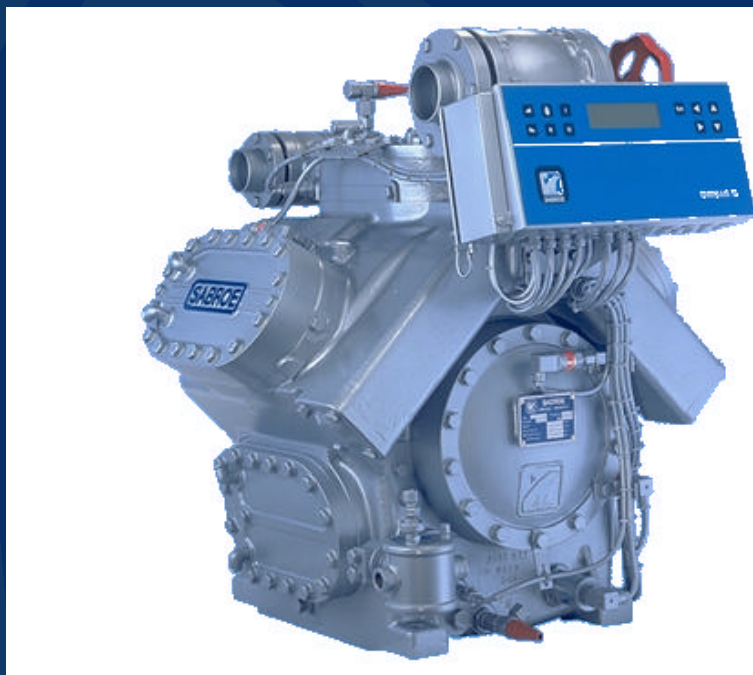


Instruction Manual SMC 104-106-108/TSMC 108 Mk 3

Reciprocating Compressor



Specifications for SMC 104-106-108 Mk3 and TSMC 108 Mk3, S-L-E

The SMC/TSMC-type piston compressor can be fitted with a range of equipment, depending on the function and requirements it is expected to meet.

Some of these variants are discussed in this

instruction manual, even if they are **not** featured on your particular unit.

The variants featured on the unit are marked with an 'x' in the following diagram, with the serial number stated below.

Compressor type		
Designation		
Serial number		
Refrigerant	R717 ☐ R22 ☐ R134a ☐ R404A ☐ R507 ☐ _____ ☐	
Control	UNISAB II Control- and regulating system	
	Analogue Control System	
Compressor cooling	Thermopump	
	Water cooled top and side covers	
	Air cooled top and side covers	
	Oil cooling (water-cooled side covers)	
	Oil cooling OSSI/HE8S	
Drive type	Coupling	
	V-belts	
Explosion-proof electrical design		
Oil pump drive	Pinion drive	
	Chain drive	
Equipment for parallel operation		
SABROE OVUR-type oil separator		

Preface

The aim of this instruction manual is to provide the operators with a thorough knowledge of the compressor and the unit, at the same time providing information about:

- the function and maintenance of the individual components;
- service schedules;
- procedure for dismantling and reassembling of the compressor.

The instruction manual also draws attention to typical sources of errors which may occur during operations. It states their cause and explains what should be done to rectify them.

It is imperative that the operators familiarize themselves thoroughly with the contents of

this instruction manual to ensure reliable and efficient operation of the plant as SABROE is unable to provide a guarantee against damage occurring during the warranty period where this is attributable to incorrect operation.

To prevent accidents during dismantling and assembly of compressors and components, these should only be carried out by authorized personnel.

The contents of this instruction manual must not be copied or passed on to any unauthorized person without Sabroe's permission.

In the space below you can enter the name and address of your local SABROE REPRESENTATIVE :

SABROE REFRIGERATION A/S

P.O. Box 1810, DK-8270 Højbjerg
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First Aid for accidents with Ammonia

(Chemical formula: NH_3 - refrigerant no.: R717)

General

Ammonia is not a cumulative poison. It has a distinctive, pungent odour that even at very low, harmless concentrations is detectable by most persons. Since ammonia is self-alarming, it serves at its own warning agent, so that no person will voluntarily remain in concentrations which are hazardous. Since ammonia is lighter than air, adequate ventilation is the best means of preventing an accumulation.

Experience has shown that ammonia is extremely hard to ignite and under normal conditions is a very stable compound. Under extremely high, though limited concentrations, ammonia can form ignitable mixtures with air and oxygen, and should be treated with respect.

Basic rules for first aid

1. **Call a doctor immediately.**
2. **Be prepared:** Keep an irrigation bottle available, containing a sterile isotonic (0.9%) NaCl-solution (salt water).
3. A shower bath or water tank should be available near all bulk installations with ammonia.
4. When applying first aid, the persons assisting should be duly protected to avoid further injury.

Inhalation

1. Move affected personnel into fresh air immediately, and loosen clothing restricting breathing.
2. **Call a doctor/ambulance with oxygen equipment immediately**
3. Keep the patient still and warmly wrapped in blankets.
4. If mouth and throat are burnt (freeze or acid burn), let the conscious patient drink water, taking small mouthfuls.
5. If conscious and the mouth is not burnt, give hot, sweet tea or coffee (never feed an unconscious person).
6. Oxygen may be administered, but **only** when authorized by a doctor.
7. If breathing fails, apply artificial respiration.

Eye injuries from liquid splashes or concentrated vapour

1. Force the eyelids open and rinse eyes immediately for at least 30 minutes with the salt water solution just mentioned
2. **Call a doctor immediately.**

Skin burns from liquid splashes or concentrated vapour

1. Wash immediately with large quantities of water and continue for at least 15 minutes, removing contaminated clothing carefully while washing.
2. Call a doctor immediately.
3. After washing, apply wet compresses (wetted with a sterile isotonic (0.9%) NaCl-solution (salt water)) to affected areas until medical advice is available.

**No plant can ever be said to be too safe.
Safety is a way of life.**

First aid for accidents with HFC/HCFC

Refrigerant no.: R134a – R404A - R410A - R505A - R507 - R22, etc

General

HFC/HCFC form colourless and invisible gasses which are heavier than air and smell faintly of chloroform at high concentrations only. They are non-toxic, non-inflammable, non-explosive and non-corrosive under normal operating conditions. When heated to above approx. 300°C they break down into toxic, acid gas components, which are strongly irritating and aggressive to nose, eyes and skin and generally corrosive. Besides the obvious risk of unnoticeable, heavy gases displacing the atmospheric oxygen, inhalation of larger concentrations may have an accumulating, anaesthetic effect which may not be immediately apparent. 24 hours medical observation is, therefore, recommended.

Basic rules for first aid

1. When moving affected persons from low-lying or poorly ventilated rooms where high gas concentrations are suspected, the rescuer must be wearing a lifeline, and be under continuous observation from an assistant outside the room.
2. Adrenalin or similar heart stimuli must not be used.

Inhalation

1. Move affected person into fresh air immediately. Keep the patient still and warm and loosen clothing restricting breathing.
2. If unconscious, call a doctor/ambulance with oxygen equipment immediately.
3. Give artificial respiration until a doctor authorizes other treatment.

Eye injuries

1. Force eyelids open and rinse with a sterile isotonic (0.9%) NaCl-solution (salt water) or pure running water continuously for 30 minutes.
2. Contact a doctor, or get the patient to a hospital immediately for medical advice.

Skin injuries – Freeze burns

1. Wash immediately with large quantities of luke warm water to reheat the skin. Continue for at least 15 minutes, removing contaminated clothing carefully while washing.
2. Treat exactly like heat burns and seek medical advice.
3. Avoid direct contact with contaminated oil/refrigerant mixtures from electrically burnt-out hermetic compressors.

**No plant can ever be said to be too safe.
Safety is a way of life.**

Protecting the environment

Increasing industrialisation threatens our environment. It is therefore absolutely imperative that we protect nature against pollution.

To this end, many countries have passed legislation in an effort to reduce pollution and preserve the environment. These laws apply to all fields of industry, including refrigeration, and must be complied with.

Be especially careful with the following substances:

- refrigerants
- cooling media (brines etc)
- lubricating oils.

Refrigerants usually have a natural boiling point which lies a good deal below 0°C. This means that liquid refrigerants can be extremely harmful if they come into contact with skin or eyes.

High concentrations of refrigerant vapours are suffocating when they displace air; if high

concentrations of refrigerant vapours are inhaled they attack the human nerve system.

When halogenated gasses come into contact with open flame or hot surfaces (over approx. 300°C) they decompose to produce poisonous chemicals, which have a very pungent odour, warning you of their presence.

In high concentrations, R717 causes respiratory problems, and when ammonia vapour and air mix 15 to 28 vol. %, the combination is explosive and can be ignited by an electric spark or open flame.

Oil vapour in the ammonia vapour increases this risk significantly as the point of ignition falls below that of the mixture ratio stated.

Usually the strong smell of ammonia will give ample warning of its presence before concentrations become dangerous.

The following table shows the values for refrigerant content in air, measured in volume %. Certain countries may, however, have an official limit which differs from those stated.

		Halogenated refrigerants						Ammonia
		HFC					HCFC	
		R134a	R404A	R407C	R410A	R507	R22	R717
TWA Time weighted average during a week	Unit							
	vol. %	0,1	0,1	0,1	0,1	0,1	0,1	0,005
Warning smell	vol. %		0,2					0,002

Further comments on refrigerants:

- If released to the atmosphere, halogenated refrigerants of the type HCFC (e.g. R22) may cause a depletion of the ozone layer in the stratosphere. The ozone layer protects the earth from the ultraviolet rays of the sun. Refrigerants of the types HFC and HCFC are greenhouse gases with contribute to an intensification of the greenhouse effect. They must, therefore, **never** be released to the atmosphere. Use a separate compressor to draw the refrigerant into the plant condenser/receiver or into separate refrigerant cylinders.
- Most halogenated refrigerants are miscible with oil. Oil drained from a refrigeration plant will often contain significant amounts of refrigerant. Therefore, reduce the pressure in the vessel or compressor as much as possible before draining the oil.
- Ammonia is easily absorbed by water:
At 15°C, 1 litre of water can absorb approx. 0,5 kg liquid ammonia (or approx. 700 litres ammonia vapour).
- Even small amounts of ammonia in water (2-5 mg per litre) are enough to wreak havoc with marine life if allowed to pollute waterways and lakes.
- As ammonia is alkaline it will damage plant life if released to the atmosphere in large quantities.

Refrigerant evacuated from a refrigerant plant shall be charged into refrigerant cylinders intended for this specific refrigerant.

If the refrigerant is not to be reused, **return** it to the supplier or to an authorized incinerating plant.

Halogenated refrigerants must never be mixed. Nor must R717 ever be mixed with halogenated refrigerants.

Purging a refrigeration plant

If it is necessary to **purge** air from a refrigeration plant, make sure you observe the following:

- Refrigerants must not be released to the atmosphere.
- When purging an R717 plant, use an approved air purger. The purged air must pass through an open container of water so that any R717 refrigerant remaining can be absorbed. The water mixture must be sent to an authorized incinerating plant.
- Halogenated refrigerants can **not** be absorbed by water. An approved air purger must be fitted to the plant. This must be checked regularly using a leak detector.

Cooling media

Salt solutions (brines) of calcium chloride (CaCl_2) or sodium chloride (NaCl) are often used.

In recent years alcohol, glycol and halogenated compounds have been used in the brine production.

In general, all brines must be considered as harmful to nature and must be used with caution. Be very careful when charging or purging a refrigeration plant.

Never empty brines down a sewer or into the environment.

The brine must be collected in suitable containers, clearly marked with the contents, and sent to an approved incinerating plant.

Lubricating oils

Refrigeration compressors are lubricated by one of the following oil types, depending on the refrigerant, plant type and operating conditions.

- mineral oil
- semi-synthetic oil

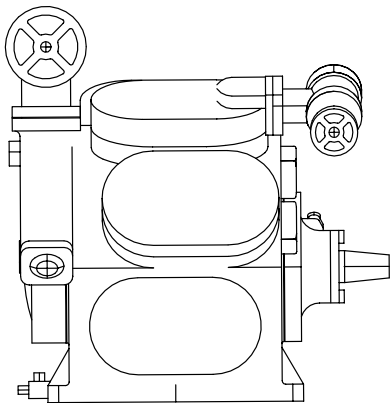
- alkyl benzene-based synthetic oil
- polyalphaolefine-based synthetic oil
- glycol-based synthetic oil.

When you change the oil in the compressor or drain oil from the refrigeration plant's vessels, always collect the used oil in containers marked "waste oil" and send them to an approved incinerating plant.

Note

This instruction provides only general information. The owner of the refrigeration plant is responsible for ensuring that all by-laws are complied with.

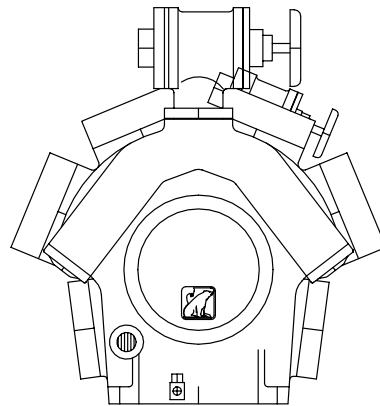
Description of compressor SMC 104-106-108 Mk & TSMC 108 Mk 3, S-L-E



The SMC 100 and TSMC 100 compressors have 100 mm diameter pistons, as indicated by the first digit in the type designation. The number of cylinders in the compressor block is indicated by the following two digits, where, for example, SMC 108 is an 8-cylinder compressor. SMC 100 is a one-stage compressor which compresses the gas in a single stage.

In the TSMC 100 two-stage compressors, the gas is compressed in two stages at a ratio of 1:3 between the number of high- and low-pressure cylinders. Thus, a TSMC 108 has 2 high-pressure cylinders and 6 low-pressure cylinders. The SMC 100 and TSMC 100 are available in three versions: an S-type with 80 mm stroke, an L-type with 100 mm stroke, and an E-type with 120 mm stroke. The compressor works on the refrigerants mentioned in the following chapter.

The type can be determined by the nameplate, located on the end face of the compressor, facing away from the coupling/belt drive. The following illustration shows a SABROE nameplate.



 SABROE AARHUS DENMARK		Type		Refrigerant	
		Shop no		Year	
		Max. speed		r.p.m.	
		Swept volume		m ³ /h	
		Working pressure		bar	
		Test pressure		bar	

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Similarly, the name-plate indicates the compressor's serial number, which is also stamped into the compressor housing near the suction chambers.

Whenever contacting SABROE about the compressor, its serial number should be stated.

In the compressors the pistons operate in cylinder linings, inserted in the compressor block with two cylinders under each top cover. The suction valves, of the ring-plate type, are mounted at the top of the cylinder linings. The pressure valves form the top of the cylin-

der linings and are kept in position by a powerful safety spring. The safety spring allows the discharge valve unit to rise, providing a greater throughflow aperture in the event of liquid strokes in the cylinder. This prevents any overloading of the connecting rod bearings.

The crankshaft is supported in slide bearings able to assimilate both radial and axial forces. The oil pressure for the bearings and the capacity regulating system is supplied from the gearwheel oil pump incorporated in the compressor.

At the axle end, the crankshaft is fitted with a balanced slide-ringtype seal consisting of a cast iron ring with an O-ring which rotates with the crankshaft, and a stationary spring-loaded carbon ring.

All compressors can be capacity-regulated by connecting or disconnecting the cylinders in pairs. The following diagram shows the capacity stages at which the compressors can operate.

Capacity regulation is controlled by means of solenoid valves mounted on the compressor.

	25%	33%	50%	67%	75%	100%
SMC 104			x			x
SMC 106		x		x		x
SMC 108	x		x		x	x
TSMC 108		x		x		x

Handling of the compressor, areas of application, safety equipment etc.

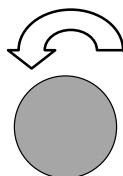
Direction of rotation

In order to reduce the noise level from the electric motors these are often executed with specially shaped fan wings, thus determining a particular direction of rotation.

In case you yourself order a motor you should take into consideration whether the motor is intended for **direct coupling** or for **belt drive** of the compressor.

The direction of rotation of the compressor for compressors CMO-TCMO and SMC-TSMC is indicated by an arrow cast into the compressor cover, near the shaft seal.

On the BFO compressors the direction of rotation is not indicated by an arrow but is standard as illustrated by the following sketch:



Seen towards shaft end

Handling of compressor and unit

For lifting of the compressor the large models are equipped with a threaded hole for mounting of the lifting eye. As to the weight of the compressor, see table on **compressor data**.

Note:

The compressor block alone may be lifted in the lifting eye. The same applies to the motor.

The **unit** is lifted by catching the lifting eyes welded onto the unit frame. These have been

clearly marked with red paint. The **weight** of the unit is stated on the package as well as in the shipping documents.

During transportation and handling care should be taken not to damage any of the components, pipe or wiring connections.

Areas of application of the reciprocating compressors

Compressor types:

BFO 3-4-5

CMO-TCMO,

SMC 100-TSMC 100 Mk3, S, L, E

SMC 180-TSMC 180,

HPO-HPC

In view of preventing an unintended application of the compressor, which could cause injuries to the operating staff or lead to technical damage, the compressors may only be applied for the following purposes:

The compressor may **ONLY** be used:

- As a refrigeration compressor with a number of revolutions and with operating limits as indicated in this manual or according to a written agreement with SABROE.
- With the following refrigerants:
R717 – R22¹ – R134a¹ – R404A¹ –
R410A¹ – R507¹ – R600¹ – R600A¹ –
R290¹ – LPG¹

¹) Exempted are the following compressors:

SMC-TSMC 100 E (only R717)

HPO and HPC (only R717 and R410A))

All other types of gas may only be used following a written approval from SABROE.

- As a heat pump:

- BFO 3-4-5

CMO - TCMO and SMC - TSMC may be used with a max. discharge pressure of 25 bar.

- HPO – HPC may be used with a max. discharge pressure of 40 bar.

- In an explosion-prone environment, provided the compressor is fitted with approved explosion-proof equipment.

The compressor must NOT be used:

- For evacuating the refrigeration plant of air and moisture,
- For putting the refrigeration plant under air pressure in view of a pressure testing,
- As an air compressor.

Emergency device

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

In case the compressor is delivered with a SABROE-control system this emergency device is found as an integrated part of the control.

The emergency device must be executed in a way to make it stay in its stopped position, following a stop instruction, until it is deliberately set back again. It must not be possible to block the emergency stop without a stop instruction being released.

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

Other demands to the emergency device:

- It must be possible to operate it by means of an easily recognizable and visible

manual handle, to which there is free access.

- It must be able to stop any dangerous situation, which may occur, as quickly as possible without this leading to any further danger.

Combustion motors

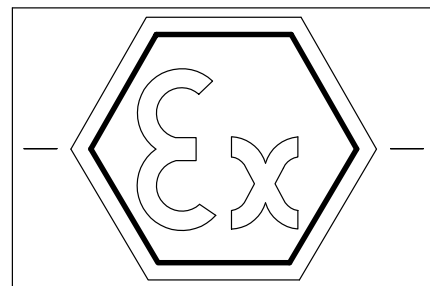
If combustion motors are installed in rooms containing refrigeration machinery or rooms where there are pipes and components containing refrigerant, you must make sure that the combustion air for the motor is derived from an area in which there is no refrigerant gas, in case of leakage.

Failure to do so will involve a risk of the lubricating oil from the combustion motor mixing with the refrigerant; at worst, this may give rise to corrosion and damage the motor.

Explosion-proof electrical execution

If the compressor is delivered in an explosion-proof electrical execution, this is stated in the table on page 1 of this instruction manual.

Likewise, the compressor will, besides the SABROE name plate, be equipped with an Ex-name plate like the one illustrated below.



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The temperature of tangible surfaces

When a compressor is working, the surfaces that are in contact with the warm discharge gas also get warm. However, the temperature depends on which refrigerants and under which operating conditions the compressor is working. Often, it exceeds 70°C which for metal surfaces may cause your skin to be burnt even at a light touch.

Consequently, the compressors will be equipped with **yellow warning signs** informing you that pipes, vessels and machine parts

close to the warning signs during operation are so hot that your skin may be burnt from 1 second's touch or longer.



Sound data for reciprocating and screw compressor units - all types of compressors

In the following tables the noise data of the compressors is stated in:

- A-weighted sound power level **LW**
(Sound Power Level)
- A-weighted sound pressure level **LP**
(Sound Pressure level)

The values for LW constitute an average of a large number of measurements on various units. The measurements have been carried out in accordance with ISO 9614-2.

The values are further stated as **average sound pressure in a free field above a reflecting plane** at a distance of **1 meter** from a fictional frame around the unit. See fig. 1.

Normally, the **immediate sound pressure** lies between the LW and LP values and can be calculated provided that the acoustic data of the **machine room** is known.

For **screw compressors** the average values are indicated in the tables for the following components.

- **SAB 81-83-85-87-89, SAB 128, Mk3, SAB 163 Mk3, SAB 202, SAB 330, SV and FV:**
Compressor block + IP23 special motor + oil separator.
- **SAB 128 HR and SAB 163 HR:**
Compressor block at max. number of revolutions + IP23 special motor + oil separator
- **SAB 110:**
Compressor block + IP23 standard motor + oil separator

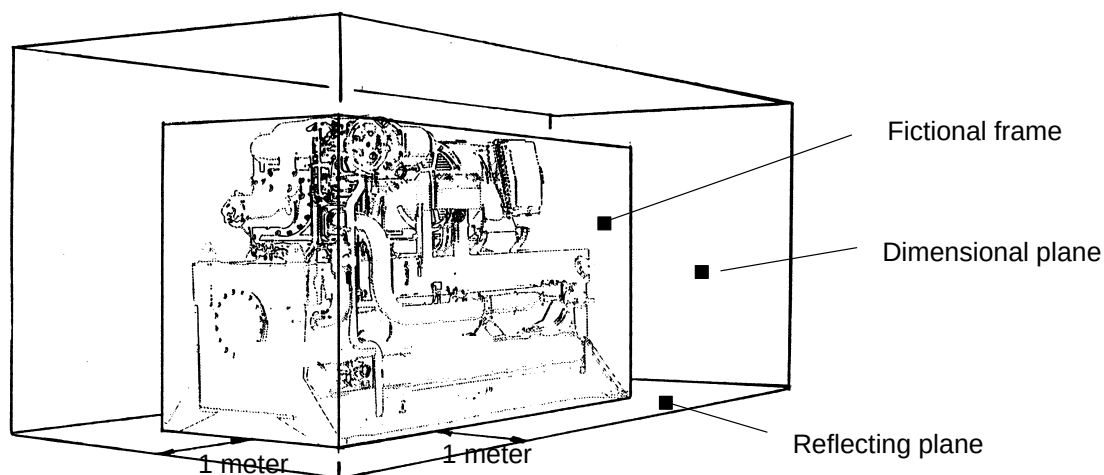
Dimensional tolerances are:

- ±3 dB for SAB, SV and FV screw compressors
- ±5 dB for VMY screw compressors

As to the **reciprocating compressors** the values are stated for the compressor block only.

The dimensional values are stated for 100% capacity.

Fig. 1



Note the following, however:

- at part load or if the compressor works with a wrongly set V_i the sound level can sometimes be a little higher than the one indicated in the tables.
- additional equipment such as heat exchangers, pipes, valves etc. as well as the choice of a different motor type can increase the noise level in the machine room.
- as already mentioned, the stated sound pressures are only average values above a fictional frame around the noise source. Thus, it is sometimes possible to measure higher values in local areas than the ones stated – for inst. near the compressor and motor.
- the acoustics is another factor that can change the sound level in a room. Please note that the sound conditions of the site have not been included in the stated dimensional values.
- by contacting SABROE you can have sound data calculated for other operating conditions.

The tables have been divided into reciprocating and screw compressors, respectively. The reciprocating compressors are further divided into one- and two-stage compressors as well as in a heat pump. In each table the operating conditions of the compressor during noise measuring have been stated, just as the refrigerant used has been mentioned.

RECIPROCATING COMPRESSORS

One-stage

Evaporating temperature = -15°C
 Condensing temperature = $+35^{\circ}\text{C}$
 Refrigerant = R22/R717
 Number of revolutions = **1450 rpm.**

Compressor block	LW	LP
CMO 24	84	69
CMO 26	86	71
CMO 28	87	72
SMC 104 S	95	79
SMC 106 S	96	80
SMC 108 S	97	81
SMC 112 S	99	82
SMC 116 S	100	83
SMC 104 L	96	80
SMC 106 L	97	81
SMC 108 L	98	82
SMC 112 L	100	83
SMC 116 L	101	84
SMC 104 E	96	80
SMC 106 E	97	81
SMC 108 E	98	82
SMC 112 E	100	83
SMC 116 E	101	84

Evaporating temperature = -15°C
 Condensing temperature = $+35^{\circ}\text{C}$
 Refrigerant = R22/R717
 Number of revolutions = **900 rpm.**

Compressor block	LW	LP
SMC 186	101	83
SMC 188	102	84

Two-stage

Evaporating temperature = -35°C
 Condensing temperature = $+35^{\circ}\text{C}$
 Refrigerant = R22/R717
 Number of revolutions = **1450 rpm.**

Compressor block	LW	LP
TCMO 28	81	66
TSMC 108 S	95	79
TSMC 116 S	97	81
TSMC 108 L	96	80
TSMC 116 L	98	82
TSMC 108 E	96	80
TSMC 116 E	98	82

Evaporating temperature = -35°C
 Condensing temperature = $+35^{\circ}\text{C}$
 Refrigerant = R22/R717
 Number of revolutions = **900 rpm.**

Compressor block	LW	LP
TSMC 188	100	82

Heat pump

Evaporating temperature = $+20^{\circ}\text{C}$
 Condensing temperature = $+70^{\circ}\text{C}$
 Refrigerant = R22/R717
 Number of revolutions = **1450 rpm.**

Compressor block	LW	LP
HPO 24	91	76
HPO 26	93	78
HPO 28	94	79
HPC 104	97	81
HPC 106	98	82
HPC 108	99	84

SCREW COMPRESSORS

Evaporating temperature = -15°C
 Condensing temperature = $+35^{\circ}\text{C}$
 Refrigerant = R22/R717
 Number of revolutions = **2950 rpm.**
 *Number of revolutions = **6000 rpm.**

Compressor block	LW	LP
SAB 110 SM	98	81
SAB 110 SF	98	81
SAB 110 LM	98	81
SAB 110 LF	98	81
SAB 128 HM Mk2	102	84
SAB 128 HF Mk2	106	88
SAB 128 HM Mk3	101	84
SAB 128 HF Mk3	104	86
SAB 128 HR*	102	84
SAB 163 HM Mk2	105	86
SAB 163 HF Mk2	109	90
SAB 163 HM Mk3	103	86
SAB 163 HF Mk3	106	87
SAB 163 HR*	103	85
SAB 202 SM	104	85
SAB 202 SF	105	86
SAB 202 LM	104	85
SAB 202 LF	105	86
SAB 330 S	106	87
SAB 330 L	106	87
SAB 330 E	106	87
SV 17	100	83
SV 19	101	84
FV 19*	101	86
SV 24	103	85
FV 24*	104	86
SV 26	103	85
FV 26*	107	85
SAB 81	101	86
SAB 83	102	85
SAB 85	103	86
SAB 87	105	86
SAB 89	108	85

Min liquid pressure for liquid injection, suction pressure bar (a) x 2+2 bar

Evaporating temperature = -35°C
 Condensing temperature = -5°C
 Refrigerant = R22/R717
 Number of revolutions = **2950 rpm.**

Compressor unit	LW	LP
SAB 163 BM	106	88
SAB 163 BF	110	92

Evaporating temperature = -15°C
 Condensing temperature = $+35^{\circ}\text{C}$
 Refrigerant = R22/R717
 Number of revolutions = **2950 rpm.**

Compressor block	LW	LP
VMY 347 H	97	82
VMY 447 H	100	85
VMY 536 H	104	88

Evaporating temperature = 0°C
 Condensing temperature = $+35^{\circ}\text{C}$
 Refrigerant = R22/R717
 Number of revolutions = **2950 rpm.**

Compressor block	LW	LP
VMY 347 M	99	84
VMY 447 M	101	86
VMY 536 M	105	89

Vibration data for compressors - all types

Vibration data for SABROE screw compressors comply with the following norm:

ISO 2372 group C

Depending on the laying of the foundation and the size of the motor a screw compressor unit can - under normal circumstances -

be classified in Class III or IV according to the following table from ISO 2372. Recip. compressor units can be classified in class IV, likewise under normal conditions.

Vibration severity ranges and examples of their application to small machines (Class I) medium size machines (Class II), large machines (Class III) and turbo machines (Class IV)

Ranges of vibration severity		Examples of quality judgement for separate classes of machines			
Range	ms-velocity V (in mm/s) at the range limits	Class I	Class II	Class III	Class IV
0.28	0.28	A	A	A	A
0.45	0.45				
0.71	0.71				
1.12	1.12	B	B	B	B
1.8	1.8				
2.8	2.8	C	C	C	C
4.5	4.5				
7.1	7.1	D	D	D	D
11.2	11.2				
18	18				
28	28				
45	45				
71	71				

SABROE screw compressor unit:

Group C, class III or IV

SABROE recip. compressor unit:

Group C, class IV.

Pay attention to the following, however:

- On placing the unit on the vibration dampers delivered by SABROE (additional) the vibrations against the foundation are reduced by:
 - 85-95% for screw compressor units
 - 80 % for recip. compressor units
- However, a higher vibration level may occur if:

- Motor and compressor have not been aligned as described in the Instruction Manual.
- For screw compressors, if the compressor runs at a wrong V_i ratio.
- The pipe connections have been executed in a way that makes them force pull or push powers on the compressor unit or they may transfer vibrations to the unit, caused by natural vibrations or connected machinery.
- The vibrations dampers have not been fitted or loaded correctly as indicated on the foundation drawing delivered together with the order.

Compressor data for reciprocating compressor

CMO 4, CMO 24-28, TCMO 28, SMC 104-116,

TSMC 108-116, SMC 186-188, TSMC 188

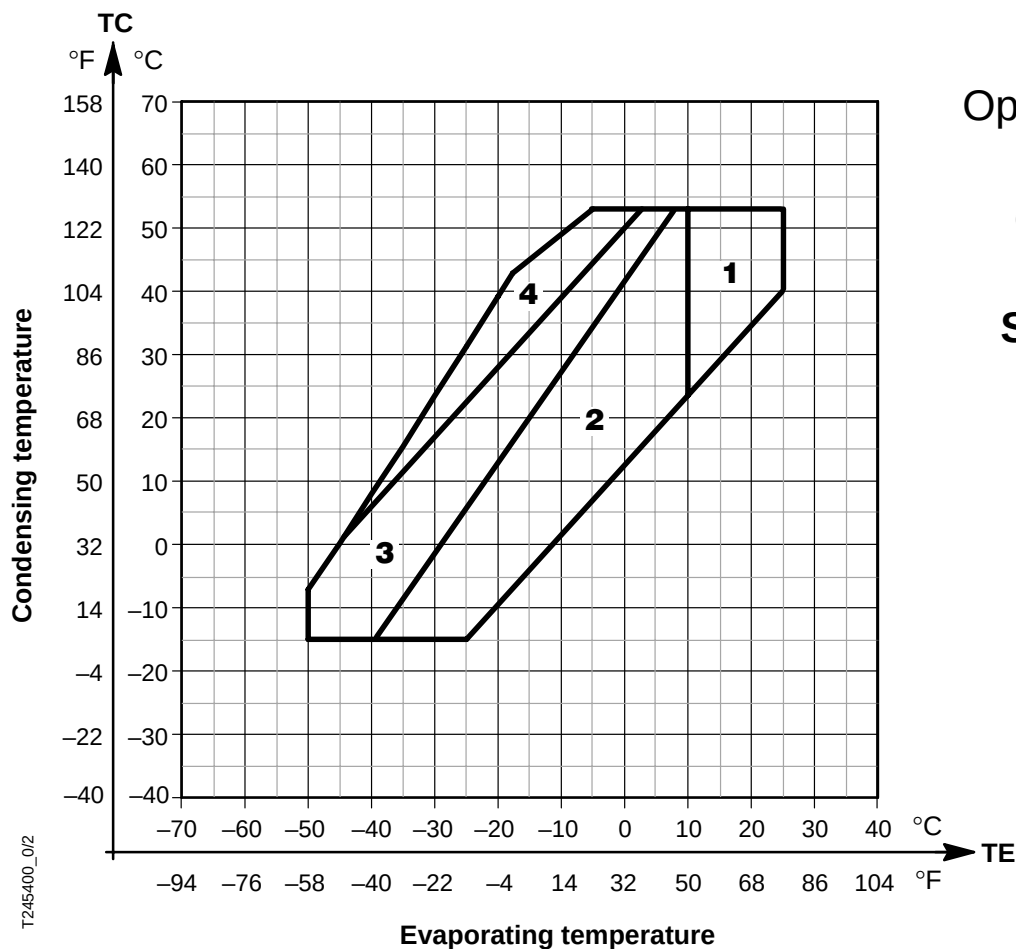
Operating limits

SABROE prescribes operating limits within which the compressor and any additional equipment must operate. These limits for R717, R22, R134a, R404A, R507 and R407C are shown in the following tables, together with the main data for the compressor.

Compressor type	Number of cylinders	Bore mm	Stroke mm	Max/min Speed RPM	Swept volume max RPM* m ³ /h	Weight (max.) compr. block kg
CMO 4	4	65	65	1800/900	93,2	200
CMO 24	4	70	70	1800/900	116	340
CMO 26	6	70	70	1800/900	175	380
CMO 28	8	70	70	1800/900	233	410
TCMO 28	2+6	70	70	1800/900	175	410
SMC 104S	4	100	80	1500/700	226	580
SMC 106S	6	100	80	1500/700	339	675
SMC 108S	8	100	80	1500/700	452	740
SMC 112S	12	100	80	1500/700	679	1250
SMC 116S	16	100	80	1500/700	905	1350
TSMC 108S	2+6 ♦	100	80	1500/700	339	775
TSMC 116S	4+12 ♦	100	80	1500/700	679	1400
SMC 104L	4	100	100	1500/700	283	580
SMC 106L	6	100	100	1500/700	424	675
SMC 108L	8	100	100	1500/700	565	740
SMC 112L	12	100	100	1500/700	848	1250
SMC 116L	16	100	100	1500/700	1131	1350
TSMC 108L	2+6 ♦	100	100	1500/700	424	775
TSMC 116L	4+12 ♦	100	100	1500/700	757	1400
SMC 104E	4	100	120	1500/700	339	600
SMC 106E	6	100	120	1500/700	509	700
SMC 108E	8	100	120	1500/700	679	770
SMC 112E	12	100	120	1500/700	1018	1300
SMC 116E	16	100	120	1500/700	1357	1400
TSMC 108E	2+6 ♦	100	120	1500/700	509	800
TSMC 116E	4+12 ♦	100	120	1500/700	1018	1450
SMC 186	6	180	140	1000/450	1283	2560
SMC 188	8	180	140	1000/450	1710	2840
TSMC 188	2+6 ♦	180	140	1000/450	1283	2900

* The maximum speed permitted can be lower than stated here depending on operating conditions and refrigerant; please see the following diagrams.

♦ Two - stage compressors (High Stage cylinders and Low Stage cylinders)



R717
Operating limits
single stage
compressors
CMO
SMC 100 S-L
SMC 180

Type	Area	rpm		Cooling	
		max	min	Booster	Single and HP-stage compr.
CMO 20	1–2	1800	900	Air-cooled top- and side covers # - or water-cooled	
	3-4			Water-cooled	Thermopump or water-cooled
SMC 100 S-L	1-2	1500	700	Air-cooled top- and side covers # - or water-cooled	
	3			Water-cooled	Thermopump or water-cooled
	4	1200			
SMC 180	1	750	450	Water-cooled	
	2-3	1000			
	4	900			

Including refrigerant-cooled oil cooler

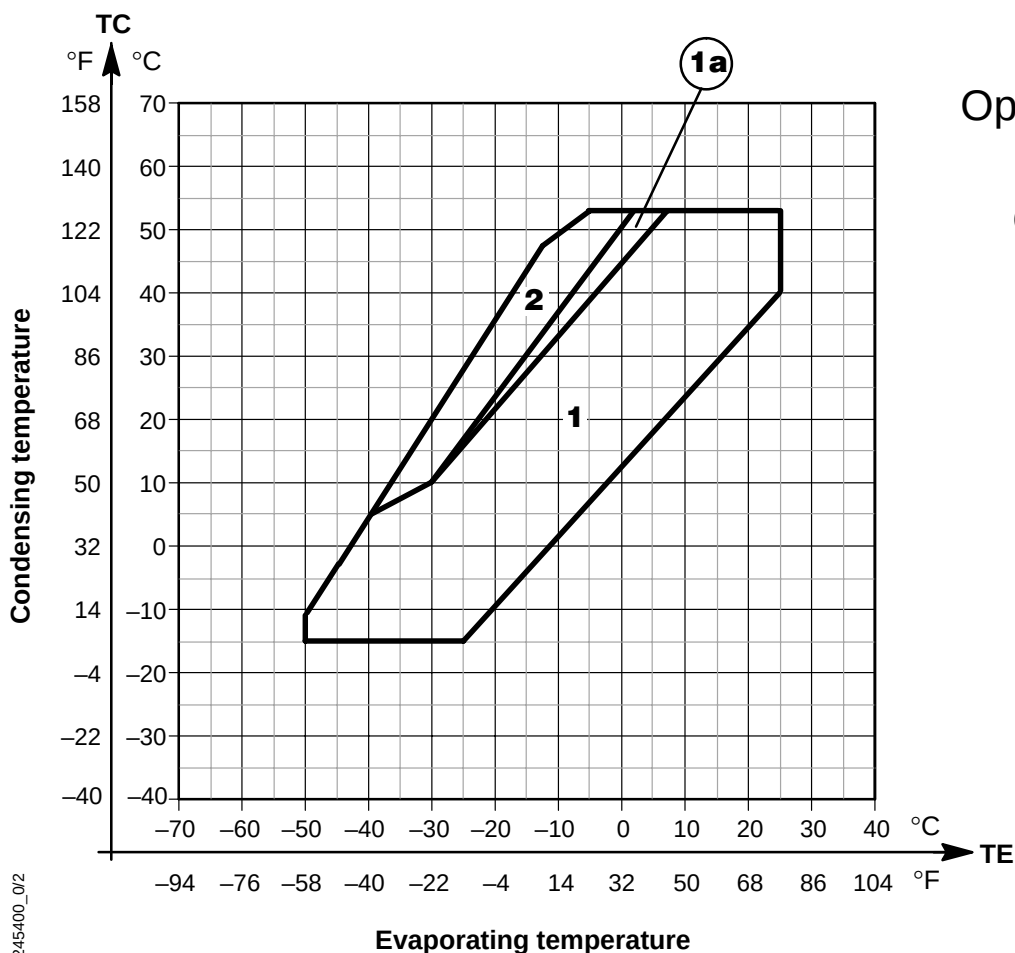
Thermopump:

Top- and side covers are cooled
by refrigerant injection.
Oil cooling included in the system

Water-cooled:

Top- and side covers.
Oil cooling included in the system.

NB: At part load the discharge gas temp. must not exceed 150°C/302°F



R717

Operating limits
single stage
compressors
SMC 100 E

Type	Area	rpm		Booster	Cooling
		max	min		Single and HP-stage compr.
SMC 100E	1-(1a)	1500	700	Water-cooled	Thermopump or water
	2	1200			

Thermopump:

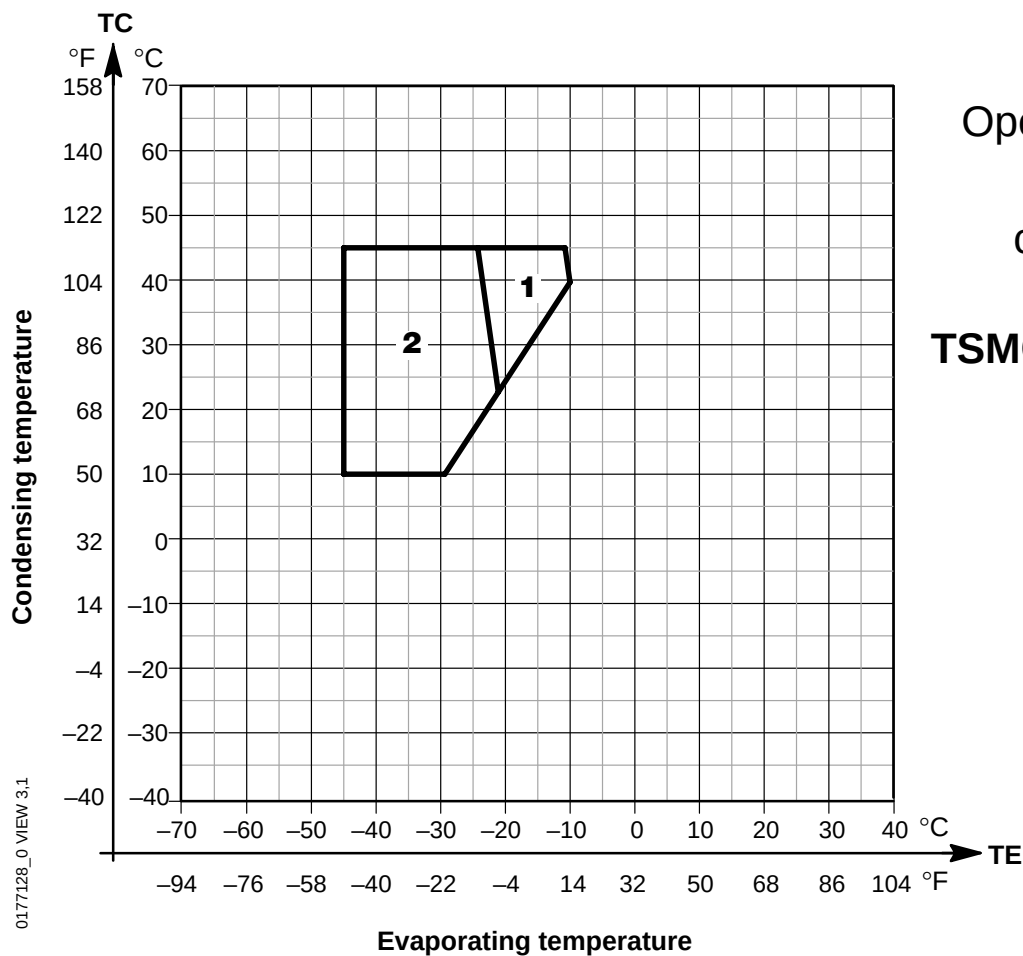
Top- and side covers are cooled
by refrigerant injection.
Oil cooling included in the system

Water-cooled:

Top- and side covers.
Oil cooling included in the system.

NB: At part load the discharge gas temp. must not exceed 150°C/302°F

1a: In this area the compressor is not allowed to run at a capacity below 50%.



R717

Operating limits
two-stage
compressors
TCMO
TSMC 100 S-L-E
TSMC 180

Type	Area	rpm		Cooling top and side	Note
		max	min		
TCMO	1-2	1800	900	Thermopump or water-cooled	
TSMC 100 S-L-E	1-2	1500	700	Thermopump or water-cooled	1)
TSMC 180	1	750	450	Water-cooled	1)
	2	1000			

Oil cooling is always necessary.

Thermopump:

Only the HP Stage top covers are cooled
by a thermo pump
Oil cooling included in the system

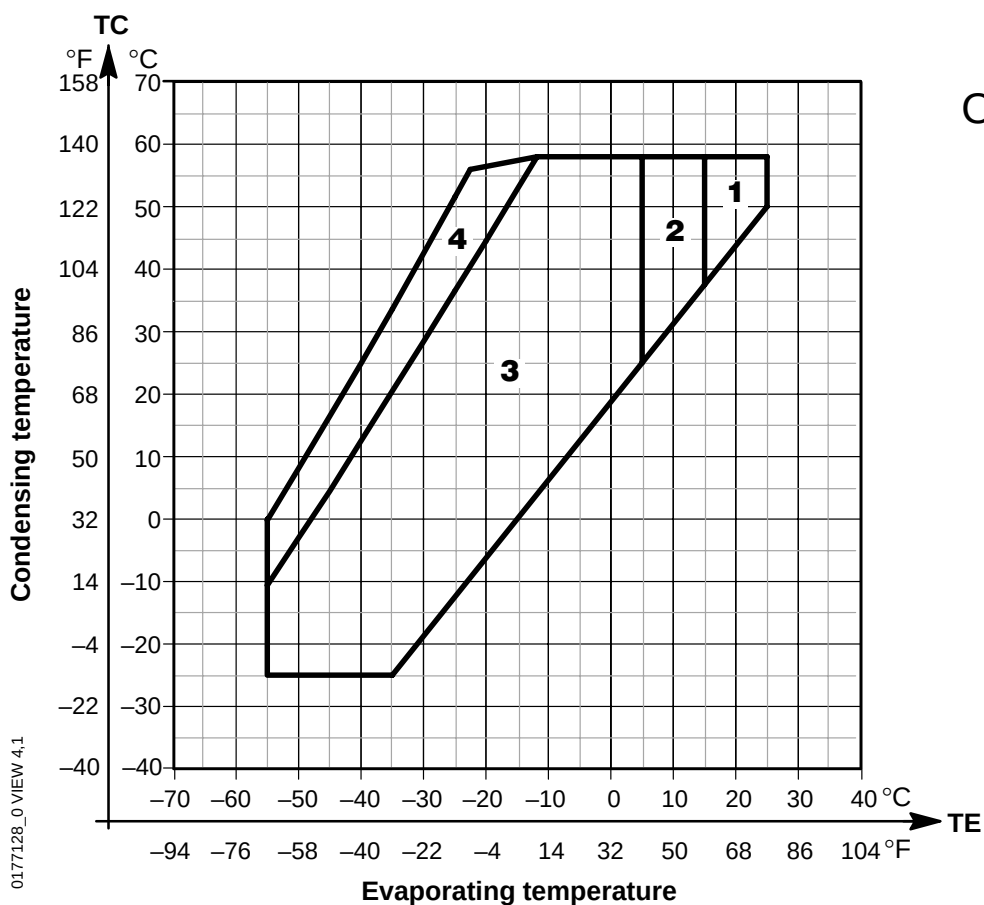
Water-cooled:

Top- and side covers.
Oil cooling included in the system.

Part-load operation:

¹⁾ Depending on the operating conditions
and the pressure on the compressor a by-
pass system may be required.

See section: *By-pass system for two-stage compressors.*



R22

Operating limits
single stage
compressors

CMO
SMC 100 S-L
SMC 180

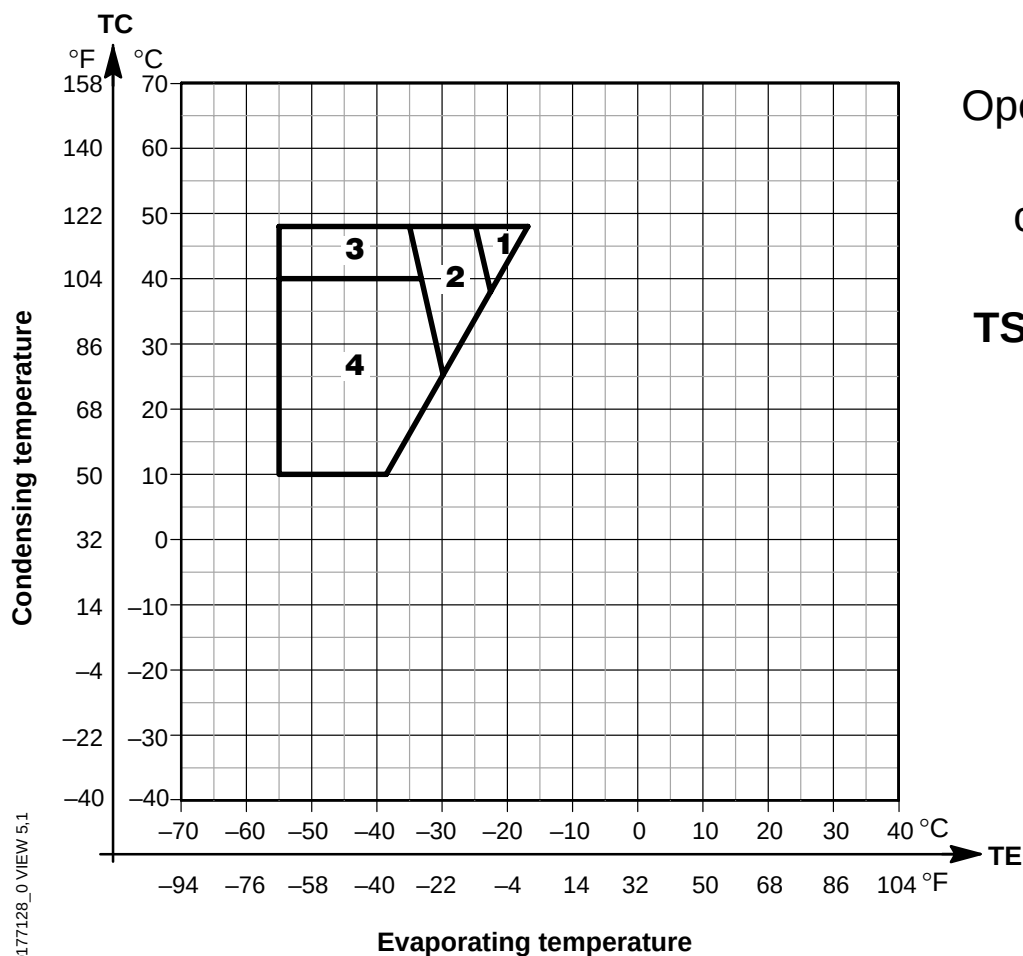
Type	Area	rpm		Oil-cooling required ¹⁾	Note
		max	min		
CMO	1	1500	900	no	
	2			no	
	3	1800		At less than 50% capacity	
	4			yes	
SMC 100 S	1	1000	700	no	
	2	1200		no	
	3	1500		At less than 50% capacity	
	4	1200		yes	
SMC 100 L	1				Not applicable
	2	1000	700	no	
	3	1200		At less than 50% capacity	
	4	1000		yes	
SMC 180	1-2				Not applicable
	3	750	450	At less than 50% capacity	
	4			yes	

Top covers: Air-cooled design only.

