooling	KP77	X	X	X	X	X	55°C		
	Thermovalve for compressor cooling	T (E) X T (E) N T (E) S	X	X	X	X		Normally set at 4°C superheat Change to min. 10°C superheat		
	Injection valve for intermediate cooling	TEAT		X	X	X		Factory setting 45°C. See Note.		
			X				X	Factory setting 75°C. See Note.		
		T (E) X TEA	X					Set at min. 10°C superheat		
							X	Set at min. 10°C superheat		
	By-pass valve	PMC+ CVC		X	X	X		-25°C		
							X	-15°C		
	Oil filter differential pressure	FPC	X	X	X	X	X	2.5 bar		
	Oil pressure regulating valve		X	X	X	X	X	4.5 bar		

* Factory setting. It can be adjusted, if required, to a breaking point 20°C higher than the highest normal discharge pipe temperature.

** Adjust the TEAT valves so that the expected discharge pipe temperature (-5°C/+10°C) is achieved at 100% compressor capacity. Increase the opening temperature 10°C by turning the spindle 5 turns clockwise.

Note: Factory setting must always be increased by min. 10°C. Adjustment of the TEAT valve must be carried out with the thermo pump out of operation.

Table 8: Pressure and temperature settings for compressor type SMC/TSMC

3.13 Monitoring of operation

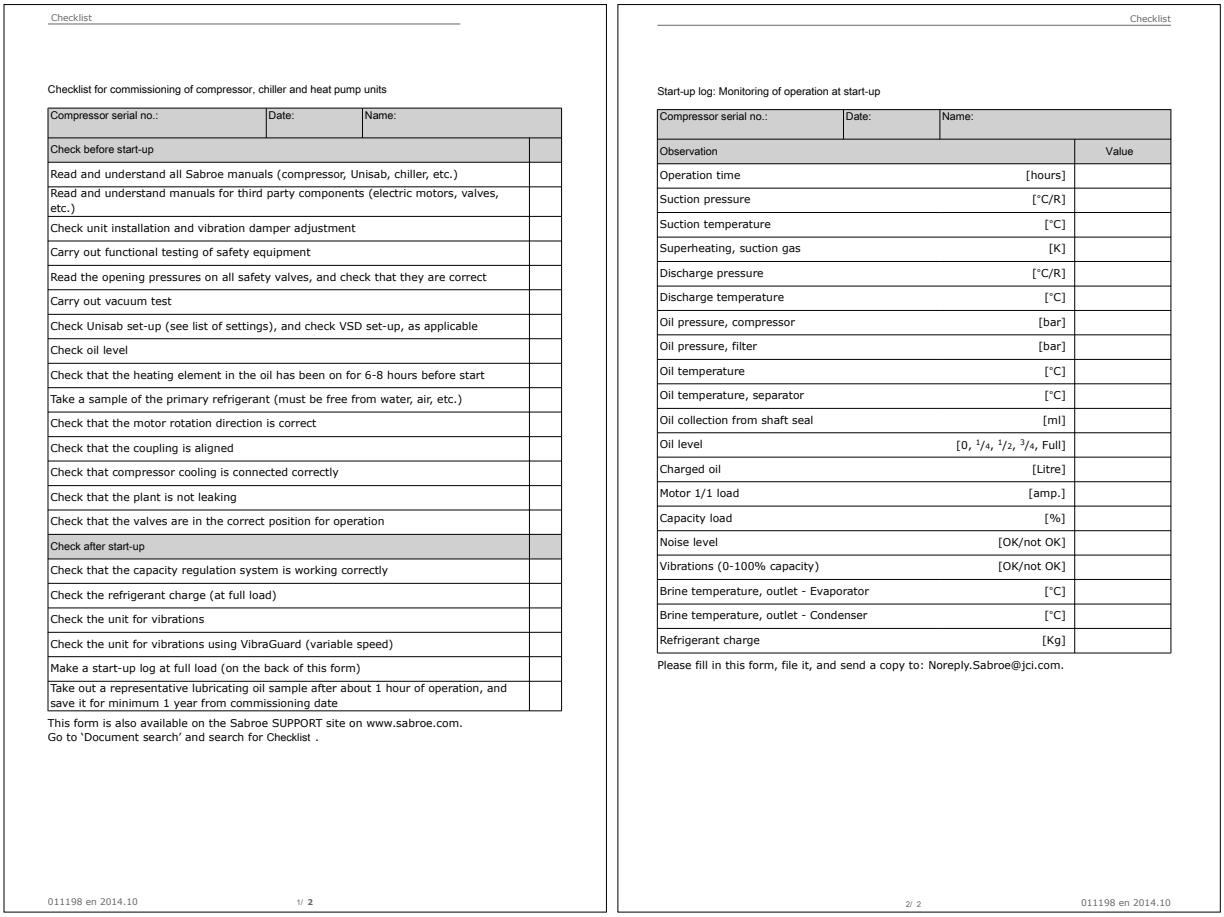
To ensure satisfactory operation, it is required that you enter certain routines in a logbook on a regular basis. You can use the items listed in the *Start-up log*, which is page 2 of the *Checklist* illustrated in Fig. 19. The service engineer will need this information in connection with, for example, error reports.

