Manual for SMC and TSMC Mk4, S-L-E

The SMC/TSMC reciprocating 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 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 compressor number stated below.

Compressor type	SMC ❑ TSMC ❑ S ❑ L ❑ E ❑ 104 ❑ 106 ❑ 108 ❑ 112 ❑ 116 ❑	
Compressor no		
Refrigerant	R717 ❑ R22 ❑ R134a ❑ R404A ❑ R507 ❑ Other __________ ❑	
Control	UNISAB II control- and regulating system	
	Analog 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 OOSI/OOKH	
Drive type	Coupling	
	V-belts	
Explosion-proof electrical design		
Equipment for parallel operation		
SABROE OVUR oil separator		

1. Introduction

The purpose of this manual is to provide the operating personnel with a thorough knowledge of the compressor as well as information about:

- The function and maintenance of each component.
- Service schedules.

This manual describes the compressor and its component parts as well as safety instructions/regulations. Moreover, the manual explains the different settings that can be of assistance to those who are responsible for the daily operation and maintenance of the equipment.

To prevent any accidents, assembly and disassembly of components should only be carried out by authorized personnel.

It is essential that the operating personnel familiarize themselves with the contents of this manual in order to ensure a proper and efficient operation. Sabroe Refrigeration (YORK Denmark ApS) - hereafter referred to as Sabroe Refrigeration - is not liable for damage occurring during the warranty period where this is attributable to incorrect operation.

Sabroe Refrigeration's manual concept covers six standard manuals: Engineering, Operating, Service, Installation and Commissioning, Transport and Spare Parts. Therefore, references may be made to chapters which are not part of this manual.

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2. Signs and Warnings

The purpose of this chapter is to describe:

- How Sabroe Refrigeration equipment can be identified.
- All warning signs used on equipment delivered by Sabroe Refrigeration.
- How information important to the safety of personnel and equipment is presented in instructions belonging to equipment delivered by Sabroe Refrigeration.

This chapter is intended for all user categories.

This chapter describes the importance of the individual signs which are attached to the Sabroe Refrigeration products.

Before a compressor/unit is put into operation it must be provided with the warning signs corresponding to the actual type of compressor/unit in accordance with the rules and regulations in force.

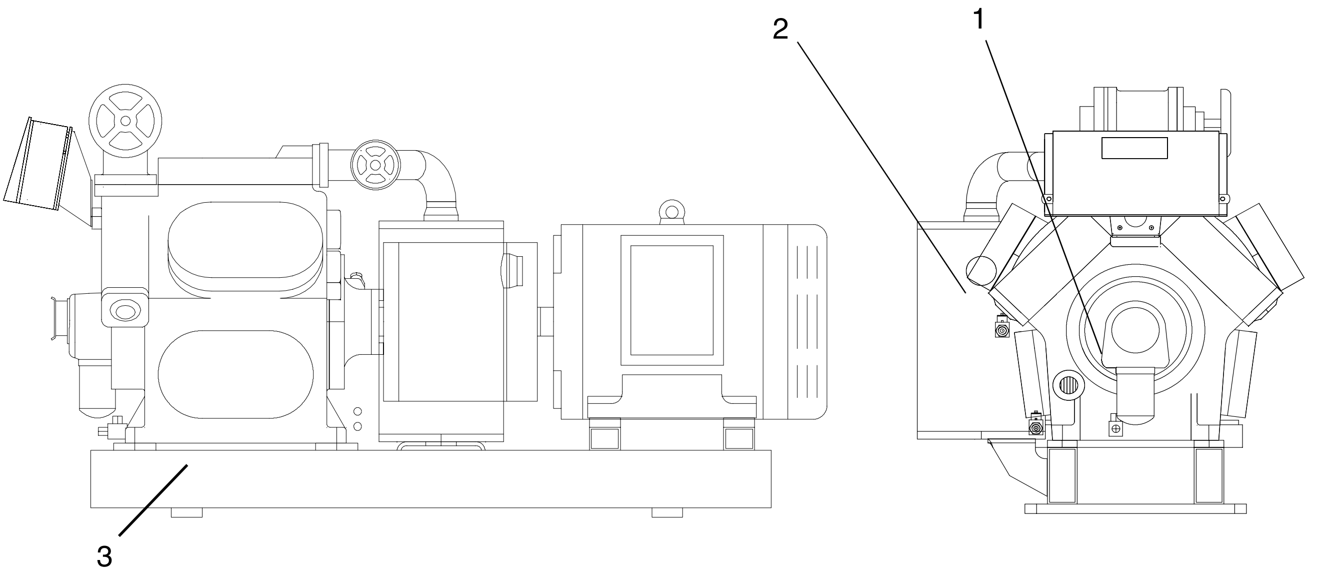
Danger!