¹⁾ When oil cooling is required there is a free choice between **A** and **B** - However, for SMC 180 only **A** may be selected.

A: Water-cooled side covers

B: Built-in refrigerant-cooled oil cooler with thermostatic expansion valve.



R22

Operating limits
two-stage
compressors

TCMO

TSMC 100 S-L

TSMC 180

Type	Area	rpm		Oil-cooling required ¹⁾	Note
		max	min		
TCMO	1-2	1500	900	no	
	3-4	1800			
TSMC 100 S	1	1000	700	yes	2)
	2-3	1200			
	4	1500			
TSMC 100 L	1				Not applicable
	2	1000	700	yes	2)
	3-4	1200			
SMC 180	1-2				Not applicable
	3-4	750	450	yes	2)

Top covers: Air-cooled design only.

1) When oil cooling is required there is a free choice between **A** and **B** - However, for SMC 180 only **A** may be selected.

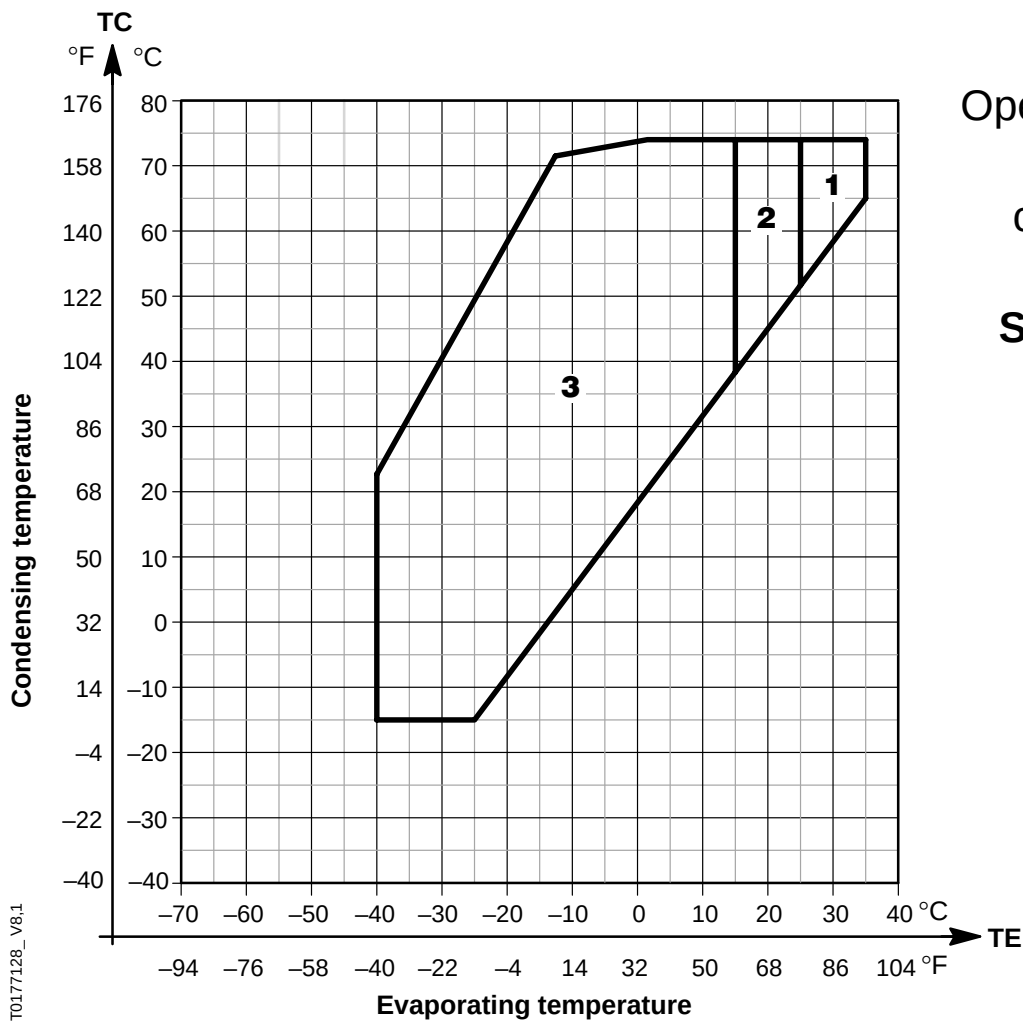
A: Water-cooled side covers

B: Built-in refrigerant-cooled oil cooler with thermostatic expansion valve.

Part-load operation:

2) Depending on the operating conditions and the pressure on the compressor a by-pass system may be required.

See section: *By-pass system for two-stage compressors.*



R134a

Operating limits
single stage
compressors
CMO
SMC 100 S-L

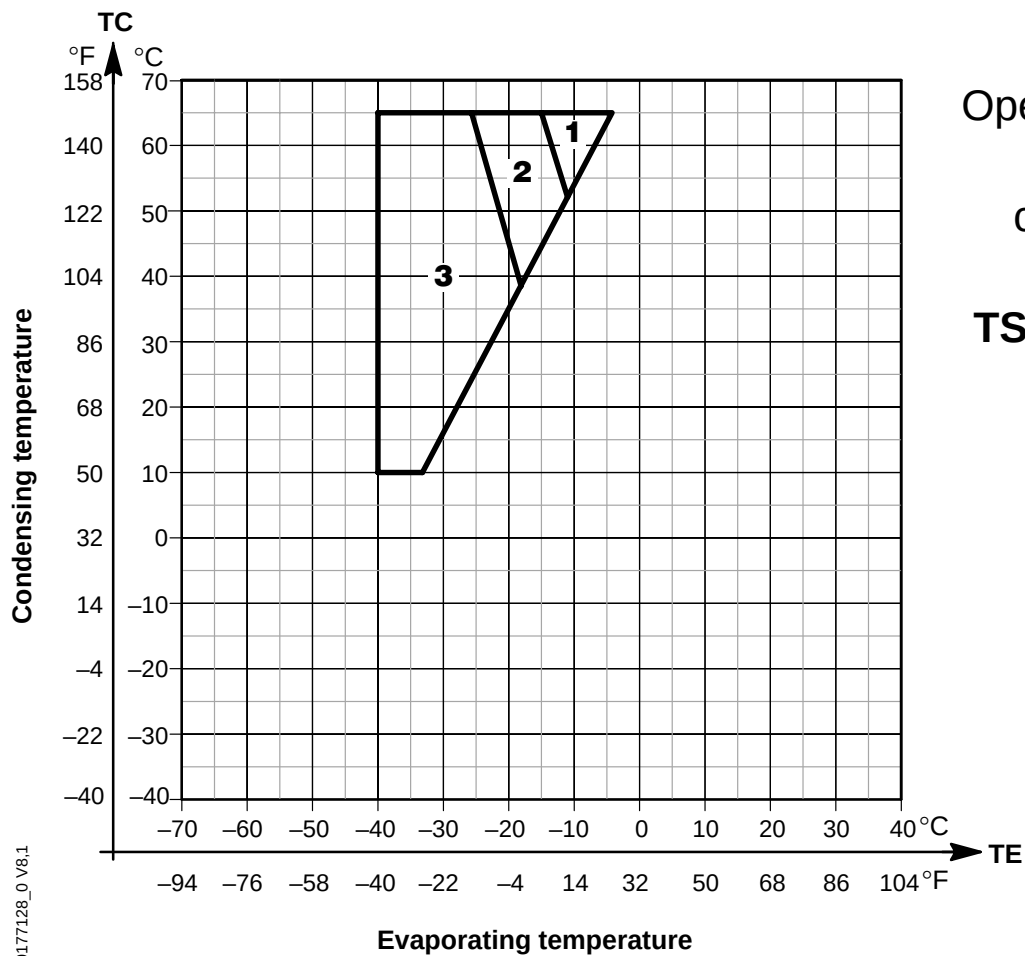
Type	Area	rpm		Oil-cooling required ¹⁾	Note
		max	min		
CMO	1-2	1200	900	no	
		1500		At less than 50% capacity	
	3	1500		no	
		1800		At less than 50% capacity	
SMC 100 S	1	1000	700	no	
	2	1200		no	
	3	1200		no	
		1500		At less than 50% capacity	
SMC 100 L	1				Not applicable
	2	1000	700	no	
	3	1000		no	
		1200		At less than 50% capacity	

Top covers: Air-cooled design only.

¹⁾ When oil cooling is required there is a free choice between **A** and **B**.

A: Water-cooled side covers

B: Built-in refrigerant-cooled oil cooler with thermostatic expansion valve.



R134a
Operating limits
two-stage
compressors
TCMO
TSMC 100 S-L

Type	Area	rpm		Oil-cooling required 1)	Note
		max	min		
TCMO 28	1-2	1500	900	1)	
	3	1800			
TSMC 100 S	1	1000	700	1)	2)
	2	1200			
	3	1500			
TSMC 100 L	1				Not applicable
	2	1000	700	1)	2)
	3	1200			

1) Oil cooling:

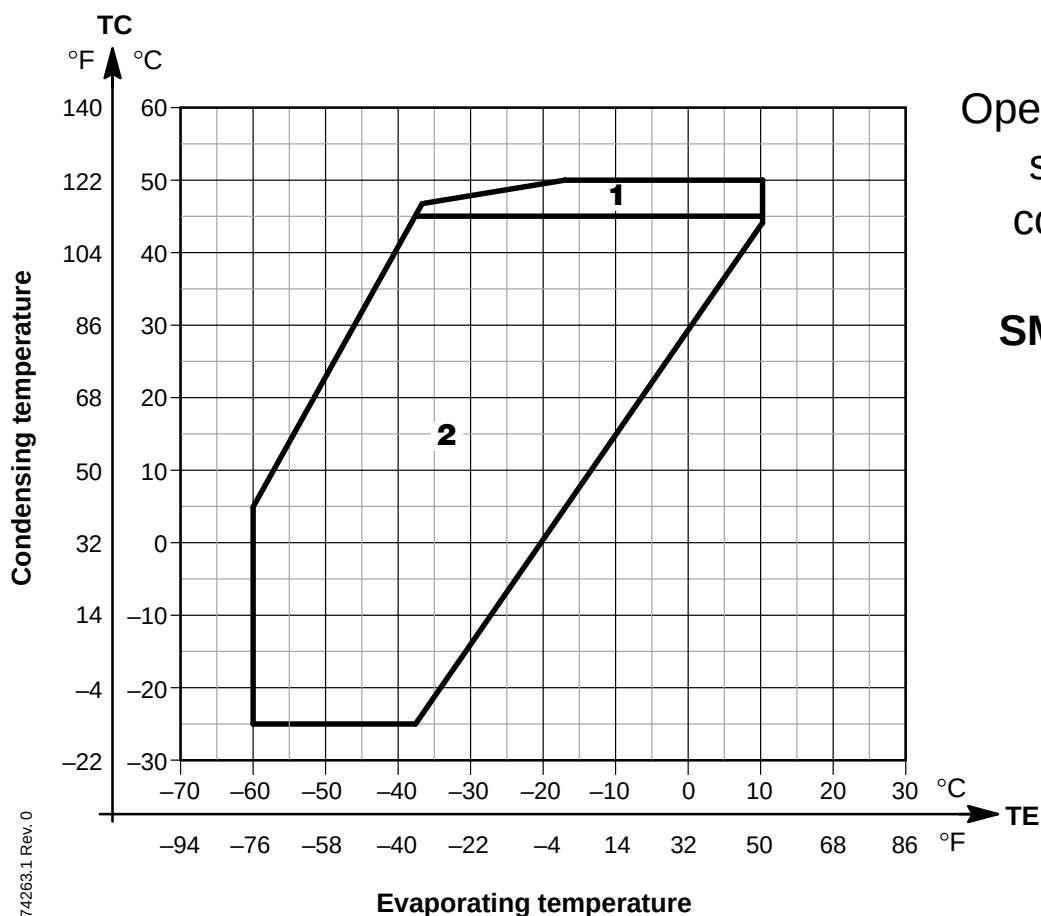
Not required.

Top- and side covers:

Only air-cooled.

2) Part-load operation:

By-pass equipment required to maintain intermediate temperature at minimum load.



R404A

Operating limits
single stage
compressors

CMO
SMC 100 S-L

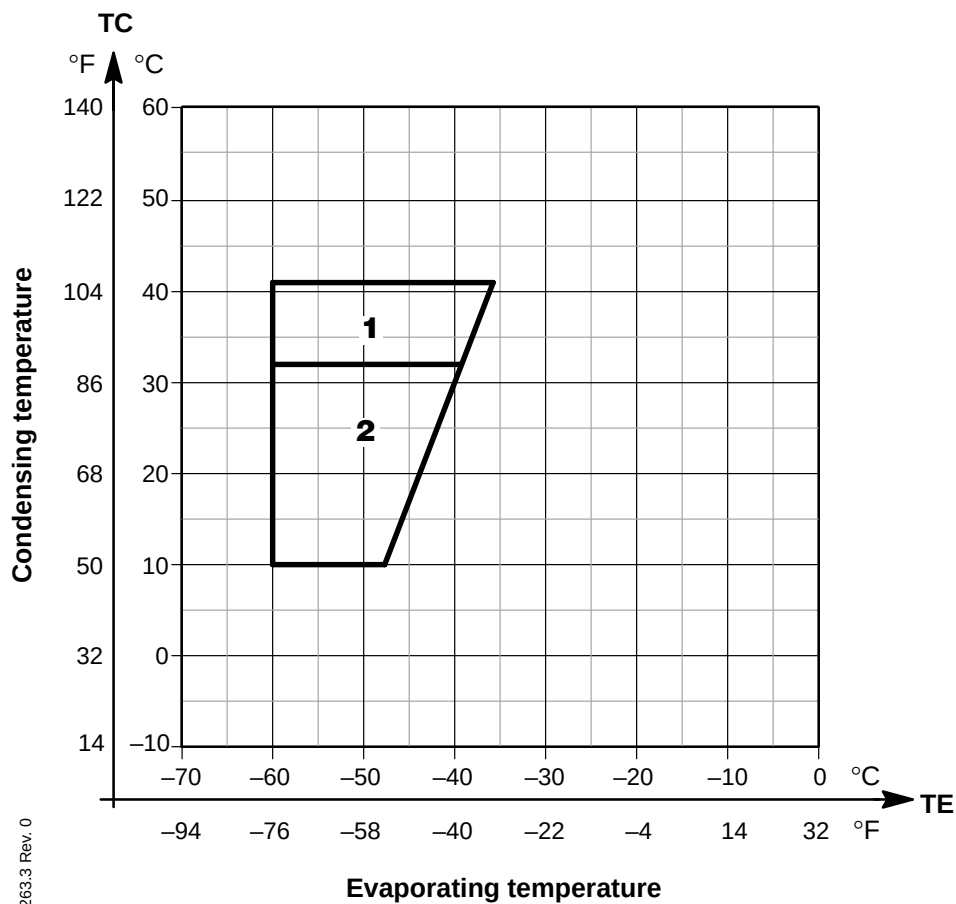
Type	Area	rpm		Oil-cooling required ¹⁾	Note
		max	min		
CMO 20	1	1200	900	no	
		1500		At less than 50% capacity	
	2	1500		no	
		1800		At less than 50% capacity	
SMC 100 S	1	1000	700	no	
	2	1200		no	
		1500		At less than 50% capacity	
SMC 100 L	1	1000	700	no	
	2	1200		no	

Top covers: Air-cooled design only.

¹⁾ When oil cooling is required there is a free choice between **A** and **B**.

A: Water-cooled side covers

B: Built-in refrigerant-cooled oil cooler with thermostatic expansion valve.



R404A
Operating limits
two-stage
compressors
TCMO
TSMC 100 S-L

Type	Area	rpm		Oil-cooling required ¹⁾	Note
		max	min		
TCMO 28	1	1800	900	1)	
	2				
TSMC 100 S	1	1200	700	1)	2)
	2	1500			
TSMC 100 L	1	1000	700	1)	2)
	2	1200			

1) Oil cooling:

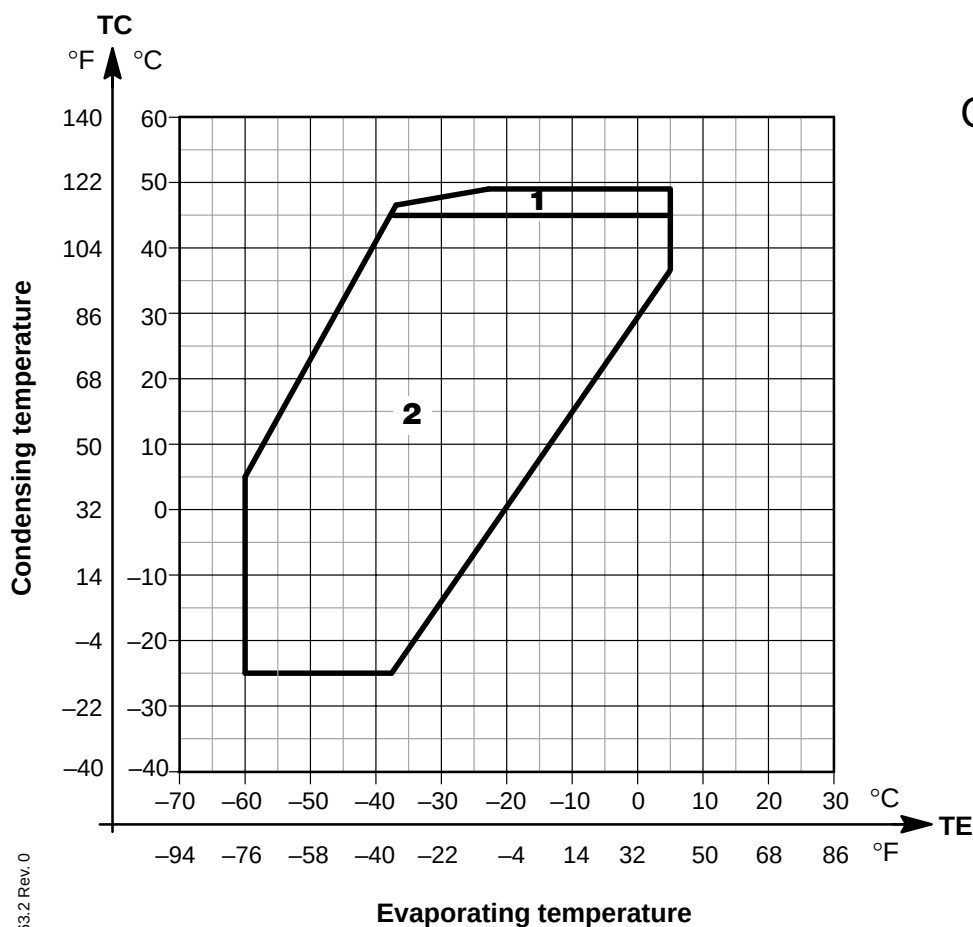
Not required.

Top- and side covers:

Only air-cooled.

2) Part-load operation:

By-pass equipment required to maintain intermediate temperature at minimum load.



R507

Operating limits
single stage
compressors
CMO
SMC 100 S-L

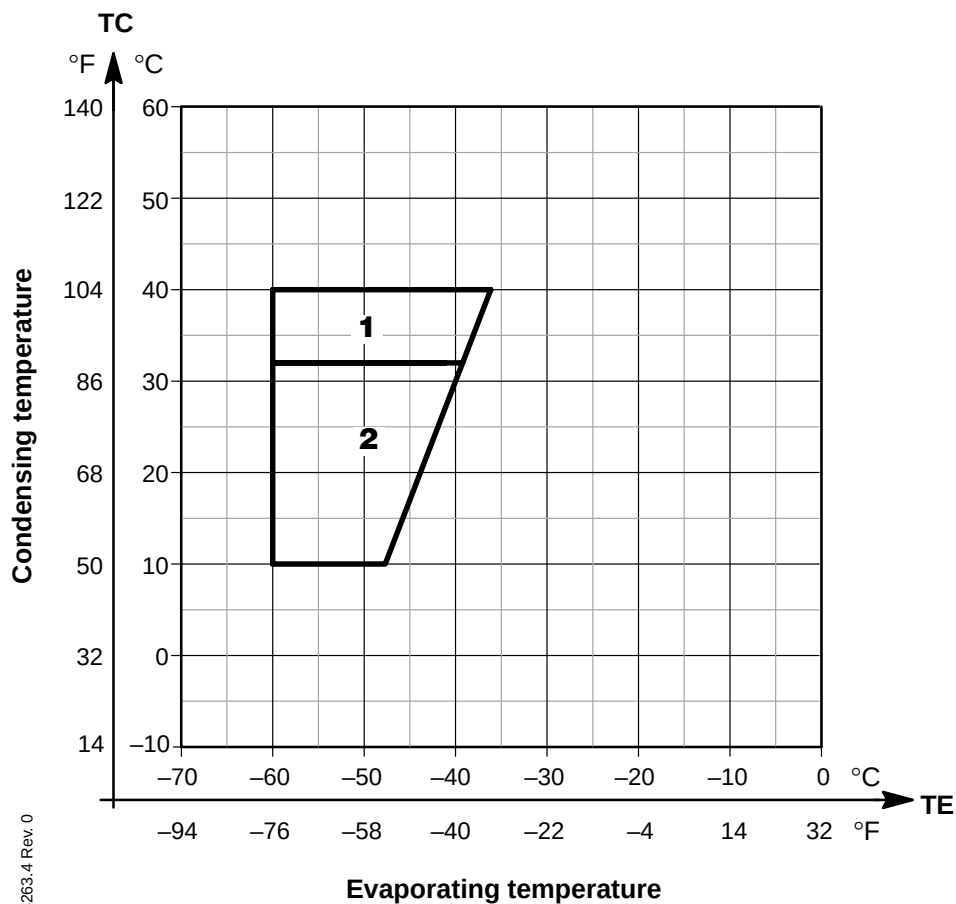
Type	Area	rpm		Oil-cooling required ¹⁾	Note
		max	min		
CMO 20	1	1200	900	no	
	2	1500		At less than 50% capacity	
	2	1500		no	
	3	1800		At less than 50% capacity	
SMC 100 S	1	1200	700	no	
	2	1200		no	
	3	1500		At less than 50% capacity	
SMC 100 L	1	1000	700	no	
	2	1200		no	

Top covers: Air-cooled design only.

¹⁾ When oil cooling is required there is a free choice between **A** and **B**.

A: Water-cooled side covers

B: Built-in refrigerant-cooled oil cooler with thermostatic expansion valve.



R507
Operating limits
two-stage
compressors
TCMO
TSMC 100 S-L

Type	Area	rpm		Oil-cooling required ¹⁾	Note
		max	min		
TCMO 28	1	1800	900	1)	
	2				
TSMC 100 S	1	1200	700	1)	2)
	2	1500			
TSMC 100 L	1	1000	700	1)	2)
	2	1200			

1) Oil cooling:

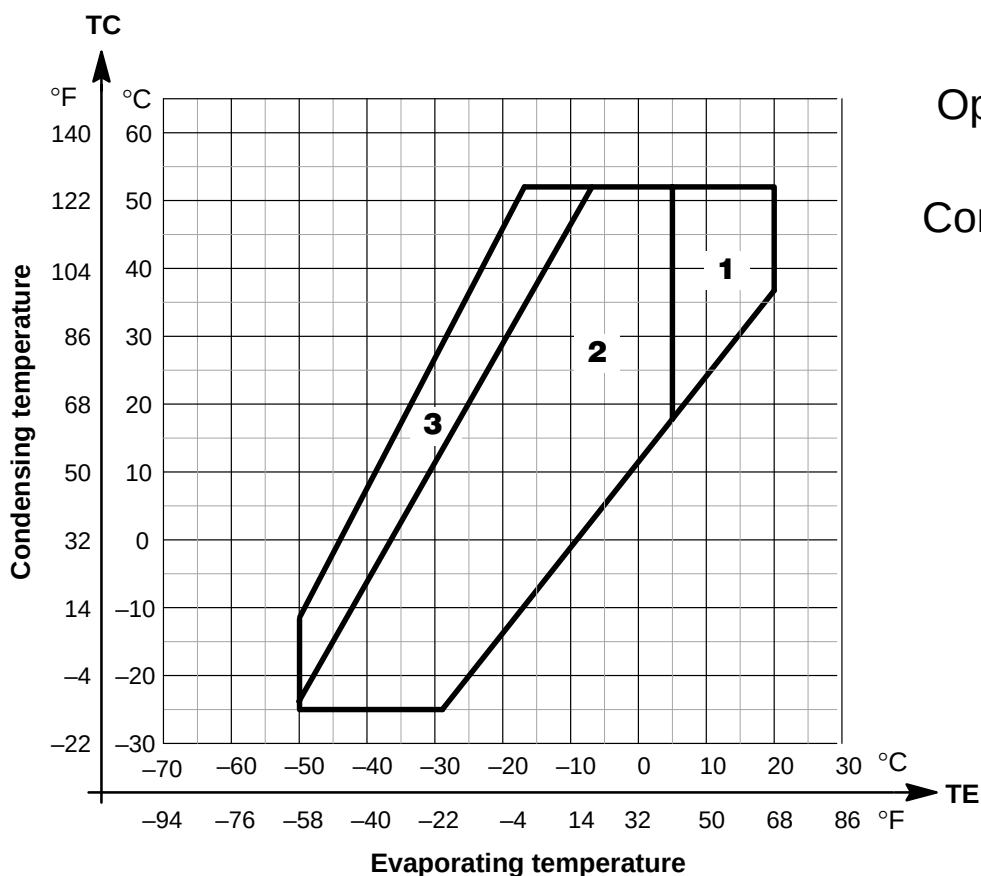
Not required.

Top- and side covers:

Only air-cooled.

2) Part-load operation:

By-pass equipment required to maintain intermediate temperature at minimum load.



R407C

Operating Limits
one-Stage
Compressor type
CMO & SMC

T245411_0 view 2

Type	Area	rpm		Oil-cooling required ¹⁾	Note
		max	min		
CMO	1	1500	900	no	
	2	1800		At less than 50% capacity	
	3			yes	
SMC 100 S	1	1200	700	no	
	2	1500		At less than 50% capacity	
	3	1200		yes	
SMC 100 L SMC 100 L	1	1000	700	no	
	2	1200		At less than 50% capacity	
	3	1000		yes	
SMC 180	1	NOT APPLICABLE			
	2	750	450	At less than 50% capacity	
	3			yes	

Top covers: Air-cooled design only.

¹⁾ When oil cooling is required there is a free choice between **A** and **B** - However, for SMC 180 only **A** may be selected.

A: Water-cooled side covers

B: Built-in refrigerant-cooled oil cooler with thermostatic expansion valve.

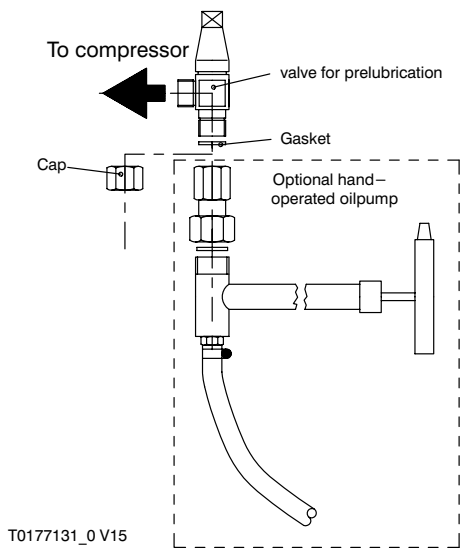
General operating instructions for CMO/TCMO, SMC/TSMC piston compressors

Starting up compressor and plant

- Before the initial start-up of the compressor following a lengthy stand-still period of several months, the compressor must be **prelubricated**. Hereby, the **bearings** are lubricated and the **oil system** filled up with oil before the compressor is set running.

Carry out the **prelubrication** by connecting the oil pump to the **prelubricating valve** which in the more recent SMC-TSMC-HPC compressors is connected to the shaft seal housing pos. 6A and on the CMO-TCMO-HPO to the cover pos. 86H or 87K. As prelubricating pump we recommend SABROE's hand-operated oil pump part no 3141-155, which is mounted as shown in fig. 1.

Fig. 1



For pre-lubrication use a **clean new refrigerant machine oil of the same type as the one found in the compressor**, and pump as follows:

Compressor type	Pump strokes w. SABROEs hand-operated oil pump	Estimated oil quantity Liters
CMO TCMO HPO	appr. 25	2.5
SMC 104 106-108 TSMC 108 HPC	appr. 35	3.5
SMC 112-116 TSMC 116	appr. 45	4.5
SMC 186-188 TSMC 188	appr. 50	5.0

- The heating rod in the crankcase **must** be energized at least 6-8 hours before starting up the compressor in order to boil any refrigerant out of the compressor oil. At the same time, the suction check valve must be open.
- Check oil level in crankcase. The oil level must always be visible in the oil sight glass. See section: *Charging the compressor with oil*.
- Start condenser cooling, brine pumps, fans at air coolers as well as any compressor cooling device.
- Check correct setting of safety automatics on compressor.
- Open discharge stop valve at compressor.
- Set capacity regulator to minimum capacity.

- In order to avoid excessive pressure reduction in the compressor on start-up, the suction stop valve **must** be opened a few turns, as there is otherwise a risk of oil foaming in the crankcase.
- Open all other stop valves except for the main valve in the liquid line and possible by-pass valves serving other purposes.
- Check that the time relay 3K13 keeps the solenoid valve in the oil return line closed for 20-30 mins. after start-up of the compressor.
- Start compressor motor and check suction and oil pressures.
- Carefully continue opening suction stop valve to its full open position.
- Open main valve in liquid line.
- If the oil in the crankcase foams, or knocking noises are heard from the compressor because droplets of liquid are being fed in with the suction gas, throttle suction stop valve immediately.
- The compressor is now operating. Increase capacity stepwise, allowing the compressor to adjust to new conditions before switching to next stage. Check carefully whether oil is foaming and whether oil pressure is correct.
- Check whether oil return from oil separator is working. (Pay attention to any clogging of filter and nozzle.) The pipe should normally be warm.
- Do not leave plant for first 15 minutes after start-up and **never** before it has stabilized.

Stopping and starting-up compressor during a short period of standstill

Before stopping the compressor, its capacity must be reduced to the lowest capacity stage for a few minutes, before it stops.

During short periods of standstill, it is **not** necessary to shut off the suction stop valve and the discharge stop valve. The heating rod **must** be energized.

If the compressor is cooled by means of cooling water, the water flow must always be stopped during periods of standstill.

This is normally done by means of a solenoid valve in the water inlet line to the compressor.

Connect the solenoid valve to the start/stop relay of the compressor motor.

Compressor start-up must always take place at the lowest capacity stage, after which capacity is increased stepwise at suitable intervals, in order to avoid that a sudden excessive pressure reduction in the evaporation system causes liquid hammering in the compressor and oil foaming in the crankcase.

Stopping plant for brief periods (until 2-3 days)

- Shut off liquid supply to evaporators for a few minutes before stopping the plant.
- Stop compressor and shut off suction and discharge stop valves. Close valve in oil return.
- Stop condenser cooling, pumps, fans and any compressor cooling.
- Cut off power supply to both master and control currents.

Stopping plant for lengthy periods (more than 2-3 days)

- Shut off main valve after receiver and pump down evaporators. If necessary, adjust low-pressure cut-out on unit to a lower pressure during evacuation.
- Allow temperature in evaporators to rise, then repeat evacuation.
- When suction pressure has been reduced to slightly over atmospheric, stop compressor. Shut off suction and discharge stop valves and close off stop valve in oil return.
- Shut off condenser cooling. If there is a risk of freezing, draw off coolant.
- Cut off power supply to master and control currents.
- Inspect receiver, condenser and pressure vessels as well as piping connections and apparatus for leakage.

Automatic plants

- Refrigeration plant should normally be put into operation as described in the Start-up section. Once started, switch over to automatic operation.
- Special instructions for automatic plant in question should be followed to the letter.
- The following should be checked daily, even on automatic plants:
 - correct oil charging,
 - automatic oil return,
 - correct oil pressure,
 - suction and condenser pressures, discharge pipe temperature,

- correct setting of safety automatics.

Pressure testing refrigeration plant

Before charging the plant with refrigerant, it must be pressure tested and pumped down.

Pressure test the plant with one of the following:

- **dry** air - pressurized cylinders containing dry atmospheric air may be used - but **never** oxygen cylinders;
- air compressor for high pressure;
- nitrogen.

Important

The plant compressors must not be used to pressurize the plant.

Water or other fluids must **not** be used for pressure testing.

If nitrogen is used, it is important to place a reducing valve with a pressure gauge between the nitrogen cylinder and the plant.

During pressure testing, it is important to ensure that pressure transducers and other control equipment are not exposed to the testing pressure. The compressor stop valves must also be closed during pressure testing.

Plant safety valves must normally be blanked off during pressure testing, as their opening pressure is lower than the testing pressure.

Important

During this pressure testing, no person should be allowed to be present in rooms housing plant parts or in the vicinity of the plant outside the rooms.

- The entire unit must be pressure tested in accordance with the local regulations for pressure testing.
- The test pressure must **never** exceed the design pressure.
- If it is required that the compressor should be pressure tested together with the unit or with the plant, the testing pressure must **not** exceed:

For reciprocating compressors:

HP side: **24 bar**

LP side: **17.5 bar**

- Please observe that manometers, pressure controls, pressure transmitters and other control equipment are **not** exposed to testing pressure.
- Afterwards, reduce pressure to **10 bar** for a period of **24 hours** - as an initial tightness test - as a tightly sealed plant will maintain this pressure throughout the period.

During the tightness test, it is permitted to enter the room and approach the plant.

- By way of a second tightness test, examine all welds, flange joints etc. for leakage by applying soapy water, while maintaining the **10 bar** pressure.

When pressure testing, compile a pressure test report containing the following:

- date of pressure testing,
- person carrying out the test,
- comments.

Pumping down refrigeration plant

Following pressure testing, the refrigeration plant must be evacuated in order to eliminate

atmospheric air and moisture. Evacuation must be carried out on all types of refrigeration plant, regardless of the type of refrigerant with which the plant is to be charged.

Observe that HCFC and HFC refrigerants mix only minimally with water, and it is therefore necessary to effect evacuation of such systems with particular care.

The boiling point of a fluid is defined as the temperature at which the steam pressure equals atmospheric pressure. For water, the boiling point is 100°C. Lowering the pressure also lowers the boiling point of the water.

The table sets out the boiling point of water at very low pressures:

Boiling point of water °C	At pressure mm HG
5	6,63
10	9,14
15	12,73
20	17,80

For evacuation, use a vacuum pump which bleeds the plant of air and steam.

The vacuum pump must be able to lower the pressure to approx. 0.1 mm Hg (mercury column) and must be fitted with a gas ballast valve. This valve should be used wherever possible to prevent water vapours condensing in the vacuum pump.

Important

Never use the refrigeration compressor to evacuate the plant.

For a satisfactorily performed evacuation, the final pressure must be lower than 5 mm Hg. Attention is drawn to the fact that there may be a risk of any water left in the refrigeration plant freezing if ambient temperatures are lower than 10°C. In such instances, it will be necessary to supply heat to the component surroundings, as ice evaporates with difficulty.

It is recommended to carry out evacuation as follows:

- Evacuate to a pressure lower than 5 mm Hg.
- Blow dry air or nitrogen into system to a pressure corresponding to atmospheric. **Never use OXYGEN cylinders.**
- Repeat evacuation to reduce pressure to less than 5 mm Hg.
- Shut the vacuum pump off from refrigeration plant and check that the pressure does not rise for the next couple of hours. If the system still contains water, this will evaporate and cause the pressure to rise, thereby indicating unsatisfactory evacuation and necessitating a repetition of the procedure.

Operating log

In order to keep tabs on the operating state of the refrigeration plant, it is recommended that an operating log be kept.

This operating log should be kept at regular intervals, thus providing important information about the cause of any undesired changes in the operating state.
(See following page)

Observation	Measuring point	Measurement unit
Time		Date and time
Suction pressure	- Compressor pressure gauge - UNISAB II Control	°C or bar
Discharge pressure	- Compressor pressure gauge - UNISAB II Control	°C or bar
Oil pressure	- Compressor pressure gauge - UNISAB II Control	bar
Oil temperature	UNISAB II Control	°C
Suction gas temp.	- Thermometer in suction pipe immediately before compressor - UNISAB II Control	°C
Discharge gas temp.	- Thermometer in discharge pipe immediately after compressor but before oil separator - UNISAB II Control	°C
Oil level in compressor	Oil level sight glass in compressor	Must be visible in oil sight glass
Recharging of oil on compressor	See section on oil charging	Number of litres
Compressor motor's consumption in amps.	- Electrical panel - UNISAB II (additional)	Amps

At the same time, attention should be paid to the following:

(tick these off in the log, if you wish)

- whether the compressor's cooling system is functioning correctly,
- whether any unusual noise is coming from the compressor,
- whether there are unusual vibrations in the compressor.

Servicing the piston compressor

In order to ensure problem-free operation, it is advisable to carry out regular servicing to the refrigeration plant. In this section, SABROE indicates some periodic services fixed on the basis of the number of operating hours from the first start-up or after over hand of the compressor.

The servicing schedules also depend on the speed of the compressor. If the compressor is running at less than 1200 rpm, SABROE permits extended service intervals. However, the compressor must always operate within the speed recommended by SABROE. See *Description of compressor*. Providing the compressor operates within the specified pressures and temperatures and the prescribed periodic services are performed, the compressor will have a long and efficient service life.

S The following must therefore be checked **daily**:

- Operating pressure,
- Operating temperatures,
- Oil level and pressure,
- Abnormal noise and vibrations.

The actual operating conditions should be entered in an operating log daily. See the Operating log section.

Pressure drop test:

Using the pressure drop test, it is possible to check the internal tightness of the compressor from discharge to suction side. The pressure drop test is performed with the compressor at standstill, as described below:

S Immediately after stopping compressor, read off pressure on discharge and suction side of compressor.

S Close discharge stop valve quickly and, from moment of closure, time how long it takes for pressure to drop on high pressure side of compressor. Normally, the pressure drop should not be more than 3 bar over a period of 5 minutes or so.

If the pressure falls more quickly, this is due to internal leakage, which may occur:

S where pressure valve ring plates are in bad contact with their seats (Pos. 20C against Pos. 20A and 19H);

S with defective seal Pos. 19T; (not CMO)

S with defective seal Pos. 19K;

S because cylinder lining and top cover have been tightened without long mounting stopper having been fitted. Cylinder lining is thus resting on rocker arms, Pos. 15A; (not CMO).

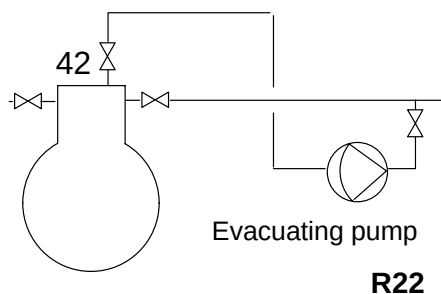
S on safety valve, because valve cone does not fit tightly against seat, or outer O-ring Pos. 24B or inner O-ring Pos. 24C is defective. (*See Safety valve section.*)

During pressure drop testing, pay attention to any piping connections to the discharge side of the compressor, which may have an influence on the test result.

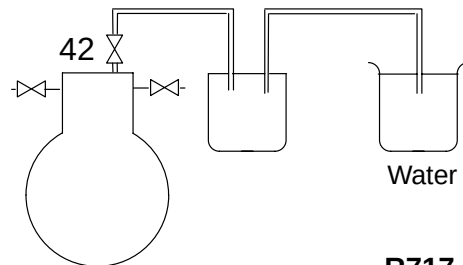
Removing refrigerant from compressor

Before the compressor can be dismantled, the refrigerant must be removed from the compressor, which can be done in the following ways:

1. Run compressor at lowest capacity stage and throttle suction stop valve slowly until completely closed.
2. The compressor will then stop on the low pressure cut-out. This can be adjusted to stop compressor at a pressure lower than normal.
3. Close discharge stop valve and other piping connections to compressor.
4. On HFC and HCFC compressors, remove remaining refrigerant gas using a pump-down compressor connected to purge valve Pos. 42.



S On the R717 compressor, adopt the following method:



Connect the purge valve Pos. 42 to a sealed, empty vessel which in turn is connected to an open tank containing water.

The water will absorb the refrigerant, which can then be dispatched for proper destruction. The moment the pressure is equalized, the valve must be reclosed in order to prevent water being sucked back into the compressor.

Note:

The following instructions apply to the compressor only. Servicing of the refrigeration plant is described in a separate section. Service the compressor motor according to your own instructions. For the various scheduled services, SABROE can supply ready-made spare-part sets, which it would be an advantage to have before carrying out the scheduled service.

In the event that the compressor cannot operate, start evacuation as described under pt. 3, and remember also to close the suction stop valve.

Scheduled services			Activity
No.	Operating hours < 1200 rpm	Operating hours > 1200 rpm	
1	75	50	1.1 Remove and discard filter bag in suction filter. Clean suction filter. Following major repair work or in event of severe soiling of filter bag, it is recommended that a new filter bag be fitted for another period of 50 operating hours. 1.2 Check tension of driving belts.
2	300	200	2.1 Check or change oil. When changing oil, change oil filter cartridge, too. See following section: <i>Assessing the oil.</i> 2.2 Clean suction filter. 2.3 Check that following function correctly: Solenoid valves Compressor cooling Thermopump Safety automatics Heating rod V-belt drive. 2.4 Retighten external piping connections. 2.5 Check oil return system from oil separator. 2.6 Retighten coupling.
3	7500	5000	3.1 Check or change oil. When changing oil, change oil filter cartridge, too. See following section: <i>Assessing the oil.</i> 3.2 Clean suction filter. 3.3 Check that following function correctly: Solenoid valves Compressor cooling Thermopump Safety automatics Heating rod V-belt drive Oil return system from oil separator. 3.4 For heat pump operation, inspect: Valve seats Cylinder linings Pistons, gudgeon pins and gudgeon pin bearings Piston and oil scraper rings. Change suction and discharge valve ring plates. 3.5 Finish off with a pressure drop test.

No.	Operating hours < 1200 rpm	Operating hours > 1200 rpm	Activity
4	15000	10000	4.1 Check or change oil. When changing oil, change oil filter cartridge, too. See following section: <i>Assessing the oil.</i> 4.2 Clean suction filter. 4.3 Check following: Solenoid valves Oil cooling system Water cooling system for any deposits and clogging Thermopump Safety automatics Heating rod V-belt drive Coupling and alignment Oil return system from oil separator Valve seats Cylinder linings Pistons, gudgeon pins and gudgeon pin bearings Piston and oil scraper rings Unloading mechanism Seal for tightness 4.4 Change: Suction and discharge valve ring plates V-belts 4.5 Finish off with a pressure drop test.
5	22500	15000	5.1 Check V-belt drive 5.2 For heat pump operation, inspect: Valve seats Cylinder linings Pistons, gudgeon pins and gudgeon pin bearings Piston and oil scraper rings. Change: Suction and discharge valve ring plates.

No.	Operating Hours < 1200 rpm	Operating Hours > 1200 rpm	Activity
6	30000	20000	6.1 Change compressor oil, Change oil filter cartridge, Clean crankcase. 6.2 Clean suction filter. 6.3 Check following: Solenoid valves Oil cooling system Water cooling system for any deposits and clogging Thermopump Safety automatics Heating rod V-belt drive Coupling and alignment Valve seats Cylinder linings Pistons, gudgeon pins and gudgeon pin bearings Piston and oil scraper rings Unloading mechanism Seal for tightness Oil pump and drive Check valves. 6.4 Change: Suction and discharge valve ring plates V-belts Half-sections of bearing for connecting rod (does not apply to CMO compressors) 6.5 Finish off with a pressure drop test.
7	37500	25000	As for service no. 5
8	45000	30000	As for service no. 4
9	52500	35000	As for service no. 3
10	60000	40000	Major overhaul; contact SABROE Refrigeration
	Then repeat scheduled services from no. 3 inclusive.		

Lubricating oil

Lubricating oil requirements

Above all, the refrigerator oil must provide satisfactory lubrication of the compressor, even at the relatively high temperatures occurring during compression. It must be incapable of coking at such high temperatures and must not precipitate solid constituents such as paraffin or wax at the lowest occurring temperatures. The oil must not have any corrosive effect, whether alone or mixed with refrigerant. According to the oil companies the oils mentioned in the Oil Recommendation in this instruction manual comply with these conditions. See section on *Choice of lubricating oils*.

General rules for use of lubricating oil in refrigeration compressors

- S Only fresh, clean refrigeration machine oil may be charged. **Oil tapped from the evaporator system in an ammonia plant must not be reused in the compressor.**
- S Use grade of oil originally prescribed for compressor.
- S As far as possible, avoid mixing different types of oil. Mixed oil is generally inferior to the two original oils. Mixing various types of oil may give rise to formation of sludge, which will lodge in valves and filters.
- S If necessary to switch to another brand of oil, this must be done at the same time as completely changing the oil in the compressor and tapping off all oil from the refrigeration plant.

- S The refrigeration oil must be free of moisture, which may give rise to operating malfunctions and attacks of corrosion.

The oil should therefore be purchased in containers corresponding to the quantity to be used for a single, or at most, two top-ups. The oil containers must be kept carefully sealed. If all the oil in a container is not used in one go, the container should be tightly sealed and stored in a warm place to prevent the absorption of moisture.

Note:

It is inadvisable to reuse oil which has been drawn from a compressor or plant.

This oil will have absorbed moisture from the air and may cause operating problems.

Always switch off the power to the heating rod before drawing off the oil.

If, after reading the above, any doubt exists as to the type of oil which has been used on your compressor, you are recommended to contact SABROE, rather than risk charging with unsuitable oil.

Instructions for choosing lubricating oil for refrigeration compressors

The instructions in *Choice of lubricating oils* offer more detailed guidelines for choosing the lubricating oil best suited to each individual case on the basis of the anticipated operating conditions.

Charging refrigeration compressor with lubricating oil

Since all SABROE piston compressors are supplied with a special oil-charging valve on

the crankcase, refrigeration oil may be topped up while the compressor is in operation.

For this purpose, use a manual oil pump or adopt the following procedure:

Note:

When charging for the first time, use the oil pump; it goes without saying that the compressor must not be started unless already charged with oil.

- S Reduce pressure in crankcase, e.g. by throttling suction stop valve, until suction pressure gauge shows pressure slightly below atmospheric.
- S Fill pipe connected to oil charging valve with refrigerator oil and insert free end of pipe down into a receptacle containing fresh refrigerator oil.
- S Open oil charging valve carefully, thereby causing external air pressure to force oil into crankcase.
- S Avoid getting air or other impurities sucked into compressor.

Note:

In order to achieve pressure below atmospheric, it will sometimes be necessary to reset the low-pressure cut-out so that the compressor can aspirate down to this pressure. Remember to reset the pressure cut-out to its normal setting after charging with oil.

When in operation, the compressor may be refilled with oil using the **manual oil pump**.

Note:

Since halocarbon refrigerants such as R22 mix with refrigeration oils, there will always be a good portion of oil blended with the refrigerant in the plant. Often,

therefore, it is necessary to refill with refrigeration oil after starting up for the first time and after charging with fresh refrigerant.

For a while after the plant is started for the first time, keep an extra sharp eye on the oil level in the compressor, therefore.

Changing oil in refrigeration compressor

- S Cut off power to heating rod.
- S Close compressor stop valves and valve in oil return line from oil separator.
- S Reduce pressure in compressor crankcase to slightly above atmospheric by throttling suction stop valve while compressor is running at its lowest capacity stage. Alternatively, raise to slightly above atmospheric pressure by stopping compressor and closing suction stop valve. Pressure in crankcase will then rise gradually.
- S Oil in the crankcase can then be forced out through drain valve Pos. 23 when compressor is at a standstill.
- S Equalize pressure in compressor to atmospheric through purge valve pos. 42. See section on *Environmental protection*.
- S Dismantle side covers.
- S Replace oil filter cartridge with a new one.
- S Clean crankcase thoroughly, wiping with a clean, dry linen cloth (not cotton waste).
- S Reassemble side covers.
- S Charge to correct level with fresh, clean refrigerator oil according to SABROE's oil recommendations.
- S Connect heating cartridge.

S Connect vacuum pump to compressor and pump down to 5-7 mm Hg; close off connection.

Then open suction stop valve a few turns, filling compressor with refrigerant gas. In the case of R717, it will suffice to blast the compressor through by carefully opening suction stop valve while purge valve Pos.

42 is open. See section on *Environmental protection*, however. When smelling R717, close purge valve.

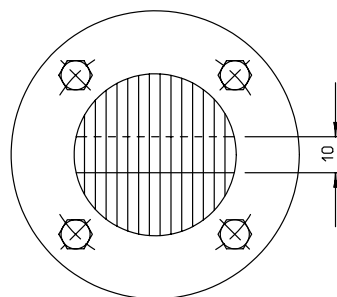
S Open discharge stop valve and valve in oil return line; compressor is then ready for start-up as described in section *General operating instructions*.