In addition to the items listed in the start-up log, all other activities of service, maintenance or repair work must be entered into your logbook as required by EN 378 and national laws.

Checklist

Along with this Operating manual we have provided a *Checklist*, as shown in Fig. 19, which will serve as a help to the service engineer and **must be filled in during commissioning and start-up**.

Keep the filled-in checklist, and send a copy to SABROE Factory as documentation that the unit has been installed and commissioned correctly. The checklist will be required in case of a warranty issue.



Checklist

Checklist for commissioning of compressor, chiller and heat pump units

Compressor serial no.:	Date:	Name:	
Check before start-up			
Read and understand all Sabroe manuals (compressor, Unisab, chiller, etc.)			
Read and understand manuals for third party components (electric motors, valves, etc.)			
Check unit installation and vibration damper adjustment			
Carry out functional testing of safety equipment			
Read the opening pressures on all safety valves, and check that they are correct			
Carry out vacuum test			
Check Unisab set-up (see list of settings), and check VSD set-up, as applicable			
Check oil level			
Check that the heating element in the oil has been on for 6-8 hours before start			
Take a sample of the primary refrigerant (must be free from water, air, etc.)			
Check that the motor rotation direction is correct			
Check that the coupling is aligned			
Check that compressor cooling is connected correctly			
Check that the plant is not leaking			
Check that the valves are in the correct position for operation			
Check after start-up			
Check that the capacity regulation system is working correctly			
Check the refrigerant charge (at full load)			
Check the unit for vibrations			
Check the unit for vibrations using VibraGuard (variable speed)			
Make a start-up log at full load (on the back of this form)			
Take out a representative lubricating oil sample after about 1 hour of operation, and save it for minimum 1 year from commissioning date			

This form is also available on the Sabroe SUPPORT site on www.sabroe.com.
Go to 'Document search' and search for Checklist .

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Checklist

Start-up log: Monitoring of operation at start-up

Compressor serial no.:	Date:	Name:	
Observation			Value
Operation time		[hours]	
Suction pressure		[°C/R]	
Suction temperature		[°C]	
Superheating, suction gas		[K]	
Discharge pressure		[°C/R]	
Discharge temperature		[°C]	
Oil pressure, compressor		[bar]	
Oil pressure, filter		[bar]	
Oil temperature		[°C]	
Oil temperature, separator		[°C]	
Oil collection from shaft seal		[ml]	
Oil level		[0, 1/4, 1/2, 3/4, Full]	
Charged oil		[Litre]	
Motor 1/1 load		[amp.]	
Capacity load		[%]	
Noise level		[OK/not OK]	
Vibrations (0-100% capacity)		[OK/not OK]	
Brine temperature, outlet - Evaporator		[°C]	
Brine temperature, outlet - Condenser		[°C]	
Refrigerant charge		[Kg]	

Please fill in this form, file it, and send a copy to: Noreply.Sabroe@jci.com.

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Fig. 19: The checklist which MUST be filled in during commissioning and start-up

3.14 Brief stop

Before stopping the compressor, reduce the capacity to the lowest capacity level for a couple of minutes. It is not necessary to shut the suction and discharge stop valve when it is only a brief stop. If the compressor is water-cooled, the water flow must always be stopped when the compressor is not in operation. The heating element must be or remain energised.