Risk of injury to personnel and damage to equipment! Always read the safety precautions belonging to this equipment before starting the installation process. Failure to comply with safety precautions may cause death or injury to personnel. It may also cause damage to or destruction of the equipment.

Identification of Sabroe Refrigeration Equipment

All Sabroe Refrigeration equipment can be identified by one or several name plates placed as illustrated by the following drawing:

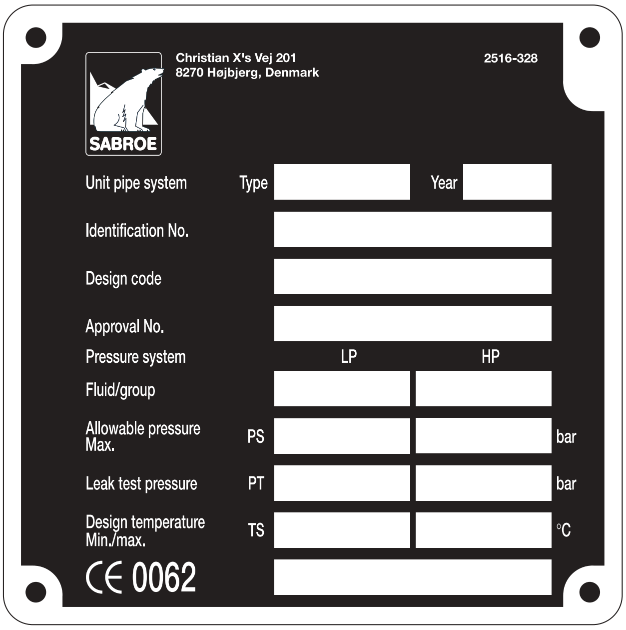
Fig. 2.1



1. Compressor name plate
2. Vessel name plate
3. Unit pipe system name plate

Unit pipe system name plate

Fig. 2.2 Unit pipe system name plate

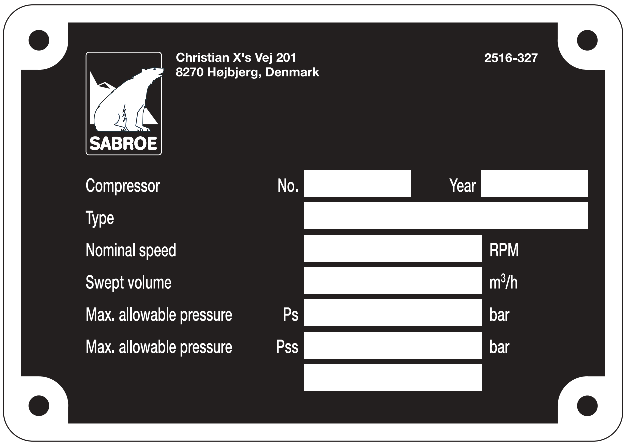


The unit pipe system name plate is positioned on the frame. The name plate contains the following information:

- **Type**
  Manufacturer's type designation.
- **Year**
  Year of manufacture.
- **Identification no.**
  Individual no. for identification of supplied pipe system.
- **Design code**
  For PED orders: EN 378-2
  If the unit has been approved by an authority, the design code will be shown here.
- **Approval no.**
  If the unit has been approved by an authority, the approval no. will be shown here.
- **Pressure system**
  Low pressure side of compressor piping is referred to as **LP.**
  High pressure side of compressor piping is referred to as **HP.**
- **Fluid/Group**
  Refrigerant designation according to ISO817 or fluid group according to directive 67/548/EEC.
- **Max. allowable pressure, PS**
  Shows max allowable pressure relative to atmospheric pressure for which the pipe system has been designed.
- **Leak test pressure, PT**
  Shows the pressure with which the pipe system has been leak tested.
- **Design temperature, TS**
  Shows min and max temperatures for which the pipe system including components has been designed.
- **CE xxxx**
  The four digits compose the registration no. of the notified body in charge of the assessment modules for the vessel.