Charging the compressor with oil

Compressor Type	Size	Volume of oil in crankcase Litres
BFO	3	1,5
	4	4
	5	5
CMO TCMO	24	14
	26	16
	28	18
	4	13
SMC 100 TSMC 100 Mk 3 S-L-E	104	26
	106	28
	108	30
	112	47
	116	50
SMC 180 TSMC 180	186	80
	188	90

The **oil level** must be checked with extreme care, particularly when starting and charging with refrigerant.

The oil level must always be visible in the oil level sight glass. The below diagram illustrates, how many litres of oil a drop in the oil level of 10 mm is approximately equal to.



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The volume of oil stated in the table is the amount which must always be present in the crankcase.

As a rule, the compressor should be charged with oil after the plant is started for the first time, as some of the oil – especially on an HCFC installation – will be absorbed by the refrigerant in the plant.

The following determinants decide the total volume of oil a refrigeration plant should contain:

- S type of refrigerant
- S refrigerant charge (volume)
- S size of plant
- S temperature range in which refrigeration plant is to operate.

Compressor type	size	10 millimeter difference in oil levels equals
CMO/ TCMO	24	~1 litre of oil
	26	
	28	
SMC / TSMC 100	104	~2 litres of oil
	106	
	108	
S-L-E	112	~6 litres of oil
	116	
SMC / TSMC 180	186 188	~6 litres of oil

Assessing the oil

Refrigeration machine oil is a vital part of the compressor, as it not only lubricates and cools the movable parts of the compressor, it also prevents abrasive particles from entering the bearings.

An analysis of the oil can give important information on how the compressor is running.

We would, therefore, advise that the **oil analyses** be carried out at the intervals prescribed.

An oil sample must be drawn off while the compressor is in operation, which gives a **representative** sample. Before taking the sample, clean the drain valve and tap a little oil off, to prevent any impurities which may have accumulated in the valve or the piping from mixing with the sample.

Visual assessment

If you pour the sample into a clean, transparent glass bottle or a test-tube and hold it up to a clear light source, it will be easy to assess the quality. You can also compare the sample with the fresh oil of the same make and grade.

An oil which you approve on the grounds of a visual assessment must:

- S be clear and shiny
- S not contain any visible particles
- S feel viscous, smooth and greasy when a drop is rubbed between two fingers.

If you don't feel that you can approve the oil by visual assessment, charge with new oil or send a sample to a laboratory for **analysis**.

Warning

If the oil sample is poured into a glass bottle, this must not be hermetically sealed until all the refrigerant in the oil sample has evaporated. Refrigerant in the oil may produce excess pressure in the bottle with subsequent risks of explosion. Never fill a bottle up completely. Do not send glass bottles through the postal service – use purpose-made plastic bottles. Please see below.

Analytical evaluation

Naturally, the oil sample can be analysed by the oil company which supplies the oil.

As a **special offer to our customers**

SABROE has developed an analytical concept, in cooperation with **Mobil Oil**, which is able to analyse all oil makes. This will mean a uniform reporting of the results.

The analysis allows the following to be determined:

- S Whether or not the oil is still usable, if necessary after filtering.
- S Whether solid particles possibly present in the oil originate from the bearings or other components exposed to wear and tear in which case the compressor must be inspected.
- S Each report will include the corresponding measuring results from **the previous 3 oil analyses**. In this way you will be able to follow up on the state of both the oil and the compressor from one analysis to the next.

Procedure

- A form set with a plastic sampling bottle and a dispatching envelope can be requested from the local Sabroe Refrigeration representation.
- The oil sample must be drained from the cleaned oil drain valve into the sample bottle. Screw the lid loosely on and let the bottle stand for a few hours to enable refrigerant contained in the oil sample to evaporate before sending it to the laboratory.
- Please follow the *Sampling and Shipping Instructions* enclosed in the form set in which the addresses of the laboratory in Holland are also mentioned.

The analysis

The following section states some average values that can be applied in practice. However, you should be on the alert whenever the results of the analyses approach these values. In some cases the water content of 100 ppm in HCFC plants may be too much and thus lead to Cu-plating in the shaft seal. Similarly, a rise in the oil viscosity of max. 65% normally does not cause any operating problems as the refrigerant reduces the oil viscosity in the plant.

Kinematic viscosity at +40°C.

Max. indication from the specified value at +40°C stated in the tables of *Selecting lubricating oil for SABROE compressors*
-15% ◀ specified value ▶ +65%

- Acid number (TAN). max.0.1
- Oxidation. max.7
- Water content (ppm). max.100 (HCFC)
- Water content (ppm). max.600 (R717)
- pH value. min.4 (HCFC)
- pH value. min.5 (R717)
- Strong acids (SAN). max.0
- The oil is filtered through two filters (1,2 micron and 5 micron).

Wear particles expressed in **ppm**, are measured for:

Lead	max.	10
Copper	max.	10
Silicon	max.	25
Iron	max.	100
Chrome	max.	5
Nickel	max.	5
Aluminium	max.	10
Tin	max.	10

A report is drawn up for every sample received. This report indicates:

Whether the oil can still be used – without taking any further action.

Whether the oil can be used after it has been filtered through a very fine filter.

If this is necessary, the oil must be pumped directly from the compressor unit through a 3 micron filter and back to the unit. The system must be completely closed, to prevent the oil being affected by moisture in the air.

Whether the oil is no longer fit for use.

The report will always be sent to the address stated on the sample label included in the form set. A copy will be sent to SABROE Refrigeration, so that we are in a position to advise you, if required.

Pressure and temperature settings for SABROE compressor types SMC-TSMC and CMO-TCMO

			Refrigerant					
			R22	R134a	R404A	R507	R717	
Safety equipment	Safety valve on the compressor	HP	x	x	x	x	x	24 bar (standard)
								22 bar (special)
		IP	x	x	x	x	x	12 bar
	High and intermediate cut-out	KP 5 (KP15)	x	x	x	x	x	Set so that the compressor stops at a pressure 2 bar lower than the safety valve setting.
	Low-pressure cut-out	KP 1 (KP15)	x	x	x	x	x	Set to a pressure with saturation temp. 5°C lower than the lowest evaporating temperature.
	Oil pressure cut-out	MP 55	x	x	x	x	x	3,5 bar ¹⁾
	Discharge pipe thermostat	KP 98	x	x	x	x		* 120 °C
							x	* 150 °C
	Oil thermostat	KP 98	x	x	x	x	x	80 °C
Control equipment	Thermostat for compressor cooling	KP 77	x	x	x	x	x	55 °C
	Thermo valve for compressor cooling	T(E) X T(E) Y T(E) F	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 set. 45 °C See below.
			x				x	Factory set. ** 75 °C See below.
		T(E) X TEA	x					Adjust to min 10°C superheat
							x	Adjust to min 10°C superheat
	By-pass valve	PMC + CVC		x	x	x		-25 °C
							x	-15 °C
	Oil pressure regulating valve		x	x	x	x	x	4.5 bar ²⁾

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

** For TCMO, R717 TEAT 20-2 spec., the factory setting is 85°C.

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.

NB: Factory setting must always be increased by min. 10°C.

Adjustment of the TEAT valve must be carried out with the thermopump out of operation

1) SMC - TSMC - CMO2 - TCMO2 3.5 bar
CMO4 0.8-1.2 bar

2) SMC - TSMC - CMO2 - TCMO2 4.5 bar
CMO4 1.3 bar

Expected discharge gas temperatures

Suction gas superheat °C	Condensing temp. °C	HFC - HCFC																	Condensing pressure bar	R717					
		R134a						R22						R404A/R507											
		Evaporating temperature or intermediate temperature °C						Evaporating temperature or intermediate temperature °C						Evaporating temperature or intermediate temperature °C											
		+10	0	-10	-20	-30	+10	0	-10	-20	-30	Condensing pressure bar	0	-10	-20	-30	-40								
10	20	5.7	38	41	43	48	55	8.2	37	48	61	76	91	11.0	40	42	46	53	62	7.6	53	71	91	110	131
	25	6.6	44	45	48	52	59	9.5	47	57	69	84	101	12.5	44	47	51	58	67	9.1	65	83	102	121	142
	30	7.7	49	50	53	58	66	11.1	55	65	77	92	108	14.3	49	52	56	63	71	10.7	77	95	113	133	151
	35	8.8	53	54	58	64	74	12.7	68	74	85	99	115	16.2	54	57	61	67	75	12.6	89	106	123	141	160
	40	10.1	57	59	63	69	79	14.5	72	82	94	106	120	18.2	59	62	66	72	79	14.6	101	117	133	151	170
	45	11.5	61	63	67	74	82	16.5	81	90	100	112	126	20.5	65	67	71	77	83	16.9	110	126	143	161	—
20	20	5.7	48	51	53	58	65	8.2	48	59	72	88	103	11.0	50	52	56	63	72	7.6	65	83	103	122	143
	25	6.6	54	55	58	62	69	9.5	57	68	80	95	110	12.5	54	57	61	68	77	9.1	77	95	114	132	153
	30	7.7	59	60	63	68	76	11.1	65	76	88	102	117	14.3	59	62	66	73	81	10.7	89	106	125	142	162
	35	8.8	63	64	68	74	84	12.7	73	84	96	109	123	16.2	64	67	71	77	85	12.6	100	116	134	152	—
	40	10.1	67	69	73	79	89	14.5	82	92	103	115	128	18.2	69	72	76	82	89	14.6	111	127	144	162	—
	45	11.5	71	73	77	84	92	16.5	90	98	109	121	133	20.5	75	77	81	87	93	16.9	121	136	154	171	—
30	20	5.7	58	61	63	68	75	8.2	59	70	83	97	113	11.0	60	62	66	73	82	7.6	78	96	115	134	153
	25	6.6	64	65	68	72	79	9.5	69	78	91	105	120	12.5	64	67	71	78	87	9.1	90	106	126	144	163
	30	7.7	69	70	73	78	86	11.1	75	86	98	111	125	14.3	69	72	76	83	91	10.7	102	118	136	154	—
	35	8.8	73	74	78	84	94	12.7	84	95	106	118	131	16.2	74	76	81	87	95	12.6	112	128	146	163	—
	40	10.1	77	79	83	89	99	14.5	92	101	111	123	135	18.2	79	82	86	92	99	14.6	123	138	155	—	—
	45	11.5	81	83	87	94	102	16.5	99	108	117	128	139	20.5	85	87	91	97	103	16.9	132	148	165	—	—
			Discharge gas temp.°C								Discharge gas temp.°C								Discharge gas temp.°C						

Servicing the refrigeration plant

During both start-up and operation it must be made sure that the plant is working correctly.

Compressor and condenser must be able to work satisfactorily, safety devices must be intact and the evaporator must function under load - that is to say:

- the desired temperatures are observed,
- the oil pressure and discharge pipe temperature on the compressor are correct,

- the condenser pressure is not excessively high, and

- the plant otherwise works as it is supposed to.

The service instructions outline some general guidelines for servicing the refrigeration plant, with some references to the instruction manual. The service instructions should therefore be read and followed carefully.

	Check	Interval	Activity
Pressure and temp.	Condensing pressure	Daily	Excessively high pressure may be due to: • reduced cooling effect • air in the condenser. Too low condenser pressure implies a risk of restricting the refrigerant supply to the evaporator.
	Discharge pipe temperature		Normal discharge pipe temperature acc. to instructions.
Filters	Filter in – liquid line – thermostatic valve – suction line – oil return	Clean when needed	Accumulated dirt causes reduced refrigerant supply to the evaporator. If a filter has a hot inflow and cold discharge, this may be due to clogging of the component.
Dehumidifier	Moisture in the sight-glass (on HFC/HCFC installations)	When needed	Some installations are provided with a sight-glass featuring moisture indicator; if the indicator colour switches from green to yellow, there is moisture in the refrigerant. Change the drying filter regularly.

	Check	Interval	Activity
Refrigerant	Refrigerant charge	Periodically	Inadequate charge results in reduced plant capacity and often leads to an excessively high discharge pipe temperature.
	Leak detection		The plant must be searched regularly for leaks. Flanges and joints <i>settle</i> during the plant's initial operation period. They must therefore be tightened and checked.
Automatic controls	Safety pressure controls Automatic operating controls Alarms	Periodically	Adjust operating point and check the function. Replace switch system if sticking.
Electric motor	Lubrication of electric motors	Periodically	Clean and lubricate according to supplier's instructions. At temperatures lower than -25°C, use special lubricant.
	Alignment of coupling V-belt drive		Check in accordance with the instructions of the instruction manual. Tighten loose V-belts, if any, or replace by new ones.
Condenser	Corrosion	Periodically – normally min. 4 times a year	Marine condensers are normally protected against galvanic corrosion by the mounting of corrosion plugs in the condenser covers. Metallic contact between corrosion plug and cover is essential to proper functioning.
Evaporator	Frosting-up	When needed	Problem-free operation is conditional on the evaporator being kept free of ice. Defrost as and when required.
	Oil draining (ammonia plant)	Periodically	Check evaporator, intermediate cooler, receiver, etc. for oil accumulation. Exercise caution; use a gas mask.

Maintenance of reciprocating compressor

SMC 104-106-108 Mk3, TSMC 108 Mk3 - S, L and E

SMC 112-116 and TSMC 116 Mk3 - S, L and E

General

When the compressor requires maintenance, it is important to follow the instructions given below. In order to make sure that the compressor is working correctly, the gauge measurements and screw torques must be strictly adhered to. Before opening the compressor, it is expedient to ensure that you have spares of those seals and gaskets to be stripped down or dismantled. An O-ring which has been exposed to oil and heat for any length of time may have expanded so much as to prevent it being refitted.

All seals and gaskets used are resistant to oil, HFC/HCFC and ammonia. All O-rings are made of neoprene rubber.

Pump-down

Before opening up the compressor for inspection, the pressure inside must be lowered to slightly above atmospheric. This can be done in the following way, depending on whether the compressor is operational or defective.

1. If the compressor is operational

Run the compressor at minimum capacity at normal operating temperature.

Adjust the low-pressure cut-out so that the compressor stops at a suction pressure of approx. 0.1 bar.

Throttle the suction stop valve very slowly. Keep an eye on the suction pressure gauge.

The suction pressure must be lowered slowly enough to give the refrigerant dissolved in

the oil time to escape without the oil foaming. This is of great importance in compressors running on HFC/HCFC. An ammonia compressor can stand having the pressure reduced somewhat more quickly without the oil foaming.

Once the pressure is down to approx. 0.1 bar, stop the compressor and perform the following steps in the order specified:

- Close suction stop valve.
- Cut off power to compressor motor.
- Close discharge stop valve.
- Draw off last remains of refrigerant gas through purge valve Pos. 42.
- Having ensured that power to compressor motor cannot be inadvertently connected, the compressor is ready for opening.
- Remove all fuses, if any.

2. If the compressor is inoperative

- Leave heating rod in crankcase connected for a couple of hours before compressor is due to be opened in order to heat up oil. Warm oil does not contain as much refrigerant.
- Suction stop valve must be open while heating rod is connected.
- Keep discharge stop valve closed.
- Close suction stop valve and disconnect heating rod.
- Equalize pressure in compressor through purge valve Pos. 42.

- Once pressure has been equalized to atmospheric, compressor is ready for opening. Remember to make sure that power cannot be inadvertently connected, thereby starting the motor.
- Remove all fuses, if any.

Dismantling and assembly

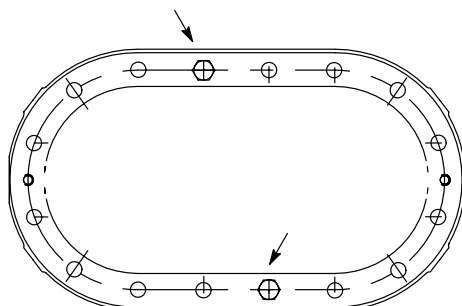
The following sections describe the individual components. When dismantling and assembling, parts should generally be fitted in the same position from which they were taken, and should therefore be marked as they are removed. Further they should be thoroughly cleaned, checked and lubricated prior to being reassembled.

Top covers

Dismantling top cover

Before dismantling the top cover, the relief mechanism must be **deactivated**; this is done by dismantling the **short plug** Pos. 12D and mounting the **long plug** from the tool kit instead. This moves the piston Pos. 12B to the opposite end of the relief cylinder.

Loosen and remove screws Pos. 2E, except for the two screws shown on the drawing.



These screws should be loosened approx. 1 mm, then checking that the cover lifts off the gasket. If, to the contrary, it remains fastened to the gasket, loosen it with a blow on the si-

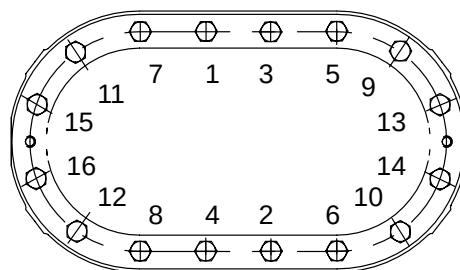
de from a soft hammer **while keeping the two screws fitted**. This must be done because of the powerful spring pressure beneath the top cover. After dismantling the two bolts - unscrewing them alternately - the top cover can be removed.

Fitting top cover

Before fitting the top cover, the **long plug** must be fitted into the relief cylinder. Check, in addition, that the gasket Pos. 2C is intact and, if necessary, check that the **clearance volume** and **lifting reserve** have been adjusted as described later on in these instructions.

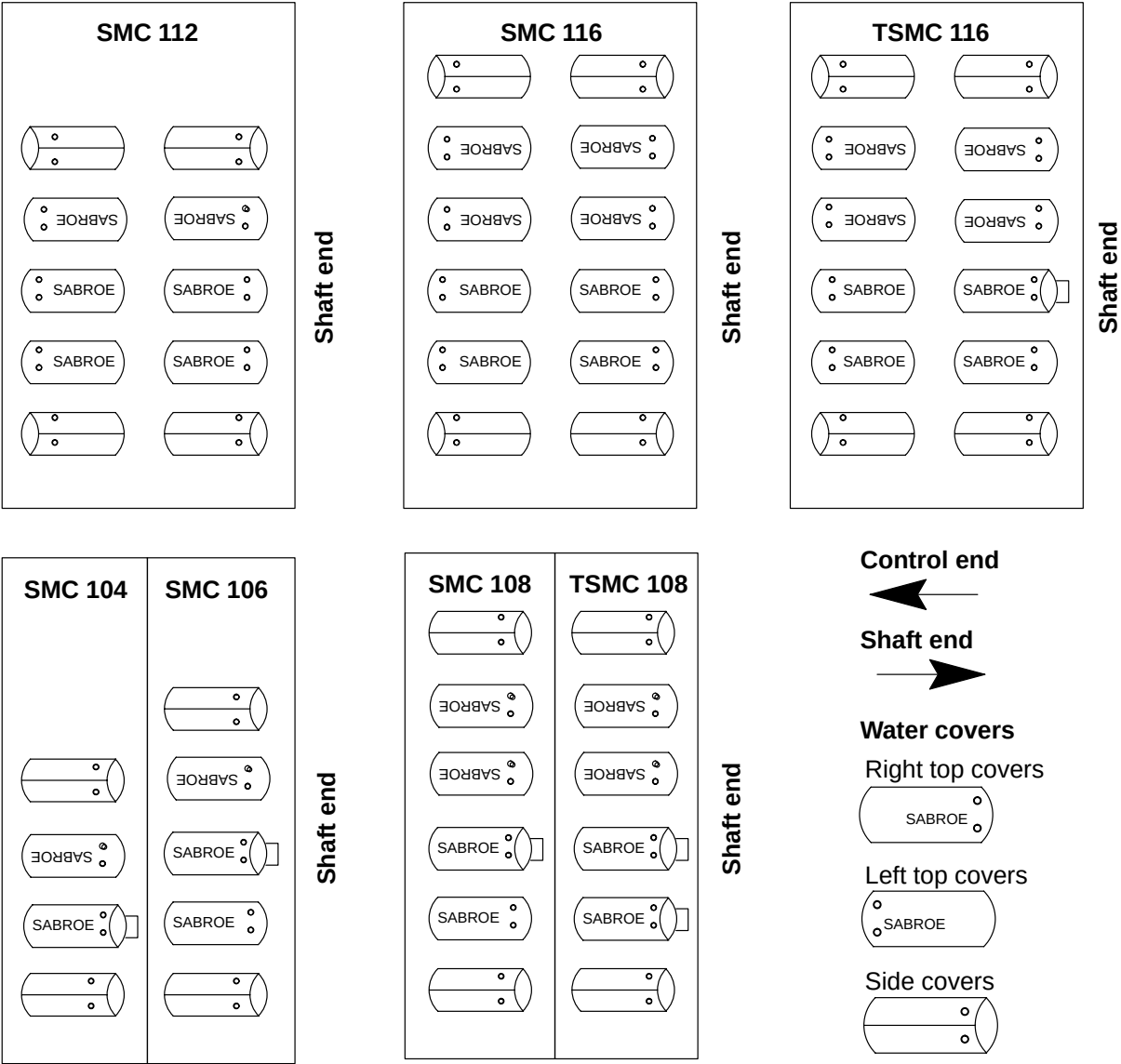
If the gasket Pos. 2C needs to be replaced at all, the graphitized side must face the compressor frame. After placing the top cover loosely on top of the springs Pos. 21, it is recommended that all screws be mounted by hand, as they will jointly guide the top cover into position. Now tighten the top cover firmly with the two screws mentioned above, then with the remaining ones.

Finally, cross-tighten all the screws to the prescribed torque in the following sequence:

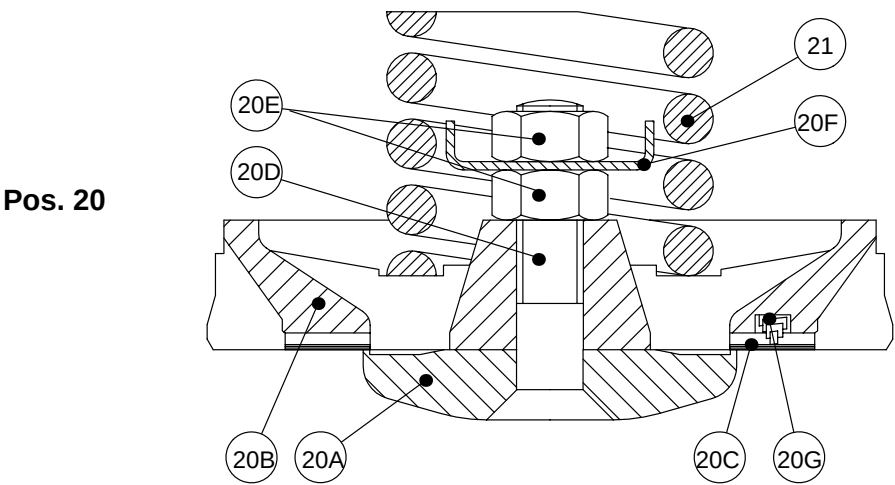


Once the top cover has been fitted, remove the **long plug** and insert the **short plug**. The top covers must be mounted as shown on the following chart.

Mounting top and water covers



Discharge valve



As shown on the above drawing, the function of the discharge valve Pos. 20 is partly to allow the compressed gas to pass from the compression chamber of the cylinder to the discharge chamber beneath the top covers and partly to create a seal from the discharge chamber to the cylinder.

Furthermore, the discharge valve acts as a safety device in the event of liquid refrigerant passing the valve together with the discharge gas, also called liquid stroke. Such stroke should normally not occur, as liquid cannot pass the valve as quickly as the compressed gas. This produces a violent increase in pressure in the compression chamber.

In order to avoid pressure of such intensity that it may damage the bearings in the compressor, the discharge valve is retained in position by the safety spring Pos. 21, which allows it to lift a little under the strain of increased pressure.

Liquid strokes are heard as a distinct hammering in the compressor; the cause must be found immediately and the malfunction rectified.

Discharge valve types:

Depending on the refrigerant and operating conditions under which the compressor operates, various discharge valves need to be used to achieve an optimal function. The discharge valves are selected as shown in the diagram below on the basis of the condensing or intermediate pressure temperature.

Refrigerant	Conditions	Valve type
R717	TC < 15°C	LP
	TC ≥ 15°C	HP
HFC/ HCFC	TC < 15°C	LP
	15°C ≤ TC < 45°C R404A-R507 50°C R22 70°C R134a	HP
	TC ≥ 45°C R404A-R507 50°C R22 70°C R134a	VHP

Marking

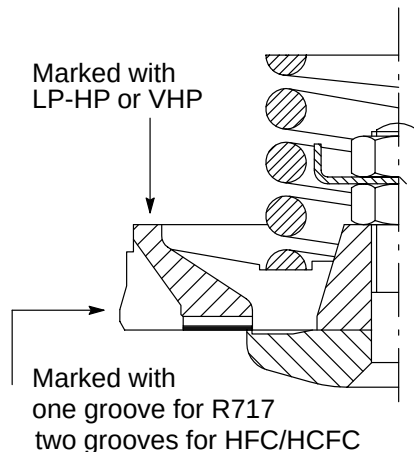
All pressure valves supplied from SABROE today are marked as described below and shown on the sketch.

Refrigerant R717 :

All discharge valves are marked with **one groove**.

Refrigerants HFC/HCFC :

All discharge valves are marked with **two grooves**.



Dismantling

- When top cover has been removed, spring Pos. 21 and discharge valve Pos. 20 can be lifted out by hand. See dismantling of top cover.
- Tighten discharge valve in a soft-jawed vice, then dismantle two nuts Pos. 20E together with spring guide Pos. 20F.
- Screw Pos. 20D, discharge valve seat Pos. 20A and ring plate Pos. 20C can now be disassembled by hand.
- Remove valve springs Pos. 20G by hand.

Assembly

Before assembling the discharge valve, you must make sure that the valve springs Pos. 20G are in good order and fixed firmly in their apertures.

Assemble the discharge valve in reverse sequence to that described above. Note the following, however:

- Tighten bottom nut Pos. 20E to torque of 10.2 Kpm $\approx$ 100 Nm. If need be, exert counterpressure with 5 mm Allen key on bolt head.
- Fit spring guide Pos. 20F and tighten top nut to same torque: 10.2 Kpm $\approx$ 100 Nm.

Tightness testing of discharge valve

This is done by means of the pressure drop test as described elsewhere in this instruction manual.

Service life of discharge and suction valves

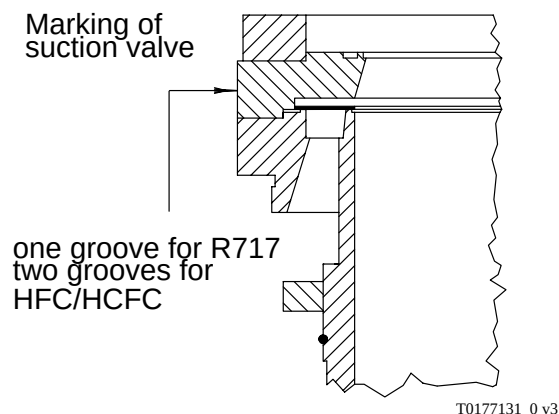
In order to ensure that the compressor always works perfectly, it is advisable - at suitable intervals - to replace the suction and discharge valve ring plates.

It is difficult to give altogether precise times for such replacements, as the durability of the valve ring plates depends on the following factors:

- If the compressor is exposed to liquid stroke or moist refrigerant gas, the service life is reduced.
- Speed of the compressor:
At 900 rpm, the service life of the valve ring plates is considerably longer than at 1500 rpm.
- The compressor ratio at which the compressor operates:
At high compression ratios, the load on valve ring plates and springs is appreciably larger than at low compression ratios. When the valve ring plates are changed, the valve springs should also be replaced.

Cylinder lining with suction valve

Marking of suction valve stop:



The cylinder lining and suction valve form an integral unit which can be dismantled by removing the screws 19N.

In order to gain access to the cylinder lining or suction valve, the top cover, spring Pos. 21, and discharge valve Pos. 20 need to be disassembled.

Extracting cylinder lining

- Rotate crankshaft to position relevant piston at top dead centre.
- Fit the two T-shape extractors no. 3 from tool kit into threaded holes in guide ring Pos. 19J.
- Carefully pull out cylinder lining with suction valve, checking that gasket Pos. 19K remains in frame.
- Insert protective plate no. 5 (from tool kit) between piston and frame so the piston can rest on it. This will enable piston and piston rings to slide onto the protective plate without being damaged when the crankshaft is turned.

Dismantling suction valve

Dismantling the screws Pos. 19N makes it possible for the guide ring Pos. 19J, suction valve stop Pos. 19H and ring plate Pos. 19F to be removed from the cylinder lining. The paper gasket Pos. 19T can be expected to disintegrate during dismantling and require replacement.

Mounting suction valve

Before reassembling the suction valve, you must ensure that the valve springs Pos. 19G are in good order and fixed firmly in their apertures.

Perform the assembly in reverse sequence to that described above. Note the following, however:

- Change paper gasket.
- Before tightening screws 19N, ensure suction valve plate can be moved freely in its guide. Tighten screws Pos. 19N to torque of $1.4 \text{ Kpm} \approx 14 \text{ Nm}$.

Inserting cylinder lining

- Rotate crankshaft to position piston at top dead centre.
- Check that long plug from tool kit is screwed into relief cylinder; see *Top covers section*.
- Check that gasket Pos. 19K is in position on frame.
- Lubricate piston, piston rings and cylinder face with clean refrigeration machine oil. Likewise, grease O-ring Pos. 19M on HP cylinder of TSMC compressor with clean refrigeration oil.
- Rotate piston rings on piston in order to stagger ring gaps at 120° to each other. Press cylinder lining down over piston carefully. The chamfering on the cylinder

interior will catch the piston rings and squeeze them to the diameter of the cylinder. If possible, fit cylinder in same place from which it was taken.

- Press cylinder lining down manually, and with no rotary movements, until it makes contact with gasket Pos. 19K.
- Check clearance volume, which is described in section *Control measurements for insertion of new cylinder lining*.
- Discharge valve Pos. 20 and safety head spring Pos. 21 can then be fitted.
- Fit gasket and top cover.
- Once top cover is in position - see *Top covers section* - remove long threaded plug and screw in short plug, having first checked aluminium gasket Pos. 12E and found it fit for use.

Connecting rod

The connecting rod pos. 17 is made of two parts carefully adapted to each other. The two parts are held together by means of two bolts secured with lock nuts.

Procedure for removing piston and connecting rod

- Bleed compressor of oil and refrigerant and safeguard against any unintended start-up.
- Disconnect any water hoses and other piping connections to top and side covers.
- Dismantle top and side covers.
- Remove spring Pos. 21, discharge valve and cylinder liner.

- Remove nuts Pos. 17D; following this, the bottom part of the connecting rod can be taken out by hand.
- Piston and connecting rod can then be lifted out through the top cover opening on the frame.

The connecting rod Pos. 17 is equipped with independent bearings at both ends. **The big end** is fitted with two bearing half bushes Pos. 17A, consisting of a half-cylindrical steel plate internally coated with white metal. These bearing half bushes are secured in the connecting rod, partly through their fit in the connecting rod bore and partly by a spring which fits into a milled groove in the connecting rod. The opposite end of the connecting rod is fitted with the gudgeon pin bearing Pos. 17B, of which the following two types are found: See *spare-parts drawing*.

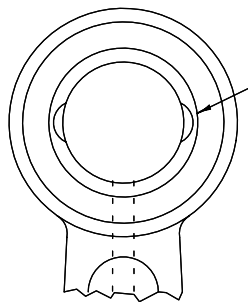
- **The bearing bushing** Pos. 17B-1 is made of special bronze and is also used in R717 compressors. The bearing bushing is used in all SMC compressors and in the low pressure stage on TSMC compressors.
- **The needle bearing** Pos. 17B-2 is 2 mm greater in outside diameter than the above bearing bush and must therefore be fitted in a piston rod bored to the diameter of this bearing. The needle bearing has no inner ring but fits the diameter of the gudgeon pin directly.
- If the bearings in the connecting rod are worn so that the clearance is greater than that prescribed in the table entitled *Various clearances and adjustment measurements*, they must be replaced with new bearings. In this connection, note that undersized half sections of bearing can be supplied for use in the crankshaft where the journals have been ground to a corre-

sponding undersize. See table in section on *Diameters for undersized bearings*.

Fitting bearings

- The bearing bushing or needle bearing can be squeezed into or out of the connecting rod in a vice or hydraulic press. Use softjaws in the vice and use tools which do not damage any components. The bearing bushing must be fitted as shown on the sketch, with the lubricating ducts facing sideways.

Fig. 1



Note:
Sleeve to be fitted with lubricating ducts positioned as shown on drawing.

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Fitting connecting rod

Before fitting the connecting rod in the compressor stand, piston and piston rings must be fitted onto the connecting rod. See the following sections. In addition, the two connecting rod bolts Pos. 17C must be fitted as shown on the spare parts drawing.

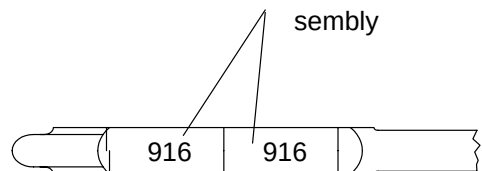
- Fit bearing bushes into both parts of connecting rod.

- Introduce connecting rod down through top cover opening in frame and guide into position on crankshaft manually. Take care so that connecting rod bolts do not leave marks in crankshaft journals.
- Position connecting rod interior through lateral opening on frame, and fit nuts.

Note:

The two parts of the connecting rod are numbered with the same number; this is only of importance when assembling. Parts with different numbers must not be assembled and it is important that the numbers are fitted in the same direction as shown in Fig. 2.

Fig. 2



Note:
Stamped number on the same side on assembly

T0177131_0 v2,b

- Tighten nuts Pos. 17D alternately with increasing torque and finish off with torque wrench.
Torque: 4.4 Kpm $\cong$ 43 Nm.

Piston

The piston is made of aluminium and fitted with two **piston rings**, nearest the piston top, and an **oil scraper ring**.

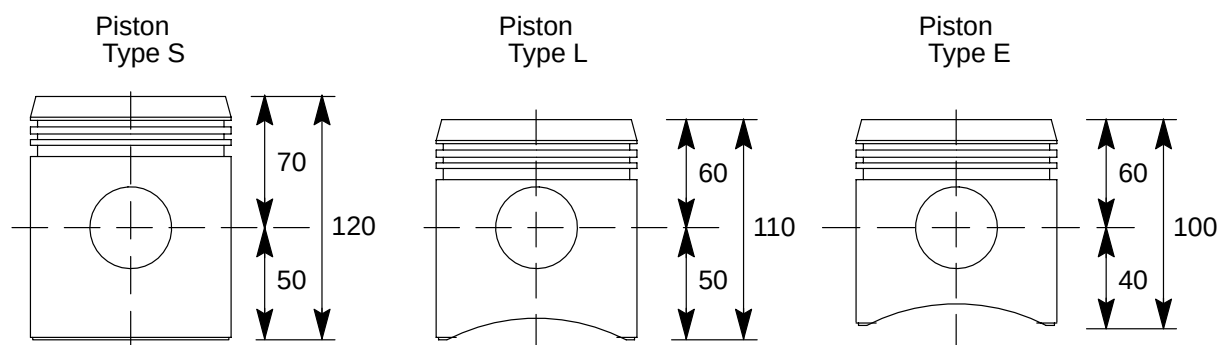
The piston comes in three versions:

For compressors with:

80mm stroke lengths, type S,
100mm stroke lengths, type L, and with
120mm stroke lengths, type E.

The difference is clearly seen from fig. 3.

Fig. 3



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The same piston and piston pin are used, irrespective of whether the connecting rod contains a sleeve or a needle bearing.

Fitting piston rings in piston

Before mounting the piston rings in the piston, their fit in the cylinder lining should be checked by measuring the ring gap. See section entitled *Various clearances and adjustment measurements*.

Assembling and stripping down piston and connecting rod

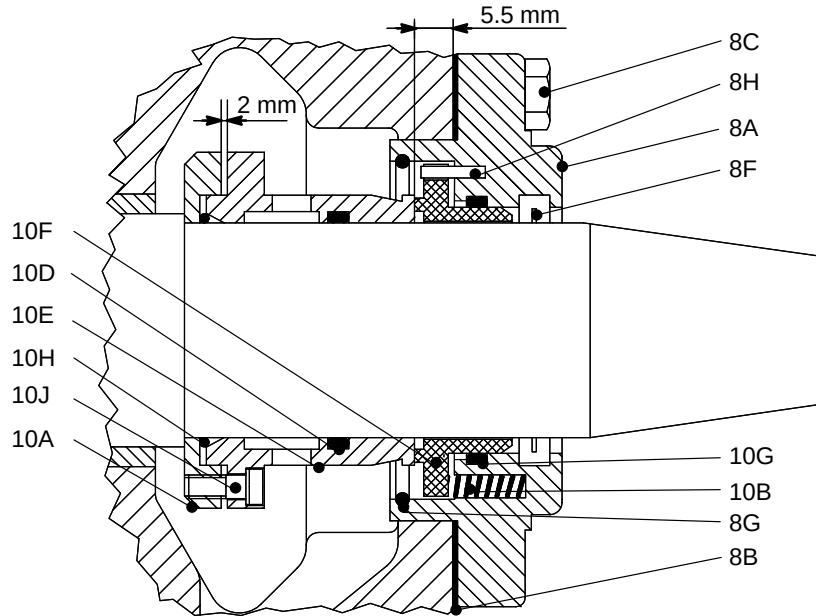
Adopt the following procedure when assembling piston and connecting rod:

- Fit one of the circlips pos. 18D into bore reserved for piston pin.
- Heat piston to 70°C in oil or on hotplate.
- After inserting bearing bush or needle bearing, guide connecting rod into place in heated piston. The piston pin can now be positioned without the use of tools. It is sometimes possible to fit the piston rod by hand without a preliminary heating of the piston.

- Fit last Seeger ring

To strip, reverse sequence; however, do not heat piston, but press piston pin out using a punch or mandrel.

Shaft seal



3126-176-R

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The purpose of the shaft seal is to create a tight seal along the crankshaft between the inside of the compressor and the atmosphere.

It comprises a slide ring Pos. 10E, manufactured from special-purpose cast iron, which is secured to the crankshaft by means of the locking ring Pos. 10H, tightening flange Pos. 10A and the four screws Pos. 10J with spring washers Pos. 10K.

The carbon slide ring Pos. 10F is pressed against the flat-machined, lapped slide ring at the end of Pos. 10E by a series of springs Pos. 10B. The carbon slide ring is prevented from rotating by means of the retention pin Pos. 8H.

The spring pressure, combined with the flat-lapped faces of the two slide rings, ensures an optimal seal between the faces, either when rotating or stationary.

It is recommended to exercise great care with the lapped slide surfaces. Even the slightest scratch or other damage to the slide surfaces will result in leaks.

The O-ring Pos. 10D creates a seal between the slide ring Pos. 10E and the crankshaft. O-ring Pos. 10G seals between the carbon slide ring Pos. 10F and the shaft seal cover Pos. 8A.

When the shaft seal is operating, a tiny amount of oil drifts out between the slide faces to lubricate them. An oil throw ring Pos. 8F has therefore been fitted to prevent this oil migrating along the axle to the transmission linkage.

The thrower ejects the oil into the groove in the shaft seal cover Pos. 8A and the oil is piped via the plastic hose to a plastic bottle positioned under the compressor.

1. Dismantling and stripping down shaft seal

- 1.1. Once the gas pressure in the compressor has been eliminated and the motor safeguarded against inadvertent start-up, dismantle coupling or V-belt disk.

Note:

On units featuring coupling, there is no need to move the motor, as the coupling and the shaft seal can be taken out between the two shaft ends.

- 1.2. Dismantle shaft seal cover Pos. 8A by alternately loosening bolts Pos. 8C so as to displace shaft seal cover outwards without jiggling. This will avoid damage to internal parts of the shaft seal.
- 1.3. Once the spring force is equalized and the bolts removed, the shaft seal cover can be taken off the shaft end by hand. Take care so that no damage is done to the carbon slide ring Pos. 10F which comes out with it.
- 1.4. The carbon slide ring Pos. 10F can be extracted by dismounting circlip pos. 8G as follows:

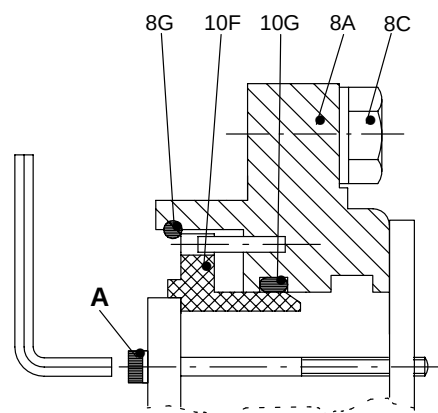
Mount tool no. 2 as illustrated in fig. 3 and tighten screw A so that the carbon slide ring does not touch the locking ring.

Take care not to tighten screw A too much as this could damage the carbon ring.

Circlip pos. 8G is now easily extracted by means of a screw driver without damaging the slide surface of the carbon slide ring.

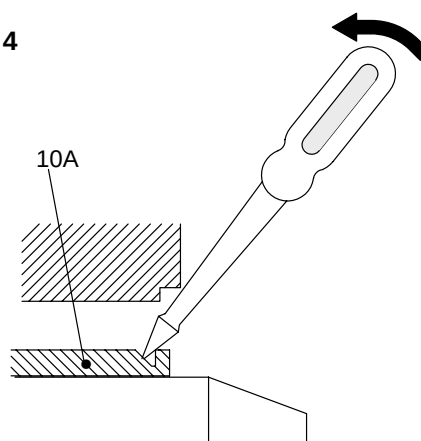
After removing tool no. 2, the carbon slide ring pos. 10F, O-ring pos. 10G and springs pos. 10B (see fig. 2) can now be dismantled.

Fig. 3



- 1.5. Dismantle slide ring 10E by turning the four Allen screws 10J a max. of 2-3 turns; the entire unit can then be taken out with the fingers or using two screwdrivers inserted into the external groove on the slide ring Pos. 10E and moved in the direction of the arrow as illustrated in fig. 4.

Fig. 4



- 1.6. O-ring Pos. 10D can now be removed.

Assembling and mounting shaft seal

After thoroughly cleaning the crankshaft, check that its sealing faces are smooth and free of scratches, blows and wear marks. Then oil the crankshaft and the shaft seal components thoroughly with the same type of oil as used in the compressor.

2. Unit with slide ring, Pos. 10E

- 2.1. Before fitting slide ring Pos. 10E, tighten screws Pos. 10J until there is approx. 2 mm spacing and parallelism between the two flanges. Check also that locking ring Pos. 10H is mounted as shown in the drawing and that O-ring Pos. 10D is in position.
- 2.2. Position slide ring Pos. 10E on shaft and ensure tightening flange makes contact with shaft shoulder.
- 2.3. Crosswise, tighten screws Pos. 10J alternately with Allen wrench from tool kit. The torque is specified in the instruction manual.
- 2.4. Check axial position of shaft seal by measuring distance from frame sealing face to slide face on Pos. 10E. This must measure approx. 5.5 mm, as shown in the drawing.

3. Unit with shaft seal cover Pos. 8A

- 3.1. Mount O-ring Pos. 10G and the ten spiral springs 10B in shaft seal cover Pos. 8A, then position carbon slide ring Pos. 10F carefully. Rotate carbon slide ring so slot fits in over retention pin Pos. 8H.
- 3.2. With tool no. 2 fitted as shown in fig. 3 press carbon slide ring pos. 10F against spring pos. 10B. Locking ring Pos. 8G can now be fitted. Observe closely that the carbon slide ring is not overloaded by misbalanced pressure and that its slide face is not damaged.
- 3.3. Give complete shaft seal cover an extra oiling on slide face of carbon slide ring and guide it in over shaft together with gasket Pos. 8B.
- 3.4. Gently pressing shaft seal cover and carbon ring in against slide ring Pos. 10E without compressing springs Pos. 10B,

measure distance from gasket Pos. 8B to sealing face of shaft seal cover.

This distance must be about 3 mm.

Make sure the hose branch Pos. 8D faces down.

- 3.5. Mount screws Pos. 8C and tighten evenly, crosswise. This will avoid damaging the carbon slide ring. Tighten screws Pos. 8C to prescribed torque according to table in instruction manual.
- 3.6. Mount oil throw ring, as shown in drawing.
- 3.7. After mounting coupling half or V-belt disk, it must be possible to turn the crankshaft easily by hand.

Crankshaft

The crankshaft is made of heat-treated SG cast iron with fine strength and glide properties. The bearing journals are superfinished and oil channels are bored for all lubricating points.

At the centre and end of the crankshaft, the oil channels are blanked off with 3 blind plugs on the SMC 104 - 106 - 108, and 6 plugs on the SMC 112 and 116.

When fitting the crankshaft, it should be checked that the plugs are mounted and tightened. By way of bores in the counterweights, the crankshaft is dynamically balanced with regard to 1st and 2nd order forces.

The crankshaft is available in three versions: an **S** type for compressors with short strokes (80mm), an **L** type for longer stroke (100mm) and an **E** type for the longest strokes (120mm). The crankshafts have an S, L or E stamped into the connecting end.

Dismantling crankshaft

Dismantle the crankshaft through the pump end of the frame in the following way:

- Bleed compressor of oil and refrigerant and safeguard against inadvertent start-up.
- Dismantle top and side covers.
- Dismantle all cylinder linings.
- Extract all pistons and connecting rods.
- Pull off V-belt pulley or coupling half .
- Dismantle shaft seal cover and shaft seal.
- Dismantle cut-outs and pipes to manometers, or piping connections to UNISAB.
- Dismantle end cover, Pos. 4A.
- Dismantle oil filter.
- Dismantle oil pump drive and oil pump.
- On **SMC/TSMC 112-116** loosen the middle bearing by dismantling the plugs pos. 49H as well as gasket pos. 49J in both sides of the compressor. Next, dismantle screws pos. 49F and locking plates pos. 49G.
- Rotate crankshaft to place connecting rod journals on horizontal level.
- Dismantle bearing cover at pump end and support the crankshaft by means of a board inserted through the side openings.
- After this the crankshaft can be drawn out of the frame. The crankshaft must still be supported.
- The middle bearing on **SMC/TSMC 112-116** can be dismantled by removing screws pos. 49B and shims pos. 49C as well as guide pins pos. 49D.

Inspection

Check bearing journals on connecting rods for wear and tear and, if necessary, measure diameter of journals. The maximum wear on the bearings is shown in the section *Various clearances and adjustment measurements*. In most instances, the permissible play in the bearing can be obtained by replacing the bearing half bushes. The bearing journals on the main bearings are normally subject to very little wear, but should be checked measured during main overhauls. If wear and tear exceeds the play stated, the crankshaft can normally be ground to 0.5 mm undersize. For the ground crankshaft, main bearings and connecting rod bearings with an undersize of 0.5 mm can be supplied as stated in the parts list.

The drawing for grinding the crankshaft to undersize is found in this instruction manual.

Note:

After grinding the crankshaft, all lubricating channels must be thoroughly cleaned with an approved cleansing fluid and blasted with compressed air. Remember to refit the blind plugs.

- Check sealing face for O-ring seal, Pos. 10D, on shaft seal. The surface must be bright and free of scratches and marks.

Refitting crankshaft

Refit the crankshaft in the reverse order to that for dismantling. Note the following, however:

- After the crankshaft has been inserted into the housing, mount main bearing cover Pos. 5A using gasket Pos. 5D as a shim.
- Check end play on crankshaft by pressing shaft up against pressure bearing Pos. 6C and measure clearance in the other bearing, using a feeler gauge.

The permissible end play is indicated in the section *Various clearances and adjustment measurements*.

End play adjustment is achieved by means of the gasket Pos. 5D.

The gasket can be supplied in the following thicknesses, see the *spare parts list*:
0.25mm 0.50mm 0.75mm 1.0mm

Main bearings

The main bearings pos. 5C and 6C are mounted on the main bearing covers and their purpose is to guide the crankshaft both radially and axially.

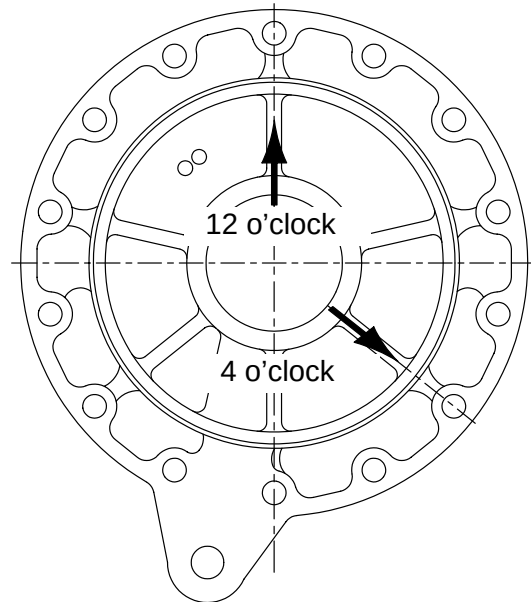
They consist of a steel bushing with collar. The collar and the inside of the bushing are provided with a thin white metal coating.

The bushing can be pressed out and replaced by new ones and need no further machining after mounting.

On mounting the bushings it is recommended to secure them with **Loctite 601**.

When a new bearing bushing **pos. 6C at the shaft seal** end is put into place in cover pos. 6A the in- and outlets of the lubricating channels must be positioned in a **four o'clock** position as illustrated on fig. 1 below. The bearing bushing pos. 5C is positioned with in- and outlets in a **12 o'clock** position.