3.15 Shutting down for a long standstill period

If the plant is stopped for a long period, 2-3 months or more, follow this procedure:

- Close the main shut-off valve after the receiver.
- Pump down evaporators. It might be necessary to adjust low pressure cut-out to a lower suction pressure during pump down. Continue pump down until the suction pressure has been reduced to a little above atmospheric pressure.
- Close the suction and discharge stop valves and the stop valve in the oil return line.
- Follow the plant instructions which indicate how to stop and close down the plant correctly.
- Shut off the main and control power supply.
- Remember to write down all actions in a logbook.

3.16 Problems

Some frequently encountered errors that can be remedied by the operator are described below.

In more complex situations, please call in skilled personnel who have access to the appropriate documentation.

3.17 Troubleshooting

Compressor does not start.

- No demand for chilling (refrigeration). Wait until the temperature rises whereupon the compressor will start automatically.
- Incorrect set point setting. Check the set point and, if necessary, make a change.
- One of the following digital entries has not been activated:
  - External start permission/Immediate stop
  - External start/Normal stop
- Restarting delay (Unisab).
- Emergency stop activated.

If an alarm caused by a tripped monitor occurs, call in skilled personnel who have access to fault-finding instructions (troubleshooting).

4. Maintenance instructions

4.1 Compressor maintenance and service

Before performing any kind of service on the compressor, it is important to make sure that the motor cannot start up inadvertently. Please read chapter *2. Safety* **before** servicing the compressor in any way. If any local rules exist, these must always be followed.

4.2 Safety measures

Danger!

Risk of injury to personnel and damage to equipment! In addition to the safety precautions in this manual, always read the safety precautions belonging to the equipment before start. Failure to comply with safety precautions may cause injury to personnel or death. Furthermore, equipment may be damaged or destroyed.

Danger!

The following sections present some important safety considerations regarding this type of compressor unit. Before carrying out any maintenance, please study carefully the general safety instructions/regulations that apply to this series of compressor units. Failure to follow these instructions/regulations may cause personal injury or death. Furthermore, equipment may be damaged or destroyed.

4.3 Basis for maintenance

Regular maintenance and inspections carried out by competent service personnel is of utmost importance to ensure smooth and reliable operation.

Benefits of regular maintenance:

- Economical operation
- Prolonged equipment life
- Possibility to schedule stops due to maintenance
- Reduction of non-scheduled repair costs.

Carrying out the prescribed service and maintenance during the warranty period documented by service certificates signed by competent personnel is considered a prerequisite for Johnson Controls Denmark to accept any warranty claim. Generally, we recommend that service and maintenance work is carried out by competent personnel. Furthermore, it is advisable to enter a service contract. The correct number of operating hours between maintenance activities depends on the specific operating conditions.

4.4 Service intervals

Determine the service intervals for a reciprocating compressor as follows:

1. Choose the appropriate diagram depending on compressor and refrigerant type.
2. Read the operating hours/service interval from the curves in the diagram.

Service intervals based on P_E and P_C are shown in Fig. 20, which applies to all refrigerants.

Specific diagrams for R717 and R744 based on T_E and T_C are shown below.