Compressor name plate

Fig. 2.3 *Compressor name plate*



The compressor name plate is positioned on the compressor. The plate contains the following information:

- **Compressor no.**
  Compressor manufacturing number.
- **Year**
  Year of manufacture.
- **Type**
  Manufacturer's type designation.
- **Nominal speed**
  Shows rotational speed of drive shaft at typical running condition.
- **Swept volume**
  Shows swept volume of compressor in m^3/h at nominal speed.
- **Max allowable pressure, Ps**
  Shows max. working pressure of compressor.
- **Max allowable pressure, Pss**
  Shows max allowable pressure at compressor standstill.

Vessel name plate

Fig. 2.4 *Vessel name plate*

The vessel name plate is positioned on the shell of the vessel. The name plate contains the following information:

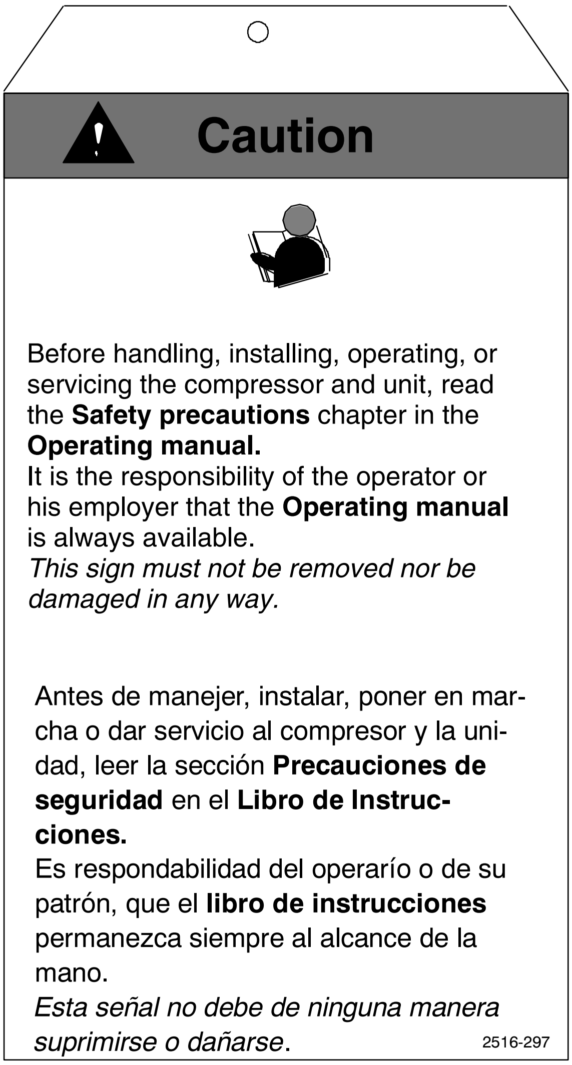
- **Vessel no.**
  Vessel number stated by Sabroe Refrigeration.
- **Year**
  Year of manufacture.
- **Type**
  Manufacturer's type designation.
- **Design code**
  Shows the design code according to which the vessel was manufactured.
- **Approval no./CAT**
  Shows the approval no. of the vessel issued by the relevant authority as well as the category according to PED 97/23/EEC, Article 9.
- **Side**
  Refers to the columns “Shell” and “Tube”.
- **Fluid**
  Shows the refrigerant designation according to ISO817.
- **Allowable pressure, PS**
  Shows min and max pressure relative to atmospheric pressure for which the vessel or vessel part has been designed.
- **Allowable temperature, TS**
  Shows min and max temperatures for which the vessel has been designed.
- **Volume**
  Shows volume of the vessel in litres.
- **CE xxxx**
  The four digits compose the registration no. of the notified body in charge of the assessment modules for the vessel.

In the following section, all signs which may be found on the equipment are described. The number of signs, however, may vary from product to product.

Signs in instructions

The sign: CAUTION

A **CAUTION** tag like the one illustrated below is fixed to the compressor. The sign imposes the users to read the *Safety precautions* chapter in the manual before handling, operating, or servicing the compressor and unit.



The sign: HIGH VOLTAGE

Danger

HIGH VOLTAGE!

Before working on any electrical circuits, turn the main switch “OFF” and lock it. Dismantle the main fuses to the compressor unit.

Unless expressly stated in applicable Sabroe Refrigeration documentation or by a Sabroe Refrigeration field service representative, do NOT work with the electrical power “ON”. Any work with the electrical power “ON” should be performed by a Sabroe Refrigeration field service representative. The customer and subsequent transferees must make sure that any other person performing work with the electrical power “ON” is trained and technically qualified.