Fig. 1 Mounting of bearing bushing pos. 6C



Cover pos. 6A seen from the inside of the compressor

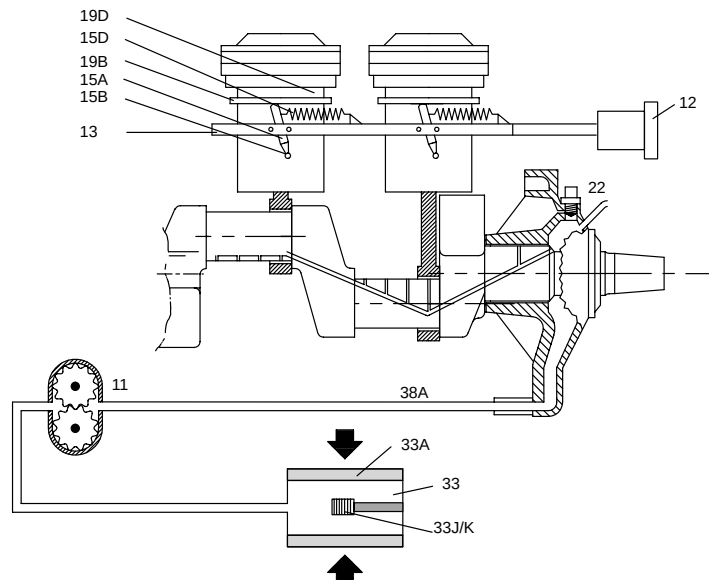
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The bearing bushings can be delivered with crankshafts ground to undersize. See Spare Parts List.

The crankshaft for the SMC 112 and 116, and for the TSMC 116, is fitted with a centre bearing. This is fitted with four sets of bearing half bushes of the same type as used in the connecting rods. The centre bearing housing is made up of two half parts which must be clamped around the crankshaft before this is inserted into the compressor stand.

The half parts are assembled by means of four screws and guided together with the aid of cylindrical guide pins. The bearing housing is prevented from rotating by two screws Pos. 49F. These screws are accessible only when the threaded plug Pos. 49H has been removed. The screws can be removed using a box wrench NV 17 and crank from the tool set.

Compressor lubricating system



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The oil pump pos. 11 sucks oil from the crankcase, through the filter element Pos. 33, where the oil passes the filter element pos. 33A and past the magnetic filter pos. 33J/K, as shown on the spare parts drawing. The pump forces the oil through an internal pipe, pos. 38A, until it reaches the shaft seal housing.

The filter element Pos. 33A is a disposable filter which cannot be cleaned. See description of oil filter.

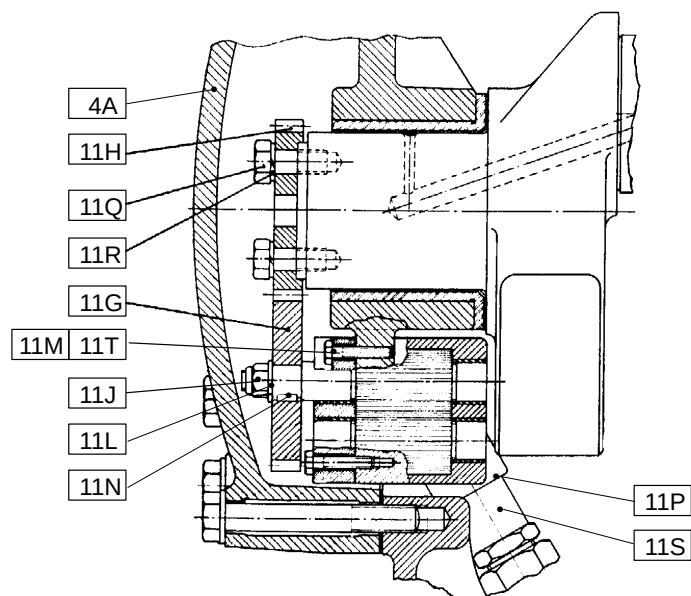
The shaft seal housing forms a distribution chamber for the oil. The oil pressure in the shaft seal housing is adjusted by means of the oil pressure regulating valve Pos. 22, which is mounted in the shaft seal housing. The regulating valve can be adjusted from the outside by means of a screwdriver. Clockwise rotation increases the pressure; anticlockwise rotation lowers the pressure.

Excess oil is returned through a bored channel to the crankcase.

From the shaft seal housing, the oil is distributed as follows:

- Through the bored channels in the crankshaft to lubricate main and connecting rod bearings. Lubrication of piston pin bearings is done by splash lubrication through a countersunk hole in the top of the connecting rod.
- To the differential oil pressure cut-out and the pressure gauge. The effective oil pressure can be read straight off the manometer (the suction pressure gauge of the compressor).
- Through external oil pipes, on to the regulating cylinders Pos. 12 for unloaded start and capacity regulation.

Oil pump



The oil pump is a gearwheel pump driven by the crankshaft via a pinion drive.

It is therefore important to ensure that the direction of rotation of the crankshaft is as indicated by the arrow on the bearing cover Pos. 6A.

If the crankshaft is to turn in the opposite direction of rotation, the oil pump can be fitted with a chain drive. See next section.

Dismantling the oil pump

Having bled the compressor of oil and refrigerant and secured it against inadvertent start-up, proceed as follows:

- Dismantle end cover Pos. 4A and side covers Pos. 3.
- Dismantle internal oil pipes and nipples screwed into pump.
- Dismantle nut Pos. 11J and extract gearwheel pos. 11G.

- When the four M6 screws pos. 11M securing the oil pump to the bearing cover have been removed, it can be taken out by hand.

Note:

The oil pump normally has a very long service life. Therefore, it is not worthwhile repairing it. Rather replace it with a new one.

Mounting the oil pump

Before finally tightening the oil pump firmly to the bearing cover, the following adjustment must be made to the gearwheel drive:

The play between the two teeth when engaged must be **0.05-0.08mm** measured with a feeler gauge. Repeat the measurement six times, turning the crankshaft 60° between each measurement, and adjust until the smallest play is measured to be as started above.

Chain-driven oil pump with inverse direction of rotation

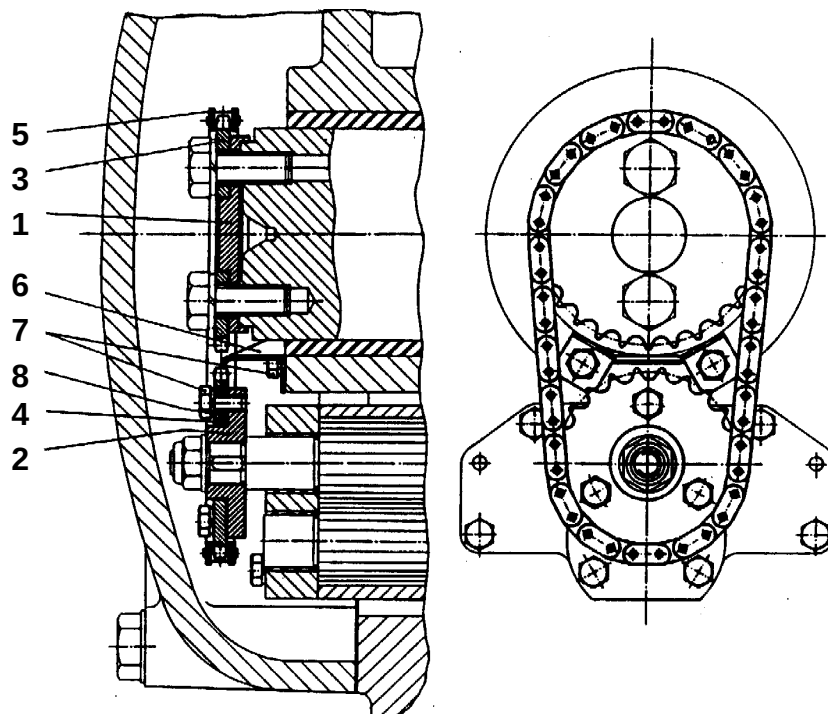
If the SMC 100 compressor is to run in the opposite direction of rotation to that shown by the arrow on the bearing cover Pos. 6A, the gearwheel drive on the oil pump must be replaced with a chain drive.

To this end, use a set of replacement parts,

stores no. 3141-127. This set contains a chain, a chain wheel (springs for old shaft seals only) and a baffle for lubricating oil, as well as all screws needed.

In case the compressor is driven by an electric motor, attention should be paid to the prescribed direction of rotation of the motor.

See section: *Direction of rotation of the compressor.*



1	Hub for the chain wheel	5	Endless chain
2	Hub for bottom chain wheel	6	Baffle for lubricating oil
3	Top chain wheel	7	Set screw M6 x 12
4	Bottom chain wheel	8	Spring washer for M6

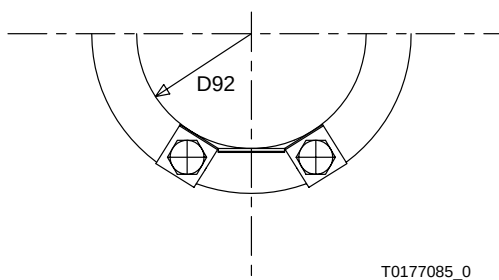
Assembling instructions

The chain system can be mounted on all types of SMC/TSMC compressor. On older compressors, however, a little adjustment may be necessary, as detailed below:

- Dismantle the two gear wheels by removing screws Pos. 11Q and nut Pos. 11J.
- On older compressors, the oil pump is linked to the principal bearing cover Pos. 5A by 2 guide pins and retained by four M6 screws. Remove two guide pins here and bore the free holes for screws up to a diameter of 8 mm. This should be done after the oil pump has been dismantled. On more recent compressors, the free

holes are oval-cast to give scope for adjustment, and there are no guide pins.

- Mount lubricating oil baffle as shown on drawing. Drill two M6 threaded holes and tap, using baffle as template; position so that the baffle is at a tangent to the external diameter of the bearing bush $D = 92$ mm.

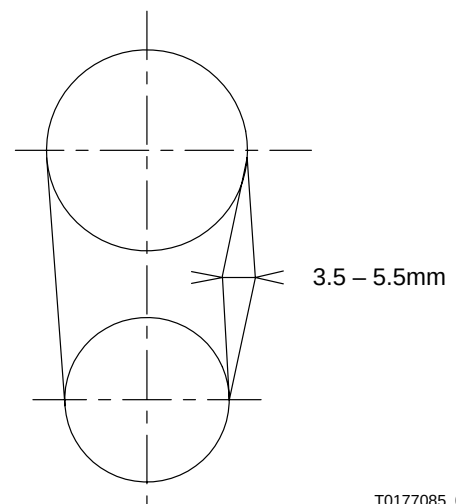


Screw dimensions: M6 x 12 mm
 Thread depth: 5 mm
 Drilling depth: 20 mm
 Core drill: 5 mm
 Secure screws with spring washers.

- Slightly tighten four screws securing oil pump to bearing cover.
- Place chain wheel with hub Pos. 4 and 2 on pump shaft. The retainer nut can be tightened once the entire chain drive has been mounted.
- Place the assembled chain, hub and chain wheel, Pos. 5, 1 and 3, in position; tighten wheel firmly with screws Pos. 11Q from gearwheel drive.

Adjusting the chain drive:

- Tighten chain by shifting oil pump. The correct tension of the chain is shown on the sketch.



Finally, when the proper centre distance has been established, secure oil pump tightly.

- Tighten chain wheel on oil pump.

Marking direction of rotation

The arrow on the end cover of the compressor should be cancelled out and replaced by one painted on the indicate the new direction of rotation.

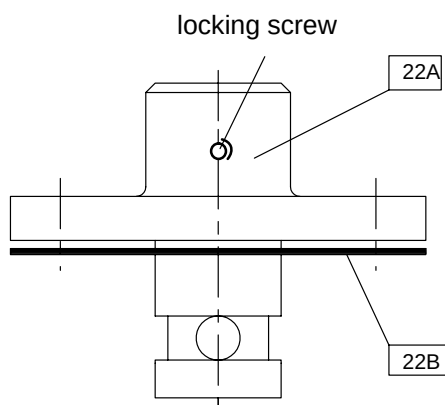
Oil pressure valve

The oil pressure valve pos. 22 regulates the oil pressure in the compressor. Mounted in the cover Pos. 6A, it connects directly with the oil pressure chamber in the shaft seal housing.

The oil pressure is regulated by a spring loaded cone, the spring pressure being adjusted by turning an adjusting screw at the valve end. Use a screwdriver for this purpose.

Turning to the right (clockwise) raises the oil pressure; turning to the left (anticlockwise) lowers the pressure.

Fig. 1



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Adjustment

Oil pressure: 4.5 bar.

The oil pressure can be read off the suction pressure gauge or on UNISAB II.

On more recent compressor models the adjusting screw may be locked by means of an M6 pointed screw, fig. 1, which must be loosened before adjustment can take place.

Service

Since the oil pressure valve is not subject to any appreciable wear or soiling, it should not be disassembled during routine services.

In the event of a malfunction, the complete valve should be replaced.

By-pass valve pos. 24

The compressor is equipped with a built-in mechanical by-pass valve, fig. 1, which safeguards it against any inadvertent excess pressure if the electrical safety equipment fails. The by-pass valve safeguards against any excess pressure between the discharge and suction sides of the compressor.

If the by-pass valve goes into action, the compressor must be immediately stopped and the cause established.

The by-pass valve is supplied ready-set and sealed in accordance with the adjustment pressures indicated in the table *Pressure and temperature settings*. The actual set pressure is stamped on the rating plate, pos. A.

The by-pass valve is of the **high-lift type** which makes it very sturdy and durable.

Further, the by-pass valve is independent of the pressure on the compressor suction side. Consequently, it only opens when the pressure on the discharge side exceeds the set pressure in relation to atmospheric.

Thus, watch out that hole pos. B does not get covered or clogged.

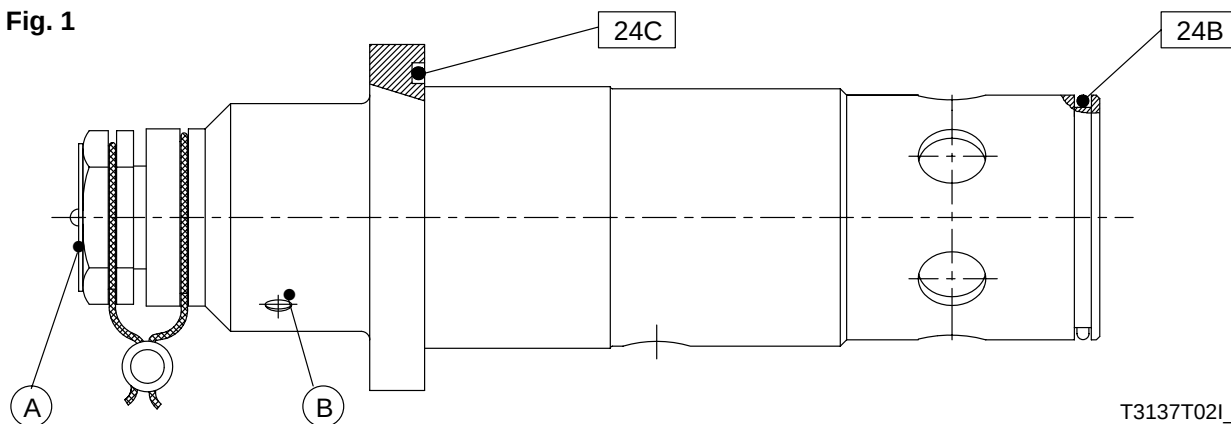
In case the pressure on the discharge side exceeds the set pressure so that the by-pass valve opens, the valve will remain open until the pressure on the discharge side has fallen to approx. half the set pressure. The valve then closes automatically. However, at great differential pressures across the compressor the valve may remain open. In that case, stop the compressor and close the discharge stop valve entirely. The equalization of pressure in the compressor will then close the safety valve and the compressor can be re-started.

The by-pass valve is supplied factory-set and sealed and need normally not be disassembled and readjusted.

If necessary, control of function and set pressure must be made in accordance with local regulations for safety valves.

On the outside the by-pass valve is sealed with two O-rings, pos. 24B and 24C. Fasten it to the compressor housing by means of screws pos. 24D and washers pos. 24E.

Fig. 1



Oil filter

All oil to the lubricating system of the compressor is filtered through a oil filter installed in the crankcase. The filtration element is a filter cartridge (Pos. 33A on the drawing) which is non-cleanable and must be replaced with a new one when the filter capacity is used up.

It is important, therefore, always to have an extra filter cartridge available.

Filter cartridge

As shown in fig. 1 the filter cartridge pos. 33A is a single unit consisting of a 60 μ primary filter, a magnetic filter and a shield which covers half of the filter.

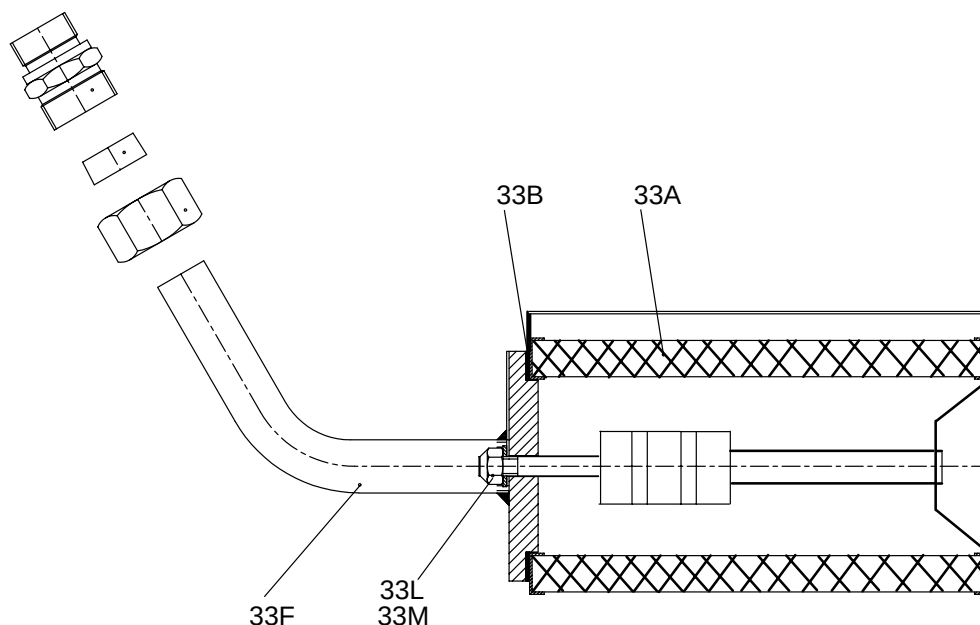
The filter cartridge is fastened to bracket pos. 33F by means of a lock nut pos. 33M and a washer pos. 33L. The gasket pos. 33B seals off the filter cartridge and the bracket pos. 33F.

Changing filter cartridge

The filter cartridge should be replaced at regular intervals. See the section entitled *Servicing compressors* on this point. In particular, it should be remembered that the filter cartridge must often be replaced after a relatively short operation time following initial start-up.

This is due to small particles of dirt originating from the plant during the initial operating period.

Fig. 1



Before changing the oil filter cartridge all preparations in connection with the opening of the compressor must be carried out in accordance with the instruction manual.

- Dismount the lock nut pos. 33M and washer pos. 33L and remove manually the

filter cartridge pos. 33A and the gasket pos. 33B.

Proceed as follows:

- Let the bracket pos. 33F stay mounted in the compressor.

- When mounting the new oil filter cartridge as illustrated in Fig. 1, first place the gasket pos. 33B on the bracket pos. 33F.
- Then place the oil filter cartridge pos. 33A on the bracket pos. 33F and turn it so that

the closed shield on the filter **faces upwards**.

Then fasten the filter by means of the lock nut pos. 33M and the washer pos. 33L.

- Tighten the nut pos. 33M to a torque of 4.5 Nm.

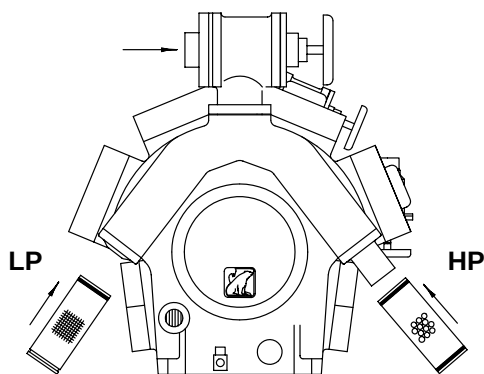
Suction filters

The purpose of the filters is to collect impurities conveyed from the plant to the compressor with the suction gas and thus prevent them from penetrating into the compressor.

The suction filters therefore have a very fine mesh and as an additional precaution have a filter bag insert, which should normally be used for 50 operating hours from the initial start-up of the compressor. The filter bag is then removed and disposed of.

If the filter bag is badly soiled after the 50 operating hours mentioned, it is recommended that a new bag be fitted for an additional 50 operating hours. Similarly, a filter bag ought to be fitted for a period of 50 operating hours after any major repair work to the refrigeration plant.

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On TSMC compressors, the suction filter located on the lefthand side opposite the low-pressure cylinders (see drawing) is the same type as on SMC compressors, i.e. open at both ends and having an O-ring in the end facing up towards the suction stop valve.

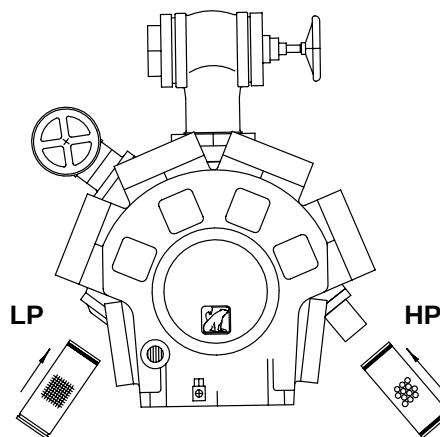
Note:

Do not forget to remove the filter cartridge after 50 operating hours, as a blocked filter bag may cause the suction filter to burst and thus contaminate the compressor to an extreme degree.

There are always two suction filters in the compressor and these are removed through the flanged opening in the bottom end of the filter housing. Attention is drawn to the fact that there are two types of suction filter, as detailed below:

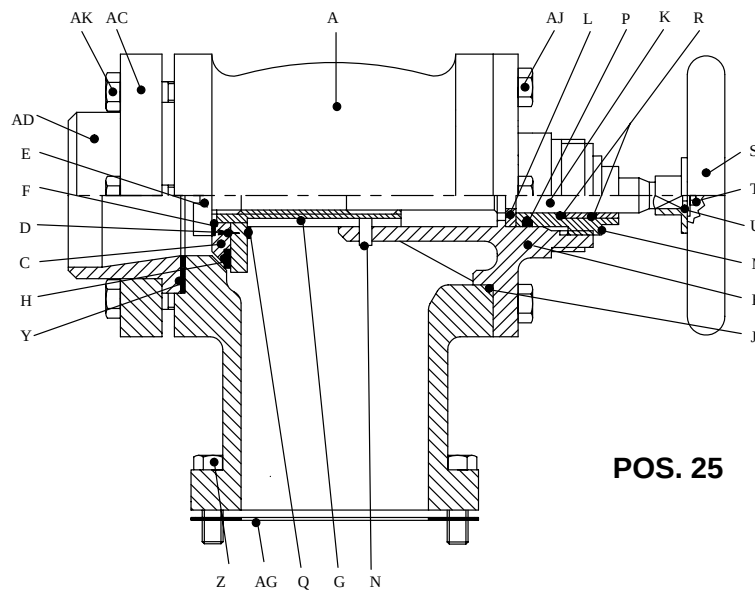
On SMC compressors, the two suction filters are identical and should only be fitted with an O-ring in the end facing up towards the suction stop valve. The filters are open at both ends.

TSMC 116



The suction filter fitted on the righthand side opposite the high-pressure cylinders has a closed end-bottom which must face upwards and close towards the suction stop valve. This suction filter must be fitted with O-rings at both ends.

Stop valves



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The suction and discharge stop valves are used to isolate the compressor from the refrigeration plant.

They are closed completely by manual tightening and it is therefore advisable not to use any tool to close the valve, as this will simply overload the valve parts.

The valve seat is sealed with a teflon ring Pos. 25H which, if necessary, can be replaced as follows:

Dismantling of valve:

- Once the pressure on the inlet and discharge sides of the valve has been equalized to atmospheric, dismantle screws Pos. 25AJ. The valve throat Pos. 25B, and with it the entire valve insert, can then be removed.
- Turn spindle clockwise until cone and threaded piece Pos. 25G can be removed by hand.

- Mount threaded piece Pos. 25G in a soft-jawed vice and dismantle screw Pos. 25E.

Note:

The screw has a lefthand thread, and it is therefore inadvisable to leave the threaded piece in the valve holder while dismantling the screw, as the guide pin Pos. 25N will be overloaded.

- The front and rear pieces Pos. 25C and 25D can now be separated and the Teflon ring Pos. 25H removed. The Teflon ring will be flattened on one outer edge, which is normally of no importance to its sealing ability providing it is free of scratches and marks.
- If required, the Teflon ring can be reversed when reassembling so that the other outer edge seals towards the valve seat in the housing.

Reassembly of valve:

Reassembly is done in the reverse order to that above. Note the following, however:

- Before mounting the complete valve insert, the valve cone with threaded piece Pos. 25G must be screwed right into the valve neck Pos. 25B.
- The O-ring Pos. 25J may have expanded under the influence of the oil in the plant and will normally have to be replaced with a new one.

The stop valve has a so-called **retroseal**, which enables the packing screw joint

Pos. 25M to be serviced even when there is excess pressure in the valve housing.

Adopt the following procedure:

- Using handwheel, open valve completely to achieve a seal between valve cone and valve throat. The gasket Pos. 25Q acts as a sealing element.
- The packing screw joint Pos. 25M can then be screwed out for inspection or replacement of the O-ring Pos. 25R and 25P. Thoroughly lubricate all parts with oil before reassembling.

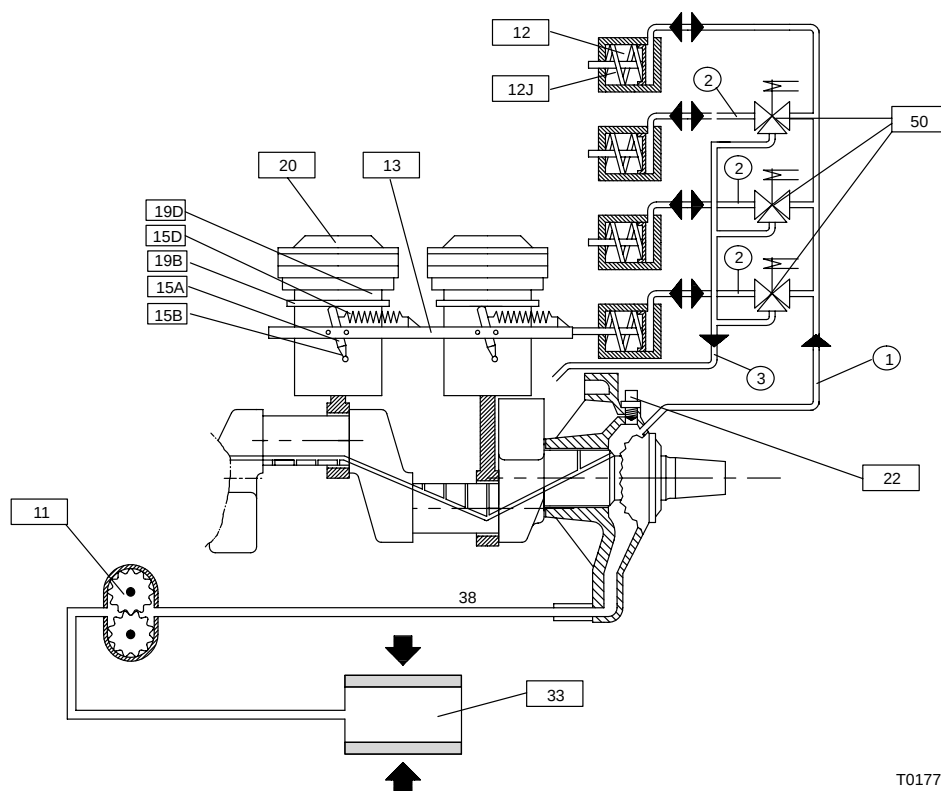
Unloaded start and capacity regulation on SMC and TSMC 100 and 180 compressors

SMC and TSMC compressors are equipped with an automatic unloader system to provide full relief to the compressor during the start-up phase. This reduces the starting torque of the compressor considerably.

The unloader system is also used to regulate the capacity of the compressor.

The following schematic outline shows the lubrication and hydraulics system on the compressors together with unloader mechanism.

Fig. 1



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Description of unloader mechanism and capacity regulation

No-load starting and capacity regulation are achieved by keeping the suction valve ring plate in the **open** position; the refrigerant gas thus aspirated into the cylinder is not compressed but thrust back out through the suction valve.

See the blue spare parts drawing of the cylinder linings at the end of this manual.

Around each pair of cylinder linings a frame Pos. 13 is fitted, controlling two sets of rocker arms Pos. 15A. The frame is connected by means of a piston rod to the regulating piston in the unloading cylinder pos. 12.

When the regulating piston is unaffected by the oil pressure - i.e. when the connected solenoid valve is de-energized or when the compressor is at standstill - the regulating piston and the entire frame are shifted to the right by the pressure from the springs Pos. 12J (see fig. 1) .

The tension springs Pos. 15D will thus raise the rocker arms Pos. 15A into the vertical position, as these rotate in the ball sockets Pos. 15B.

This movement lifts the relief ring and the pins Pos. 19B, opening the suction valve by force.

If oil pressure is placed on the relief cylinder during operation, the unloader system is shifted to the left (see sketch). This lowers the rocker arms Pos. 15A, and the relief ring with pins Pos. 19B is moved away from the suction valve ring plate, allowing this to oper-

ate freely and close during the compression phase.

During operation, the unloader system can therefore regulate the capacity of the compressor by causing the solenoid valve - which is linked to the relief cylinder - to open or close for oil pressure to the relief cylinders, controlled by an electrical regulation system.

On TSMC compressors, attention is drawn to the two types of relief cylinder - for the LP and HP stage, respectively, as shown on the spare parts drawing.

Note:

Adjust the oil pressure on the regulating valve Pos. 22 to 4.5 bar. At an oil pressure lower than 3.5 bar (the breaking pressure for the safety automatics), there is a risk of the unloader system not being moved effectively and thus being damaged.

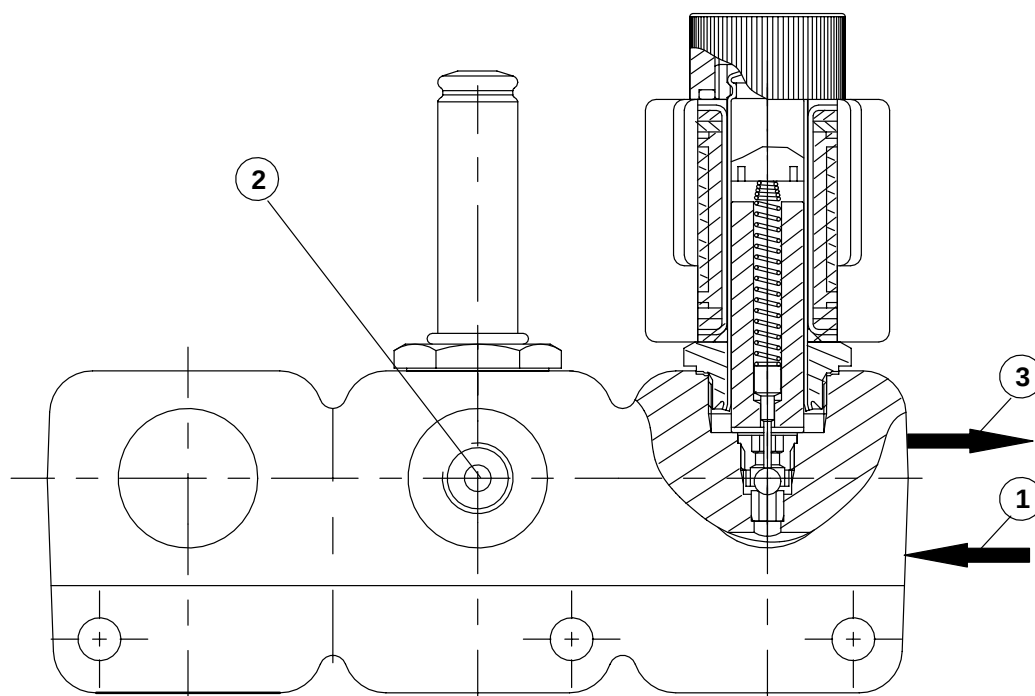
Pilot solenoid valves

The pilot solenoid valve is an electromagnetic three-way valve which with a dead coil connects the unloading cylinder to the crankcase (the path for the oil flow from pipe 2 to pipe 3 is open). See fig. 1. If the coil is energized, the valve switches so that the path for the oil flow from pipe 1 to pipe 2 is open and the connection to pipe 3 is closed off.

The solenoid valves are integrated in blocks (fig. 2) with 1,2,3, or 4 solenoid valves in each block. In these blocks the solenoid valves have a collective supply of pressure oil (pipe 1) and a collective connection to the crankcase (pipe 3). Each individual solenoid valve has its own oil connection to the relevant unloading cylinder (pipe 2).

Sectional drawing of capacity regulating valve

Fig. 2



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Schematic outlines

The following schematic outlines shows the oil pipe connections and the wiring diagram with cut-out functions.

The schematic outlines also indicate the percentual capacity at which the compressor operates at the various capacity stages.

The lowest capacity percentage indicated on schematic outlines 1 corresponds to the lowest permissible capacity step at which the compressor may work by continuous operation.

In special instances, e.g. where the start-up phase is lengthy, it may prove necessary to relieve the compressor altogether until the motor has achieved a sufficient torque. In such cases, an extra solenoid valve marked 'S' can be mounted as shown on schematic outlines 2.

The S-valve is connected to the regulating cylinder(s) not involved in capacity regulation.

The valve is designed to prevent fast rising oil pressure actuating the compressor cylinders before the motor starter has changed over to the delta position, or a gas or diesel motor has reached full rotation speed.

TSMC compressors are always equipped with S-valves and thus feature totally unloaded start as standard.

Note:

*Please note that the solenoid valve S must **not** be wired so as to form part of the capacity regulation.*

The compressor may operate totally unloaded for no more than 5 minutes, as its operating temperature will otherwise become too high.

Standard unloaded start and capacity regulation

The SMC and TSMC compressors always start **totally unloaded** and in their standard design will activate a number of cylinders corresponding to the lowest capacity stage once the oil pump has built up the necessary oil pressure.

See discussion of the 'S' solenoid valve in the *Totally unloaded start and capacity regulation* section, however.

It is recommended that solenoid valves be wired so as not to receive the opening signal until the drive motor has achieved full torque.

Schematic drawings 1

Regulating sequence

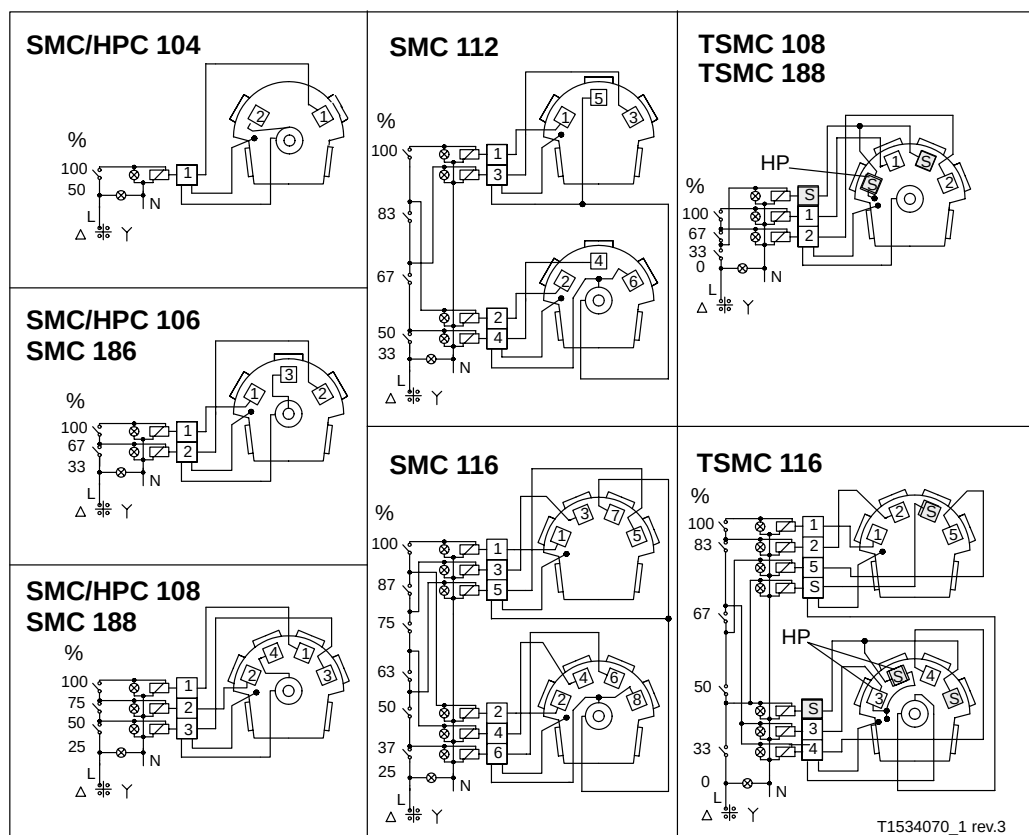
The unloading is effected for two cylinders at a time by cutting off the voltage to the accompanying solenoid valve.

The **unloading** must be effected in numerical order (1 - 2 - 3 - 4), while **loading** should be done in reverse order (4 - 3 - 2 - 1).

Note:

*TSMC 116 **must** always have valves 3 and 4 connected simultaneously, as this capacity stage includes both low- and high-pressure cylinders.*

The regulating sequence may be seen from the schematic drawings.



Totally unloaded start and capacity regulation

Further to the standard equipment, as shown on the previous page, the compressor may feature an extra solenoid valve marked S. TSMC compressors, however, are invariably equipped with this S-valve.

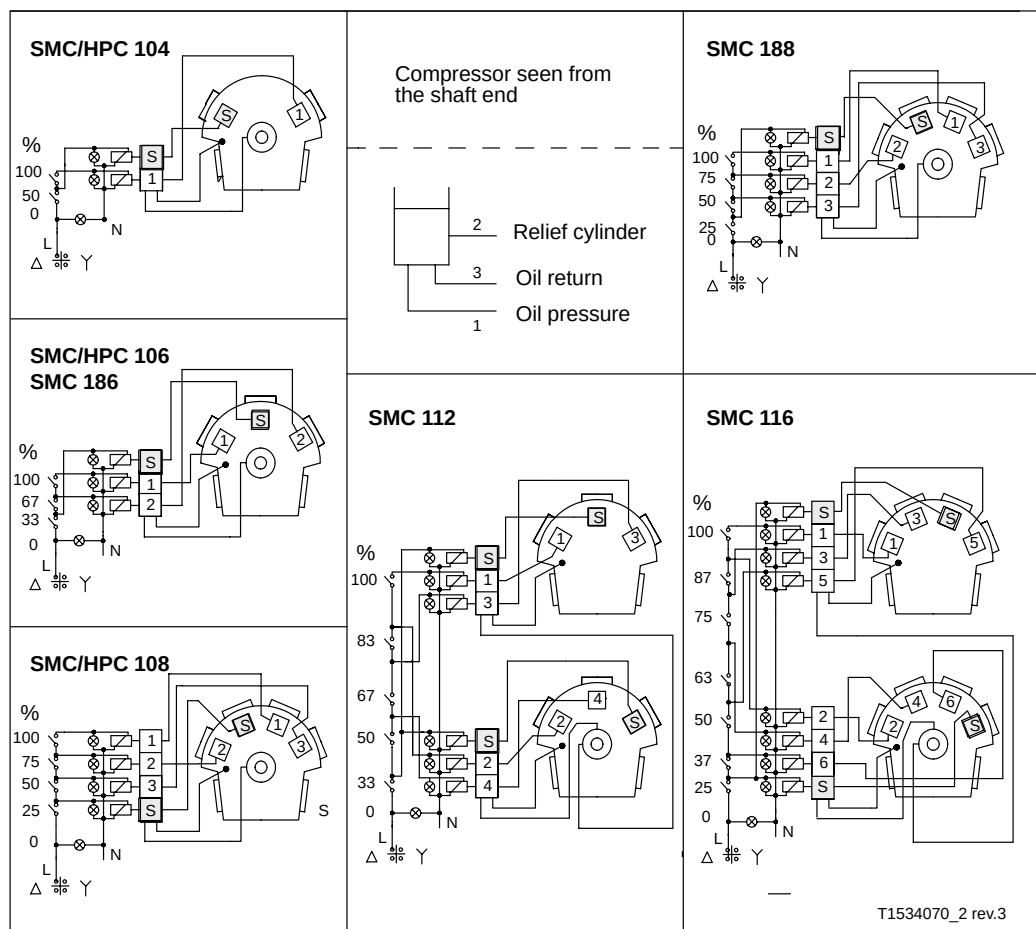
The 'S' solenoid valve makes total unloading of the compressor possible, i.e. 0% capacity over a shorter period during operation. However, the 'S' solenoid valve must **never** be involved in normal capacity regulation, as there is a risk of the compressor overheating if operated for some length of time at 0% ca-

capacity. The 'S' solenoid valve may therefore be used only as follows:

- Where total unloading is required until the motor has achieved max. torque.
- Where a refrigeration plant is occasionally subject to brief operating stops and compressor stop is not desirable. The compressor may then be allowed to run for a maximum of 5 minutes at 0% capacity.

The regulating sequence may be seen from the schematic drawings:

Schematic drawings 2



Service

It will normally not be necessary to service the solenoid valves, and it is therefore recommended not to strip them down. Should it be considered necessary to replace the solenoid valve, however, unscrew it from the block and replace by a new one. See the spare parts list.

Regulating sequence

The schematic outlines show that disconnection of a cylinder pair is done by cutting off the current to the relevant magnetic coil. Disconnection must be done by numerically ascending sequence, while connection should be done by numerically descending sequence.

The automatic gear which controls the solenoid valves must cut off or connect the cur-

rent to the number of solenoid valves needed to supply the compressor with the capacity required.

Note:

*When starting a compressor this must be done at the lowest capacity stage and it should be allowed to run for a few minutes (e.g. 3 to 5 minutes) before its capacity is increased. This will prevent the oil in the compressor from heavy foaming and the refrigerant from being sucked into the compressor from the evaporating system; something which can lead to liquid strokes. For the same reasons the compressor should always, **when a new stage has been loaded**, be allowed to run for 3 to 5 minutes at this stage before the next higher capacity stage is loaded. Unloading of capacity on the compressor can usually take place more quickly.*

Automatic capacity regulation

Where there is an automatic capacity regulating facility, solenoid valve control can be effected in the following ways:

- using pressure cut-outs
- using thermostats
- using microelectronics such as e.g. the UNISAB II.

Relief cylinders

The relief cylinders vary in type, depending on the position they have on the compressor. The chart below shows the number and dimensions of the relief cylinders for the individual compressor types.

Pos.	Piston rod Dimensions ¹⁾		Relief Cylinder Part no.	Number in each compressor									
	S mm	L mm		SMC 100					TSMC 100		SMC 180	TSMC 180	
				104	106	108	112	116	108	116	186	188	188
12-1	21.5	75	3135-149	1	1	1	2	2		1			
12-2	46.5	100	3135-150	1	1	1	2	2	1	1			
12-3	71.5	125	3135-151		1	1	2	2	1	2			
12-4	96.5	150	3135-152			1		2	1	2			
12-5	24.5	82	3135-161						1	1			
12-7	49.5	107	3135-154							1			
12-1	49	122	3135-019								1	1	
12-2	94	167	3135-020								1	1	1
12-3	139	212	3135-021								1	1	1
12-4	184	257	3135-022									1	1

1) See spare parts drawing at the end of this instruction manual

Heating rods, pos. 30

In order to keep the lubricating oil in the compressor warm during a period of standstill, the oil reservoir has one or two heating rods built in. Before start-up, the heating rod (s) must have been activated for 6-8 hours in order to ensure that there is only a minimum of refrigerant in the oil. When containing much refrigerant, the oil will lose its lubricating property and the following operational interruptions may occur:

In **reciprocating compressors** there is a serious danger of vigorous oil foaming when the compressor starts as a result of a falling suction pressure.

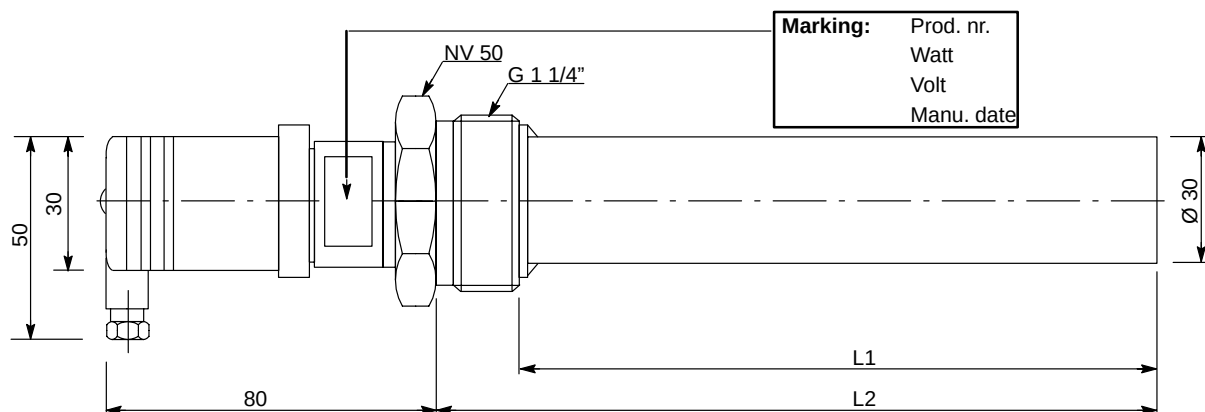
For **screw compressors** starting with much refrigerant dissolved in the oil, there is a risk of the compressor being stopped by the Flow Switch as the oil will be foaming owing to the fall in pressure through oil pipe and oil filter.

As illustrated on the drawing the heating rod consists of an electric heating element, incorporated in a dia. 30 mm pipe. The entire heating cartridge is screwed on tight at the G 1 1/4" thread.

Note:

The heating rod must not be energized if the oil level in the reservoir is below the minimum mark in the sight glass, and it should generally be switched off during compressor operation. Remember to turn off the heating rod whenever the crank-case of the reciprocating compressor is opened for inspection.

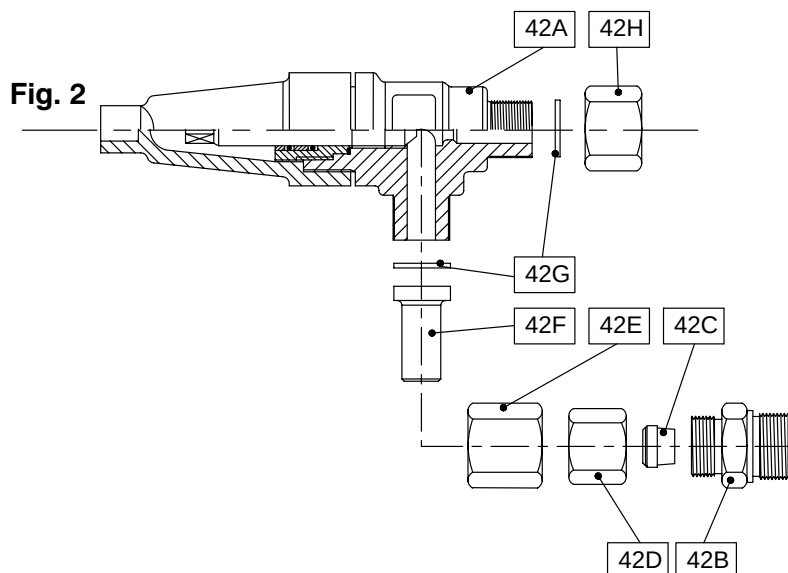
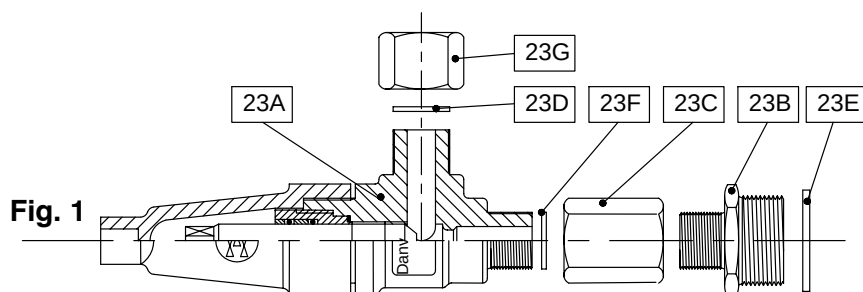
The following table indicates which heating rods are used for the various compressor types. In the spare parts lists for compressor or unit you will find the current part numbers.



Heating rods				Used for:
Power Watt	Voltage V	L1 mm	L2 mm	
270 270 270	250 230 115*	158	175	CMO - TCMO - SMC 100 - TSMC 100
460 460 460	250 230 115*			HPO - HPC, SMC 180 - TSMC 180 VMY 347 /447 – 536 SAB 110 – 128 – 163 – 202 – 330

* Can be delivered with a UL approval.
All heating rods are executed in **Degree of Protection IP54**.

Stop valves pos. 23 and 42



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The compressor is fitted with stop valves pos. 23 for charging of oil and pos. 42 for draining of oil. They are service-free valves and should as a rule not be dismantled.