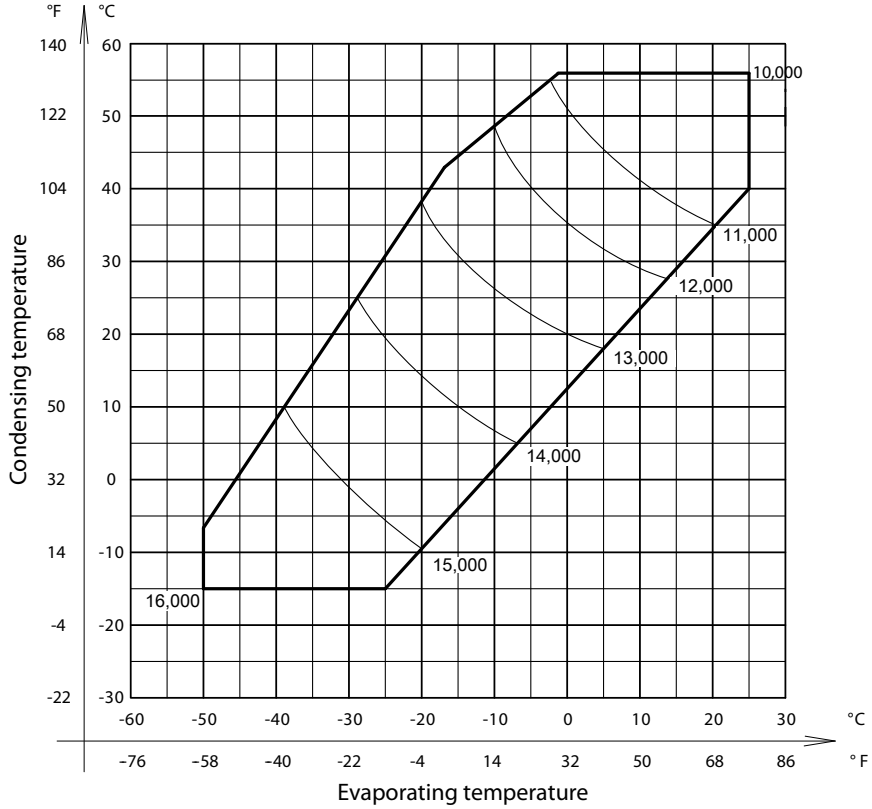
The service intervals should be considered guidelines only as many factors may cause increased wear, for example: operation under non-specified conditions; water, acid or solid particles in the lubricating oil or refrigerant; forced starts and stops; part load; using an unsuitable oil type; and failure to monitor the oil condition.

The service interval diagrams specify the number of maximum operating hours between scheduled maintenance work. The diagrams are based on refrigerant type, standard rpm, operating hours, pressure level and differential pressure over the compressor. Note that they do not take into account unspecified conditions, such as the ones mentioned above.

4.5 Service interval diagrams for SMC-TSMC

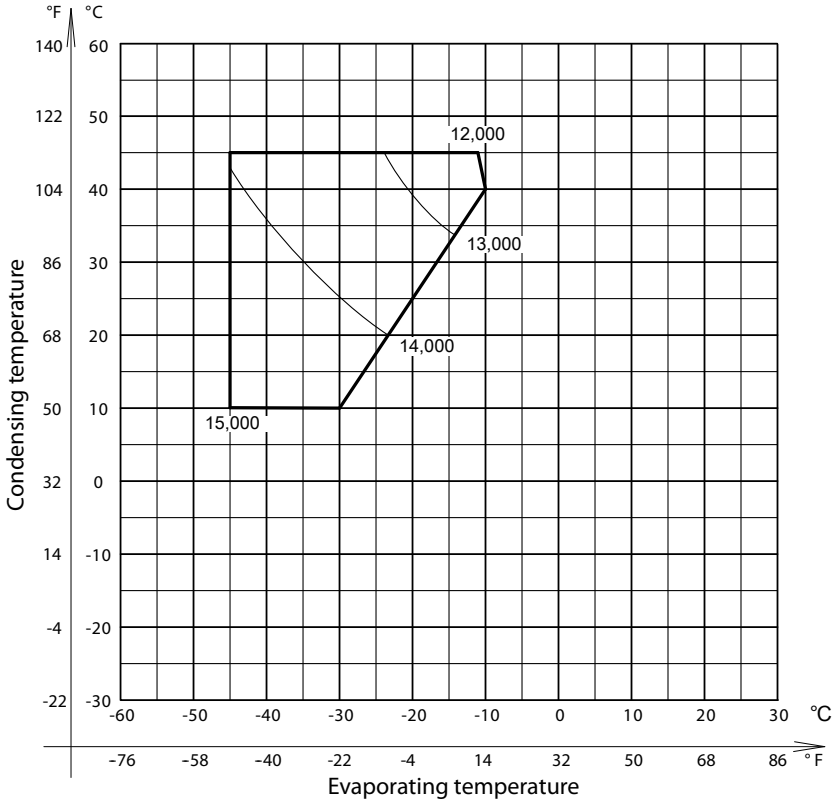
SMC (R717)

E-type: Multiply by 0.75.



TSMC (R717)

E-type: Multiply by 0.75.