The sign: The temperature of tangible surfaces

When a compressor is working, the surfaces which are in contact with the warm discharge gas will also get warm. However, the temperature depends on the refrigerants used as well as the operating conditions of the compressor. Often the temperature exceeds 70°C [158°F], which for metal surfaces may cause skin burns even at a light touch.

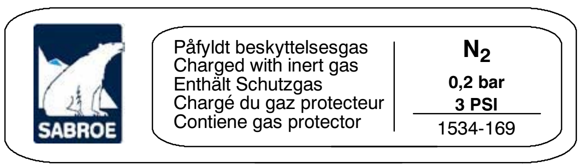
Consequently, the compressors are equipped with yellow warning signs signalling that pipes, vessels, and machine parts will become so hot during operation that your skin will get burnt if you touch them for one second or more.

The sign: Internal protection

Compressor blocks and units are usually delivered **without** any refrigerant or oil.

To protect the compressors against internal corrosion, they are delivered evacuated of all atmospheric air and charged with Nitrogen (N_2) to an overpressure of **0.2 bar [3 psi]**.

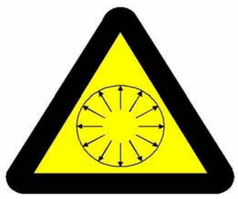
In such cases a yellow sign is affixed to a visible spot on the compressor.



Other warning signs

Hazardous substance!

Dangerous noise level, use hearing protectors!



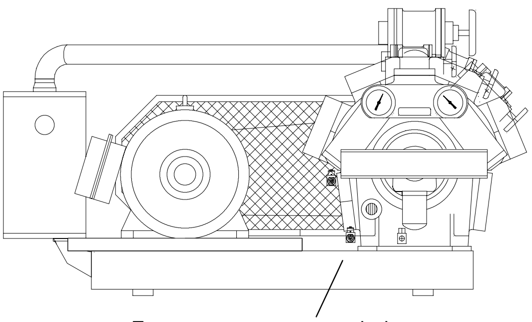
Internal overpressure!

Cold surfaces!

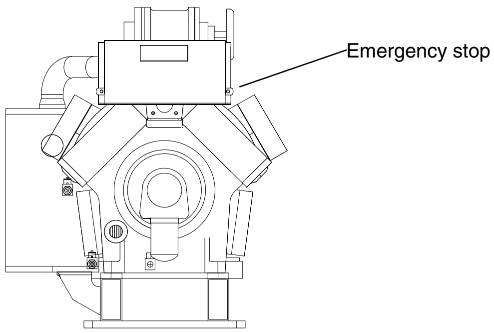
Emergency Stop

Fig. 2.5 *Emergency stop on the reciprocating compressor unit*

Electromechanical control system



UNISAB II control system

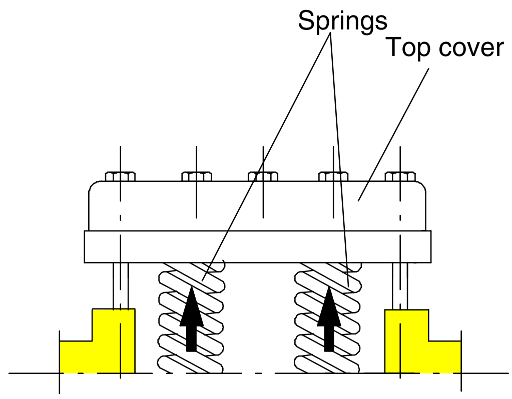


Safety during Service

Before dismantling or servicing a compressor or unit attention should be paid to the following points:

- Read the *Safety Precautions* in chapter 3 before opening the compressor and other parts of the refrigeration plant.
- Make sure that the motor cannot start up inadvertently. It is recommended to remove all main fuses.
- Switch off all electric components on the compressor/unit before the dismantling/servicing.
- Make sure that there is neither overpressure nor any refrigerant in the part to be dismantled. Close all necessary stop valves.
- Use gloves and safety goggles and make sure to have a gas mask ready for use.
- Use the prescribed tools and check that they are properly maintained and in good working condition. In explosion-proof areas, use tools especially suited for this specific purpose.
- When dismantling the top covers, attention should be paid to the considerable spring force beneath the covers. When the screws are loosened, the cover must lift itself from the frame as described in the instruction manual.

Fig. 2.6



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

Warnings in Instructions

This section describes warnings used in instructions pertaining to Sabroe Refrigeration equipment.