The valves are safeguarded against inadvertent opening by means of a red cap.

The red cap can further be used for opening or closing the valve by unscrewing it and turning it upside down. The square hole in the top of the cap fits the square in the valve spindle.

The valves are equipped with a blank nut pos. 23G/42H that prevents dirt from pene-

trating the valves whenever they are not used.

- If the valve is used as an oil charging valve it is fitted with a nut pos. 23C and threaded nipple pos. 23B as shown by fig. 1.
- If the valve is used as a purge valve it is fitted with a screwed connection as illustrated by fig. 2.

The purge valve is fitted either directly on the top cover or by means of an intermediate connection in the cast pressure channels in the frame.

Monitoring cylinder lining insertion

When reassembling the slide linings, it is important to check the **clearance volume** as described in section 1 below.

When mounting **new** cylinder linings, both the **clearance volume** and the so called **lift-ing reserve** must be checked in the order mentioned and as described in sections 1 and 2. It is recommended that the cylinder linings be marked so that they can be reassembled in the same place as before.

1. Checking clearance volume

After each cylinder lining assembly, it is recommended that the clearance volume be checked.

Adjustment of the clearance volume is done by means of gasket pos. 19K which, in addition to its sealing function, is also used as an adjusting element. Consequently, the gaskets come in two sizes and may sometimes be used at the same time under the same cylinder lining.

Gasket thickness 19K	HPC SMC 100 part no.	SMC 180 part no.
0.5mm	2356-111	2356-116
0.8mm	2356-233	2356-249

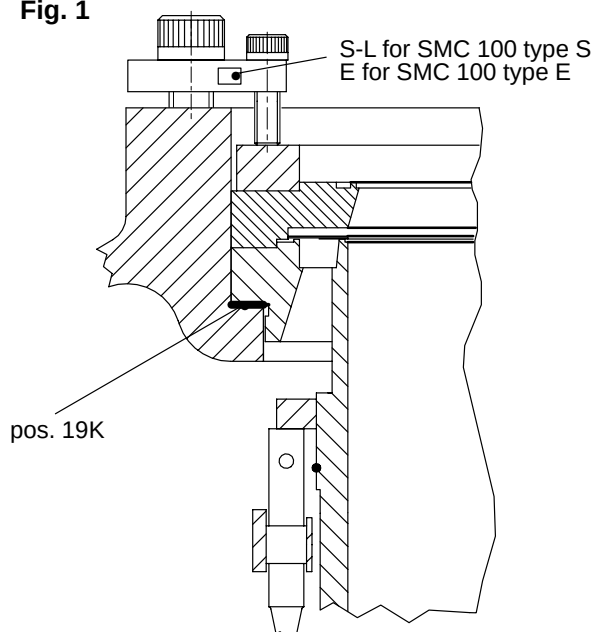
Adjustment is made as follows:

- The rocker arm system is **lowered** by fitting the long plug no. 4 from the tools kit in the unloading cylinder pos. 12 instead of screw pos. 12D.
- Insert an 0.5mm gasket pos. 19K and mount cylinder lining.
- Press cylinder lining against gasket pos. 19K by means of two locking devices –

no. 1 from the tools kit.

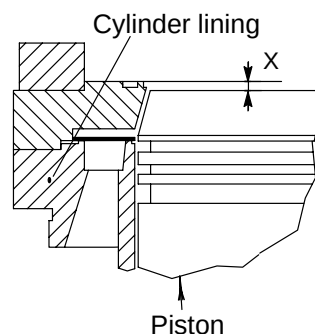
Fit the locking devices diagonally as shown in fig. 1.

Fig. 1



- Turn crankshaft until piston is in top position.
- Using a depth or slide gauge, measure "X" as shown in fig. 2

Fig. 2



T0177131_0 v6

- "X" must lie between the below mentioned limits and may, as mentioned earlier, be adjusted by the use of gasket pos. 19K.

Clearance volume "X"	min. mm	max. mm
HPC SMC 100 Mk1, Mk 2, Mk 3	0.6	1.0
SMC 180 Mk1, Mk 2	0.9	1.5

- Adjustment of the lifting reserve can now be performed if necessary. See point 2.

2. Checking lifting reserve

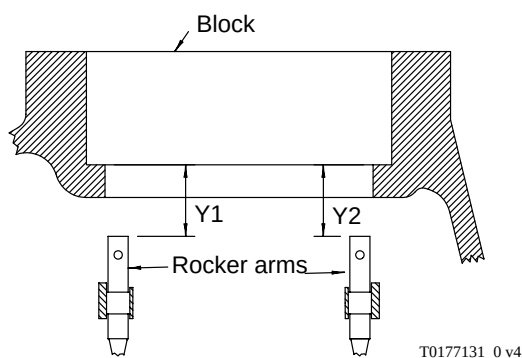
When fitting a **new** cylinder, or if the compressor is to be changed from running on R717 to some other refrigerant, or vice versa, or in the event of any major overhaul to the compressor, the **lifting reserve** must be checked.

Note:

The lifting reserve must not be checked until the clearance volume has been adjusted. Start by checking that the mutual height of the rocker arms is the same as described in the following:

Having removed the cylinder lining, measure distance "Y" from the contact face of the cylinder lining in the frame to the top of the two rocker arms which interact on either side of the cylinder lining. See fig. 3.

Fig. 3



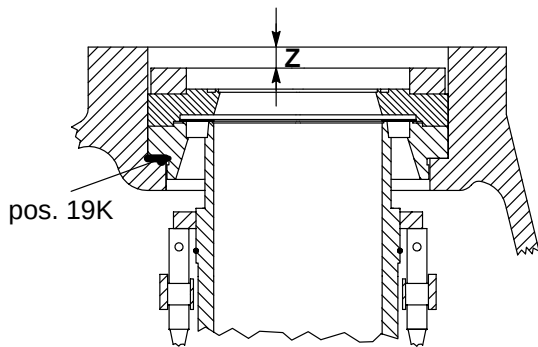
The rocker arms must be in their vertical position i.e. with the short screw pos. 12D and gasket 12E fitted. The measured distances "Y1 and Y2" may not vary more than max. 0.25mm.

In case this difference is greater, a shim Pos. 15E must be placed under the lowest rocker arm bearing pos. 15B or a shim removed from the highest bearing. Normally, there is no shim or max. 2 shims under the rocker arm bearing.

Check lifting reserve:

- The lifting reserve of the rocker arm is important in order to make sure that the rocker arm in its upright position can keep the suction valve ring plate open while the cylinder is unloaded. However, it must not be possible for them to be so upright that there is a risk of their jamming, this making them unable to be **lowered** again when the cylinder is put into service. Perform the adjustment as follows:
- Position cylinder lining incl. the correct gasket pos. 19K in the compressor block and press down against rocker arms by hand.
- The rocker arms are in their upright position as the normal plug pos. 12D as well as gasket pos. 12E have been mounted in the unloading cylinder.

Fig. 4



T0177131_0 v5

- Measure distance "Z" as shown in fig. 4. Note down the "Z" measure.
- Replace normal plug pos. 12D with the long plug no. 4 from the tools kit, **lowering** rocker arms in the process.
- Press cylinder lining down against gasket pos. 19K using the two locking devices no. 1 as shown in fig. 1, and repeat measurement "Z".

- The difference in the two measurements of "Z" must be within the limits stipulated in the following table.

Lifting reserve "Z"	Min. mm	Max. mm
HPC SMC 100 Mk 1, Mk 2, Mk 3	0,6	1,0
SMC 180 Mk 1, Mk 2	0,8	1,5

- If the difference between the two measurements does not fall within the parameters stated, it must be regulated by inserting or removing shims pos. 15E under the rocker arm bearings.
- It is important that the long threaded plug is fitted while the top cover is being mounted.

Note:

Remember to put the normal plug in once the top cover has been tightened.

Pressure gauges

The analog instrumentation on the compressor includes two pressure gauges: one that measures the discharge pressure on the compressor and one combined suction and oil pressure gauge. These pressure gauges are filled with glycerine, which both attenuates the deflections of the indicators and lubricates the gauge works.

However, a fluctuating ambient temperature has an influence on the volume of the glycerine (warm glycerine takes up more space than cold glycerine), which can affect the measuring accuracy of the gauge.

Furthermore, it is essential that no excess pressure can possibly occur in the gauge housing, as this involves a risk of explosion of the housing.

Both these considerations have been effectively solved in the gauges by a combination of internal temperature compensation and the so-called *blow-out* safety device which is fitted in the back plate of the pressure gauge housing.

Adjustment to other temperature ranges:

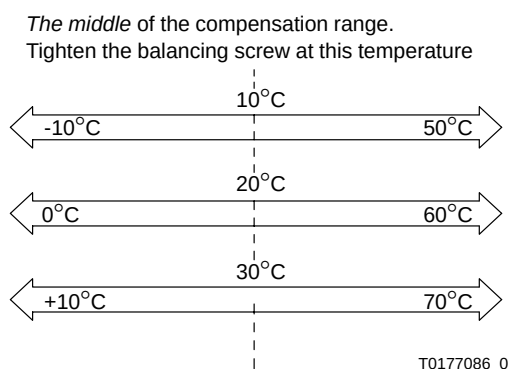
A balancing screw on the rear of the instrument is firmly tightened at a temperature of 20°C – the normal ambient temperature.

If ambient temperatures change considerably thus requiring a general shift in the compensation range, slacken the balancing screw for approx. 1 minute, then retighten. This must be done at the average operating

temperature under which the instrument will be functioning.

Example:

If the mid-compensation range is to be moved from 20°C to 10°C, equalization must be performed at 10°C. When the screw is then retightened, the middle of the compensation range will have been moved down to 10°C. The total stretch of the compensation range remains unchanged.



Cleaning and refilling glycerine-filled gauges

- Remove *blow-out* disk and temperature compensator from back of housing.
- Wash gauge interior with warm water and allow to dry carefully.
- Fill gauge housing with fresh glycerine until it flows out of bleeder hole.

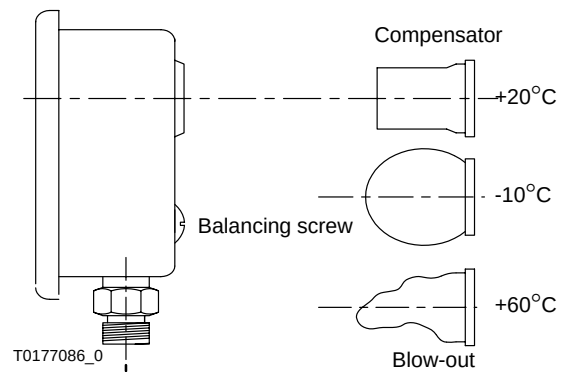
Note: *The glycerine must be absolutely waterfree.*

- Refit compensator and *blow-out* disk in gauge housing and cover centrehole in *blow-out* disk with a piece of tape.

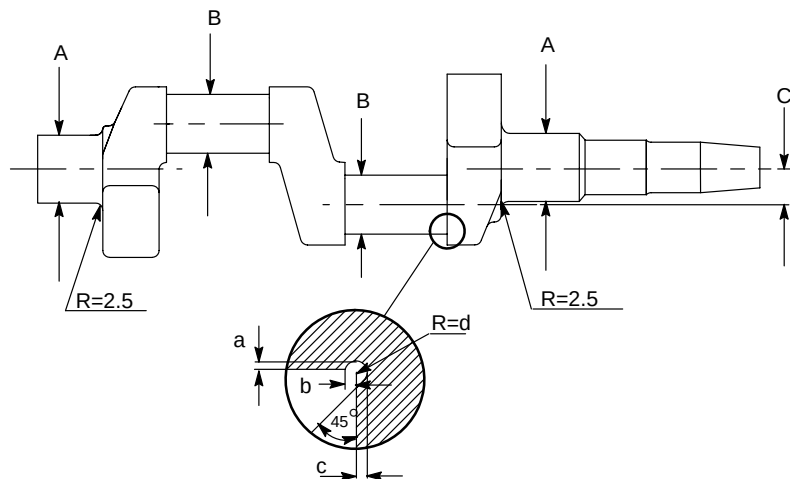
Note:

Glycerine should be refilled at a room temperature of 20°C; when mounted, and the compensator must be its normal shape as shown at the top of the following drawing.

- Clean gauge exterior with warm water.
- Remove tape from centrehole.
- Refit gauge.



Undersize Bearing Diameters for Crankshaft Reciprocating Compressors with 4 to 8 Cylinders



T0177137_0

Compressor type	A Main bearing		B Connecting rod bearing		C	a	b	c	d
	First grinding mm	Super finish or Final grinding mm	First grinding mm	Super finish or Final grinding mm					
HPO CMO 2	-0.060 59.5 -0.070	-0.060 59.5 -0.090 R _a =0,20	-0.030 54.5 -0.049	-0.035 54.5 -0.050 R _a =0,20	0.0 35 -0.1	0.2	0.0 1.0 -0.3	2.5	2.5
HPC, SMC/TSMC 100 S	-0.070 79.5 -0.080	-0.070 79.5 -0.090 R _a =0.35	0.000 79.5 -0.010	0.000 79.5 -0.020 R _a =0.35	0.0 40 -0.1	0.2	1	3	3.5
SMC/TSMC 100 L					0.0 50 -0.1				
SMC/TSMC 100 E					0.0 60 -0.1				
SMC/TSMC 180	-0.110 134.0 -0.120	-0.110 134.0 -0.140 R _a =0,63	0.000 134.0 -0.010	-0.015 134.0 -0.040 R _a =0,63	0.0 70 -0.1	0.16	1.15	5	6

Undersize bearings: See SABROE spare parts list.

Sundry clearances and check dimensions

Bearing clearance

All measurements stated are in mm

			CMO 1 CMP 1 TCMO1 CMO4	CMO 2 TCMO 2 HPO	SMC 65 TSMC 65	SMC 100 TSMC 100 4–10 cyl. HPC	SMC 100 TSMC 100 12–16 cyl.	SMC180 TSMC 180 Mk1 & Mk2
Main bearings	manufactured		0.08	0.08	0.08	0.08	0.08	0.14
	max.		0.20	0.20	0.20	0.20	0.20	0.35
Connecting rod bearings	manufactured		0.08	0.08	0.08	0.10	0.10	0.14
	max.		0.15	0.15	0.15	0.20	0.20	0.30
Piston pin bearings	manufactured		0.04	0.04	0.04	0.04	0.04	0.09
	max.		0.10	0.10	0.10	0.10	0.10	0.20
Piston	Parallel to piston pin	manufactured	0.18	0.18	0.18	0.20	0.20	0.25
		max.	–	–	–	–	–	–
	At right angles to piston pin	manufactured	0.11	0.11	0.11	0.15	0.15	0.35
		max.	0.30	0.30	0.30	0.40	0.40	0.90

If the maximum value has been exceeded, replace the parts.

Crankshaft end-play

min.	0.30	0.30	0.30	0.40	0.75	0.95
max.	0.55	0.55	0.55	0.64	1.00	1.20

The end-play can be adjusted by means of the gasket under the bearing cover.
The gasket is available in the following thicknesses: 0.3, 0.5, 0.75 and 1.0 mm.

Piston ring gap

min.	0.25	0.25	0.25	0.33	0.33	0.66
max.	1.00	1.00	1.00	1.30	1.30	2.50

The piston ring gap must be measured with the ring placed in the cylinder liner.

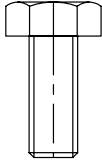
Dimensions of crankshaft bearing journal

New	Main bearing journals	55 ^{-0.06 -0.09}	60 ^{-0.06 -0.09}	55 ^{-0.06 -0.09}	80 ^{-0.07 -0.09}	80 ^{-0.07 -0.09}	135 ^{-0.11 -0.14}
	Connecting rod bearing journals	50 ^{-0.025 -0.040}	55 ^{-0.030 -0.049}	55 ^{0 -0.02}	80 ^{0 -0.02}	80 ^{0 -0.02}	135 ^{-0.015 -0.040}
	Intermediate journals					80 ^{-0.010 -0.029}	
Ground down	Main bearing journals	54.5 ^{-0.06 -0.09}	59.5 ^{-0.06 -0.09}	54.5 ^{-0.06 -0.09}	79.5 ^{-0.07 -0.09}	79.5 ^{-0.07 -0.09}	134 ^{-0.11 -0.14}
	Connecting rod bearing journals	49.5 ^{-0.025 -0.040}	54.5 ^{-0.025 -0.040}	54.5 ^{0 -0.02}	79.5 ^{0 -0.02}	79.5 ^{0 -0.02}	134 ^{-0.015 -0.040}
	Intermediate journals					79.5 ^{-0.010 -0.029}	

Bushing and bearing halves can be supplied for all above journals.

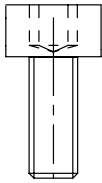
Torque moments for screws and bolts

Metric thread (ISO 8.8)



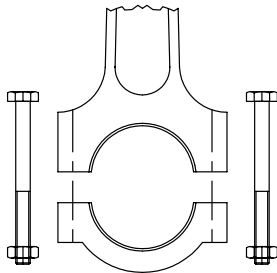
M	4	5	6	8	10	12	14	16	18	20	22	24	27
Kpm	0.28	0.53	0.94	2.2	4.1	7.0	11	15	23	30	38	52	68
ft.lbf.	2.1	3.9	6.8	16	30	50	80	110	170	220	270	370	490
Nm	2.7	5.2	9.2	22	40	69	108	147	225	295	375	510	670

Metric thread (ISO 12.9)



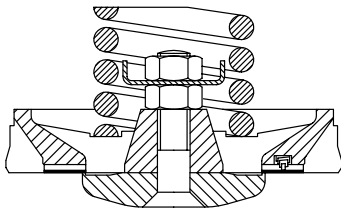
M	4	5	6	8	10	12	14	16	18	20	22	24	27
Kpm	0.42	0.78	1.4	3.2	6.1	10	16	23	34	44	55	76	100
ft.lbf.	3.0	5.7	10	23	44	75	120	160	240	320	400	550	720
Nm	4.1	7.6	14	31	60	98	157	225	335	430	540	745	980

Connecting rods with UNF thread



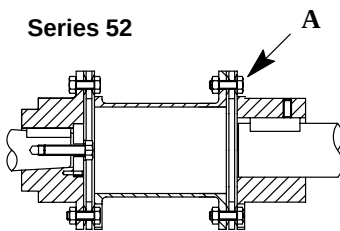
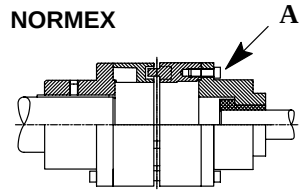
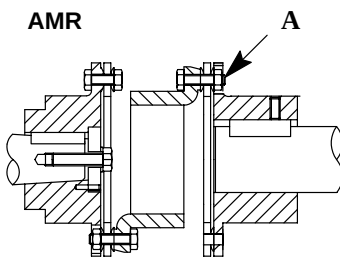
	HPO/CMO	HPC/SMC 100	SMC 180
UNF	5/16"	3/8"	5/8"
Kpm	2.1	4.4	17
ft.lbf.	15	32	130
Nm	20	43	167

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Bolt on discharge valve

	HPO/CMO	HPC/SMC 100	SMC 180
Kpm	3.2	10.2	35
ft.lbf.	23	75	255
Nm	32	101	344



Compressor type		Coupling type	Thread	Torque (A)			
				Kpm.	ft.lbf.	Nm	
HPO/CMO/TCMO		AMR225	5/16"	3.5	25	34	
HPC/ SMC/ TSMC	104-108	AMR312S	7/16"	5.6	40	55	
	112-116	AMR350S	1/2"	13	95	128	
	186-188	AMR450S	11/16"	28	200	275	
SAB	128	NORMEX	H148	M8	2.2	16	22
	163		H168	M8	2.2	16	22
	128	Series 52	225	5/16"	3.5	25	34
	163		262	3/8"	4.2	30	41
	202		312	7/16"	5.6	40	55
VMY depending on the motor size	Series 52	200	5/16"	3.5	25	34	
		225	5/16"	3.5	25	34	
		262	3/8"	4.2	30	41	
		312	7/16"	5.6	40	55	
		350	1/2"	13	95	128	
		375	9/16"	18	130	177	
		425	5/8"	25	175	245	
		450	11/16"	28	200	275	

Refrigeration Plant Maintenance

Operational reliability

The prime causes of operating malfunctions to the plant are:

1. Incorrect control of liquid supply to the evaporator.
2. Moisture in the plant.
3. Air in the plant.
4. Anti-freezing liquid is missing.
5. Congestion due to metal shavings and dirt.
6. Congestion due to iron oxides.
7. Congestion due to copper oxides.
8. Inadequate refrigerant charge.

Below, some information is given about ways of keeping contaminants out of the refrigerating system and at the same time facilitating day-to-day supervision of the refrigeration plant.

Pumping down the refrigeration plant

Before dismantling any parts of the refrigeration plant for inspection or repair, pump-down must be carried out.

1. Open suction and discharge stop valves on compressor.
2. Close liquid stop valve after condenser or receiver so that liquid refrigerant can be collected in the tank. Any solenoid valves in the liquid line should be opened by force, adjusting the thermostat to its lowest position so that the liquid line can be

bled of refrigerant. Adjust any constant-pressure valves to bring evaporator pressure down to atmospheric.

3. Start up the compressor. Adjust regulating system to lower suction pressure.
4. **Keep a close eye on the suction pressure gauge!** When the suction pressure is equal to atmospheric, stop the compressor and quickly shut off the discharge stop valve. Shut off any stop valve in the oil return line.

If the receiver has an extra stop valve in the feed line, this can be closed; practically the entire refrigerant charge will then remain shut off in the receiver.

Note:

The receiver must not be overfilled! There should be a minimum gas volume of 5%.

5. A slight overpressure should normally remain in the piping system - this safeguards the system against the penetration of air and moisture.
6. Before dismantling parts, **the operator should put a gas mask on.**

Dismantling plant

In order to prevent moisture penetrating into the refrigeration plant during any repair work, it is advisable to follow the rules below:

1. No component should be opened unnecessarily.
2. When dismantling the system, the pressure in the system should be a little higher than atmospheric.

3. **Note:**

*If the piping system is colder than the surroundings, there is a considerable risk of damp precipitation (condensation) on cold plant parts. Plant components to be dismantled **must** be warmer than the ambient temperature.*

4. No two points in the system should be opened at the same time.
5. Plug, close or at least cover opening with oiled paper or suchlike.
6. Be aware of the possibility of filters being very moist.

Tightness testing and pump-down of refrigeration plant

Before charging refrigerant into that part of the refrigeration plant which has been opened, this should be pressure-tested as described in the section entitled *Pressure testing*.

Afterwards, pump down in order to eliminate air and moisture. In this regard, consult the section on *Evacuation*.

Otherwise, follow the instructions given in the separate instruction manual on plant components.

Note:

If the oil in the crankcase of the piston compressor or the oil separator of the screw compressor has been in contact with the atmospheric air for any length of time, it must be replaced with fresh oil of the same grade and make.

Trouble-shooting on the Reciprocating Compressor Plant

Operating condition

Experience shows that pressure and temperature variations in a refrigeration circuit can provide information about the operating condition of the refrigeration plant.

In particular, suction and condenser pressures as well as the temperatures of suction and discharge gases may provide important information as to the operating conditions of the plant.

It often takes only very slight modifications to variable pressures and temperatures to produce considerable changes in operating conditions.

Using the following troubleshooting chart, it is possible to ascertain the cause of and remedy for any operating disturbance.

Using the trouble-shooting chart

In the following chart, each individual error option is indicated by a code number in the

lefthand column, the error being briefly described in the next column. The third column states code numbers for the possible **causes** of the error.

The code numbers refer to the subsequent chart.

The section entitled *Remedying malfunctions* states how to remedy the observed error.

See the following example for the correct procedure.

Example

Observed error: *discharge pipe temperature too low* - error code 15.

Cause codes:

26 (Liquid in suction line)

32 (Too much coolant/air to condenser)

39 (Expansion valve produces too little superheating)

Any explanatory comments will be stated in the section that follows.

Error code	Observed error	Cause code
1	Compressor fails to start	1, 2, 3, 4, 5, 6, 7, 9, 10, 12, 14.
2	Compressor starts and stops too often	9, 10, 11, 13, 21, 22, 23, 24, 32, 34, 35, 36, 37, 40, 41, 43, 44, 51, 52, 54, 56, 59.
3	Compressor starts but stops again immediately	3, 5, 6, 9, 10, 11, 12, 13, 14, 15, 17, 18, 41, 42, 49, 50, 55, 61.
4	Compressor operates continuously	8, 21, 22, 24, 41, 46, 52, 53, 56, 60.
5	Abnormal noise from compressor	16, 17, 18, 19, 26, 48, 49, 50, 51, 52, 53, 54, 56, 57, 58.
6	Insufficient capacity on compressor	13, 15, 17, 18, 20, 21, 22, 23, 24, 32, 34, 35, 36, 37, 40, 41, 44, 45, 46, 49, 50, 51, 52, 53, 56, 60.
7	Liquid stroke in compressor during start up	16, 18, 26, 37, 38, 39, 44, 56, 61.
8	Liquid stroke in compressor during operation	21, 23, 26, 37, 39.
9	Excessive condenser pressure	9, 25, 28, 29, 30, 31, 33.
10	Too low condenser pressure	22, 32, 51, 52, 54, 60.
11	Excessive suction pressure	13, 17, 26, 34, 39, 52, 53, 54, 5., 60.
12	Too low suction pressure	11, 13, 20, 21, 22, 23, 32, 35, 36, 37, 40, 41, 42, 44, 45, 56, 59.
13	Too low oil pressure	12, 15, 17, 18, 26, 49, 50, 55.
14	Excessive discharge pipe temperature	11, 21, 22, 23, 28, 29, 30, 31, 33, 34, 35, 36, 37, 40, 41, 46, 52, 54.
15	Too low discharge pipe temperature	26, 32, 39.
16	Excessive oil temperature	33, 34, 35, 36, 37, 40, 50, 52.
17	Oil level in crankcase falling	16, 18, 20, 26, 51, 57, 58.
18	Oil foaming vigorously in crankcase	16, 26, 39, 61.
19	Crankcase sweating or frosting up	16, 18, 26, 37, 39.
20	Capacity regulating oscillating	13, 15, 16, 17, 18, 49, 55, 56.
21	Impossible to bleed plant	10, 43, 51, 52, 53, 54, 60.

Code	Case	Code	Case
1	No power - master switch not cut in	34	External pressure equalization on expansion valve closed
2	Blown fuses - loose wiring or connections	35	Expansion valve partly clogged by ice, dirt, wax
3	Electrical voltage too low	36	Expansion valve has lost charge
4	No control current	37	Expansion valve sensor misplaced
5	Motor protection device activated	38	Expansion valve is leaky
6	Control current circuit open	39	Expansion valve provides too little superheating
7	Pump/fan not started	40	Expansion valve produces excessive superheating
8	Welded contacts in motor protection	41	Filters in liquid/suction line clogged
9	High-pressure cut-out has cut	42	Solenoid valve in liquid/suction line closed
10	Low-pressure cut-out has cut	43	Solenoid valve leaky
11	Low-pressure cut-out differential too small	44	Evaporator iced up or clogged
12	Oil pressure cut-out has cut	45	Cooling air being recirculated (short-circuited)
13	Capacity regulator incorrectly set	46	Excessive load on plant
14	Defrosting timer breaks current	47	Refrigerant collecting in cold condenser (close off by-pass)
15	Oil charge insufficient	48	Coupling misaligned or loose bolts
16	Compressor capacity too high during start-up	49	Oil pump defective
17	Oil pressure too low (adjust oil pressure regulating valve)	50	Bearings worn out or defective
18	Oil foaming in crankcase	51	Defective piston rings or worn cylinder
19	Oil overcharge	52	Discharge valves defective or leaky
20	Poor oil return - oil in evaporators	53	Suction valves defective or leaky
21	Restricted supply of refrigerant	54	Compressor by-pass open - leaky safety valve
22	Refrigerant charge insufficient	55	Compressor oil filter clogged
23	Refrigerant vapour in liquid line	56	Capacity regulator defective
24	Leaky refrigeration plant	57	Solenoid valve in oil return clogged/defective
25	Refrigerant overcharge	58	Filter in oil return clogged
26	Liquid in suction line	59	Compressor capacity too high
27	At low temperature operation, degree of charge in evaporators rises	60	Compressor capacity too low
28	Insufficient coolant/air to condenser	61	Heating element in crankcase defective
29	Temperature of coolant/air too high		
30	Non-condensable gases in condenser		
31	Condenser needs cleaning		
32	Too much coolant/air to condenser		
33	Water valve closed		

Remedying malfunctions

1. Compressor fails to start

1.6	Control current circuit open owing to activated: pressure cut-outs thermostats motor protection device defrosting timer	Pinpoint open switch and remedy cause of interruption.
1.9	High-pressure cut-out has cut	Reset pressure cut-out and investigate cause of high condenser pressure.
1.10	Low-pressure cut-out has cut	Compressor cannot start before suction pressure has risen above set point for pressure cut-out restarting.
1.12	Oil-pressure cut-out has cut	Compressor starts at reset. Check oil level. If oil foams in crankcase, see section 18.

2. Compressor starts and stops too often

2.9	High-pressure cut-out cuts at high pressure	High condenser pressure - see section 9. Check condenser cooling and adjust pressure cut-out to correct breaking pressure - see table <i>Pressure and temperature settings</i> . Replace defective pressure cut-out.
2.10	Low-pressure cut-out cuts at too low suction pressure.	Low suction pressure - see section 12. If low-pressure cut-out is set too high, adjust pressure cut-out.
2.11	Low-pressure cut-out differential is too small between stopping and starting	Increase differential pressure - see also special instructions.
2.13	Compressor capacity too high	Check operating conditions and, if need be, reduce capacity.

2.41	Filter in suction line clogged	Check suction filters on compressor.
2.43	Solenoid valve in liquid line does not close tight.	Check direction of flow. Replace defective valve.
2.52	discharge valves on compressor are leaky.	At compressor stop, pressure equalizes relatively quickly between suction and discharge side Clean or change discharge valves.

3. Compressor starts but stops again immediately

3.5	Motor protection cuts	Look for cause of overloading. If star-delta start, set starting time to minimum.
3.10	Low-pressure cut-out has cut	Open any suction stop valve which is closed.
3.12	Defective oil-pressure cut-out	Replace cut-out - see special instructions.
3.15	Oil charge insufficient	Top up with oil and investigate cause of oil shortage.
3.18	Oil pressure failing owing to formation of foam in oil.	Reduce capacity. See sections 17 and 18.

4. Compressor operates continuously

4.10	Thermostat or low-pressure cut-out does not cut at too low temperature/pressure	Adjust operating points.
4.21	Restricted supply of refrigerant to evaporator. Compressor working at too low suction pressure.	Remove dirt in filters and check function of expansion device as per special instructions.
4.22	Refrigerant charge insufficient	Top up with refrigerant of correct type.

5. Abnormal noise from compressor

5.16	Compressor capacity too high during start-up	Reduce capacity.
5.17	Oil pressure too low	See section 13.
5.26	Liquid refrigerant in suction line	Liquid stroke. See points 7 and 8. Adjust expansion or float valves.
5.48	Incorrect alignment of motor and compressor Loose bolts in coupling	Check alignment as per special instructions. Tighten with torque wrench
5.50	Worn or defective bearings	Overhaul or replace.
5.51 5.53 5.57 5.58	Too much oil circulating through the plant, resulting in too low oil level in compressor	Check oil level. Solenoid valve, filter or jets in oil return system may be clogged. Leaky suction valve ring plates, piston rings and worn-out cylinder may also produce such oil consumption.
5.56	Capacity regulation oscillating owing to failing oil pressure	Low oil pressure - see section 13.

6. Too little capacity on compressor

6.15	Insufficient oil charge	Top up with fresh oil of same type and make.
6.44	Iced-up evaporator	Defrost evaporator; adjust defrosting time if required.
6.49	Defective oil pump and hence failing oil pressure	Repair or replace oil pump
6.56	Defective capacity regulating system	Cause is most often failure in oil pressure or refrigerant in oil; see section 4.5.

7. Liquid stroke in compressor during start-up

	Liquid stroke in the compressor should not occur, as in the worst instance this can cause rupture to the valve ring plates and damage to the inbuilt relief devices. Furthermore, it can result in damage to the connecting rod bearings and cylinders if the coolant degreases the faces and impairs the lubricating capacity of the oil.	
7.18	Adsorption of (H)CFC refrigerant in oil Sudden reduction in pressure across the oil sump (suction pressure) produces foaming	Reduce compressor capacity or start with throttled suction stop valve. Follow instructions in section 18.
7.26	Refrigerant has condensed in suction line or crankcase Suction line has free fall towards compressor	Heating element in crankcase should be connected for 6-8 hours before starting, so that refrigerant dissolved in oil can be boiled out before starting compressor up. Start with throttled suction stop valve - stop when hammering is heard. Liquid separator should be mounted in suction pipe.

8. Liquid stroke in compressor during operation

8.23	Refrigerant gas in liquid line	Expansion valve is oscillating.
8.39	Superheating of expansion valve is set too low	Adjust superheating, which should normally be 5-8°C.

9. Excessive condenser pressure

In the event of abnormally high pressures in the refrigeration system, there is a risk of damage to the compressor. At very high pressures (<i>see pressure testing</i>), the risk of the components in the refrigeration plant exploding can constitute a threat to life. Abnormally high pressures can occur in the case of: - extreme heating of plant parts (fire, solar radiation or other abnormal heating); - volumetric expansion of fluids in sealed-off premises.		
9.25	Overfilling with refrigerant	Refrigerant fills condenser and reduces its effective area. Draw off coolant.
9.28	Insufficient condenser cooling, e.g. if cooling water fails, fan/cooling water pump clogs, soiling, scaling or fouling of heat-transmitting surfaces	Regulate water/air supply or reduce compressor capacity, if called for. Check condenser as per instructions for same.
9.30	Presence of non-condensable gases (especially air) in condenser.	Blow air out at condenser. Follow instructions for condenser.

10. Too low condenser pressure

10.32	Excessive condenser cooling	Regulate condenser cooling.
10.51	Defective piston rings or worn cylinders	Replace worn parts. See compressor instructions.
10.52	Discharge valves are defective or leaky	See compressor instructions. Check valve ring plates and piston rings.
10.54	Bypass between high-pressure side and suction side of compressor	Check compressor for internal leakage by performing pressure-drop test. See compressor instructions.
10.60	Compressor lacks capacity.	Check whether compressor capacity corresponds to load on plant. Reduce condenser cooling.

11. Excessive suction pressure

11.26	Error in setting of liquid regulation valve	Liquid refrigerant in suction line. Adjust, repair or replace expansion valve.
11.53	Leaky suction valves	See compressor instructions. Remove cylinder covers; check valve plates. Renew if needed.
11.54	Open by-pass between suction side and high-pressure side of compressor. Safety valve leaky, or opens prematurely.	Check system for any by-pass detectable as a warm connection. Adjust or repair leaky valves.
11.60	Compressor lacks capacity.	Regulate compressor capacity. Check whether all cylinders are operating. Check function of capacity regulator.

12. Too low suction pressure

Abnormally low pressure in the refrigeration plant will increase the compression ratio of the compressor with a subsequent risk of damage to the compressor. The danger of air being sucked into the refrigeration plant also increases at abnormally low pressure.		
12.20	Oil in evaporator	Draw off oil.
12.22	Refrigerant charge on plant insufficient Bubbles in liquid line sight glass and possibly a warm liquid line	Check refrigerant charge. Charge plant with refrigerant. Find and seal any leak.
12.35	Freezing-up of expansion valve (HFC/HCFC plant)	Thaw out expansion valve with hot, wet cloths. Replace dessicant in drying filter.
12.36	Thermostatic expansion valve has lost charge	Valve fails to open - change valve.
12.40	Excessive superheating of suction gas	Regulate expansion valves to higher capacity.

12.41	Filter in liquid line clogged	Check and clean filter in liquid line.
12.42	Solenoid valve in liquid line fails to open	Coil may have blown. Control signal lacking.
12.59	Compressor has excessive capacity	Reduce compressor capacity. Check capacity regulating system.

13. Oil temperature too low

13.15	Too little oil in compressor	Top up compressor with oil and investigate cause of oil consumption.
13.18	Oil foams in compressor	See point 18.
13.49	Oil pump defective	Repair or replace.
13.50	Bearings worn	Repair or replace.
13.55	Oil filter clogged	Change filter cartridge

14. Excessive discharge pipe temperature

If, after approx. 1 hour's operation, the discharge pipe temperature is more than 10°C higher than indicated in the table, the error may be due i.a. to:		
14.21	Excessive suction temperature as result of reduced refrigerant supply to evaporator (extensive superheating) owing to insufficient refrigerant charge.	Check refrigerant charge
14.22	Excessive suction temperature as result of reduced refrigerant supply to evaporator (extensive superheating) owing to incorrectly adjusted liquid regulating valves	Check thermostatic expansion valves
14.52	Leaky discharge valves	Leaking in discharge valves gives rise to generation of heat. Change defective valves.
14.54	Open by-pass between high and low-pressure side of compressor, e.g. leaky safety valve	Localize by-pass and remedy any leakages.

15. Too low discharge pipe temperature

15.26	Low suction temperature as result of overflow of liquid refrigerant from evaporator	Adjust liquid regulating valve. Increase superheating.
-------	---	--

16. Excessive oil temperature

During operation, the heat of the compressor crankcase must be 40-70°C. When working with R717 and R22, it may be necessary to supply the compressor with oil cooling.		
	See point 14.	

17. Oil level in crankcase falling

Where HFC/HCFC refrigerants are used, there will be some blending of refrigerant and oil during the initial operating period. It may therefore prove necessary to top up the oil after initial start-up of the plant. Note: <i>The oil level must always be visible in the oil level sight glass on the compressor.</i>		
17.20	Filter in solenoid valve or jet in oil return line clogged	Oil return pipe must be warm during operations. Clean filter.
17.26	Liquid in suction line and crankcase may cause foaming in oil and thus increase oil consumption	Examine evaporator system and check superheating of suction gas.
17.51	Worn-out piston rings or cylinders	Renew piston rings and, if need be, renew pistons and cylinder linings.
17.57	Solenoid valve in oil return line defective	Coil in solenoid valve defective. - Replace coil. - Electrical control signal lacking.

18. Heavy oil foaming in crankcase

18.26	Liquid in suction line	See 17.26.
18.61	Too much refrigerant dissolved in oil	- Before starting compressor, heating element must have been on for at least 8 hours in order to boil refrigerant out of oil. During start-up phase, capacity should be connected at a slow rate to prevent sudden drop in pressure on suction side with resultant foaming. - Under normal operating conditions, compressor should operate under as stable pressure conditions as possible.

19. Crankcase sweating or frosting up

19.26	Liquid in suction line	See 17.26.
19.37	Expansion valve sensor misplaced	Check positioning of expansion valve sensor - cf. instructions for expansion valve.
19.39	Liquid regulating valve or float valve producing too much liquid	Increase superheating on thermostatic expansion valve.

20. Capacity regulation oscillating

20.18	Oil foaming in crankcase	See point 18.
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21. Impossible to bleed plant

21.43	Solenoid valve leaky	Pinpoint and seal leak, or change leaky component.
21.51	Defective piston rings	Check and replace any defective parts.
21.52	Defective discharge valves	Check and replace any defective parts.
21.53	Defective suction valves	Check and replace any defective parts.

Selecting lubricating oil for SABROE compressors

During the past few years YORK Refrigeration has experienced a number of problems with mineral oils, particularly in R717 plants. The problems can be divided into two groups:

- a: The oil changes viscosity
- b: The oil decomposes (becomes very black)

The problems have been seen with several mineral oil brands, often occurring within a few operating hours and resulting in severe consequences for both compressor and plants.

Following the careful investigation undertaken by YORK Refrigeration during the past few years, it has been decided to introduce a range of synthetic oils which can fulfil the demands of modern refrigeration plants.

Mineral oils may continue to be used in refrigeration plants, providing the lubricating quality is carefully monitored. For modern, high capacity refrigeration plants, where long lifetime for both lubricants and moving parts is expected, YORK Refrigeration recommends the choice of synthetic lubricating oils.

The application areas and specifications for these synthetic oils can be found in the following pages. Installers and/or users are at liberty to choose either YORK Refrigeration's own or alternative oil brands which fulfil the necessary specifications.

General

This recommendation only deals with the lubrication of the compressor. The performance of the lubricant in the plant (receiver, evaporator, etc.) must, however, also be taken into consideration.

Lubricating oils with relatively high viscosities must be used to ensure satisfactory lubrication of refrigeration compressors.

To obtain the best lubrication, the oil must:

- Provide the required fluidity at the lowest evaporating temperature encountered in the plant and at the highest permissible temperatures in the compressors.
- Provide acceptable fluidity at start-up.
- Provide sufficient oxidation stability (the oil must be moisture-free when added to the system).
- Provide sufficient chemical stability when used together with the particular refrigerant.

In addition, the extent to which different refrigerants dissolve in the oil must be determined, so that the oil return systems, etc. can be designed to function properly.

Stratification

It should be noted that in certain plants, particularly with HFC and HCFC refrigerants, the oil may stratify into layers in the refrigerant receivers and evaporators at certain operating conditions and at particular oil concentrations.

The *Oil recommendation diagrams* for SABROE compressors for HFC and HCFC will indicate the limits for Sabroe oils at which this stratification occurs. The oil concentrations stated in these diagrams must not be exceeded. This will enable suitable oil rectification/return systems to be designed to balance with the compressor oil "carry-over" so that the maximum concentration is not exceeded.

For area **A** in the diagrams, the max oil concentration in liquid phase must not exceed

2%. For the other area, the max. oil concentration must not exceed 5%. For area **B**: please contact YORK Refrigeration.

Plants with several different compressor types/makes

In plants comprising several different interconnected compressor types and makes, it is strongly recommended that all compressors should use the same type of oil. This is essential where automatic oil return systems are employed.

If it is intended to change the oil from one type to another, please refer to the *Oil changing on SABROE compressors* later in this publication.

Selecting the lubricating oil

There are a number of operating diagrams for the selection of lubricating oils for Sabroe compressors operating with various refrigerants. Once the **general** conditions concerning the lubrication of the compressor and oil type in the plant have been considered, the **specific plant conditions** must be taken into consideration.

Use the *Oil recommendation diagrams* to select the appropriate **oil code number**.

The **oil code number** consists of letters designating the oil type together with the Sabroe viscosity grade number.

Code design	Oil types
M	Mineral oil
A	Synthetic oil based on Alkylbenzene
PAO	Synthetic oils based on Polyalphaolefin
AP	Mixture of A and PAO-oils
E	Synthetic ester-based lubricants

In the *oil recommendation diagrams* for each refrigerant and compressor type, it is possible to determine the **code number** for the oil best suited to the operating conditions. With this **code number**, it is possible to select the correct Sabroe oil for the application. The marked area on each side of the separating line in the diagram shows the zone where both oils are useable.

Oil types and oil companies

As a result of the large number of oil companies world-wide that deals in oil for refrigeration plants, it is impossible for YORK Refrigeration to test the many different brands of oil on the market. It is our experience, however, that some oil brands during use can change character and thus no longer fit the specifications given by the companies at delivery. We have thus experienced changes in the specifications as well as in the formula and performance without having had any information about this from the oil company. This makes it very difficult for YORK Refrigeration to give a general approval of the various oil brands.

For this reason YORK Refrigeration has, in cooperation with a large recognised oil company, developed a series of three oils which cover most purposes. YORK Refrigeration has however, also listed a limited number of oils which can be supplied through YORK Refrigeration. The typical data of these oils can be found in the *Data Sheet for Sabroe Oils*. We suggest you to use these Sabroe oils, which are delivered in 20 litre pails and 208 litre drums and can be ordered using the parts no. listed in the *List of Oils*.

It is of course possible to use similar oils from other oil companies, and in this connection,

the *Data Sheet for Sabroe Oils* may be helpful.

Please note, however, that YORK Refrigeration has not tested any other oils than our own brand, and hence we cannot answer for the quality, the stability or the suitability of other oils for any purposes. The oil company in question is thus solely responsible for the quality and suitability of the oil delivered, and if any problems are experienced with these oils in the compressors or in the refrigeration plant, the oil supplier should be contacted directly.

When choosing oils from other oil companies, please pay particular attention to the oil's effectiveness in the compressor and the refrigeration plant as a whole.

Pay particular attention to the following aspects:

- Oil type
- Refrigerant type
- Compressor type
- Miscibility between refrigerant and oil
- Operating data for the compressor
 - Discharge gas temperature
 - Oil temperatures:

Reciprocating compressors:

Normal oil temp. in the crankcase
50-60 °C

Max. permitted oil temperature = Setting point for alarm

Min. permitted oil temperatures = setting point for alarm - if fitted

Screw compressors:

The oil temperature before injection in the compressor, but after the oil cooler

Max. permitted oil temperature = setting point for alarm

Min. permitted oil temperature = setting point for alarm

- Condensing pressure
 - Evaporating pressure
 - Oil viscosity in the compressor during operation and under the influence of:
 - Refrigerant type and solubility of refrigerant in the oil
 - Operating temperatures
 - Vapour pressure in the oil reservoir
- Reciprocating compressor:* Suction pressure and oil temperature in the crankcase.
- Screw compressor:* Discharge pressure and gas temperature.
- Compatibility with the neoprene O-rings: the aniline point gives an indication of how the O-ring material reacts to the oil. At an aniline point less than approximately 100°C the material tends to swell, and at an aniline point higher than approximately 120°C it tends to shrink.

For this reason it is not recommended to change oil type from M oil to PAO oil as a leakage may occur if the O-rings are not changed. YORK Refrigeration therefore recommends using the Sabroe AP68 oil as it reduces the risk of leaks considerably in this case.

YORK Refrigeration can supply a calculation showing the operating data on request.

Attention is drawn to the following viscosity limits during operation:

- Optimum viscosity range
(to be designed for) = 20 to 50 cSt
- Max. permissible viscosity = 100 cSt
- Min. permissible viscosity = 10 cSt
(only applicable to HCFC and HFC under certain operating conditions: 7cSt)
- Max. permissible viscosity during the starting of the compressor = 500 cSt

Maximum refrigerant concentration in the oil at running condition: 25% - also if viscosity requirements are met.

Use of mineral oil

Lately we have experienced a number of problems with mineral oil, particularly in R717 plants. The problems can be divided into two groups:

- a:** The oil changes viscosity within a few operating hours.
- b:** The oil decomposes (becomes very black) within a few operating hours.

The problems have been seen with several oil brands and have resulted in severe consequences for both compressors and plants.

When using mineral oil, it is thus important that the plant is monitored very closely, that oil samples are taken regularly (every 1-2,000 hours) and that the condition/colour of the oil is checked on a weekly basis.

YORK Refrigeration therefore recommends only to use M oil at moderate operating conditions - cf. the attached oil recommendation diagrams.

YORK Refrigeration is aware, however, that several customers have been using mineral oils for many years without problems. Those customers who wish to continue using mineral oils in existing, as well as new, compressors can do so, providing the compressor type and operating conditions are similar to the existing ones (excepting the HPC and HPO series compressors).

YORK Refrigeration has therefore decided to market a brand of mineral oil which has been tested and found to be suitable for most general refrigerating purposes.

If another brand of mineral oil is chosen, the specifications in the data sheet in this recommendation should be followed as a guideline.

Mineral oil can be used in refrigerating plants, providing the lubricating quality is carefully monitored. For modern, high capacity refrigeration plants, in which a long life-time for both lubricant and moving parts is expected, YORK Refrigeration recommends using synthetic lubricating oils.

A benefit of using the synthetic lubricant oil is a much lower oil carry-over to the plant and longer intervals between oil changes. A better fluidity at lower temperatures also gives an easier drainage at the cold parts of the plant.

How to use the oil recommendation diagrams:

To determine the **code number**, first refer to the *Oil recommendation diagram* for the refrigerant and compressor type and then plot the proposed operating conditions.

Example (recip. compressors):

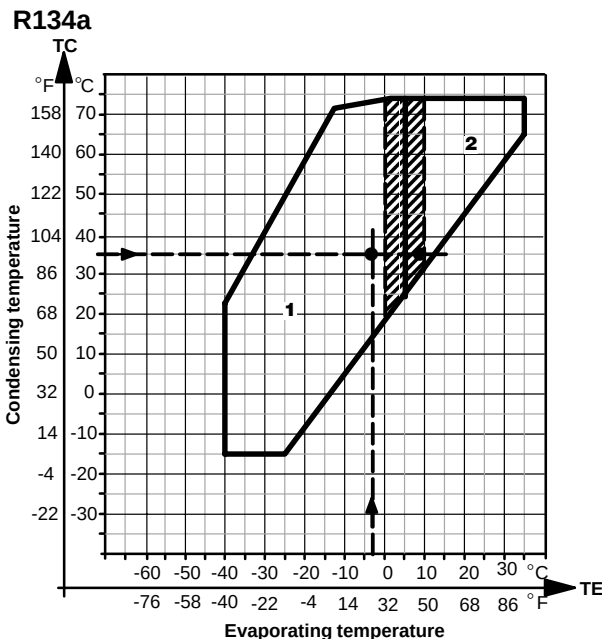
Refrigerant: **R134a**

Condensing temp. **TC +35°C**

Evaporating temp. **TE -3°C**

Please observe !

Plants may operate at different conditions from time to time, for example at different evaporating temperatures due to plant variations or at different condensing temperatures due to seasonal changes. By plotting TC and TE in the oil recommendation diagram, this example would require a No 1 oil. If, however, TE changes at certain times, e.g. from -3 to +7°C, a No 2 oil should be utilised. But, as +7°C is inside the marked area, the No 1 oil can be utilised also at this TE.