Service intervals, pressure

SMC/TSMC/HPC/HPX (all refrigerants)

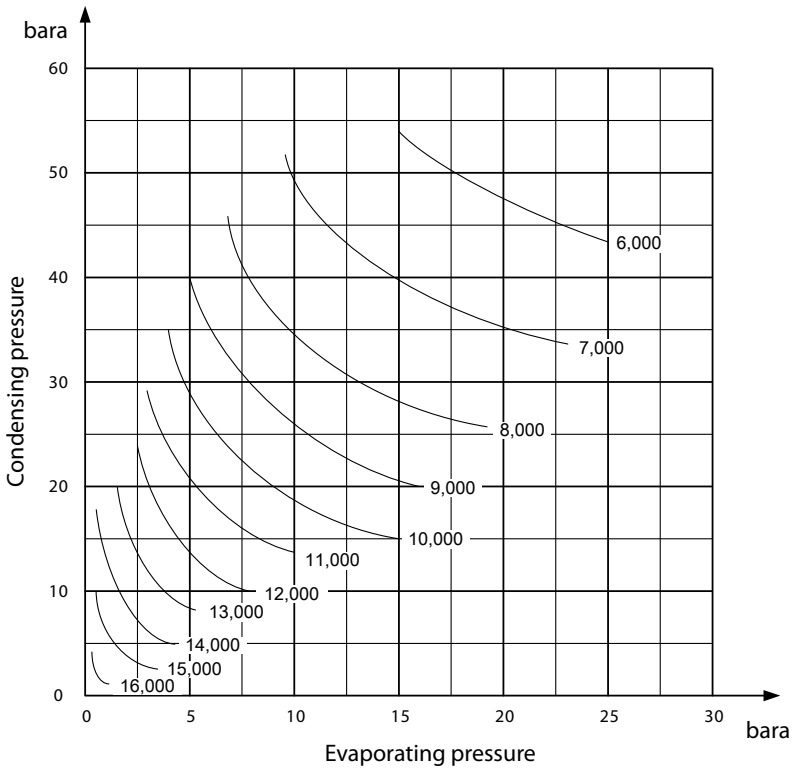


Fig. 20

If the compressor operates at another speed than 1460 rpm, correct the service interval according to Table 9.

Rpm	970	1170	1460	1760
Correction factor	1.5	1.25	1.00	0.83

Table 9

Correction may also be calculated according to this formula:

$$\text{Correction} = \frac{1460}{\text{rpm}}$$

Example

The service interval of a compressor is 10,000 hours according to the diagram.

If the compressor runs at 970 rpm, the service interval will be 1.5 x 10,000 = 15,000 h.

Note: The oil filter should always be replaced when changing oil, or when indicated by the control lamp or Unisab III.

Standard service inspections will be performed in cycles consisting of four preventive maintenance service visits:

1 x service interval: Use service set "A"

2 x service interval: Use service set "A"

3 x service interval: Use service set "A"

4 x service interval: Use service set "C".

The service sets include parts that should always be replaced, regardless of how they appear when the compressor is opened. Repeat the above cycle as long as the compressor is in operation.

After the first 200 hours of operation, use the commissioning set/service set "0" supplied with the compressor.

Inspection of parts

In addition to the planned replacement of parts according to the service sets mentioned above, certain parts must be inspected. Inspections and replacement criteria for inspected parts are specified in the service guide included in the Engineering manual.

4.6 Annual service

If the time interval between two standard service visits exceeds one year, an annual service inspection should be carried out. Please check national rules. The service inspection includes the activities specified in Table 10 and Table 11.

Prescribed service
Change oil filter
Check leak rate of shaft seal
Check oil condition
Clean suction gas filter
Inspect one of the discharge valves and one of the cylinder liners
Check bolt and nut for one connecting rod
Check one of the connecting rod bearing shafts, one of the crankshaft journals and the large end of the connecting rods. If any of these parts are worn, replace the bearings.
Change gaskets for covers that have been opened
Perform functional test of safety devices
Check for correct operation and working order of: - all safety controls - all measuring devices - all alarm systems
Check for leaks in: safety valves, bursting discs and fusible plugs
Perform oil and refrigerant leak test
Adjust refrigerant charge
Check vibration dampers for cracks and adjustment
Check for abnormal noise and vibrations
Check coupling for any signs of cracks and/or other kinds of damage

Table 10: Prescribed service

Recommended service
Take out an oil sample for analysis
Check when the operating personnel were last instructed/trained
Check that the logbook is available and updated
Check that the machine card and piping diagram are available
Check the safety devices on site: switching devices, emergency signals, alarm systems and external pressure relief devices
Check personal protective equipment for emergency use

Table 11: Recommended service

4.7 Regular service schedule - refrigeration plant

As stated in EN 378-4:2016, section 5 and Annex E, refrigeration systems must be maintained and repaired by competent personnel only (see EN 13313).