Information of importance to the safety of personnel or equipment is given at three levels.

- Danger!
- Warning!
- Caution!

There is an important distinction between these three levels. However, as shown below, the principle is the same at all three levels.

Note: Information is sometimes given in a Note. A Note is used to emphasise information but it is never used for information vital to the safety of personnel and equipment.

Texts Marked with Danger!

The example below shows how information vital to the safety of involved personnel is presented.

⚠ ***Danger!***

Risk of electrical shock! Always turn off the main switch before servicing the unit! Contact with high voltage may cause death or serious injury.

Failure to observe information marked with Danger! may cause death or serious injury to personnel or even to a third party.

Texts Marked with Warning!

The example below shows how information of importance to the safety of involved personnel or of major importance to the safety of equipment is presented.

⚠ ***Warning!***

Risk of damage to compressor! Always consult your supplier before using a compressor under operating conditions outside the specified working range.

Texts Marked with Caution!

The example below shows how information of importance to the safety of equipment is presented.

⚠ ***Caution!***

Risk of incorrect viscosity! Always make sure that all oils used are mixable without causing chemical reactions. Chemical reactions might have serious effects on the viscosity.

Failure to observe information marked with Caution! may cause damage to equipment.

3. Safety Precautions

The purpose of this chapter is to provide general safety precautions for this equipment. Additional safety precautions relating to a specific task are given in the corresponding documents.

The safety precautions are intended for all user categories.

⚠ ***Danger!***

Risk of injury to personnel and damage to equipment! Always read the safety precautions belonging to this equipment before start. Failure to comply with safety precautions may cause death or injury to personnel. It may also cause damage to or destruction of the equipment.

⚠ ***Warning!***

Read related safety precautions before operating the compressor/unit. Failure to follow safety instructions may result in serious personal injury or death.

Important!
The safety precautions for this Sabroe Refrigeration compressor have been prepared to assist the operator, programmer and maintenance personnel in practicing good shop safety procedures.

Operator and maintenance personnel must read and understand these precautions completely before operating, setting up, running or performing maintenance on the compressor/unit.

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

a. All other manuals pertaining to the compressor/unit.

b. Local, plant and shop safety rules and codes.

c. National safety rules, regulations and directives.

General Safety Instructions and Considerations

Personal Safety

Owners, operators, set-up, maintenance and service personnel must be aware that constant day-to-day safety procedures are a vital part of their job. Accident prevention must be one of the principal objectives of the job, regardless of the activity involved.

Know and respect the compressor/unit. Read and carry out the prescribed safety and checking procedures.

Make sure that everyone who works for, with or near you fully understands and - more importantly - complies with the following safety precautions and procedures when operating this compressor/unit.

Observe the safety warnings on the compressor/unit.

Use safety equipment. Wear approved eye or face protection as well as gloves when working with parts containing refrigerant and/or lubricating oil. Safety shoes with slip-proof soles can help you avoid injuries. Keep your safety equipment in good condition.

Never operate or service this equipment if affected by alcohol, drugs or other substances or if in a condition which decreases alertness or judgment.

Work Area Safety

Always keep your work area clean. Dirty work areas with such hazards as oil, debris or water on the floor may cause someone to fall onto the floor, into the machine or onto other objects resulting in serious personal injury.

Make sure your work area is free of hazardous obstructions and be aware of protruding machine parts.

Always keep your work area tidy so that you can escape if a dangerous situation should arise.

Report unsafe working conditions to your supervisor or safety department.

Tool Safety

Always make sure that the hand tools are in proper working condition.

Remove hand tools such as wrenches, measuring equipment, hammers, etc. from the compressor/unit immediately after use.

Transmission safety

Coupling

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

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

Do not start the compressor until the coupling guard or belt drive is mounted correctly. Before performing any kind of work on the coupling, make sure that the compressor motor cannot start up unintended.

When performing service where the motor is dismantled from the base frame, follow the instructions for coupling alignment in the Installations Instructions section.

Belt drive

The belt guard is not designed to resist unintended load and is therefore marked with a warning sign - “No step”. When the belt guard is mounted it should be checked after 20 hours whether tightening-up is required. Check the belt guard for correct tightening, cracks or other defects every 5000 hours.

Lifting and Carrying Safety

Contact Sabroe Refrigeration if you have any questions or if you are not sure about the proper procedures for lifting and carrying.

Before lifting or carrying a compressor/unit or other parts, determine the weight and size by means of e.g. tags, shipping data, labels, marked information or manuals.