By referring to the *Oil recommendation table* placed at the bottom of each *oil recommendation diagram*, it is possible to select the **code number** for the appropriate oil type. In

the example above, a **oil code number E5** can be selected.

Code no	Area no	
	1	2
E5	▲	
E9		▲

In plants which incorporate both screw and reciprocating compressors and where the recommendations indicate the use of different oil types, please contact YORK Refrigeration for advice.

Changing oil on Sabroe compressors

The oil should never be changed to another type without consulting the oil supplier. Nor is it advisable to "top up" compressors with an other oil than the one already used for the particular plant and compressor.

Mixing different oils may result in operating problems in the refrigerant plant and damage to the compressors. Incompatibility between the different oil types may degrade the lubricating properties or may cause oil residues to form in the compressor or oil separator or in the plant. These oil residues can block filters and damage the moving parts in the compressor.

Furthermore, changing the oil from one type or make to another should only be undertaken in connection with a careful procedure involving the drainage and thorough evacuation of the refrigeration plant. Information on a suitable procedure can be obtained from YORK Refrigeration as well as from a number of oil companies.

It is imperative that oil is only used from the original container and that both the make and type complies with the specification for the plant.

Ensure that the original container is sealed during storage to prevent moisture from the air being absorbed into the oil - many oils, particularly the polyolester oils, are extremely hygroscopic. Consequently, it is recommended that the oil is only purchased in containers corresponding to the amount to be used on each occasion.

If the oil is only partially used, make sure that it is effectively re-sealed in the original container and that it is stored in a warm, dry place. Ideally with nitrogen blanketing of the oil to keep the water content below 50 ppm.

Oil drums should, ideally, be "racked" and mounted with a proper barrel tap to ensure an effective airtight seal.

Oil changing intervals

A list of the recommended intervals for changing the oil can be found in the compressor instruction manual. These are provided for guidance only. The actual interval between oil changes will often be determined by a variety of operating parameters within the plant.

It is strongly recommended to monitor the quality of the oil by carrying out oil analyses with regular intervals. This will also give a good indication of the condition of the plant. The service can be supplied by YORK Refrigeration or the oil suppliers.

Oil recommendation diagram symbols:

- ▲ : In case of a new plant. Very suitable.
- ☆ : In case you wish to change from mineral oil
- Ⓐ : Max oil concentration in liquid phase at: T_E : 2% W
- Ⓑ : Max oil concentration in liquid phase: contact YORK Refrigeration
- Ⓒ : Min suction temperature -50°C : at $T_E < -50^{\circ}\text{C}$ superheating must be introduced.
- * : Dry expansion systems only. Flooded systems to be considered individually: contact YORK Refrigeration
- SH: Suction gas superheat, K (Kelvin)
- ↘ : Zone in which both oils are useable
- ⌗ : Calculation must be performed using COMP1

Data sheet for listed Sabroe oils

Typical data for lubricating oils for Sabroe compressors

Sabroe code	Viscosity		Viscosity Index	Spec. grav. at 15°C	Flash p. COC °C	Pour p. °C	Anilin °C point	Acid no. mg KOH/g
	cSt 40°C	cSt 100°C						
M1	63	6.4	14	0.91	202	−36	81	0.02
A3	97	8.1	13	0.86	206	−32	78	0.05
AP1	64	9.3	121	0.858	195	−51	121	0.04
PAO3	66	10.1	136	0.835	266	<−45	138	0.03
PAO5	94	13.7	147	0.838	255	<−45	144	0.03
PAO9	208	25	149	0.846	260	<−39	154	0.03
E3	Due to the big difference between polyolester-based lubricants from various suppliers, it is not possible to present typical data for these oils. When using another oil brand than the one recommended by YORK Refrigeration, please contact the oil supplier to select the correct oil type.							
E5								
E9								
E11								

The listed data are typical values and are intended as a guideline only when selecting a similar oil from a different oil company. Data equivalence alone does not necessarily qualify the oil for use in YORK Refrigeration's Sabroe compressors.

List of part numbers for available Sabroe oils

Oil brand	Oil code no.	Part no.	
		20 litre pail	208 litre pail
Mobil Gargoyle Arctic 300	M 1 (M68)	1231-264	1231-296
Sabroe Oil A100	A 3 (A100)	1231-263	1231-262
Sabroe Oil AP68	AP 1 (AP68)	1231-257	1231-260
Sabroe Oil PAO68	PAO 3 (P68)	1231-256	1231-259
Mobil Gargoyle Arctic SHC 228	PAO 5 (P100)	1231-282	1231-283
Mobil Gargoyle Arctic SHC 230	PAO 9 (P220)	1231-284	1231-285
Mobil EAL Arctic 68	E 3 (E68)	1231-272	1231-273
Mobil EAL Arctic 100	E 5 (E100)	1231-274	1231-275
Mobil EAL Arctic 220	E 9 (E220)		1231-279
Sabroe H oil	E11 (E370)	3914 1512 954 ¹⁾	9415 0008 000

¹⁾ 18.9 litre pail (5 US gallons)

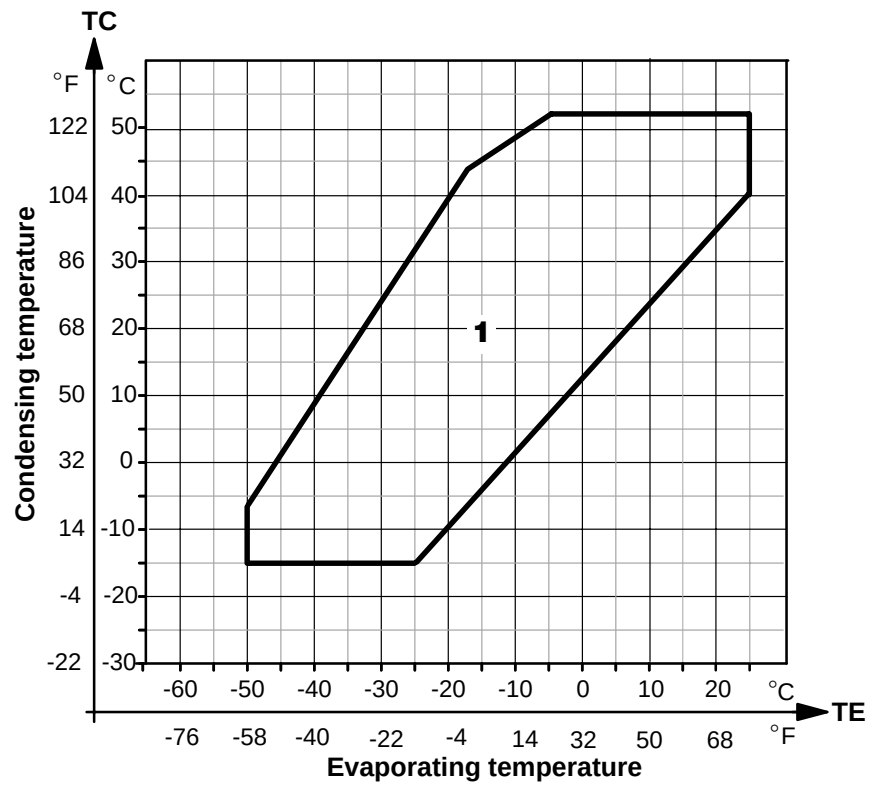
The oils recommended by the former Stal Refrigeration correspond to the following oils:

Stal Refrigeration oil type	Sabroe oil		
A	Mobil Gargoyle Arctic 300	–	M1 (M68)
B	Sabroe Oil PAO 68	–	PAO 3 (PAO 68)
C	Mobil Gargoyle Arctic SHC 230	–	PAO 9 (PAO 220)
H	Sabroe H oil	–	E 11 (E 370)

R717

one-stage
reciprocating
compressors

Code no	Area no 1
PAO 3	▲
AP 1	☆/▲
M1	See note



Note: YORK Refrigeration recommends that the use of M oils is restricted to moderately loaded compressors and that the oil quality is monitored carefully via regular oil analyses.

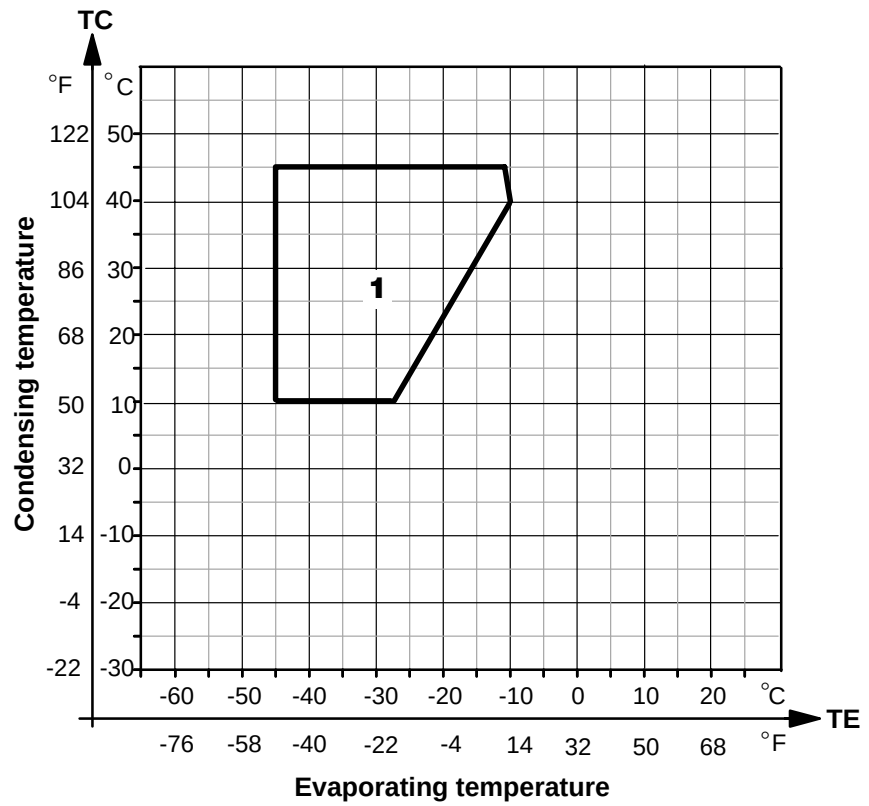
▲ : In case of a new plant. Very suitable.

☆ : In case you wish to change from mineral oil

R717

two-stage
reciprocating
compressors

Code no	Area no
	1
PAO 3	▲
AP 1	☆/▲
M1	See note



Note: YORK Refrigeration recommends that the use of M oils is restricted to moderately loaded compressors and that the oil quality is monitored carefully via regular oil analyses.

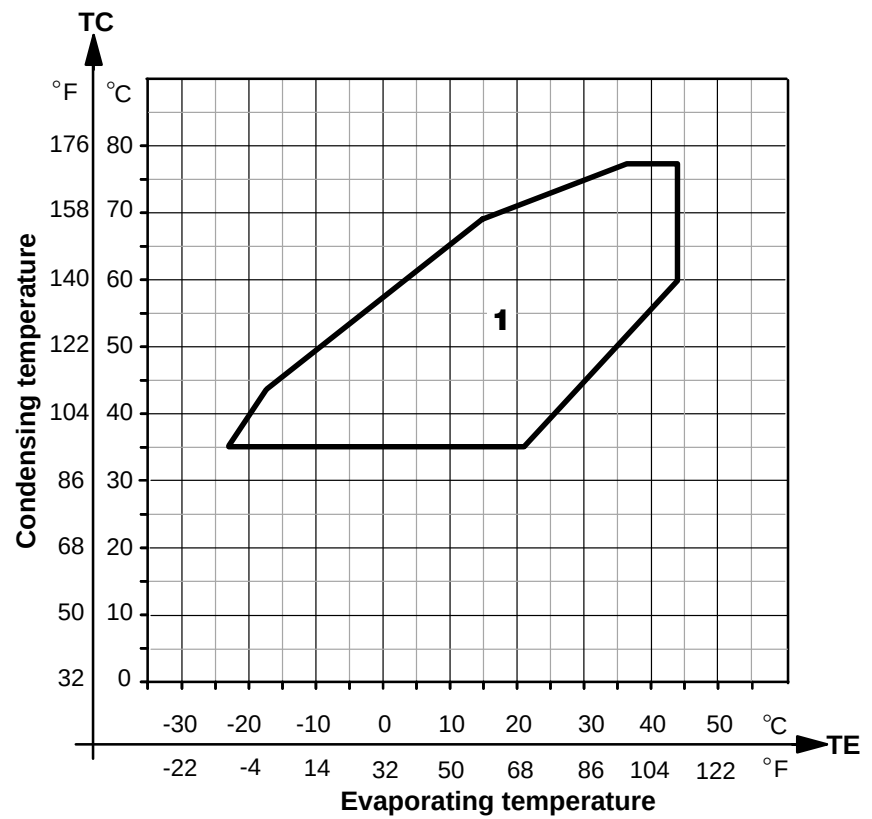
▲ : In case of a new plant. Very suitable.

☆ : In case you wish to change from mineral oil

R717

HPO and HPC
reciprocating
compressors

Code no	Area no
PAO 5	▲



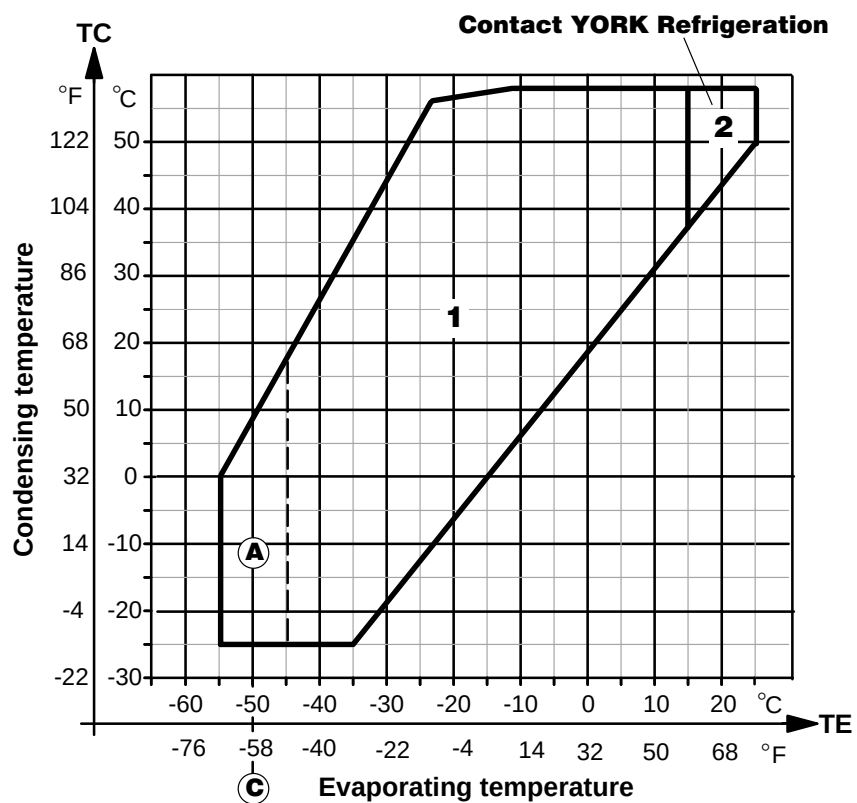
Please observe: PAO 5 oil is the only oil which can be used in the HPO and HPC compressors.

▲ : In case of a new plant. Very suitable.

R22

one-stage
reciprocating
compressors

Code no	Area no
	1
A 3	▲

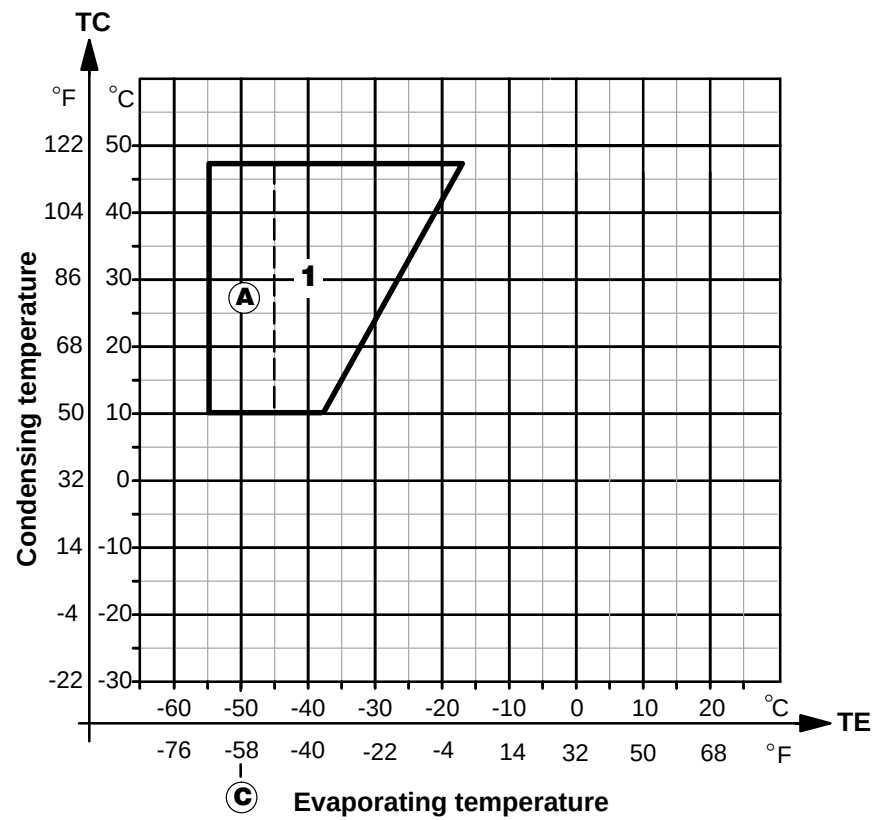


- ▲ : In case of a new plant. Very suitable.
- Ⓐ : Max oil concentration in liquid phase at: T_E : 2% W
- Ⓒ : Min suction temperature -50°C : at $T_E < -50^{\circ}\text{C}$ superheating must be introduced.

R22

two-stage
reciprocating
compressors

Code no	Area no
	1
A 3	▲

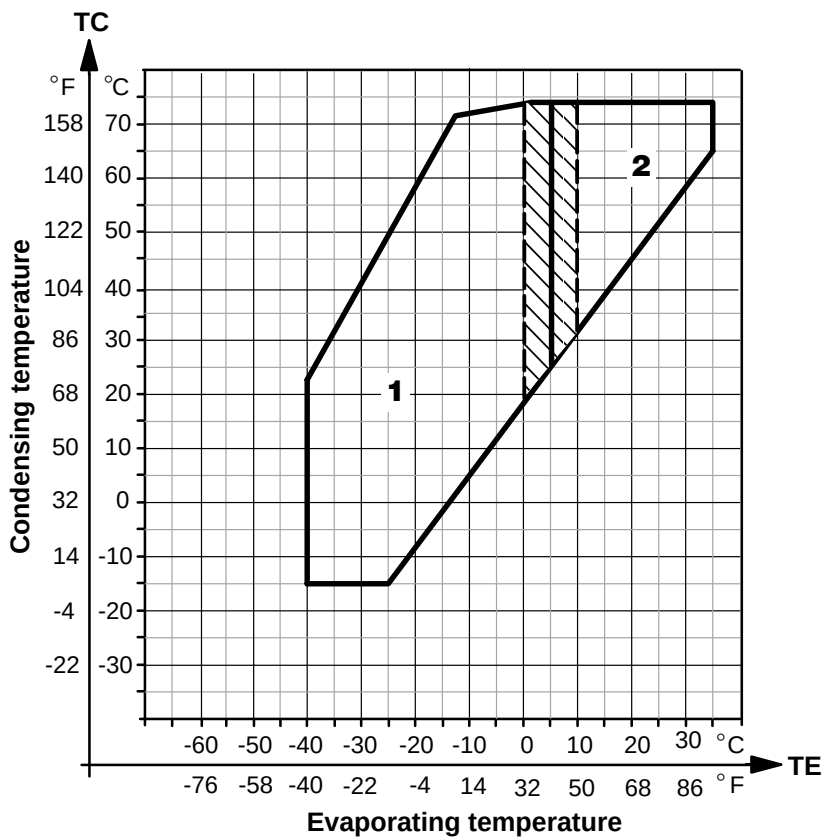


- ▲ : In case of a new plant. Very suitable.
- Ⓐ : Max oil concentration in liquid phase at: T_E : 2% W
- Ⓒ : Min suction temperature -50°C : at $T_E < -50^\circ\text{C}$ superheating must be introduced.

R134a

one-stage
reciprocating
compressors

Code no	Area no	
	1	2
E 5	▲	
E 9		▲

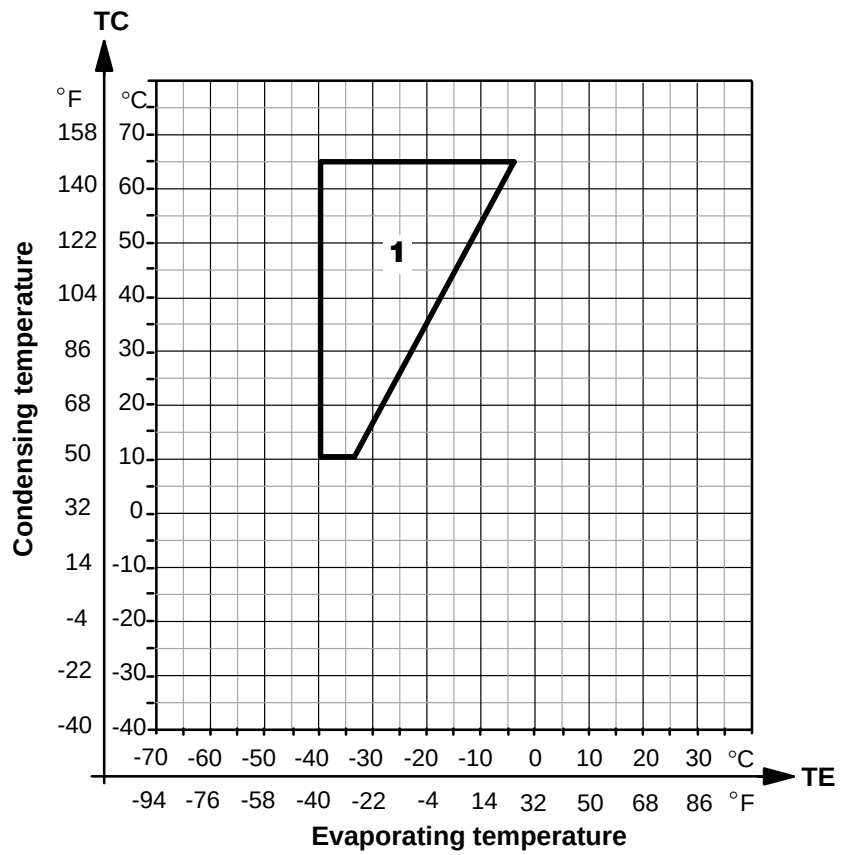


- ▲ : In case of a new plant. Very suitable.
- \\ : Zone in which both oils are useable

R134a

two-stage
reciprocating
compressors

Code no	Area no
	1
E 5	▲

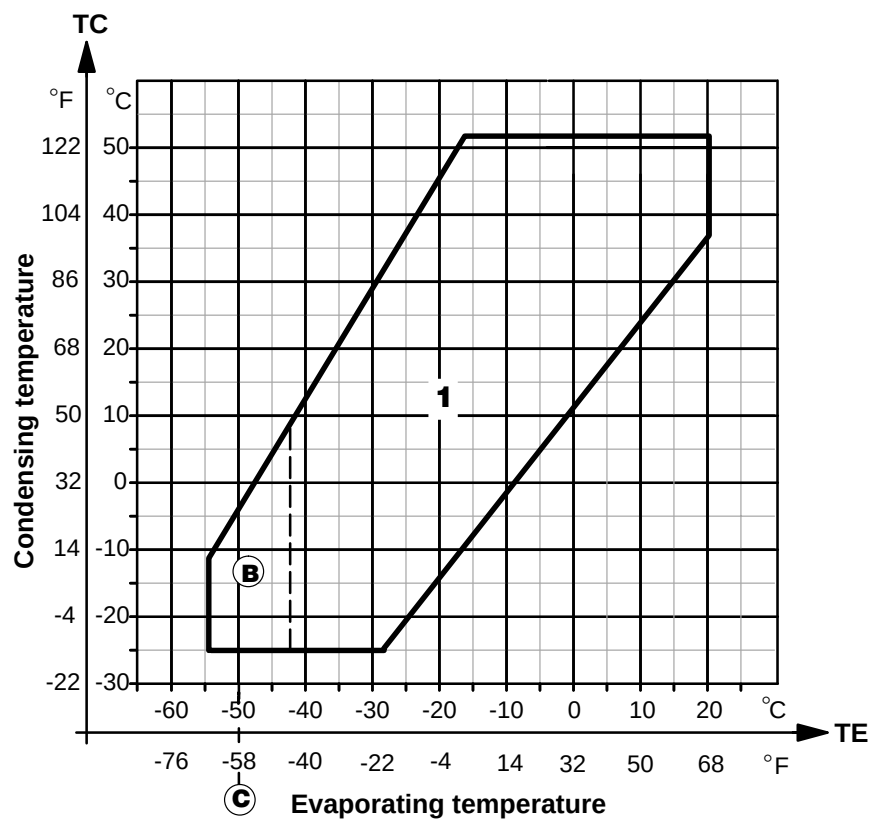


▲ : In case of a new plant. Very suitable.

R407C

one-stage
reciprocating
compressors

Code no	Area no
E 3	1 ▲

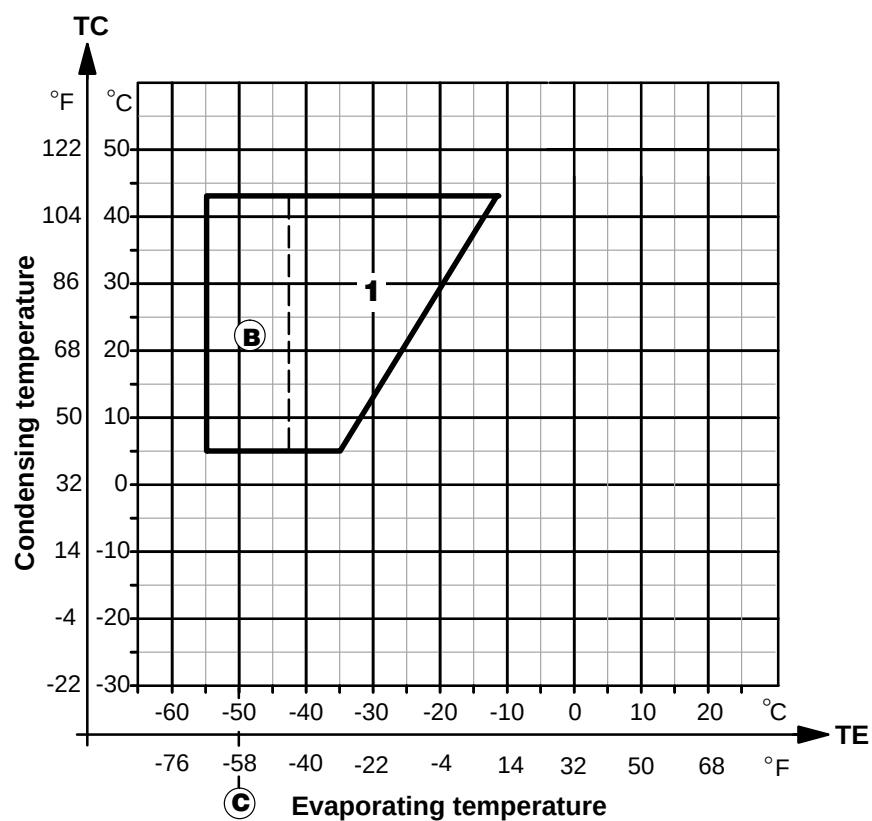


- ▲ : In case of a new plant. Very suitable.
- Ⓑ : Max oil concentration in liquid phase: contact YORK Refrigeration
- Ⓒ : Min suction temperature -50°C : at $\text{TE} < -50^{\circ}\text{C}$ superheating must be introduced.

R407C

two-stage
reciprocating
compressors

Code no	Area no
	1
E 3	▲

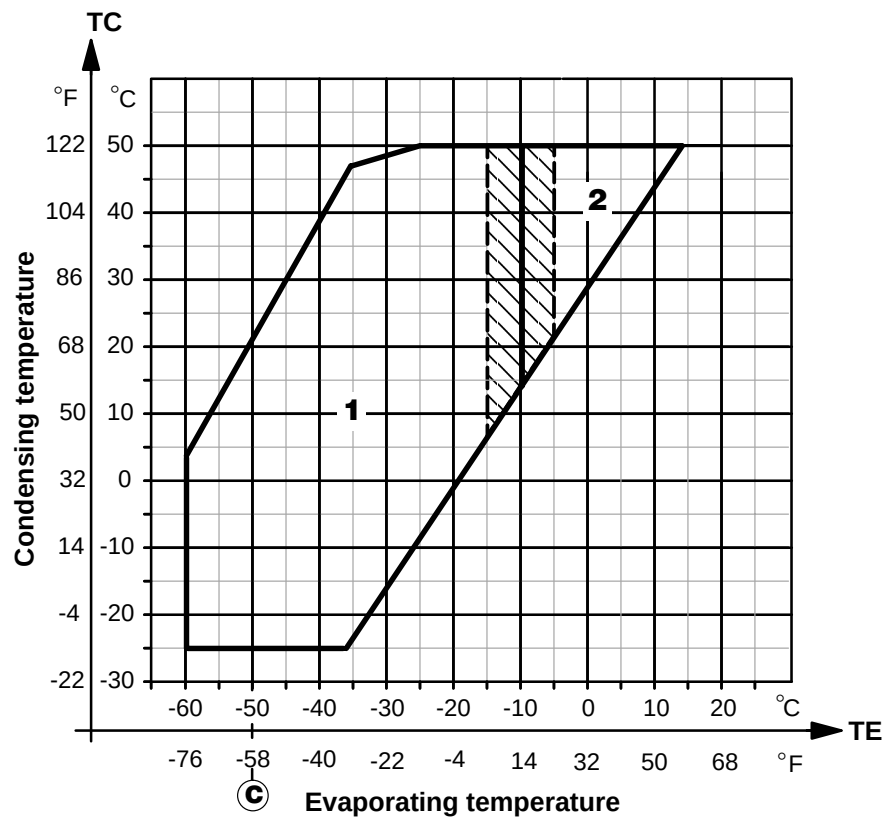


- ▲ : In case of a new plant. Very suitable.
- Ⓑ : Max oil concentration in liquid phase: contact YORK Refrigeration
- Ⓒ : Min suction temperature -50°C : at $\text{TE} < -50^{\circ}\text{C}$ superheating must be introduced.

R404A

one-stage
reciprocating
compressors

Code no	Area no	
	1	2
E 3	▲	
E 5		▲

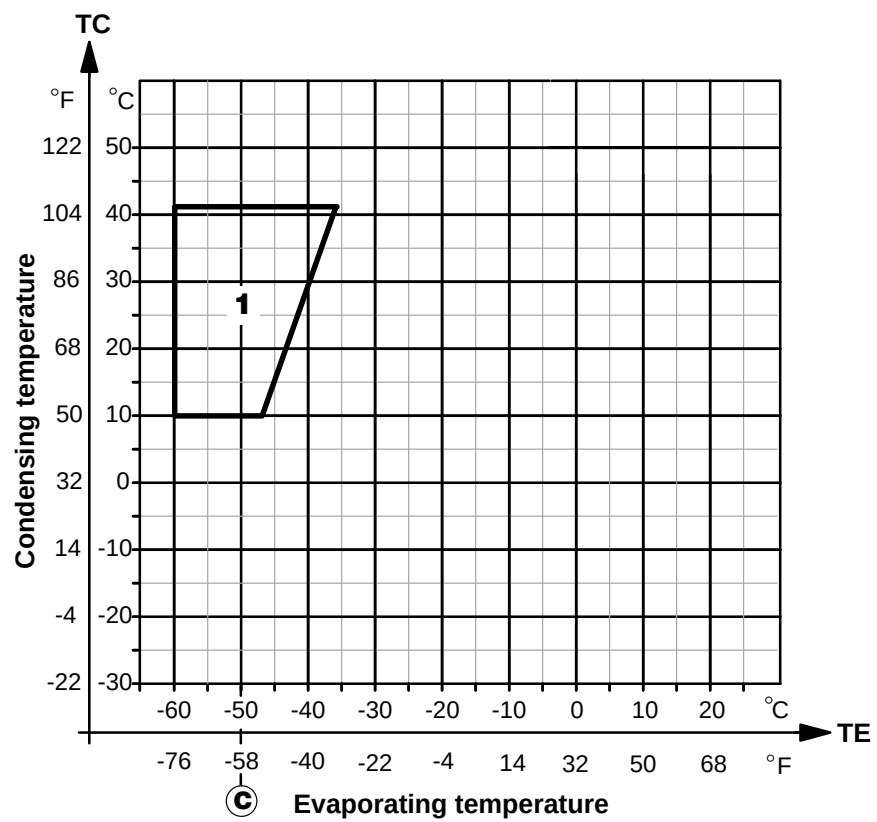


- ▲ : In case of a new plant. Very suitable.
- Ⓒ : Min suction temperature -50°C : at $\text{TE} < -50^{\circ}\text{C}$ superheating must be introduced.
- /// : Zone in which both oils are useable

R404A

two-stage
reciprocating
compressors

Code no	Area no
E 3	▲



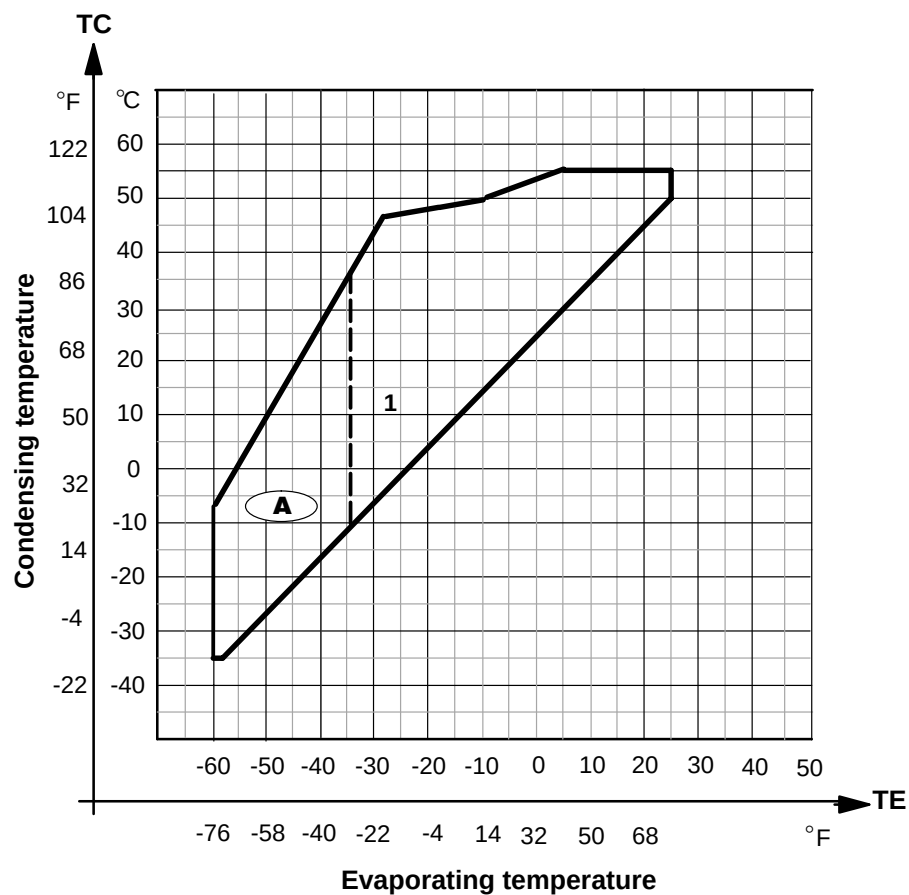
▲ : In case of a new plant. Very suitable.

Ⓒ : Min suction temperature -50°C : at $\text{TE} < -50^{\circ}\text{C}$ superheating must be introduced.

R410A

HPO og HPC
reciprocating
compressors

Code no	Area no
	1
E 5	▲

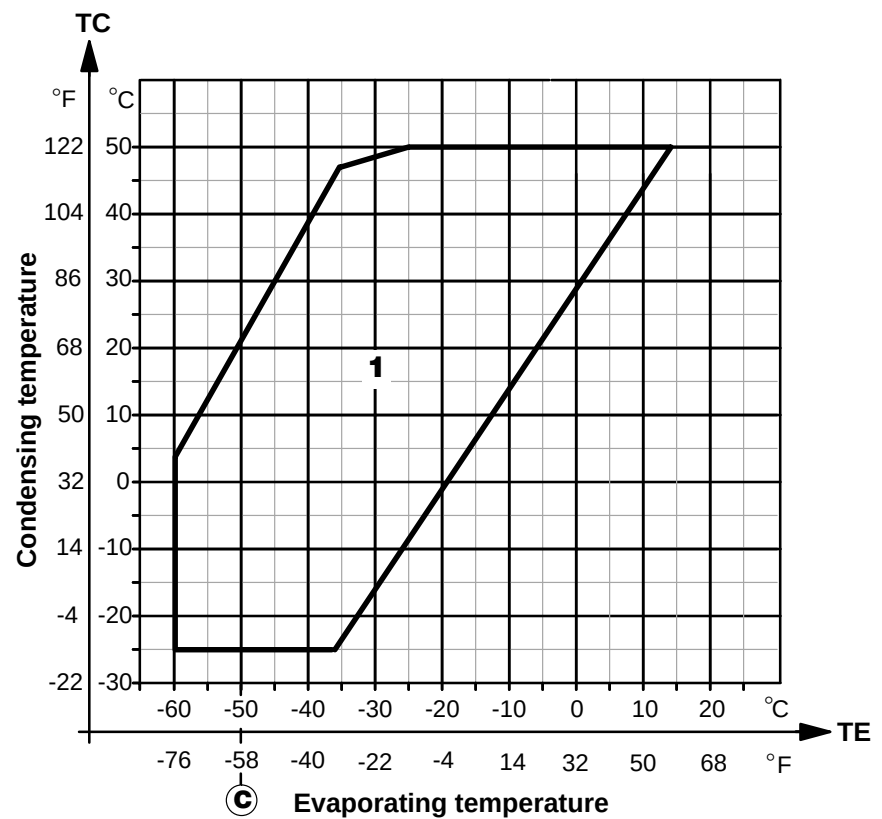


- ▲ : In case of a new plant. Very suitable.
 (A) : Max oil concentration in liquid phase at: T_E : 2%

R507

one-stage
reciprocating
compressors

Code no	Area no
E 5	▲



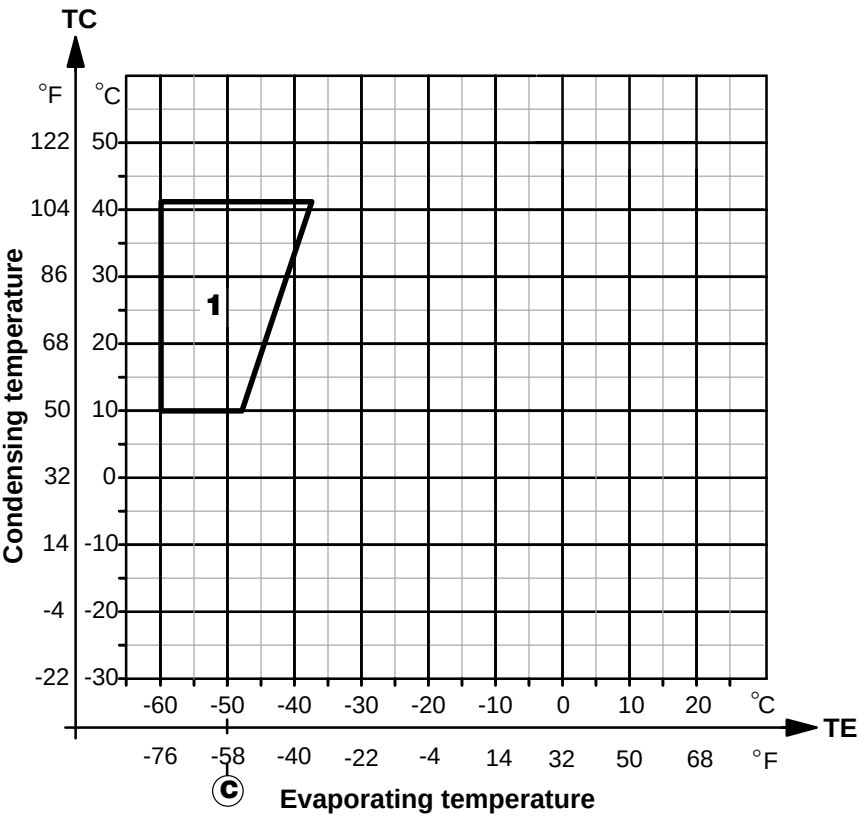
▲ : In case of a new plant. Very suitable.

Ⓒ : Min suction temperature -50°C : at $\text{TE} < -50^{\circ}\text{C}$ superheating must be introduced.

R507

two-stage
reciprocating
compressors

Code no	Area no
	1
E 5	▲

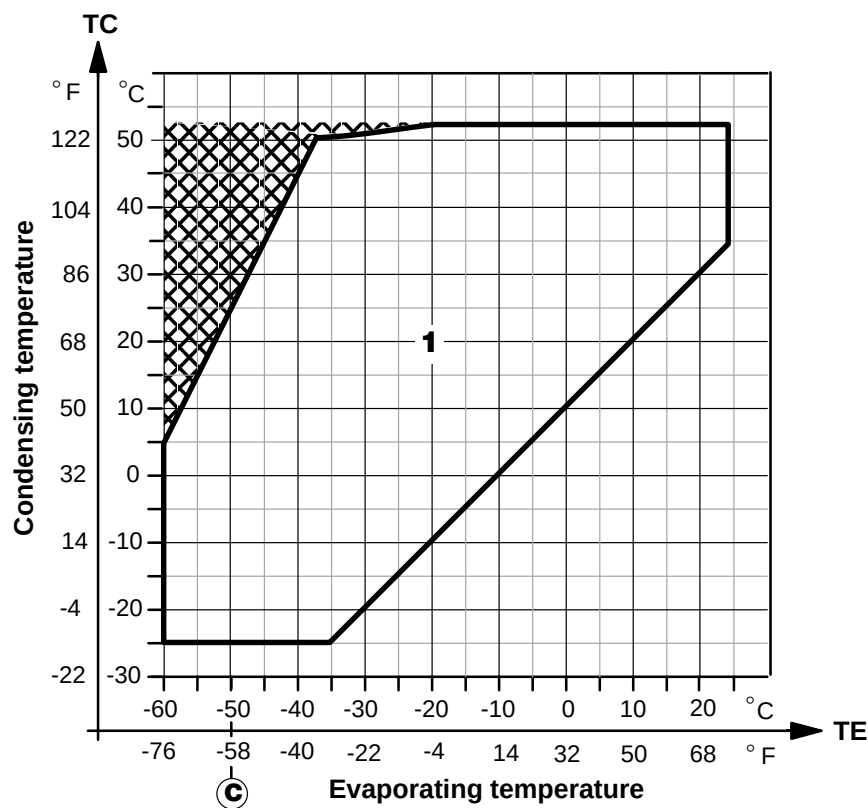


- ▲ : In case of a new plant. Very suitable.
- Ⓒ : Min suction temperature -50°C: at TE< -50°C superheating must be introduced.

R717

Screw compressors

Code no	Area no
	1
PAO 3	▲
AP 1	☆/▲
M1	See note



Note: YORK Refrigeration recommends that the use of M oils is restricted to moderately loaded compressors and that the oil quality is monitored carefully via regular oil analyses.

HLI: Calculation must be performed using COMP1

▲ : In case of a new plant. Very suitable.

☆ : In case you wish to change from mineral oil

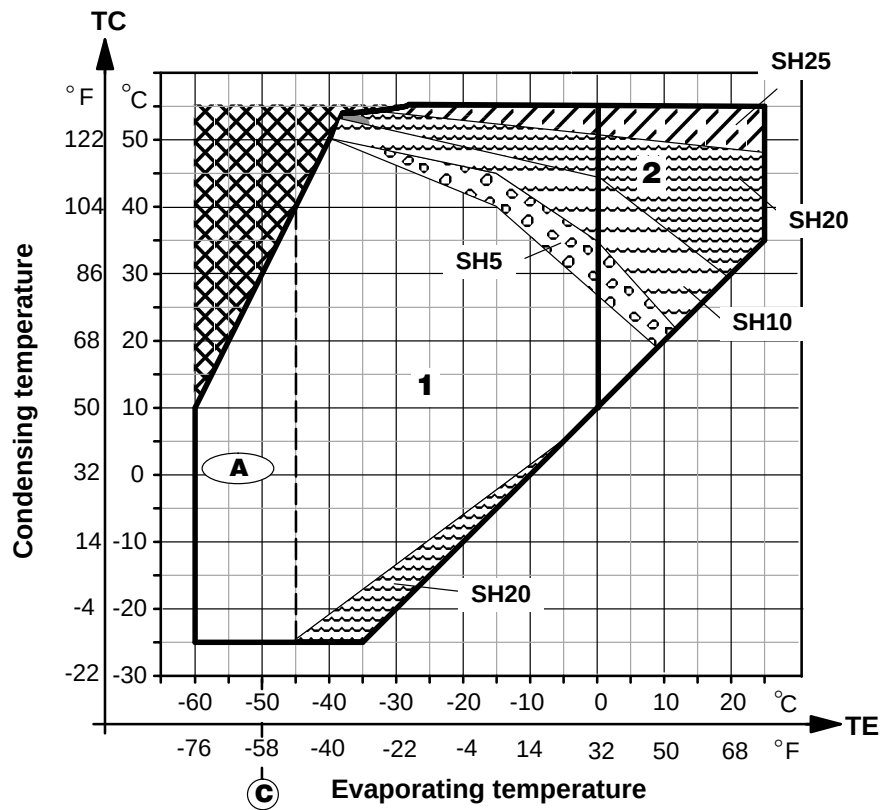
Ⓒ : Min suction temperature -50 °C: at TE < -50 °C superheating must be introduced.

⊗ : Calculation must be performed using COMP1.

R22

Screw compressors

Code no	Area no	
	1	2*
A 3	▲	
PAO 5		▲



Using the calculating programme COMP1 it is possible to optimize the requirement for suction superheat values (SH) as stated in the diagram. See *Oil types and oil companies* in this section. Due to the ongoing development of lubrication oils, please contact YORK Refrigeration for an update on the requirement for superheat.

HLI: Calculation must be performed using COMP1.

▲ : In case of a new plant. Very suitable.

Ⓐ : Max oil concentration in liquid phase at: T_E : 2% W

Ⓒ : Min suction temperature -50°C : at $T_E < -50^{\circ}\text{C}$ superheating must be introduced.

* : Dry expansion systems only. Flooded systems to be considered individually: contact YORK Refrigeration

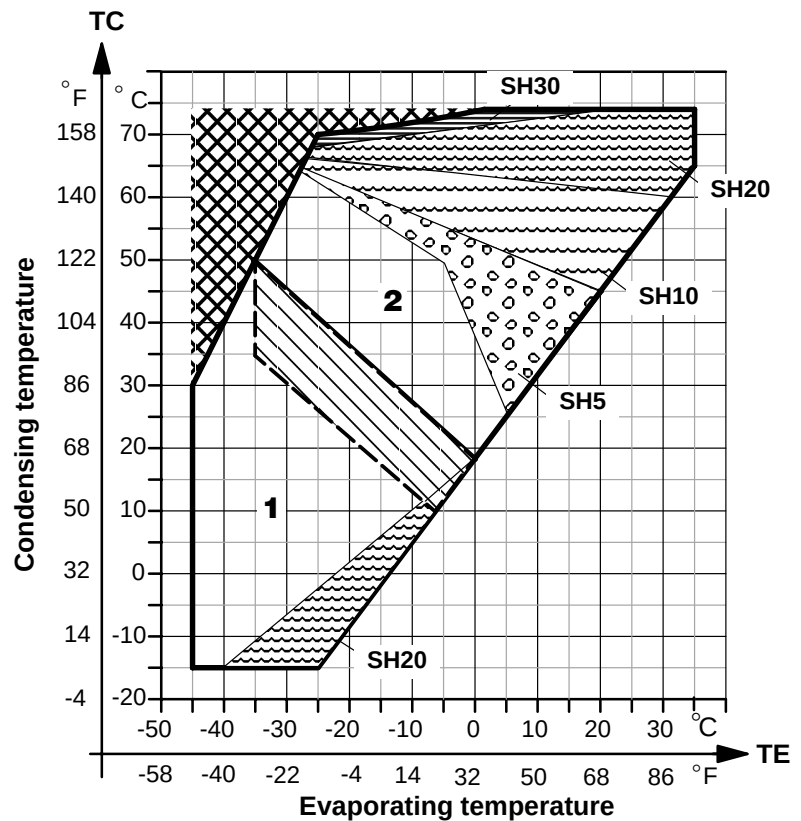
SH: Suction gas superheat, K (Kelvin)

⊗ : Calculation must be performed using COMP1

R134a

Screw compressors

Code no	Area no (See note)	
	1	2
E 5	▲	
E 9		▲



Note: For the compressors type "S", "Rotatune", "SAB 81", "SAB 83", and "SAB 85" only Sabroe oil H is approved.