Safety	Service to be performed	
	at each periodic maintenance and/or repair	minimum annually
Check for correct operation and working order of: - all safety controls - all measuring devices - all alarm systems	**X**	
Check if machine card is available	**X**	
Check if diagram of piping layout is available	**X**	
Check on site: Safety switching devices, emergency signals and alarm systems		**X**
Perform leak test	**X**	
Check and perform leak test of safety valves, bursting discs and fusible plugs		**X**
Perform functional test of safety devices	**X**	
Perform "pressure drop test"		**Re**
Perform refrigerant leak test on all components and systems		**Re**
Check personal protective equipment	**X**	**Re**
Check if the operating personnel are properly instructed and familiar with the contents of the operating manual	**X**	
Function		
Perform evacuation	**X**	
Adjust refrigerant charge	**X**	
Analyse oil		**Re**
Check for corrosion	**X**	**Re**
Check for damaged insulation/vapour barrier	**X**	**Re**
Check composition of secondary cooling medium	**X**	**Re**
Check that the logbook is updated	**X**	

Table 12: Service activities - refrigeration plant

Re = Replace, if necessary
X = Mandatory according to EN 378.

4.8 Regular service schedule - compressor unit

As stated in EN 378-4:2016, section 5 and Annex E, refrigeration systems must be maintained and repaired by competent personnel only (see EN 13313).

Compressor parts		Planned service activities (enter in logbook)			
	Annual service	1 x interval	2 x interval	3 x interval	4 x interval
Internal parts according to the contents of the service sets	**Set 0**	**Set A**	**Set A**	**Set A**	**Set C**
Check the condition of wear parts	Ch/Re	Ch/Re	Ch/Re	Ch/Re	Ch/Re
Built-on/external parts					
Check for leaks in: safety valves, bursting discs and fusible plugs	X	X	X	X	X
Check on site: Safety switching devices, emergency signals and alarm systems	X	X	X	X	X
Perform evacuation	X	X	X	X	X
Adjust refrigerant charge	X	X	X	X	X
Perform "pressure-drop test"	Re	Re	Re	Re	Re
Perform refrigerant leak test on all components and system	X	Re	Re	Re	Re
Analyse oil	Re	Re	Re	Re	Re
Check vibration dampers for cracks and adjustment	Re	Re	Re	Re	Re
Check for abnormal noises and/or vibrations	Re	Re	Re	Re	Re
Check crankcase heating	Re	Re	Re	Re	Re
Check alignment and coupling condition	Re	Re	Re	Re	Re
Check solenoid valves	Re	Re	Re	Re	Re
Check compressor cooling	Re	Re	Re	Re	Re
Check thermopump	Re	Re	Re	Re	Re
Check oil return to compressor	Re	Re	Re	Re	Re
Check that the logbook is updated	X	X	X	X	X
Safety parts - built-on/external					
Perform functional test of safety devices	X	X	X	X	X
Check for correct operation and working order of: - all safety controls - all measuring devices - all alarm systems	X	X	X	X	X
Electric motor					
See manufacturer's instruction manual about lubrication and control	Re	Re	Re	Re	Re
Check for abnormal noise and vibrations	Re	Re	Re	Re	Re

Table 13: Service activities (intervals according to service interval diagrams)

Ch = Change, regardless of appearance
Re = Replace, if necessary
X = Mandatory according to EN 378.

4.9 Visual inspection

Oil pressure

Check that the oil pressure complies with the recommendations in *Table 8: Pressure and temperature settings for compressor type SMC/TSMC*.

Oil level

Check the oil level in the compressor. It is of vital importance for the service life of the compressor that an optimal lubrication is maintained. The oil level must always be visible in the oil level glass. If the oil level is below the lowest part of the oil level glass, oil must be recharged.

Recharging of oil ("topping up") can be carried out during operation, either by means of a hand-operated oil pump or as described in *4.10 Charging the compressor with lubricating oil*. Use recommended oil type only.

Remember to write down drained or recharged amount of oil.

4.10 Charging the compressor with lubricating oil

As all Johnson Controls Denmark reciprocating compressors are supplied with a special oil charging valve on the crankcase, lubricating oil may be charged while the compressor is operating.

For this purpose, use a hand-operated oil pump as mentioned earlier, or follow the procedure below.

See oil charge in Table 14 and oil level in Table 15.

Note: When charging for the first time, use the oil pump. Never start the compressor, if it is not charged with oil.

- Reduce pressure in the crankcase, e.g. by throttling the suction stop valve until the suction pressure gauge shows a pressure slightly below atmospheric.
- Fill the pipe connected to the oil charging valve with lubricating oil, and place the free end of the pipe in a receptacle containing fresh lubricating oil.
- Open the oil charging valve carefully. External air pressure will force oil into the crankcase.
- Avoid air or other impurities being sucked into the compressor.

Note: In order to achieve pressure below atmospheric, it will sometimes be necessary to set the low-pressure cut-out so that the compressor can operate down to this pressure. Remember to reset the pressure cut-out to its normal setting after oil charging. During operation, the compressor can be recharged with oil by means of the hand-operated oil pump.

Note: As halocarbon refrigerants are miscible with lubricating oils, there will always be a good portion of oil blended with the refrigerant in the plant. Therefore, it is often necessary to recharge with lubricating oil after starting up for the first time, and after charging with fresh refrigerant.

Watch the oil level in the compressor closely after start-up.

Compressor		Amount of oil in crankcase	
Type	**Cylinders**	**Litre**	**US gal.**
SMC/HPC/HPX	4	26	6.9
	6	28	7.4
	8	30	7.9
SMC/HPC/HPX	12	47	12.4
	16	50	13.2
TSMC	8	30	7.9
	16	50	13.2

Table 14: Oil charge

Compressor		10 mm difference in oil level corresponds to
Type	**Cylinders**	
SMC/HPC/HPX	4	2 litres of oil [0.5 US gal.]
	6	
	8	
TSMC	8	
SMC/HPC/HPX	12	6 litres of oil [1.6 US gal.]
	16	
TSMC	16	

Table 15: Oil level

4.11 Oil charge

Usually, the compressor is delivered without any oil in the crankcase. As a principal rule, the amount of oil indicated in *Table 14: Oil charge* should be charged to the compressor.

After a few hours of operation, the compressor must be recharged with oil as part of the oil has been absorbed by the refrigerant. This particularly applies to HFC and HCFC refrigerants.

The amount of oil to be recharged depends on the size of the refrigeration plant and the amount of refrigerant. Oil is charged to the middle of the oil level glass, and the amount of oil needed in order to increase the oil level 10 mm is indicated in *Table 15: Oil level.*

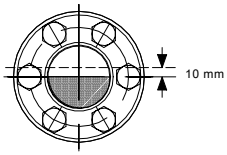


Fig. 21: Oil level glass

4.12 Compressor prelubrication

Warning!

Do not start the compressor without prelubricating bearings and shaft seal.

Before starting up the compressor for the first time after a standstill period of several months, the compressor must be prelubricated. This way the bearings will be lubricated and the oil system filled with oil before the compressor is started. Prelubrication is carried out by connecting an oil pump to the prelubrication branch, which is connected to the pump housing, pos. 4F, on SMC-TSMC-HPC-HPX compressors.

The SABROE hand-operated oil pump, part no. 3141-155, is recommended as prelubrication pump, see Table 16. For prelubrication: use clean fresh refrigeration oil of the same type as the one in the compressor, and pump as follows:

Compressor type	Pump strokes with SABROE hand-operated oil pump	Estimated amount of oil Litres
SMC 104-106-108 TSMC 108 HPC 104-106-108 HPX 704-706-708	approx. 35	3.5
SMC 112-116, TSMC 116 HPC 112-116 HPX 712-716	approx. 45	4.5

Table 16

The heating rod in the crankcase must be switched on for at least 6-8 hours before compressor start-up in order to boil out any refrigerant from the compressor oil. At the same time, the suction stop valve must be open.

Check the oil level in the crankcase. The oil level must always be visible in the oil sight glass.