Using the calculating programme COMP1 it is possible to optimize the requirement for suction superheat values (SH) as stated in the diagram. See *Oil types and oil companies* in this section. Due to the ongoing development of lubrication oils, please contact YORK Refrigeration for an update on the requirement for superheat.

HLL: Calculation must be performed using COMP1.

▲ : In case of a new plant. Very suitable.

SH : Suction gas superheat, K (Kelvin)

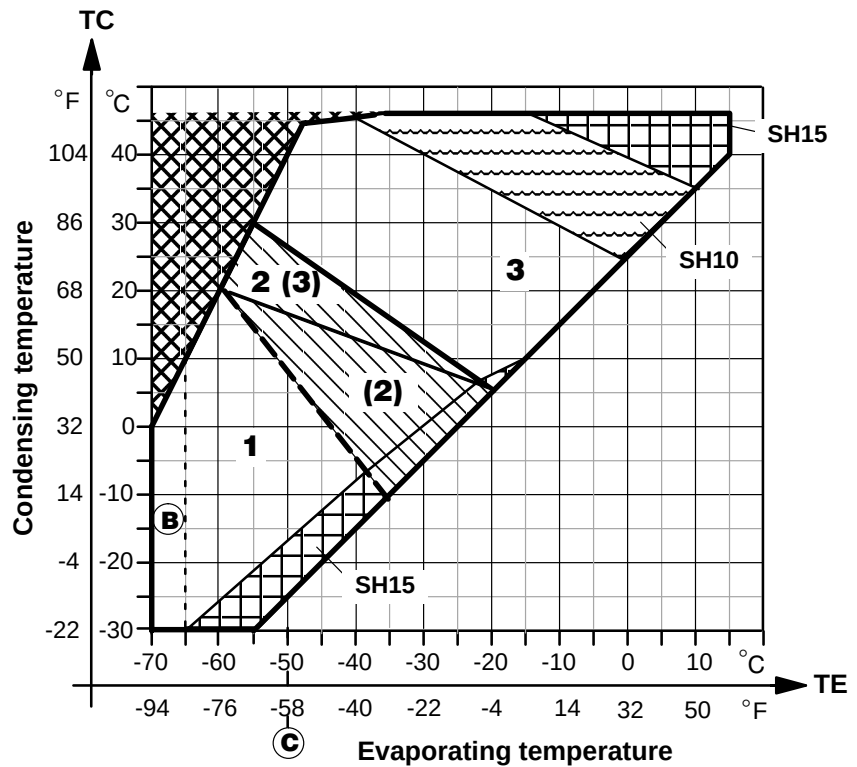
\\ : Zone in which both oils are useable

⊗ : Calculation must be performed using COMP1

R404A

Screw compressors

Code no	Area no (See note)		
	1	2	3
E 3	▲		
E 5		▲	
E 9			▲



Note: For the compressors type "S", "Rotatune", "SAB 81", "SAB 83", and "SAB 85" only Sabroe oil H is approved.

Using the calculating programme COMP1 it is possible to optimize the requirement for suction superheat values (SH) as stated in the diagram. See *Oil types and oil companies* in this section. Due to the ongoing development of lubrication oils, please contact YORK Refrigeration for an update on the requirement for superheat.

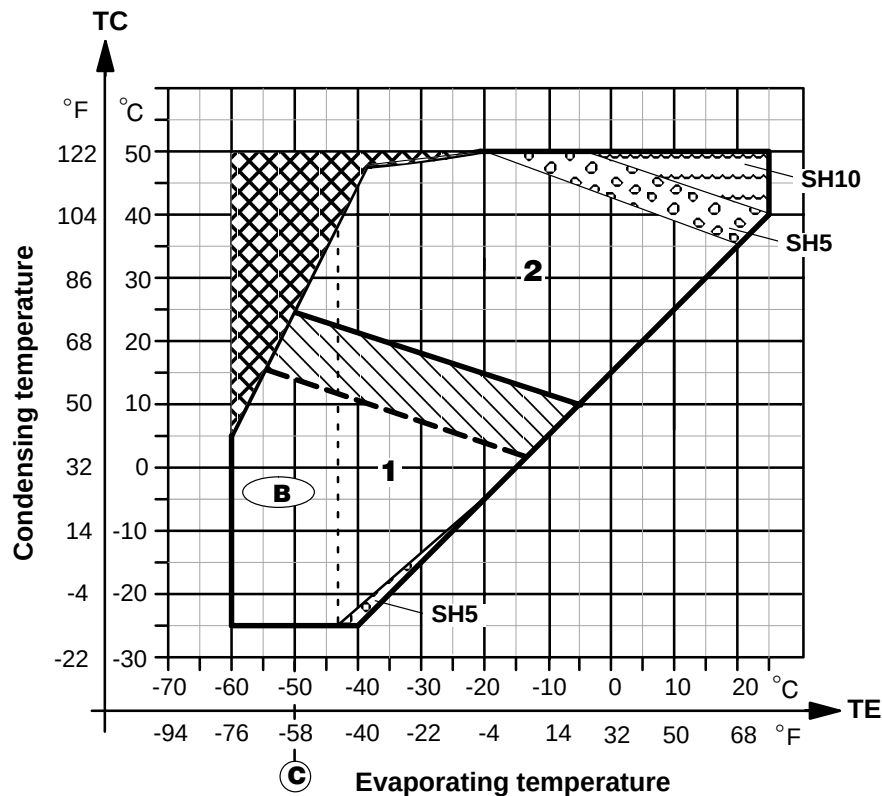
HLI: Calculation must be performed using COMP1.

- ▲ : In case of a new plant. Very suitable.
- (B) : Max oil concentration in liquid phase: contact YORK Refrigeration
- (C) : Min suction temperature -50°C : at $\text{TE} < -50^{\circ}\text{C}$ superheating must be introduced.
- SH: Suction gas superheat, K (Kelvin)
- Zone in which both oils are useable
- ✕ : Calculation must be performed using COMP1

R407C

Screw compressors

Code no	Area no (See note)	
	1	2
E 3	▲	
E 9		▲



Note: For the compressors type "S", "Rotatune", "SAB 81", "SAB 83", and "SAB 85" only Sabroe oil H is approved.

Using the calculating programme COMP1 it is possible to optimize the requirement for suction superheat values (SH) as stated in the diagram. See *Oil types and oil companies* in this section. Due to the ongoing development of lubrication oils, please contact YORK Refrigeration for an update on the requirement for superheat.

HLL: Calculation must be performed using COMP1.

▲ : In case of a new plant. Very suitable.

Ⓑ : Max oil concentration in liquid phase: contact YORK Refrigeration

Ⓒ : Min suction temperature -50°C : at $\text{TE} < -50^{\circ}\text{C}$ superheating must be introduced.

SH: Suction gas superheat, K (Kelvin)

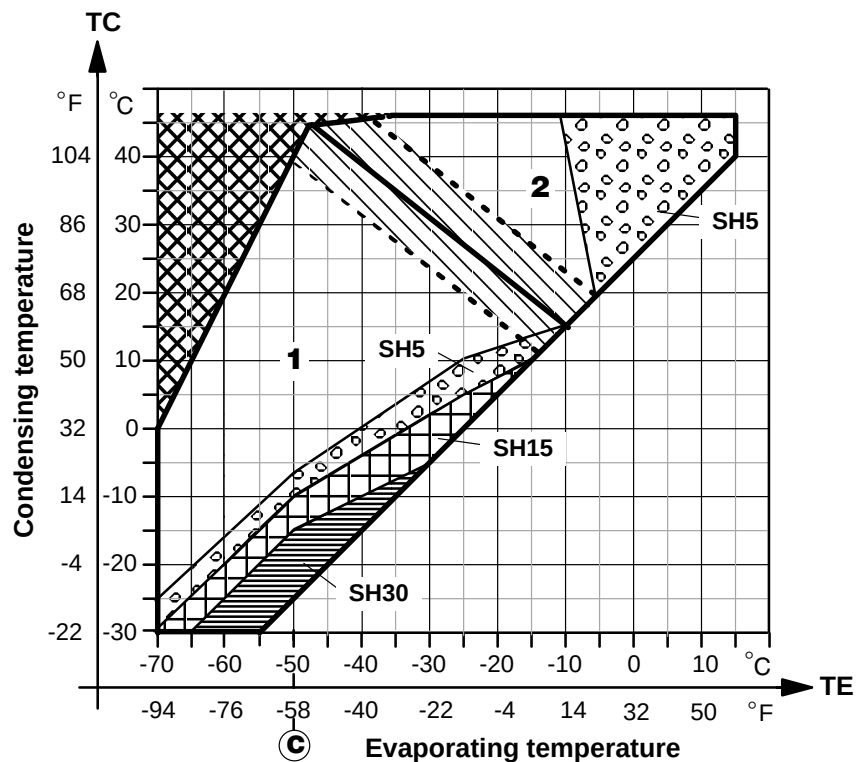
\\ : Zone in which both oils are useable

XX: Calculation must be performed using COMP1

R507

Screw compressors

Code no	Area no (See note)	
	1	2
E 5	▲	
E 9		▲



Note: For the compressors type "S", "Rotatune", "SAB 81", "SAB 83", and "SAB 85" only Sabroe oil H is approved.

Using the calculating programme COMP1 it is possible to optimize the requirement for suction superheat values (SH) as stated in the diagram. See *Oil types and oil companies* in this section. Due to the ongoing development of lubrication oils, please contact YORK Refrigeration for an update on the requirement for superheat.

HLI: Calculation must be performed using COMP1.

- ▲ : In case of a new plant. Very suitable.
- Ⓒ : Min suction temperature -50°C : at $\text{TE} < -50^{\circ}\text{C}$ superheating must be introduced.
- SH: Suction gas superheat, K (Kelvin)
- \\ : Zone in which both oils are useable
- ⊗ : Calculation must be performed using COMP1

List of major oil companies

The oil from the companies listed below are NOT tested by YORK Refrigeration and are therefore NOT approved by YORK Refrigeration either. The following list reflects the information provided by the companies themselves. The assessment of durability and suitability of specific oils for specific purposes are entirely at the companies' own discretion. Oils tested and approved by YORK Refrigeration can be found in the *"List of part numbers for available Sabroe oils"*.

Oil Company	Oil Types				
	M	A	PAO	AP	E
Aral	•				•
Avia	•				
BP	•	•	•		•
Castrol	•	•	•		•
Chevron (UK: Gulf Oil)	•		•		•
CPI Engineering Services	•		•		•
DEA	•	•	•		•
Elf / Lub Marine 1	•	•			•
Esso/Exxon	•	•	•		
Fina	•	•			•
Fuchs	•	•	•		•
Hydro-Texaco	•	•	•		•
ICI					•
Kuwait Petroleum (Q8)	•			•	
Mobil	•	•	•	•	•
Petro-Canada	•				
Shell	•	•	•		•
Statoil	•	•			
Sun Oil	•				•

Notes:

[illegible]

Alignment of unit, AMR coupling

Where the compressor and motor are directly interlinked, an AMR coupling is used; this is a torsionally rigid coupling with enough radial and axial flexibility to assimilate small movements between the two machines.

In order to ensure compressor and motor a long life as well as noise- and vibration-free operation, compressor unit and coupling need to be aligned with care. Misalignment of the compressor unit or coupling may produce stresses and vibrations which can be transmitted to the compressor and motor bearings and thus cause major damage.

Vibrations may be caused by the following:

- Distortion between compressor unit and foundation.
- Distortion between compressor and base frame.
- Distortion between motor and base frame.
- Strains from pipe connections between compressor and plant.
- Misalignment of coupling linking compressor and motor.
- Untruth in compressor or motor shafts.
- Untruth in coupling.
- Imperfect balancing of coupling.
- Imbalance in compressor or motor.

The points up to and including coupling alignment are the responsibility of the fitter setting up the unit. The other points must be checked by the compressor or motor

manufacturer prior to delivery. The following sections will deal with the individual points concerning the fitter.

Alignment of unit with foundation

Whenever installing a unit directly onto the foundation or machine floor, it should stand free of stresses and press down evenly on all supports.

The unit can be installed in the following ways:

- on vibration dampers
- straight onto a foundation, using foundation bolts.

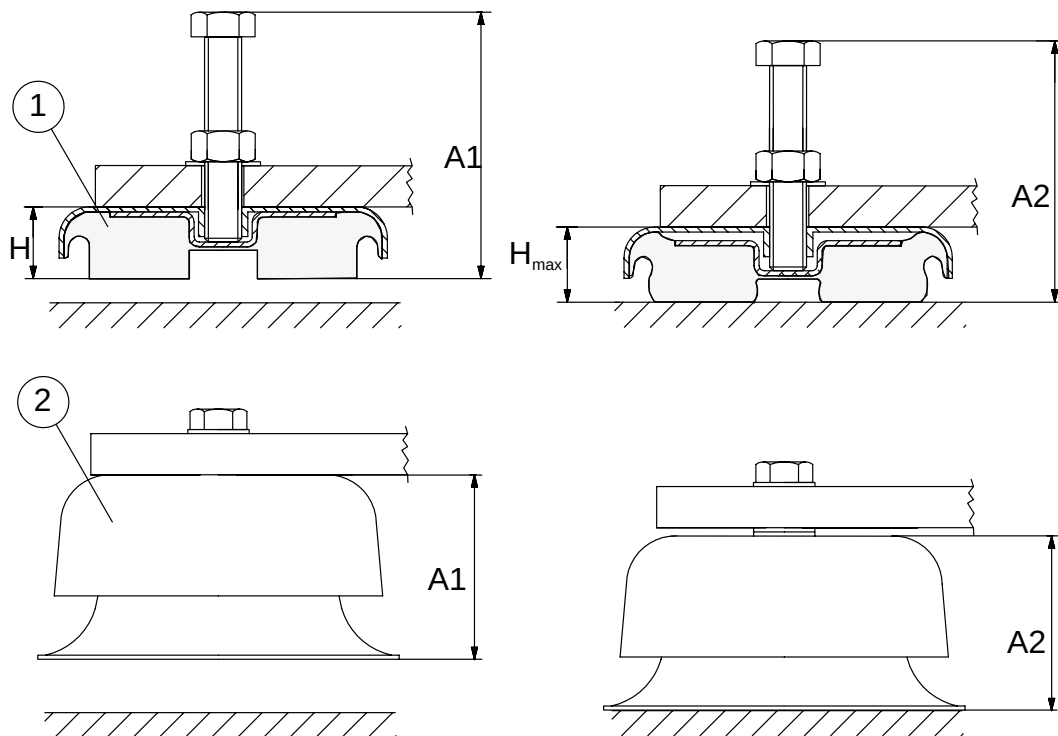
Whichever method is used, the unit must be aligned **before** hooking the connection pipes up to the installation.

Vibration dampers are supplied as shown at the top or bottom of drawing T0177040, depending whether the compressor unit is intended for use on land or at sea.

The purpose of the vibration dampers is to diminish the vibrations from the compressor unit to the foundation. In addition, the marine vibration dampers serve to cushion vibrations from the foundation to the compressor unit, at the same time securing the unit to the foundation.

It is imperative that the vibration dampers be placed correctly, as shown in the completed drawing forwarded to customer or distributor. This drawing is valid **only** for the unit in question .

Installation on vibration dampers



T0177040_0

The vibration dampers supplied are marked with a code, for instance LM6-60. LM6 indicates the size; 60 indicates the rubber hardness and is therefore an expression of bearing and damping ability.

When using vibration dampers, the machine room floor is assumed to have the necessary bearing strength and to be level enough to enable adjustment of the vibration dampers to be made within the adjusting measurements stated on the drawing submitted.

In order for the individual vibration damper to cushion properly, a sufficient load must be imposed. Measure A1 and H in an unloaded and A2 in a loaded set-up, as shown in drawing T0177040.

	Industrial type ①	Marine-type ②
Flexion A1-A2	min 1,0 max 2,0	min 3,0 max 5,0
Height adjustment	$H_{max} = H + 12$	with disks supplied as shown

The flexion of a damper is adjusted by increasing or decreasing the load in relation to the other supports. The foot can be raised by screwing the adjusting rod down or inserting more disks between damper and foot (marine design), thereby increasing load and hence also the flexion.

Once the installation has cooled down, check during operation that the flexion of the dampers is still correct!

Installing directly on foundation

When installing a unit directly on a concrete foundation, the foundation should be cast in accordance with the foundation drawings dispatched.

When the foundation has been cast - with the holes shown for foundation bolts - and has set, place the unit in position, allowing it to rest on beams levelled at a suitable height so that the foundation plates are recessed slightly into the foundation.

Check that the foundation plates are right next to the base frame. This can be achieved by binding them to the resting surfaces of the base frame with steel flex.

The concrete cast down around the foundation bolts should contain only a small amount of water, so that it can be well tamped around the bolts. Low water content produces no contraction of the setting concrete.

10-14 days should be allowed to elapse before removing the beams and tightening the nuts for the foundation bolts.

Before that, however, remove the steel flex and check that there is no space between the base frame and the foundation plates. If there is, place shims between the plates before tightening.

Alignment of compressor with base frame

Check that the entire footing of the compressor makes full contact against the milled-off faces of the base frame.

Perform this check with the bolts loosened. If slip occurs at one or more resting surfaces, shim up before tightening. If unaligned, there is a risk of stresses occurring in the compressor frame, which will damage the bearings.

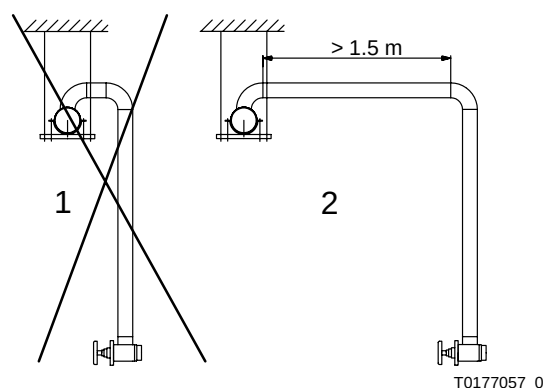
Alignment of motor with base frame

Check the contact faces of the motor against the base frame in the same way as for the compressor.

Stresses from piping connections

In order to prevent stress being transmitted from piping connections between unit and plant, pipes must be laid so as not to generate compressive stresses or tensile strains in the event of expansions or contractions due to temperature changes. Steel piping expands approx. 1 mm per metre per 100°C.

We recommend that piping be laid as shown in example 2 of the sketch. Example 1 demonstrates too rigid pipe laying.



Final alignment of compressor and motor can be performed once all piping has been connected to the unit.

Fitting and alignment of AMR-type coupling

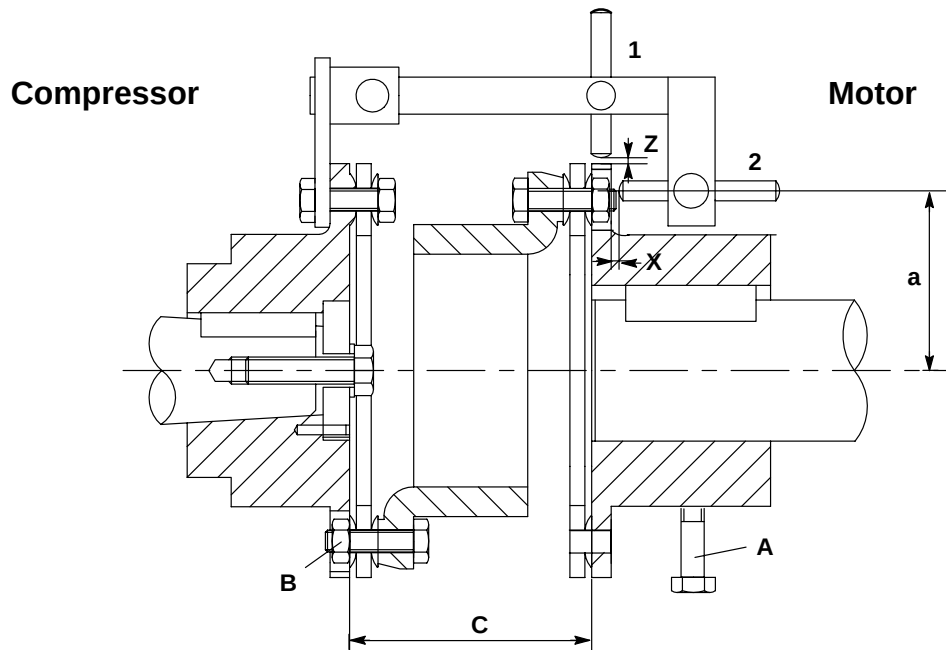
Installation and alignment

In principle, alignment involves manoeuvring the motor so as to make the shaft form an extension of the crankshaft.

Important

Before any work on the coupling, ensure that the compressor motor cannot be started inadvertently.

Fig. 1



T0177120_0/V2

Compressor	AMR type of coupling	Distance C nominal* mm	Torque moment		Max. variation measured with a feeler gauge at a 180° turning of the af coupling		
			A Nm	B Nm	Pos. 1 Horizontal max. mm	Pos. 1 Vertical min./max. mm	Pos. 2 max. mm
HPO/CMO 2	225	76,0		34	0,1	0,1/0,2	0,1
HPC/SMC 104-108	312 S	103,5	147	55	0,2	0,1/0,3	0,2
SMC 112-116	350 S	114,5	147	128	0,2	0,1/0,3	0,2
SMC 180	450 S	149,0	295	275	0,3	0,1/0,4	0,3

* See Final mounting, pt. 4

Preliminary installation

- Check tightening of coupling flange on compressor.
- Tighten 8 coupling bolts securing lamellar segments to intermediate piece to prescribed moment stated in table. It is worthwhile doing this before placing the intermediate piece in position.

- Mount retaining plate from coupling screen onto compressor and insert support ring for coupling screen over motor flange.
- Insert coupling intermediate piece. Create space between flanges either by shifting entire motor or just motor coupling flange. **The intermediate piece should only be secured to the compressor flange. Do not insert the last four bolts in the motor flange until the coupling has been aligned.**

As the compressor shaft rotates during the alignment procedure, the motor must turn with it, as the bolts in the intermediate piece engage in the free holes in the motor coupling flange.

- Line up motor so that free holes in motor feet are right over threaded holes in base frame.
- Shift motor coupling flange to make up distance "C" in table. See fig. 1.
- Tighten two bolts in coupling hub. On CMO units, the motor flange must be correctly positioned before putting the motor into place.
- Tighten measuring pin on coupling flange of compressor, as shown in drawing.

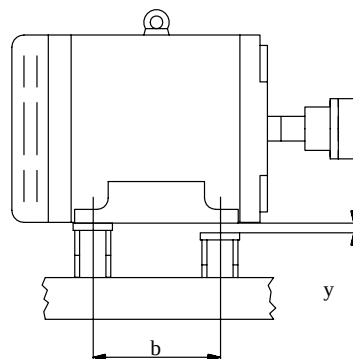
Alignment

Check that the motor with loose bolts stands with all four feet on the base frame. Insert any liner plates needed where there is an air gap beneath the feet. Tauten the bolts slightly.

Achieving parallel shafts in horizontal plane

- Turn coupling so that alignment gauge is in upper position. See fig. 1.
- Guide measuring pin (Pos. 2) towards coupling flange, using a 1.0 mm feeler gauge, and fix pin. Remove feeler gauge.
- Rotate coupling 180° and measure change in distance from measuring pin to flange, using feeler gauges. This change is called "x".
- Insert shims of thickness "y" either under **both** front feet or **both** rear feet, thereby tilting motor in direction required. Shim thickness "y" is calculated using the following formula (see drawings):

$$y = X \cdot \frac{b}{2 \times a}$$



- After tightening motor bolts, repeat measurement and compare result with values in table under Pos. 2.

Achieving correct centre height

- Turn coupling so that alignment gauge faces vertically down.
- Guide measuring pin (pos. 1) towards coupling flange, using a 1.0 mm feeler gauge, and fix pin. Remove feeler gauge.
- Rotate coupling 180° and measure increase in distance "z" from one millimetre using feeler gauges.
- Then lift motor by placing shims of thickness equal to half value of "z" **under all four feet**.
- After securing motor, repeat measurement and compare result with table values in pos. 1 vertical. Remember that the centreline of the motor shaft must be at least 0.05 mm higher than the centreline of the compressor, corresponding to a minimum of 0.1 mm distance less at the top position of the alignment gauge.

Achieving parallel shafts in vertical plane

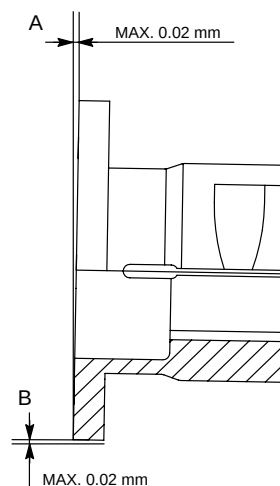
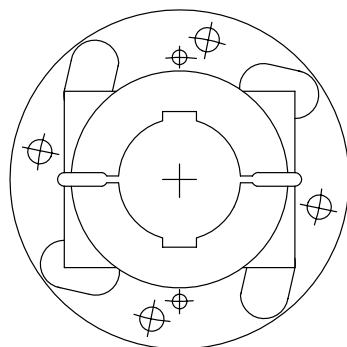
- The motor is now positioned at its correct height. What now remains is to push and turn the motor at the level on which it is already lined up.
- Turn coupling so that alignment gauge faces out to one side horizontally.
- Guide both measuring pins towards coupling with a 1.0 mm feeler gauge in between.

- Turn coupling 180° and, using feeler gauges, measure deviations from one millimetre at both pins.
- Moving and turning motor and repeating this measurement, align motor in accordance with pos. 1 horizontal and pos. 2 in table. Remember that the motor must be firmly secured during any measurements.

Final installation

- Tighten foundation bolts on motor (see torque table).
- Fit four bolts into motor coupling flange so that *thin* shims are placed between flange and lamellae, with rounded side facing lamella. There are no *thin* shims on couplings for CMO and HPO.
- Tighten bolts to torque specified in table.
- Readjust flange distance "C" so that lamellae are aligned, by moving motor flange on shaft and fastening motor flange.
- Check alignment of coupling in horizontal and vertical planes for pos. 1 and pos. 2.
- Dismantle measuring pin and tighten screw to prescribed torque.
- Fit coupling guard.
- Once normal operating temperature has been achieved, double-check coupling alignment.

Boring of motor flange for AMR coupling



T0177131_0 V12

Unless the necessary data for the motor are known prior to dispatch, the motor flange for the AMR coupling will not be supplied in ready bored form.

In such case, the motor flange is supplied prebored and balanced.

Finish-boring is done as follows:

- Secure flange in lathe or jig-boring machine. Observe following tolerances for alignment purposes:

Max. axial eccentricity measured at point A	0.02 mm
Max. axial eccentricity measured at point B	0.02 mm

Max. boring diameter:

Compressor	CMO - TCMO - HPO	SMC - TSMC 100 - HPC	SMC - TSMC 180
Coupling size	AMR 225	AMR 312 - 350	AMR 450
Max. bore	60 mm	95 mm	110 mm
Boring tolerance	H7	H8	H8

- The bore should then be made to the relevant dimensions and to the following tolerances:

H8 for AMR 312, 350 and 450,
H7 for AMR 225.

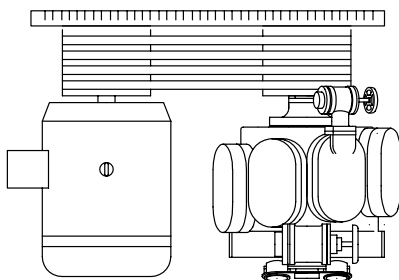
- Cut keyways.
For reasons of balance, coupling AMR 312, 350 and 450 must be executed with the two keyways shown.
- Make the width of the keyway to a tolerance of H7.
- The keyway must be deep enough to allow a clearance between parallel keys and hub of 0.2-0.3 mm.

V-belt drive for piston compressor types (T)CMO and (T)SMC

If your SABROE compressor is belt driven, V-belts are used with profiles specified in the table below.

Compressor type	Belt profile	Nom. centre distance mm	15 mm sag	
			K. max. kg	K.min. kg
CMO - TCMO 24-26-28	SPB (16 x 13)	700	11,00	8,00
SMC - TSMC 104 - 108	SPB (16 x 13)	900	8,00	6,00
SMC - TSMC 112 - 116	SPB (16 x 13)	500	14,00	10,00
SMC - TSMC 186 - 188	SPC (21 x 18)	1230	9,00	6,50

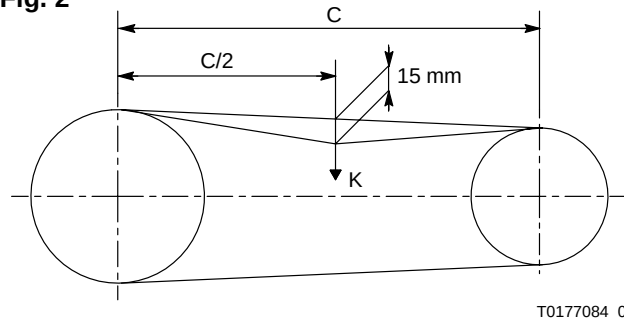
Fig. 1



Fitting V-belts

- Before fitting V-belts, belt pulley tracks must be carefully cleaned of oil and dirt and checked of any burrs and marks.
- Move motor on slide rails, shortening centre distance sufficiently to enable belts to be mounted without use of force. Belts must never be forced over the pulleys, as the power-transmitting fibres may be damaged, reducing their lifetime considerably.
- After mounting V-belts, separate compressor and motor again and align by means of an alignment plate as shown in Fig. 1.

Fig. 2



Tracks must be flush and shafts absolutely parallel.

- To achieve optimal operating conditions, belt tension must be correct. This is achieved as follows:
 - a) Measure centre distance C as shown in Fig. 2.
 - b) At half centre distance $C/2$, place a weight weighing K ; if necessary, this can hang in a piece of welding flex or suchlike on one of the V-belts and be moved from belt to belt.
 - c) Weight K must be between the minimum and maximum values for the belt drive in

question, as stated in the table. Tighten belt drive so that sag is approx. 15 mm for all V-belts.

- A new belt drive always has to be tightened to the max. value.
- Run transmission for a few minutes and then check tension.
- It is important that the tension is inspected at regular intervals, as stipulated in the section *Servicing the piston compressor*.
- When changing worn V-belts, the whole set should be replaced.
- A set of V-belts must always be within the same tolerance group.
- Never use belt lubricant.

Remember

The safety guard always be mounted whenever the belt drive is in operation.

Oil Separator OVUR for SMC/TSMC 100 HPC - SMC/TSMC 180

Application

The purpose of the oil separator is, under all operating conditions, to separate the oil conveyed out of the compressor with the discharge gas in order that it may be returned to the compressor crankcase.

However, with the hot discharge gas some oil is going to leave the oil separator - **the so-called oil consumption**.

With a normal standard oil separator the oil consumption will be approx. 35 to 45 ppm (parts per million) for R717 compressors.

The oil consumption depends, however, on the discharge gas temperature. Rising temperatures often lead to an increased oil con-

sumption. Further, oil products with a low **flame point** can lead to an increased oil consumption in the R717 compressors.

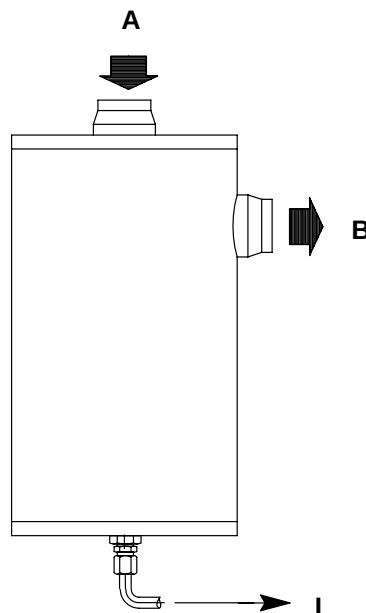
For HCFC compressors the oil consumption is of minor importance as the oil normally returns to the compressor from the plant.

Functioning

The discharge gas from the compressor flows through the oil separator, fig. 1, from pos. A to pos. B. On its way it passes through a number of filters in which the oil is separated from the discharge gas.

The filters consist of stainless steel wire mesh which, as a rule, needs no cleaning, nor does it get worn. Consequently, the filters cannot be removed from the oil separator.

Fig. 1



A: Discharge gas inlet

B: Discharge gas outlet

L: Oil return to the compressor

Oil return to the compressor

The separated oil leaves the oil separator through the pipes pos. L, and can be regulated by the following systems:

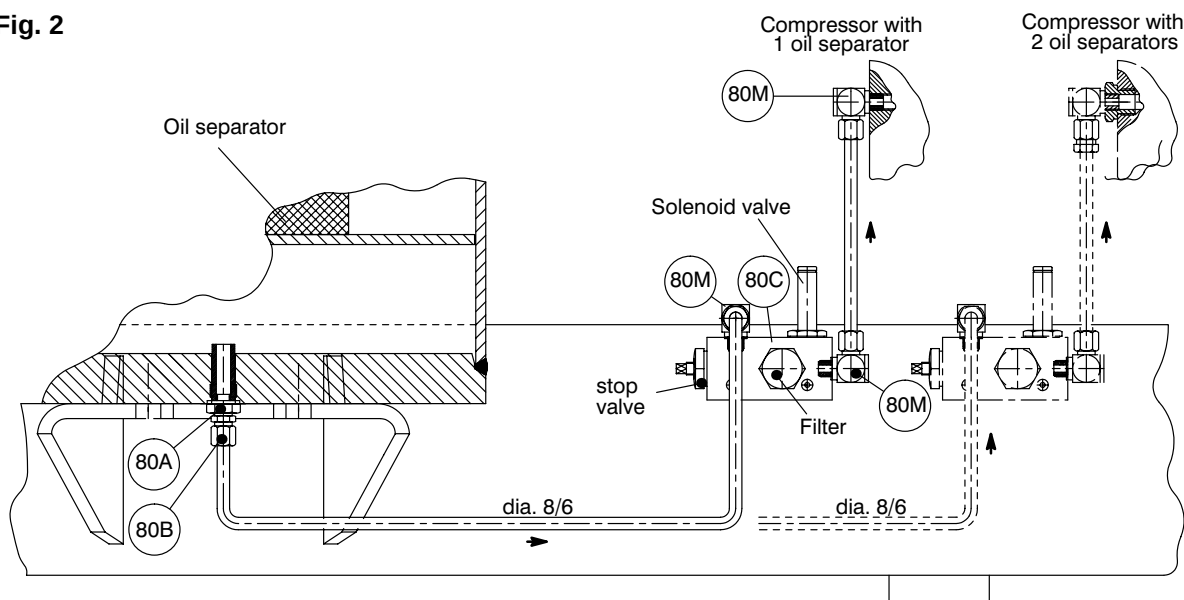
a: Solenoid valve controlled oil return

b: Float valve controlled oil return

a: Solenoid valve controlled oil return

As illustrated in fig. 2 the oil is conveyed from the oil separator through the screwed connections pos. 80A and 80B. Fig. 2 pos. also shows that pos. 80A is of such a length that it pierces the base plate by approx. 10mm. In this way any dirt particles may be collected on the bottom of the oil separator instead of being returned with the oil to the compressor.

Fig. 2



At point A the oil flows into the valve block pos. 80 and from point B is led to the compressor as illustrated in fig. 3.

The valve block consists of a stop valve pos. 80D, which is closed and opened by turning of the spindle. This valve may be dismantled by unscrewing the big union nut from the valve block. On mounting, tighten it once more with a 60 Nm torque.

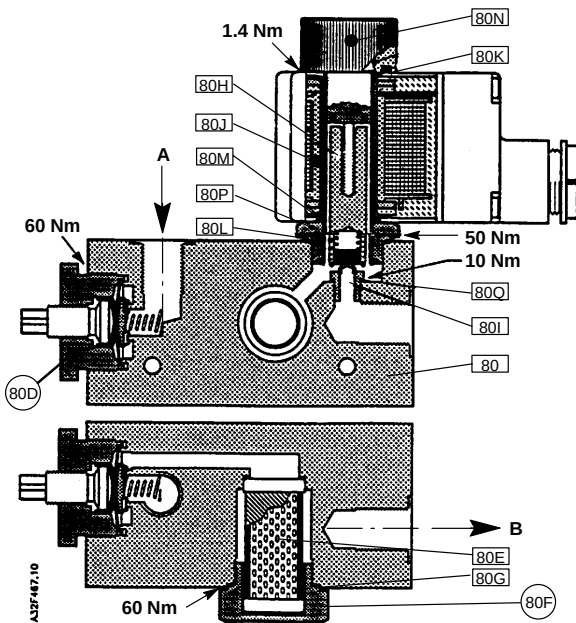
From the stop valve the oil passes filter pos.

80E, which can be removed by dismounting cover pos. 80F. The filter can be cleaned in a cleansing fluid and blown clean with compressed air.

On remounting of the cover tighten it with a 60 Nm torque. **Remember gasket pos. 80G.**

Before removing the oil filter, close stop valve pos. 80D and evacuate the compressor to atmospheric pressure as described earlier on in this manual.

Fig. 3



During start-up of the compressor, the solenoid valve can be kept **closed for 20 to 30 mins.** by means of a time relay, available as an additional equipment. This prevents any refrigerant from entering the compressor during start-up.

The seat of the solenoid valve **pos. 80I** also acts as a nozzle that regulates the oil flow back to the compressor.

Select the nozzle size on the basis of table 4. We recommend **not to use a bigger nozzle size** than prescribed. In order to replace the nozzle the compressor must first be depressurized. Next, dismantle coil **pos. 80J** and armature tube **pos. 80P**.

The nozzle is screwed into the valve block and, on remounting, use gasket **pos. 80Q** for the nozzle and gasket **pos. 80L** for the armature tube. Tighten with the prescribed moments of 10 and 50 Nm – see fig. 3.

On mounting the coil keep it in place by using hand screw **pos. 80N** and O-ring **pos. 80K** and **80M**.

After the oil has been cleaned, it flows to the solenoid valve, which is always closed at compressor standstill.

Fig. 4

R717				
		One stage compr.		
		CMO Mk 2	SMC 100	SMC 180
Number of cylinders	4	0.6	0.6	0.6
	6	0.6	0.6	0.6
	8	0.6	0.6	0.6
	12		0.6	
	16		0.6	

HFC/ HCFC				
		One stage compr.		
		CMO Mk 2	SMC 100	SMC 180
Number of cylinders	4	0.6	0.6	0.8
	6	0.6	0.6	0.8
	8	0.6	0.6	0.8
	12		0.8	
	16		0.8	

		Booster compr.		
		CMO Mk 2	SMC 100	SMC 180
		0.6	0.6	0.8
		0.6	0.6	0.8
		0.6	0.6	0.8
			0.8	
			0.8	

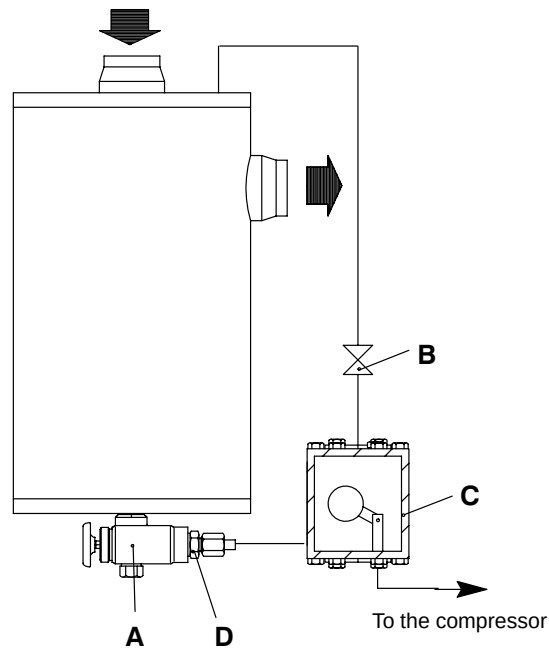
		Booster ompr.		
		CMO Mk 2	SMC 100	SMC 180
		0.6	0.8	1.0
		0.6	0.8	1.0
		0.6	0.8	1.0
			1.0	
			1.0	

Two stage compressor					
TCMO Mk 2		TSMC 100		TSMC 180	
LP	HP	LP	HP	LP	HP
	0.6	0.8	0.6	1.0	0.6
		0.8	0.6		

Two stage compressor					
TCMO Mk 2		TSMC 100		TSMC 180	
LP	HP	LP	HP	LP	HP
	0.6		0.6		0.8
			0.6		

b: Float valve controlled oil return

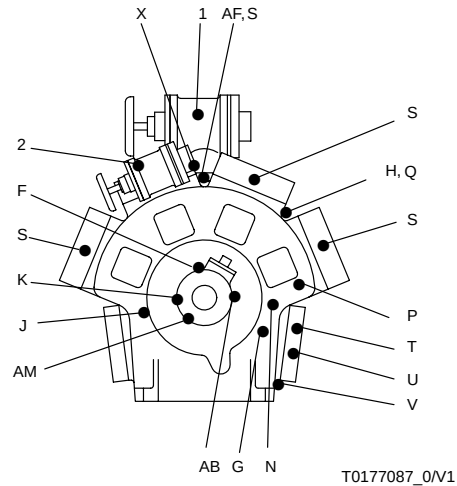
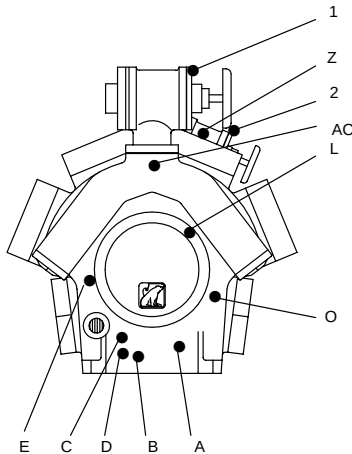
Fig. 5



As shown in fig. 5, the separated oil is drained to the float valve pos. C while valves pos. A and B are open. At a rising oil level the float valve will open and lead the oil back to the compressor crankcase.

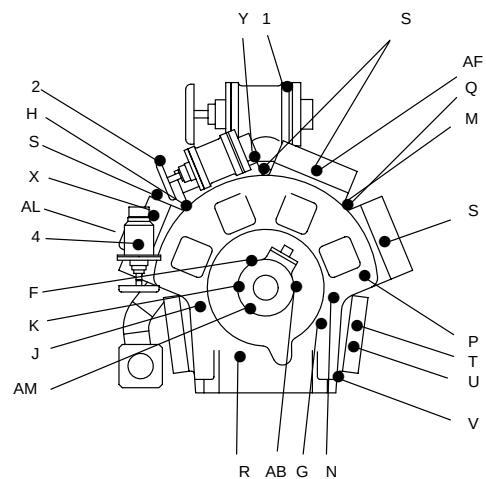
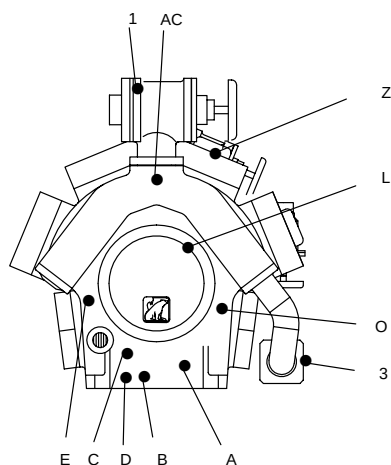
The filter pos. D and the float valve can be cleaned by dismantling the threaded nipple on the stop valve housing and removing the cover on the float housing after the valves pos. A and B are closed and the pressure in the compressor equalized to atmospheric.

Connections on SMC 104-106-108 Mk3, HPC 104S-106S-108S



Pos.	Thread RG (Inch)	Pressure	Oil, gas or liquid	Air- cooled Water- cooled	Air- cooled w/built-in oil cooler	Ther- mo- pump	Booster with oil cooler	Normal application	
A	1 1/4	suction	oil	+	+	+	+	Heating rod	
B	3/4	suction	oil	+	+	+	+	Oil charging valve	
C	1/2	suction	oil	+	+	+	+	Oil temperature	
D	1/2	suction	oil	plugged	+	plugged	+	Oil temperature	
E	1/4	suction	gas	plugged	plugged	plugged	plugged	Available	
F	1/4	oil	oil	+	+	+	+	Oil pressure to unloading cylinder	
G	1/2-1/4	suction	gas	plugged	+	+	+	Return from built-in oil cooler *	
H	1/4	discharge	gas	+	+	+	+	High pressure connection (HP)	
J	1/4	suction	gas	+	+	+	+	Oil return from solenoid valves	
K	1/4	oil	oil	+	+	+	+	Oil pressure to solenoid valves	
L	1/4	suction	gas	+	+	+	+	Low pressure connection (LP)	
N	1/4	suction	gas	+	+	+	+	Oil return from oil separator	
O	1/2-1/4	oil	oil	+	+	+	+	Oil pressure connection	
P	1/4	suction	gas	plugged	+	+	plugged	Return from built-in oil cooler/ equalization from thermopump *	
Q	1/4	discharge	gas	plugged	plugged	+	plugged	Return from oil cooler (thermopump cooled)*	
S	1/4	discharge	gas	plugged	plugged	+	plugged	Refrigerant cooling to top covers *	
T	1/4	discharge	gas	—	—	+	—	Equalization to suction pressure end from thermopump	
U	1/4	discharge	liquid	—	—	+	—	Liquid inlet to thermopump*	
V	1/2-1/4	suction	liquid	plugged	+	+	+	Supply to built-in oil cooler*	
X	1/2	discharge	gas	+	+	+	+	Discharge gas temperature	
Z	3/4	discharge	gas	+	+	+	+	Purge valve	
AB	1/4	oil	oil	+	+	+	+	Prelubrication of bearings	
AF	1/4	discharge	gas	plugged	+	+	+	Return from oil cooler (booster) *	
AC	1/2	suction	gas	Used in connection with UNISAB II				Suction temperature (superheat temp.)	
AM	1/4	oil	oil	plugged	plugged	plugged	plugged	Available	
1	Suction stop valve				* These connections are not applied on HPC compressors				
2	Discharge stop valve								

Connections on TSMC 108 Mk3



Pos.	Thread RG (Inch)	Pres- sure	Oil, gas or liquid	Air-cooled Water- cooled	Air-cooled w/built-in oil cooler	Ther- mo- pump	Normal application
A	1 1/4	suction	oil	+	+	+	Heating rod
B	3/4	suction	oil	+	+	+	Oil charging valve
C	1/2	suction	oil	+	+	+	Oil temperature
D	1/2	suction	oil	plugged	+	plugged	Oil temperature
E	1/4	suction	gas	plugged	plugged	plugged	Available
F	1/4	oil	oil	+	+	+	Oil pressure to unloading cylinder
G	1/2-1/4	suction	gas	plugged	+	plugged	Return from built-in oil cooler
H	1/4	high	gas	+	+	+	High pressure connection (HP)
J	1/4	suction	gas	+	+	+	Oil return from solenoid valves
K	1/4	oil	oil	+	+	+	Oil pressure to solenoid valves
L	1/4	suction	gas	+	+	+	Low pressure connection (LP)
M	1/4	suction	gas	+	+	+	Intermediate pressure connection (IP)
N	1/4	suction	gas	+	+	+	Oil return from oil separator
O	1/2-1/4	oil	oil	+	+	+	Oil pressure to manometer and cut-outs
P	1/4	suction	gas	plugged	+	plugged	Return from built-in oil cooler
Q	1/4	suction	gas	plugged	plugged	plugged	Available
R	1/4	suction	gas	+	+	+	Suction pressure to rear of unloading cylinder
S	1/4	high	gas	plugged	+	+	Refrigerant to HP top covers
T	1/4	suction	gas	-	-	+	Equalization to suction pressure end from thermo-pump
U	1/4	high	liquid	-	-	+	Liquid supply from thermopump
V	1/2-1/4	suction	liquid	plugged	+	plugged	Connection to built-in oil cooler
X	1/2	high	gas	+	+	+	Discharge gas temperature
Y	1/2	interm.	gas	plugged	plugged	plugged	Intermediate pressure temperature (IP)
Z	1/4	interm.	gas	+	+	+	Purge valve
AB	1/4	oil	oil	+	+	+	Prelubrication of bearings
AF	1/4	interm.	gas	plugged	+	+	Return from built-in oil cooler (Booster)
AL	3/4	high	gas	+	+	+	Purge valve
AC	1/2	suction	gas	Used in connection with UNISAB II			Suction temperature
AM	1/4	oil	oil	plugged	plugged	plugged	Available
1	Low pressure suction stop valve				3	Connection from intermediate pressure	
2	Low pressure discharge stop valve				4	High pressure discharge stop valve	

Oil return in parallel operation for reciprocating compressors

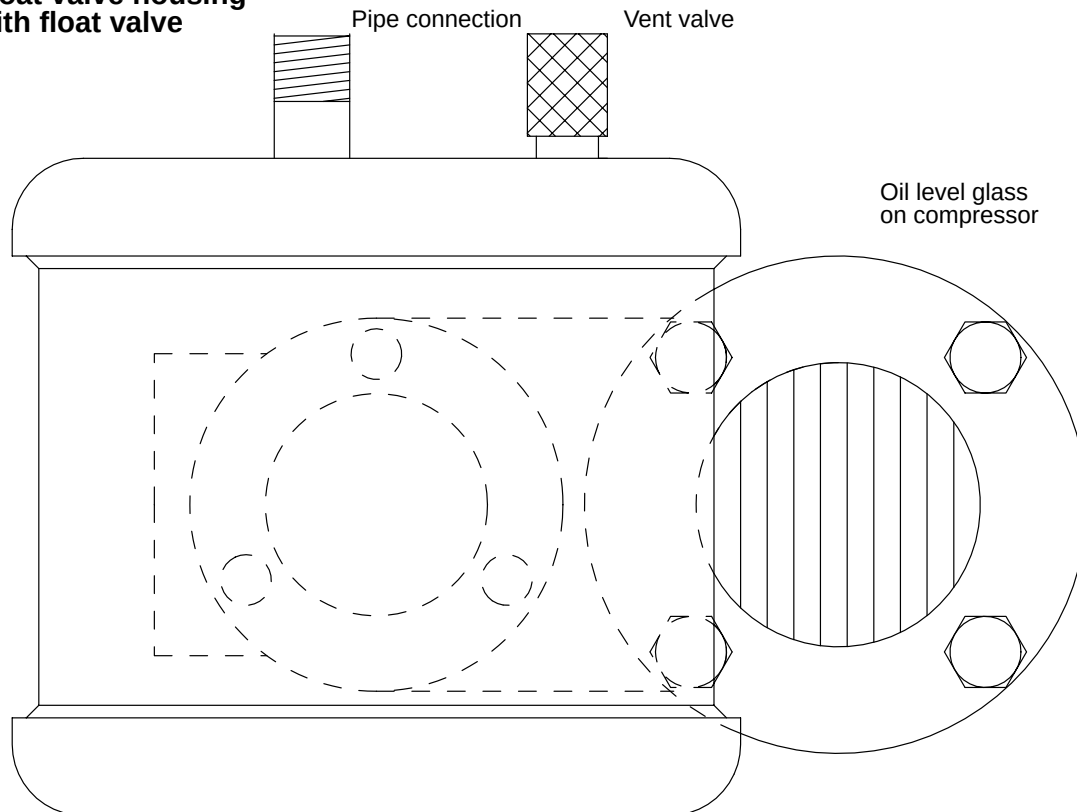
On halocarbonic piston compressors operating in parallel on the same plant, it is important to regulate the oil return flow to the crankcases of the compressors so that they have the same oil level.