A hand-operated oil pump connected to the oil charging valve, pos. B, can be used for the first as well as the following oil charges. See *3.9 Valves for operation of compressor.*

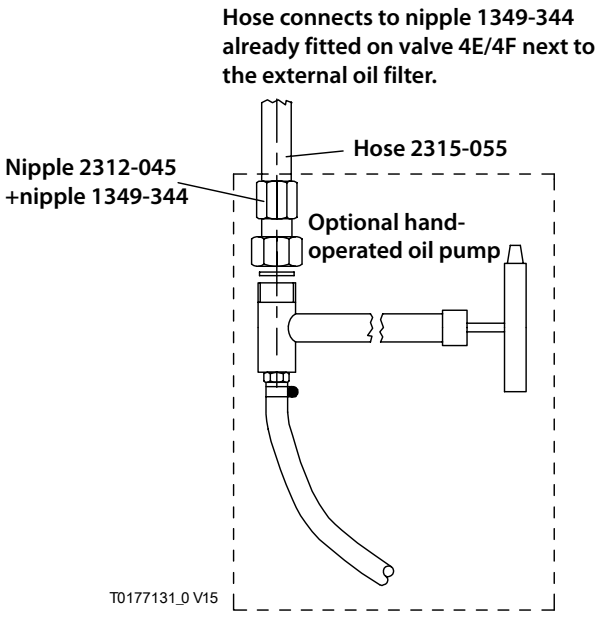


Fig. 22: Hand-operated oil pump

Note: When the evaporating pressure (P_E) is higher than 2 bar, the pressure must be relieved before oil charging. On HPC and HPX compressors, P_E is **always** higher than 2 bar.

4.13 Shaft seal

The rotating sealing surface on the mechanical shaft seal is made of a soft material, which will tend to wear during operation. Therefore, the shaft seal must be checked regularly for tightness and wear in accordance with the service intervals applying to the compressor.

4.14 Motor lubrication

In connection with electric motors, it is absolutely essential to lubricate the bearings correctly and use the appropriate type of grease.

Please refer to the motor manual and/or the motor name plate.

4.15 Major overhaul of the compressor

Contact Johnson Controls Denmark's service organisation.

5. Final disposal

5.1 Safety precautions

Danger!

Before dismantling the plant, read the safety precautions carefully.

Dismantling a refrigeration unit to be scrapped must be carried out safely.

Only competent refrigeration personnel must perform the dismantling as fundamental knowledge of refrigeration systems and the risks involved are required.

Before dismantling the unit, refrigerant and oil must be drained into suitable containers. Disconnect all electrical connections to the unit and remove fuses in the main switchboard.

During the dismantling process, the individual machine parts and components must be sorted to ensure proper disposal. Hazardous waste must be handled at a site complying with the prevailing national rules and regulations.

Danger!

Be very careful when using cutting tools, such as angle grinders or flame cutters, during the dismantling process, as pipes and the like contain oil residue and refrigerant, which may be toxic and/or flammable.

5.2 Waste disposal

Machine parts

When dismantling the plant, it is important to properly sort the parts that should be disposed of. The compressor, frame, containers and so on belonging to the category of iron and metal scrap must be brought to an approved scrap dealer who complies with the prevailing national rules and regulations.

Oil and refrigerant

Oil and refrigerant waste must be disposed of in accordance with the prevailing national rules and regulations. Do not transport oil in open containers in a closed car.

Electric components

Electric and electronic products such as wiring, panels and hardware must be disposed of in accordance with prevailing national rules and regulations.

Batteries

Used batteries, for example from the control system backup, must be disposed of in accordance with prevailing national rules and regulations.

6. Compliance

6.1 Declaration of conformity

Johnson Controls Denmark declares on the signed declaration of conformity that the unit is manufactured and CE-marked in conformity with relevant directives and standards.

The printed version of this operating manual, which is delivered with the unit, contains a translated version of the declaration, however not filled in with the specific data for your unit. The translated version is also included in the operating manual that is available for download with the rest of the order specific documentation.

The original signed declaration of conformity is sent separately in accordance with the 'Guide to application of the Machinery Directive'.

If more than one declaration of conformity is required, all relevant individual declarations will be contained in a dossier in accordance with the EU 'Blue Guide'. Dossiers are uploaded with the other order specific documentation.

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