This is achieved by using an oil distribution system as described in this instruction.

Each compressor is fitted, via an intermediate piece, with a mechanical float which regulates the oil level in the crankcase.

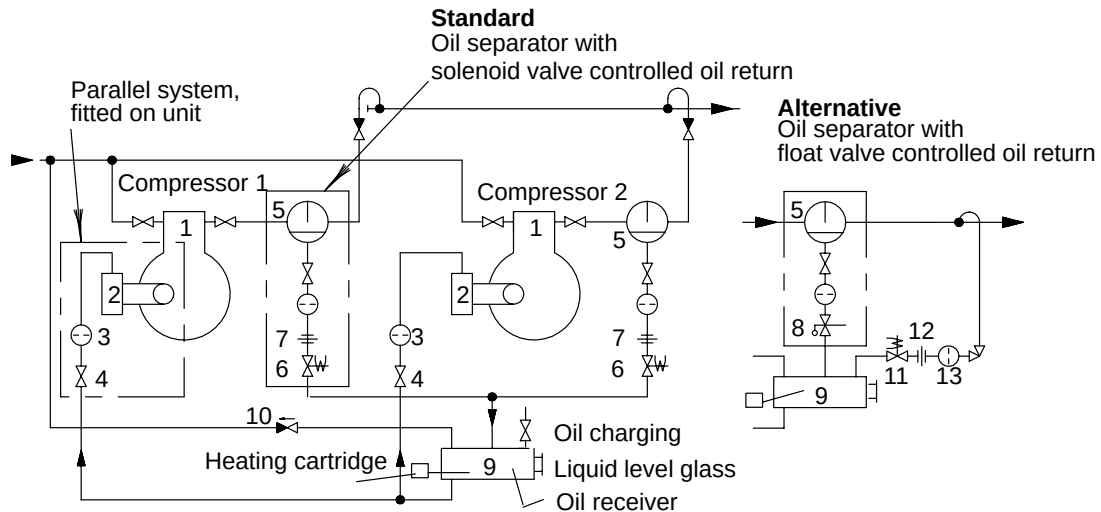
This intermediate piece is mounted between the compressor frame and the oil level glass, as shown in the drawing. This allows visual inspection of the oil level in the crankcase.

Float valve housing with float valve



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Schematic diagram



- | | |
|--|---|
| 1. Compressor | 8. Float valve for oil separator |
| 2. Float valve for parallel operation (1374-005) | 9. Oil receiver |
| 3. Filter | 10. Non return valve, 1 bar |
| 4. Stop valve | 11. Solenoid valve for driving pressure line |
| 5. Oil separator | 12. Nozzle dia. 0.4mm for driving pressure line |
| 6. Solenoid valve for oil separator | 13. Filter for driving pressure line |
| 7. Nozzle for oil separator | |

Function

The piping diagram is based on each compressor pos. 1 being equipped with an oil separator pos. 5, from which the oil via solenoid valve pos. 6 and nozzle pos. 7, or through float valve pos. 8, is conveyed to an oil tank pos. 9.

The nozzle size for pos. 7 is stated in the section on *Oil Separator*.

The oil tank pos. 9 must have a volume equal to approx. 50% of the total oil volume to be contained in the compressors. However, it should never be filled more than halfway with oil, corresponding to approx. 25% of the total oil quantity.

There should be an oil level glass on the oil tank and a heating element to ensure warm, and hence refrigerant free, oil.

From the oil tank, an oil pipe is drawn directly to the mechanical float pos. 2 controlling the oil level in the crankcase.

From the top of the oil tank pos. 9, a pipe is routed to the suction side of the plant.

A non-return valve pos. 10 is inserted in the pipe, opening at a differential pressure of 1 bar. Note the flow direction. A pressure 1 bar higher than the suction pressure in the plant is thus obtained in the oil tank. This is sufficient to pump the oil through the float valve without generating any foaming in the float valve housings.

Note:

After the initial starting up of the float system, the float housing must be ventilated in the following way. See drawing of float housing.

Unscrew the cap on the vent valve and activate the spring-loaded valve in the branch by pressing it down with a screwdriver or similar.

If the **float-valve controlled oil return Pos. 8** is used, the oil tank must - in order to maintain the driving pressure at 1 bar - also be

connected to the discharge side of the plant, as shown in the schematic diagram.

In the pipe connection to the discharge side, mount a 0.4 mm diameter nozzle Pos. 12 and a solenoid valve Pos. 11, which must be open also when only one compressor is operating.

Reciprocating compressors used for air conditioning CMO 24-26-28 and SMC 104-106-108

When the CMO or SMC compressor is used for air conditioning, you can choose to control the compressor capacity by means of one or two KP1 pressure cut-outs.

CMO compressors are all controlled by three solenoid valves. When these are to be controlled with pressure cut-outs, cut-out **A** must be connected in parallel with solenoid valves nos. 1 and 2. Cut-out **B** must be connected with solenoid valve no. 3.

The SMC 108 must be connected in the same way as CMO.

The SMC 106 is controlled by two solenoid valves, where pressure cut-out **A** must be connected to solenoid valve no. 1 and cut-out **B** to solenoid valve no. 2.

The SMC 104 is controlled by a solenoid valve to be connected to pressure cut-out **A**. Only one cut-out is to be used for the SMC 104.

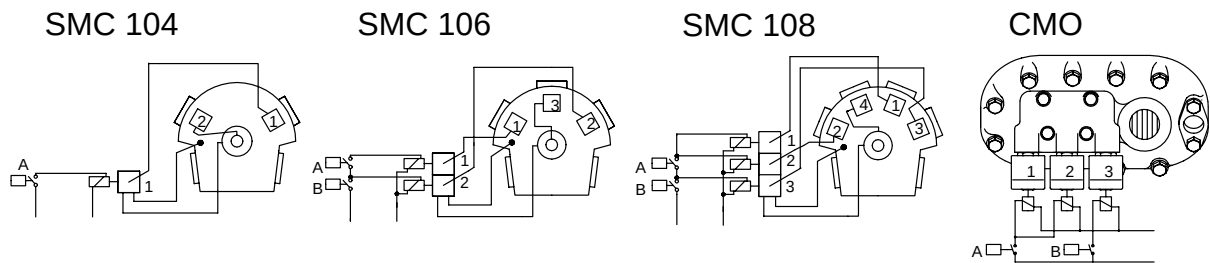
If the compressor features a solenoid valve for totally unloaded start, this must not be

connected to any of the above pressure cut-outs.

Pressure cut-out **A** must be set to a close at a pressure approx. 0.5 bar higher than the setpoint for cut-out **B**.

A third cut-out, the low-pressure cut-out, must be set to break at a pressure equal to the lowest evaporator temperature that can occur, however, never lower than started in section *Pressure and temperature settings*. At this temperature, the compressor must stop. This control form provides the following capacity stages:

	Capacity in %		
Capacity stage	1	2	3
CMO 24	100	50	25
CMO 26	100	50	35
CMO 28	100	50	25
SMC 104	100	50	–
SMC 106	100	66	33
SMC 108	100	50	25



Water-cooling of reciprocating compressors

SMC 104-106-108 and TSMC 108

SMC 186-188 and TSMC 188

HPC 104 S-106 S and 108 S

The reciprocating compressor can be cooled with water on the top and side covers, the cooling requirement being dependent on the operating conditions and the refrigerant on which the compressor operates.

See page 1 for details.

Water cooling is obtained by mounting an extra cover (water cover) Pos. 2B on the outside of top and side covers with an intervening seal Pos. 2D.

Tighten top and water covers with the bolts Pos. 2E, which are longer than the bolts for the air-cooled version. See the *Spare-parts list* at the back of this instruction manual for details.

For water cooling of the side covers, a special finned side cover Pos. 3A is used together with a water cover Pos. 3B and a seal Pos. 3D. These are also listed in the spare-parts list.

The water cover, together with the cover on which it is mounted, forms a channel system in which the water is channelled back and forth and effectively cools the top or side cover. By virtue of their large surface area, the cooling fins on the interior of the side cover Pos. 3A provide excellent cooling of the oil in the crankcase.

When dismantling top or side covers with water covers, it is a good idea first to dismantle the topmost covers on the compressor. In addition, you should ensure that the two covers are kept tight against the intervening ga-

sket. This will prevent water flowing into the compressor block.

Salt water-cooling

If it is expedient not to use fresh water for the cooling of the top and side covers, salt water can be used to cool the **side covers**. The top covers must **never** be cooled with salt water as the high temperature combined with the salt water will corrode the covers in a short period of time. For R717 compressors the top covers may in some cases be cooled by means of a thermal pump, see the diagram of the operating range of the compressor in question.

Fitting cooling water hoses

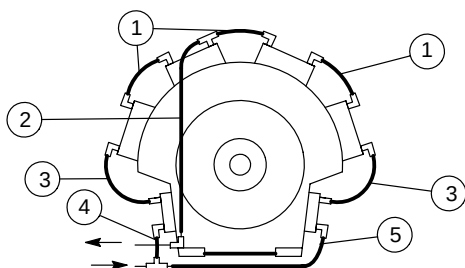
- When supplied, the compressor is not fitted with cooling water hoses or any relevant assembling parts. These are provided loose. This avoids damage to the parts in transit. Fit the cooling water hoses as shown in the following drawing, corresponding to the specification enclosed with the delivery.

Please note:

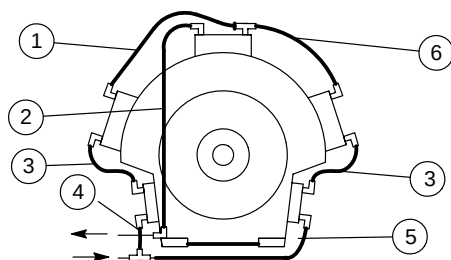
- The direction of water throughflow is shown by arrows on the drawing.
- The hose length is indicated opposite the respective Pos. nos. on the drawing.
- The hoses must not be in contact with the frame, covers, discharge pipe or similar components.

In the supply pipe to the water system a solenoid valve must be fitted which **shuts off the water flow** in the refrigeration system at compressor standstill.

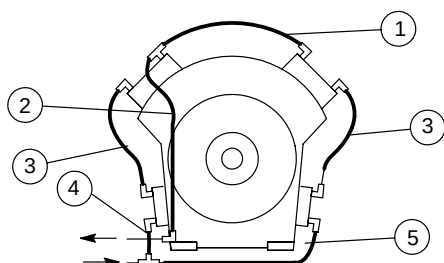
However, we do recommend to continue the water cooling for approx. 10 mins after the compressor has been stopped as this protects the cooling water hoses against excessive temperatures



SMC 108 TSMC 108 HPC 108		
Pos Nr.	Length (mm)	Length (mm)
1	300	325
*)2	790	1300
3	400	470
4	160	300
5	700	1100

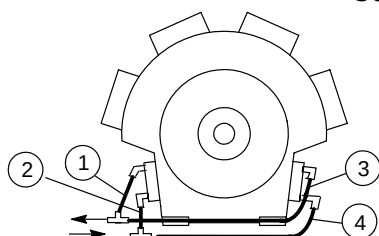


SMC 106 HPC 106 SMC 186		
Pos Nr.	Length (mm)	Length (mm)
1	500	760
*)2	820	1300
3	325	525
4	150	300
5	670	1100
6	380	550



SMC 104 HPC 104	
Pos Nr.	Length (mm)
1	610
*)2	750
3	370
4	160
5	670

Cooling of side covers only



SMC 104- 106-108 TSMC 108 SMC 186/ 188 TSMC 188		
Pos Nr.	Length (mm)	Length (mm)
1	300	400
2	200	300
3	800	1170
4	700	1100

*) To be secured to the vertical oil pipe using two pieces of plastic tape. T0177088_0/1

Necessary water consumption

To achieve satisfactory distribution of cooling water and hence good compressor cooling, the following limit values should not be exceeded:

Min. water through flow:

5.5 litres per hour per Kw motor output.
On water circulation plants, greater water throughflow is recommended.

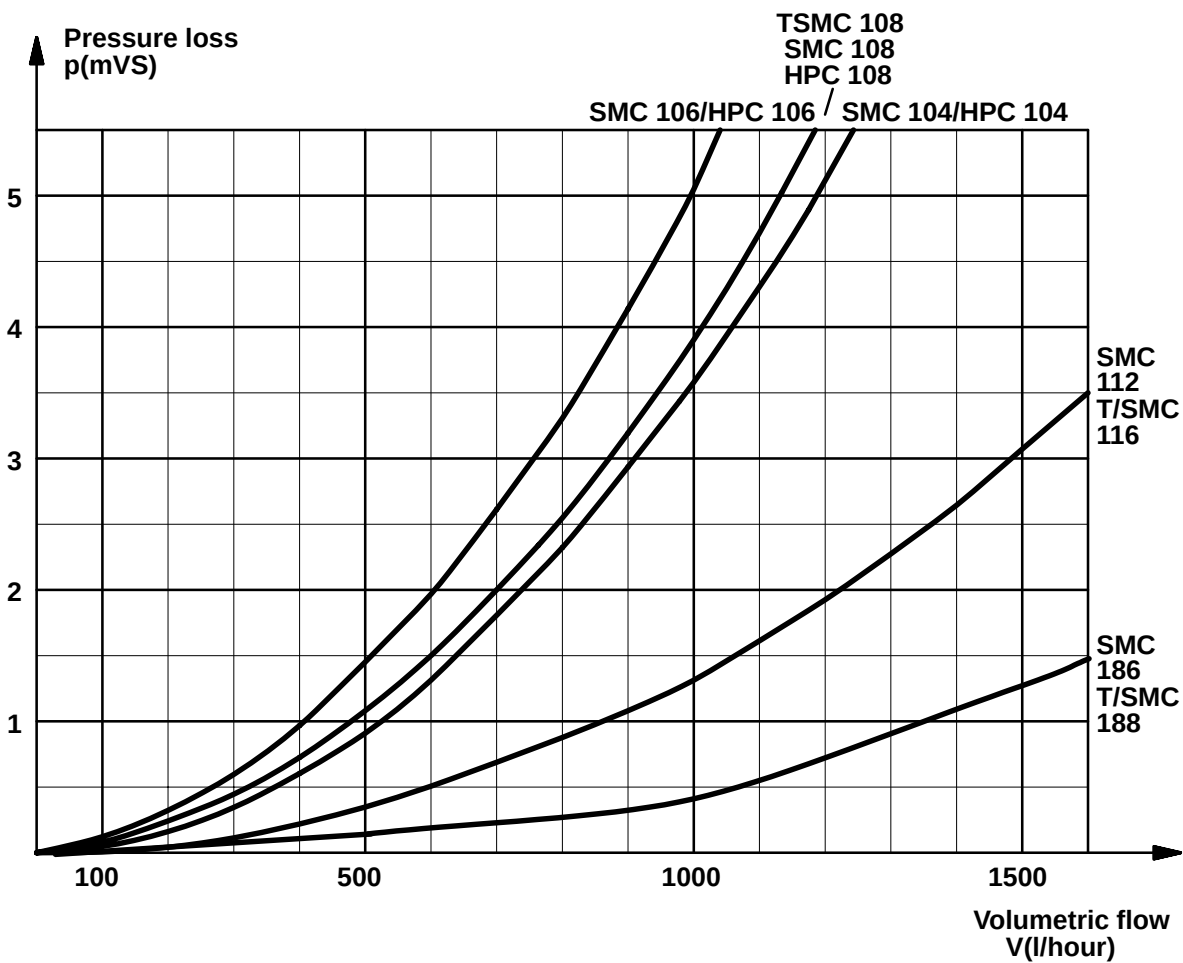
Max. permissible inlet temperature:
+40°C

Min. permissible inlet temperature:
+10°C

Max. permissible outlet temperature:
+55°C

Max. permissible temperature rise from inlet to outlet on the compressor:
15°C

Pressure loss in water cooling
on SMC/TSMC/HPC compressors



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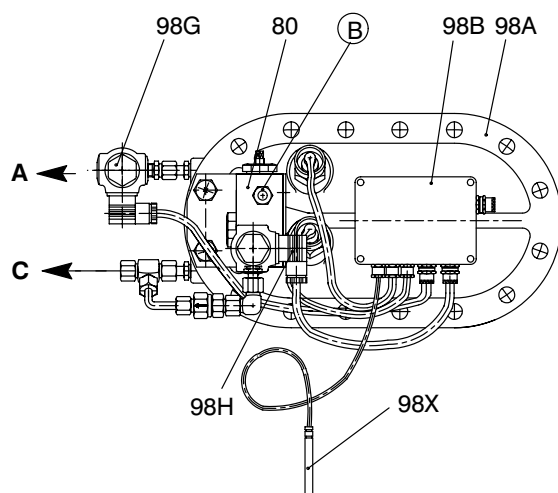
Structure of the thermo pump

Together with the cooling cover, pos. 98Q, the side cover, pos. 98A, forms a pump vessel, pos. 98, which is supplied with heat from the oil bath in the crankcase. The cooling cover is equipped with cooling fins in order to provide a satisfactory thermal contact with the oil.

As illustrated in the principle drawings, the pump vessel has the following three pipe connections:

- Connection **pos. A** which is linked to the compressor suction side and which can be blocked by means of solenoid valve pos. 98G. Used to lower the pressure in pump vessel pos. 98. Part of the pumping cycle.
- Connection **pos. B** emerges from the receiver or the priority tank and goes right to the valve block pos. 80 which is of the same type as the one described in the section on: **Solenoid valve controlled oil return** in this instruction manual.
Please, note that the size of orifice pos. 80I must be 3.3 mm.
- Connection **pos. C** is connected to the top covers and the oil cooler pos. 98T through a number of nozzles pos. 98M.

Filling and evacuation of the pump vessel is controlled by two level sensors, pos. 98C, which by means of the control box, pos. 98B,



control the solenoid valves, pos. 98G and pos. 98H, so that they are open and shut simultaneously. The thermo pump is safeguarded by the following systems:
(See *principle drawing*)

- a:** A thermostat built into the control box pos. 98B with sensors pos. 98X fitted on the compressor discharge pipe.

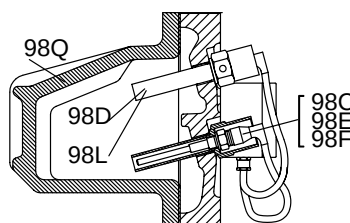
Fasten the sensor to the discharge pipe right next to the discharge stop valve by means of two clips. **Ensure a proper thermal contact.**

The thermostat is factory set to start up the thermo pump once the discharge gas temperature is **above 80°C**.

- b:** An evacuation system emptying the pump vessel through solenoid valve pos. 98V whenever the thermo pump stops.

Please, notice that the pipe connection pos. D to the plant evaporating side must be made at a spot where there is no risk of the liquid flowing back to the compressor. Connection should, f.inst., be made to the liquid separator or the evaporator.

- c:** A safety circuit with a non-return valve pos. 98Z that opens for the flow at a pressure **3 bar higher** in the pump vessel than the one in the compressor discharge gas line.



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Description of pumping cycle

Filling of pump vessel

As soon as the liquid leaves the bottom level sensor, the control box will activate the solenoid valves pos. 98H in valve block pos. 80 and pos. 98G.

Hereby, solenoid valve pos. 98G opens in the pipe connection to the compressor suction side and the pressure in the pump vessel decreases slightly. At the same time solenoid valve pos. 98H opens and refrigerant liquid starts flowing to the pump vessel through pipe connection B.

Evacuation of pump vessel

When the top sensor has registered that the liquid has reached the top level both solenoid valves will be closed by the control box.

The pressure in the pump vessel now rises as a consequence of the heat impact from the compressor oil and - when exceeding the pressure on the compressor discharge side - will make the refrigerant flow through the pipe connections to the top covers and the oil cooler.

At the top covers the refrigerant expands through the nozzles pos. 98M directly into the hot discharge gas, with immediate cooling of the discharge gas.

The oil cooler (not always required) is a heat exchanger in which the expanding refrigerant - after cooling of the oil - is taken to the compressor discharge side.

Once the liquid in the pump vessel has returned its lowest level, it is registered by the bottom sensor and the control box opens the two solenoid valves for a new pumping cycle.

Capacity regulation of thermo pump

On reducing the compressor capacity it becomes necessary also to reduce the cooling effect of the thermo pump. This is done as follows:

SMC 104-106-108, TSMC 116 CMO 24-26-28

The pipe connection from the pump vessel to the top covers is on its way divided into two pipe lines. In one of these pipe lines a solenoid valve, pos. 98U, is fitted.

This solenoid valve is connected to the capacity regulating system of the compressor and closes when the compressor capacity has been reduced, as indicated in the following table:

Compressor capacity	Solenoid valve pos.98U	
	open	closed
SMC 104	100%	50%
SMC 106	100-67%	33%
SMC 108	100-75%	50-25%
TSMC 116	100-83-67%	50-33%
CMO 24	100-75%	50-25%
CMO 26	100-67%	50-33%
CMO 28	100-75%	50-25%

SMC 112-116

On the SMC 112-116 two thermo pumps have been mounted as shown on the principle drawings.

The total capacity of the thermo pumps is adapted to the compressor capacity by a power disconnection of the thermo pump

positioned at the compressor shaft end and marked X on the principle drawing.

The disconnection is achieved through the connection of the thermo pump via terminals 5 and 6/7 or 8 to the capacity regulating system of the compressor. The supply voltage to the thermo pump must be switched off once the compressor capacity has been reduced to the values indicated in the table below.

Compr. capacity	Thermo pump at compr. shaft end	
	working	not working
SMC 112	100-83-67%	50-33%
SMC 116	100-87-75-63%	50-37-25%

The pipe connections are shown on the principle drawings on the previous pages.

When the compressor is stopped the current to the thermo pump is cut off, closing the solenoid valves pos. 98H and pos. 98G. At the same time solenoid valve pos. 98V opens and drains the liquid in the thermo pump back to the evaporating side of the plant. See the previously mentioned point **b**.

Checking the pumping cycle

On dismantling the cover plate on the control box four light diodes are made visible (2 green and 2 red ones).

One of the green diodes that is connected to the top level sensor is switched on for a relatively short period, i.e. from the moment the sensor has registered the upper liquid level and until evacuation of the vessel has lowered the level below the sensor.

Similarly, the other green diode for the bottom sensor will only be switched off from the moment the bottom level has been registered and until the liquid rises once more on filling of the vessel.

At the bottom level a time lag of a few seconds has been built in order to prevent the solenoid valves from clattering in the event of any lapping in the vessel.

One of the red diodes, LD3, lights up once the temperature of the discharge gas rises above 80°C. The other red diode LD4 lights up when the relay to the solenoid valves has closed.

Functional testing

When stop valve in valve block pos. 80 is closed the functioning of the pump may be tested as follows:

- Roll off the rubber cap on the external part of the level sensors so that the part without insulation can be touched with a finger.

Note

It is quite safe to touch the level sensors at this point as the voltage is extremely weak.

- Touching the sensor alters its capacity as if the sensor were surrounded by liquid in the pump vessel.

By touching the sensors in the order in which they are usually surrounded by liquid at increasing liquid level it is possible to check whether the solenoid valves receive any voltage and open when the sensors are released.

Possible sources of error

In case the above tests should reveal that one or both of the diodes do not light up when touched, this may be due to:

1. No voltage to the control box.
2. Loose power connection.
3. Defective control box.
(To be replaced by a new one)

In case both diodes switch on and off correctly but the built-in relay is not working, replace the control box.

If the diodes light up and the relay is working, the error may be found in the solenoid valves:

1. Loose connections to the solenoid valves.
2. Burnt coils in the solenoid valves.
3. Some other malfunction in the solenoid valves.

If the above-mentioned sources of error are not present and the thermo pump still fails, the reason may be:

1. Closed stop valve in the liquid line.
2. Clogged filter in the liquid line.
3. Dirt in the solenoid valves.
4. Flash-gas in the liquid supply pipe or liquid shortage.
5. A very low differential temperature between oil and condensing temperature.
6. Clogged nozzles pos. 98M.

Both diodes are constantly lit

If one or both diodes are constantly lit, even with no liquid on the sensor, this may be due to a conductive connection between the inner and the outer part of the level sensor rod.

Outside the side cover the level sensor rod is protected by O-rings and a protective cap preventing water and moisture from making contact.

An oil drop may have slipped inside the side cover. In this case it is recommended to strip down the sensor rod and clean the parts. On mounting make sure that the sensor rod centers in the sensor tube.

If, after remounting, the error persists, the control box must be replaced.

Ensuring liquid to the thermo pump

The thermo pump must always be ensured liquid from the plant, no matter whether the plant lacks liquid or some other factor prevails.

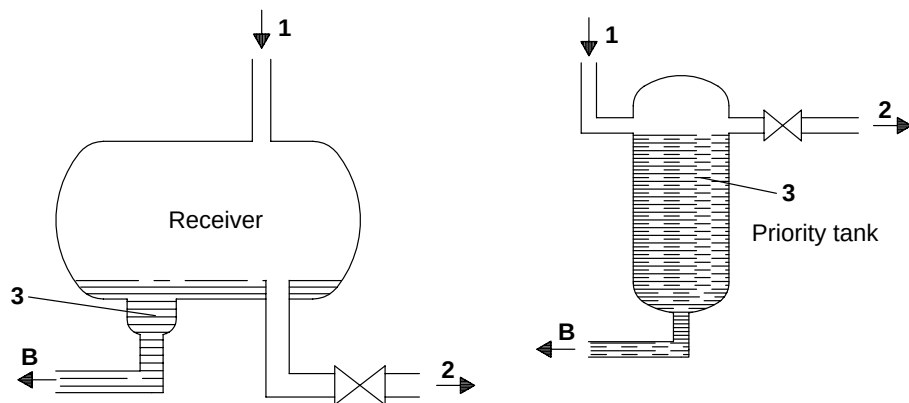
Thus, the thermo pump must also be ensured liquid during a possible pump down by means of the compressor.

In other words: *During operation the compressor must never be short of cooling.*

This safety is achieved by either taking the liquid directly from the receiver, pipe connection B or by building a **priority tank** into the liquid line of the plant (see drawing).

The liquid volume A of the priority vessel must be minimum 10 litres per thermo pump.

The liquid tube from the priority vessel to the thermo pump must be dimensioned to prevent the formation of flash gas along the way.



- 1: Refrigerant liquid from condenser/receiver
- 2: Refrigerant liquid to evaporator
- 3: Refrigerant liquid reserve for oil cooling
- B: Refrigerant liquid for oil cooling

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Stopping a compressor equipped with a thermo pump

When the compressor is stopped there must still be a pilot current on the unit so that the solenoid valve pos. 98V is kept open until the pump vessel has been emptied of liquid.

At the same time, stop valve pos. 98Y is kept open.

Opening of compressor for repair

Pump down of the compressor must take place with the thermo pump system set out of function and after the pump vessel has been emptied as described above.

During pump down close stop valve in valve block pos. 80 and pos. 98Y.

Cleaning of filter in the liquid supply line

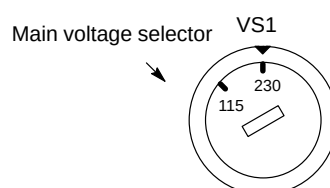
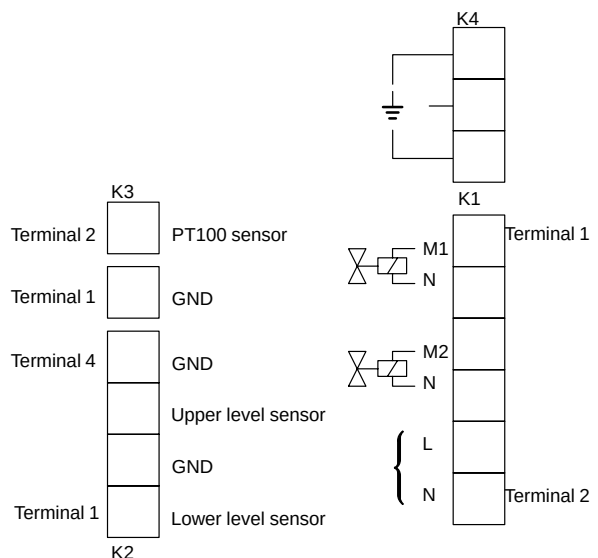
Pump down the compressor before opening the filter in the liquid supply line for cleaning.

Power connection

The control box is geared for 3 different

voltages:	110V -	50/60Hz
	220V -	50/60Hz
	240V -	50HZ

The control box contains a terminal strip as shown in the sketch below.



Oil cooling of SMC and TSMC-type reciprocating compressors with an OSSI or HE8S oil cooler

Depending on the operating conditions and type of refrigerant, the SMC and TSMC compressors can be designed with an oil cooling system. This includes a heat exchanger of the OSSI (R717) or HE8S (HCF/HCFC) type built into the crankcase of the compressor.

In the heat exchanger (oil cooler), the refrigerant is expanded and cools the oil pumped out by the oil pump into the oil system of the compressor. The oil cooler is mounted instead of the oil pressure pipe Pos. 38.

The oil cooling system is controlled by a thermostatic injection valve or expansion valve as shown in the following drawings. A thermostat KP77 (or UNISAB II Control) ensures that the oil cooling system is not activated until the oil temperature in the crankcase exceeds +55°C.

A valve block pos. 80 is built into the liquid system.

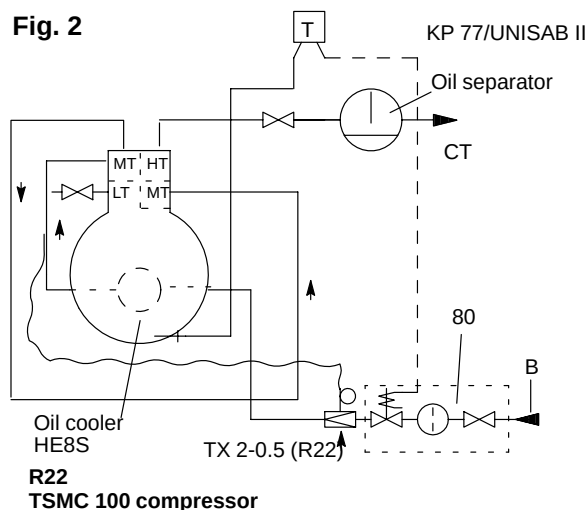
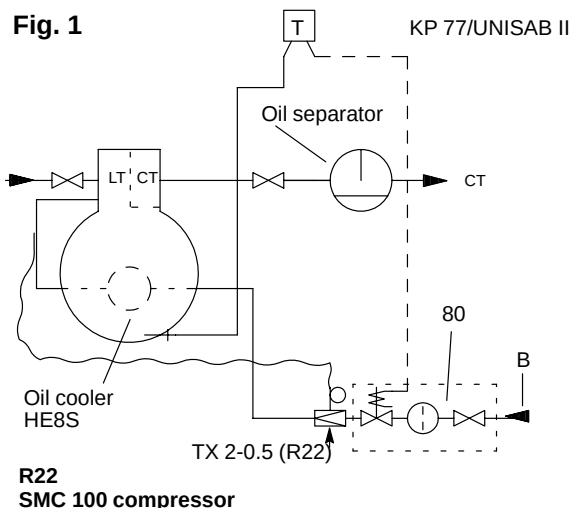
- Connection, **pos. B**, pipe dimension OD 10 mm, emerges from receiver or priority vessel and is conveyed to valve block pos. 80 which is the same type as the one described in section entitled: *Solenoid controlled oil return* of this instruction manual.
- The solenoid valve should always be closed whenever the compressor is idle.

Please note:

that nozzle size pos. 80I must be 3.3mm.

HFC and HCFC compressors:

- On SMC 100 and TSMC 100 compressors, the oil cooling system is designed as shown in fig. 1 and 2.



Before putting the oil system into operating for the first time, the superheating of the TX valve must be adjusted from 4K, which is the factory setting, to 10K. This is achieved by rotating the spindle 1,5 turn clockwise (1 revolution = 4K).

- The SMC 180 and TSMC 180 have no built-in HE8S-type oil cooler.

Cooling of the intermediate gas on TCMO and TSMC 100 and 180

At two-stage operation it is necessary to cool the discharge gas from the LP stage before it enters into the HP stage. This intermediate cooling is done with the systems described below, depending on the type of refrigerant used.

Common for these intermediate cooling systems is the fact that they must cool the intermediate pressure gas sufficiently and, at the same time, ensure that no liquid is admitted into the HP stage, as liquid can produce liquid stroke in the HP cylinders and result in wear to the moving parts. It is important, therefore, to check the systems as indicated below.

Intermediate cooling system with intermediate cooler type DVEA, R717

The two-stage R717 plant may consist of two compressors, one low pressure compressor (LP) and one high pressure compressor (HP) as illustrated in fig. 1. The plant may also consist of two-stage compressors as shown in fig. 2.

In both cases the compressors are connected to an intermediate cooler in which the warm gas from the LP-stage is cooled down before it flows on to the HP-stage.

Fig. 1

CMO, SMC 100/180 compressor

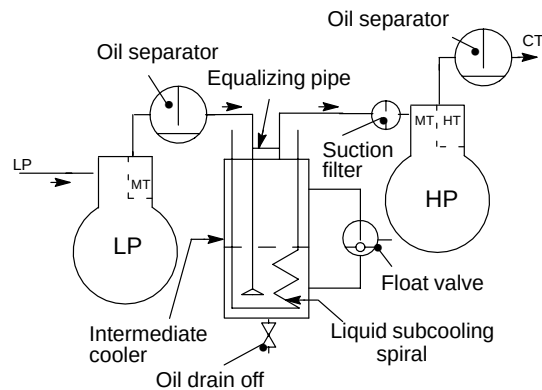
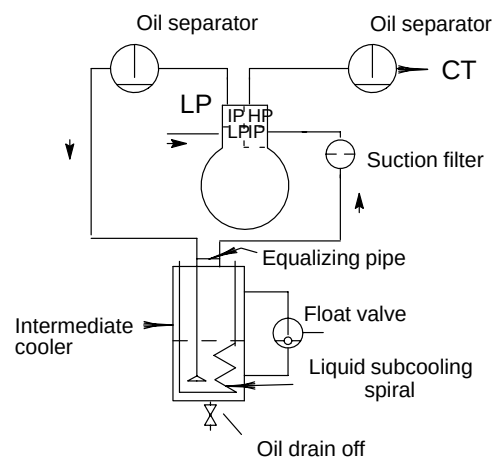


Fig. 2

TCMO, TSMC 100/180 compressor



In the intermediate cooler, the liquid level of R717 is regulated by the float valve and the discharge gas from the LP stage is cooled by bubbling up through the refrigerant from the distributor at the bottom of the intermediate cooler.

In the liquid subcooling spiral, the refrigerant flowing from the receiver to the evaporator side of the refrigeration plant is cooled. The intermediate cooler is dimensioned so that the cooled gas is free of liquid refrigerant before leaving the top of the intermediate cooler. It is important to check that the float valve is functioning correctly and keeping the liquid level constant. Frosting of the liquid level pipe on the intermediate cooler indicates the liquid level.

In order to avoid violent foaming of the liquid in the intermediate cooler, the compressor should run for a few minutes after start-up at the lowest capacity stage to stabilize plant pressures. Capacity can then be increased stage by stage at suitable time intervals.

Make sure that the equalizing pipe on the intermediate cooler has been connected. The equalizing pipe safeguards against backflow of liquid from the intermediate cooler to the LP stage of the compressor, when the compressor is not working.

At regular intervals, the intermediate cooler must be drained of oil through the oil drain valve.

Intermediate cooling system with liquid injection into the intermediate discharge gas, R22 and R717

Two-stage compressors can be equipped with a pipe connection from the LP stage outlet branch to the HP stage suction branch as shown in fig. 3.

In the pipe connection the hot discharge gas from the LP stage is cooled by injection of

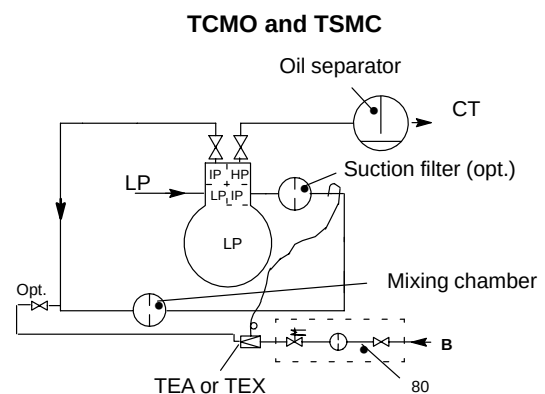
liquid refrigerant into the intermediate pipe. This is achieved with the following systems 1 and 2:

1: Intermediate cooling with thermostatic expansion valve type:

TEA (R717) or TEX (R22)

TCMO and TSMC 100/180

Fig. 3



In the system in fig. 3 the liquid refrigerant conveyed to the intermediate pipe is regulated by a **thermostatic expansion valve type TEA (R717) or TEX (R22)** with a sensor placed on the intermediate pipe close to the HP stage.

A valve block pos. 80 is built into the liquid system.

Connection, **pos. B**, pipe dimension OD 10 mm, emerges from receiver or priority vessel and is conveyed to valve block pos. 80 which is the same type as the one described in section entitled: *Solenoid controlled oil return* of this instruction manual.

Please note:

that nozzle size pos. 80I must be 3.3 mm.

It is essential to make sure that the intermediate cooling system functions correctly in order to prevent too much liquid refrigerant from being injected into the IP gas.

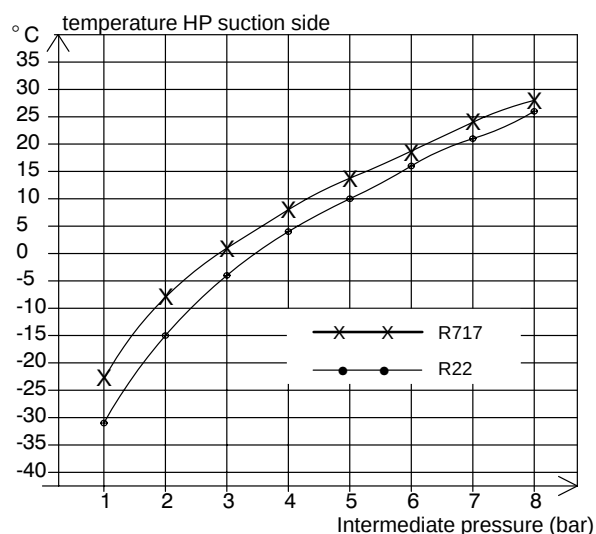
Too much liquid refrigerant may impede the evaporation of the liquid before the IP gas is sucked into the HP stage of the compressor. This may result in liquid hammer and wear and tear on moveable parts.

The expansion valve must be adjusted to superheat the intermediate gas at a temperature not below 10 K.

This is done by measuring the pressure and the temperature of the intermediate gas before it enters the compressor to the HP stage. (For this purpose SABROE has mounted an empty sensor pocket. To ensure an exact measurement the pocket can be filled with oil before the thermometer is introduced).

Compare the measured values with the curves in fig. 4. For any given intermediate pressure the temperature must be close to the curve, **but never below**.

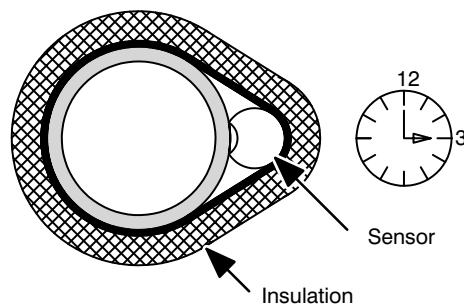
Fig. 4



Position the sensor of the expansion valve on the intermediate pressure pipe immediately

before the HP-stage suction filter. The sensor must be fitted on the side of the pipe and insulated as shown in fig. 5

Fig. 5



Note:

- The necessary superheat of 10 K is included in the curve, fig. 4.
- An exact measurement of the temperature cannot be read until after a stabilisation period which is not under 5 minutes for R22 and not under 15 minutes for R717.
- Before the initial adjustment of the valve it must be adjusted to its highest level to make sure that the superheat is above 10 K. Do this by turning the spindle 20 turns **clockwise** for R717 and 2.5 turns for R22. The superheat can now be regulated on the basis of measurements and the curves in fig. 4.
- The valve for R717 changes the superheat 0.5 K per rotation of the adjusting screw. The valve for R22 changes the superheat 4 K per rotation. By turning the adjusting screw **clockwise** the superheat is increased. By turning the screw **anti-clockwise** the superheat is reduced.
- SABROE has adjusted the valve to 10 K superheat.

2: Intermediate cooling with thermostatic injection valve type:

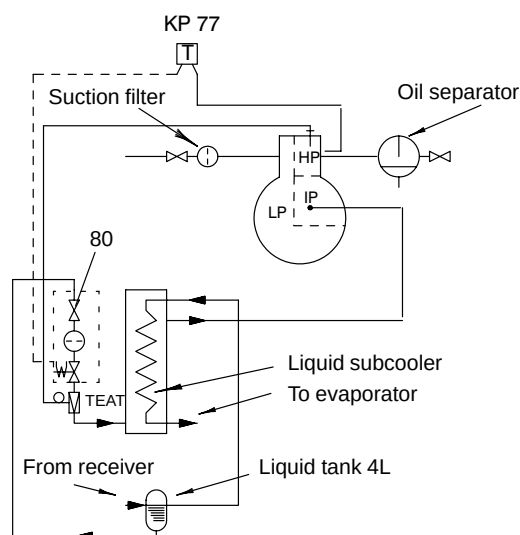
TEAT (R22)

TCMO and TSMC 100/180

Different systems are applied for TCMO and TSMC 100/180 as described below in **sections A and B**.

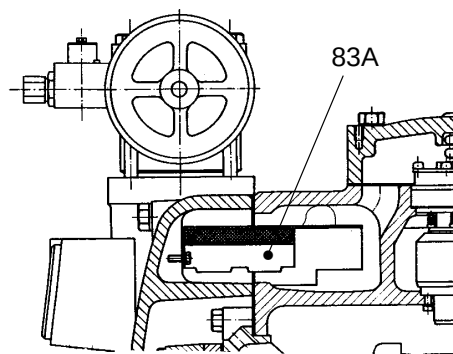
A: TCMO

Fig. 6



As illustrated in fig. 6 the intermediate gas is cooled by injecting refrigerant into the **low pressure stage pressure chamber** in the compressor. The liquid is thoroughly mixed with the hot discharge gas by means of the distributor pos. 83A as may be seen from fig. 7.

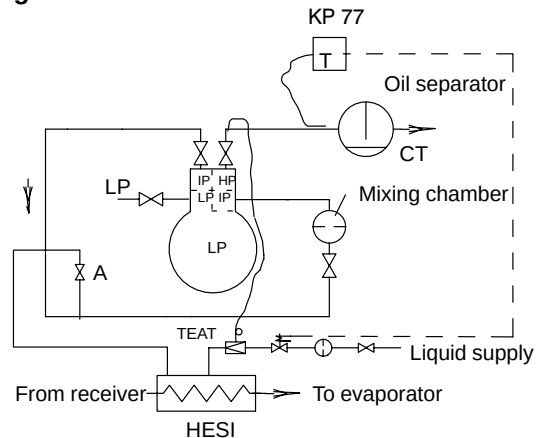
Fig. 7



For sub-cooling of liquid to the evaporators the injected liquid first passes a **liquid sub-cooler**, mounted on the compressor. The liquid injection is controlled by a TEAT valve.

B: TSMC 100/180

Fig. 8



On TSMC 100 and 180 plants, the intermediate cooling system can be designed as illustrated in fig. 8, in which the intermediate cooling is carried out by a thermostatic injection valve of the TEAT type, and in which the sub-cooling takes place in a HESI heat exchanger.

Adjusting the TEAT valve:

For both systems, A and B, the following applies:

The sensor of the TEAT valve is placed in a sensor pocket at the discharge branch of the compressor, and a proper thermal contact is obtained by means of the heat conducting compound.

The solenoid valve is opened by the KP77 thermostat whenever the temperature of the pressure pipe is above 55°C.

It is important to make sure that the intermediate cooling system functions correctly and thus prevent too much refrigerant from being injected into the intermediate pressure gas.

Excess refrigerant may lead to the liquid being unable to evaporate before the intermediate pressure gas is sucked into the HP stage of the compressor and may thus cause liquid strokes and wear to the moving parts.

When supplied, the TEAT valve is **factory set** to the following regulating temperatures:

Refrigerant	Regulating temp.
R22	75°C
R717	75°C

Before using the valve, the **regulating temperature** must be changed to the same value as the discharge gas temperature indicated in the table *Anticipated discharge gas temperatures* in this instruction manual.

Adjustments are made by rotating the regulating spindle clockwise, 5 turns for every 10K of temperature increase.

Example:

Refrigerant R22

Regulating temperature
factory setting 75°C

Estimated discharge
gas temperature

IT = -10°C

CT = 35°C 96°C

Superheat = 20°C

Adjustment

$$96 - 75 \times \frac{5}{10} = \underline{10.5 \text{ revolutions}}$$

Under all circumstances, the regulating temperature of the valve must be raised **at least** 10K, corresponding to 5 revolutions (clockwise).

When the plant has stabilized and the compressor is working at 100% capacity, the valve must be readjusted to the same value as the discharge temperature with the *Anticipated discharge gas temperature* in the table, within -5K to +10K. (In the example, 91°C < 96°C < 106°C)

At reduced compressor capacity, the discharge gas temperature may rise somewhat; under these circumstances it should be checked that the discharge gas temperature does not exceed the **Set point** for the KP98.

Ordering Spare Parts

When placing an order for spare parts, please state the following:

1. Shop No.

All compressors are fitted with an identification plate, which states the type and shop no. of the compressor and indicates what refrigerant is to be used.

2. Part No.

Spare parts drawings and parts lists inserted in an instruction manual identify spare parts with the following:

- a) Spare part no. – which is a reference number to facilitate finding a part in the drawing and cross-referencing in the parts list or vice versa.
- b) Designation of the part.
- c) Part no. – a 7-digit number which refers to SABROE's stores.

When you order spare parts, please always advise at least the designation and part num-

ber. If you are in any doubt, add the spare part no. too.

3. Forwarding instructions

When ordering spares, please advise the forwarding address, and the address to which the invoice should be sent. If appropriate, please state the name of your local bank, the way in which you want the goods transported and required delivery date.

4. Classification certificate

If you require a certificate from a Classification authority, please mark the order appropriately, as the inspection and issuing procedures take extra time and incur extra expenses.

5. Quotation No.

If a quotation no. has been given during earlier correspondence, please refer to this when placing your order – it will help us to identify and execute your order quickly.

Spare parts sets for compressors and units

CMO/TCMO - SMC/TSMC 100 - SMC/TSMC 180

On servicing compressor and unit it is always an advantage if you, as our customer, have some of the most commonly used spare parts at your disposal. This enables you or a summoned SABROE service engineer to carry out the necessary service work without having to spend extra time on procuring the spare parts needed.

Spare parts are obtainable in sets as mentioned in the following.

By contacting **SABROE's local representative** it is possible to receive a list of the spare part sets recommended by SABROE.

Compressor block

- **Standard spare part set**
Contains a suitable selection of O-rings as well as valve ring plates and valve springs.
- **Extended spare part set**
Further to the parts included in the **standard spare part set** this set contains a cylinder lining and discharge valve as well as an extended number and types of gaskets and fittings.

- **Certificate spare part set**
Further to the parts from the **extended spare part set** this set contains a major number of components and wearing parts selected by the classification societies.
- **Special spare part set**
This is a more comprehensive set than the **extended spare part set** as almost all O-rings and gaskets are included and for the most wearing parts the number of parts has been extended.

Spare part set for Basic Unit

- **Standard spare part set**
This is a set consisting mainly of O-rings and gaskets for some of the components included in the unit.
- **Certificate spare part set**
Further to the parts from the standard spare part set this set contains other components selected in accordance with the requirements of the classification societies.