Use power hoists or other mechanical lifting and carrying equipment for heavy, bulky or unwieldy objects. Use hook-up methods recommended by your safety department and familiarise yourself with the signals for safely directing a crane operator.

Never place any part of your body under a suspended load or move a suspended load over any other persons. Before lifting, be certain that you have a safe spot for depositing the load. Never work on a component while it is hanging from a crane or any other lifting mechanism.

If in doubt as to the size or type of lifting equipment, the method and procedures to be used in connection with lifting, contact

Sabroe Refrigeration before proceeding to lift the compressor, motor, unit or its components.

Always inspect slings, chains, hoists and other lifting devices prior to use. Do not use lifting devices which are defective or in a questionable condition.

Never exceed the lifting capacity of cranes, slings, eyebolts and other lifting equipment. Follow standards and instructions applicable to any lifting equipment used.

Before inserting an eyebolt, be certain that both the eyebolt and the hole have the same size and type of threads. To attain safe working loads, at least 90% of the threaded portion of a standard forged eyebolt must be engaged.

⚠ ***Warning!***

Failure to follow safety instructions on this page may result in serious personal injury or death.

Installation and Relocation Safety

Before lifting the compressor, unit or other parts of the plant, consult the Engineering manual or Sabroe Refrigeration for proper methods and procedures.

An electrician must read and understand the electrical diagrams prior to connecting the machine to the power source. After connecting the machine, test all aspects of the electrical system for proper functioning. Always make sure that the machine is grounded properly. Place all selector switches in their OFF or neutral (disengaged) position. The doors of the main electrical cabinet must be closed and the main disconnect switch must be in the OFF position after the power source connection is complete.

Before starting the compressor for the first time, make sure that all the motors rotate in the indicated direction.

Set-Up and Operation Safety

Read and understand all the safety instructions before setting up, operating or servicing this compressor. Assign only qualified personnel instructed in safety and all machine functions to operate or service this compressor.

Operators and maintenance personnel must carefully read, understand and fully comply with all warnings and instruction plates mounted on the machine. Do not paint over, alter or deface these plates or remove them from the compressor/unit. Replace all plates which become illegible. Replacement plates can be purchased from Sabroe Refrigeration.

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

All safety features, disengagements and interlocks must be in place and function correctly before this equipment is put in operation. Never bypass or wire around any safety device.

Keep all parts of your body off the compressor/motor/unit during operation. Never lean on or reach over the compressor.

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

Maintenance Safety

Do not attempt to perform maintenance on the compressor unit until you have read and understood all the safety instructions.

Assign only qualified service or maintenance personnel **trained by** Sabroe Refrigeration to perform maintenance and repair work on the unit. They should consult the service manual before attempting any service or repair work and contact Sabroe Refrigeration in case of questions. Use only Sabroe Refrigeration original spare parts; other parts may impair the safety of the compressor/unit.

Before removing or opening any electrical enclosure, cover, plate or door, be sure that the Main Disconnect Switch is in the OFF position and the main fuses are dismantled.

If any tool is required to remove a guard, cover, bracket or any basic part of this compressor, place the Main Disconnect Switch in the OFF position and lock it in the OFF position. If possible, post a sign at the disconnect switch indicating that maintenance is being performed. Dismantle main fuses to the unit.

Danger
HIGH VOLTAGE!

Before working on any electrical circuits, place the Main Disconnect Device of the compressor/unit in the "OFF" position and lock it. Dismantle the main fuses to the compressor unit. Unless expressly stated in applicable Sabroe Refrigeration *documentation or by appropriate* Sabroe Refrigeration *Field Service Representative, do NOT work with the electrical power "ON". If such express statement or advice exists, work with the electrical power "ON" should be performed by a* Sabroe Refrigeration *Field Service Representative. The customer and subsequent transferees must make sure that any other person performing work with the electrical power "ON" is trained and technically qualified.*
FAILURE TO FOLLOW THIS INSTRUCTION MAY RESULT IN DEATH OR SERIOUS PERSONAL SHOCK INJURY.

When maintenance is to be performed in an area away from the disconnect, and the switch is not locked, tag all start button stations with a **“DO NOT START”** tag.

Adequate precautions such as warning notices or other equally effective means must be taken to prevent electrical equipment from being activated electrically when maintenance work is being performed.

When removing electrical equipment, place number or labelled tags on those wires not marked. If wiring is replaced, be sure it is of the same type, length, size and has the same current carrying capacity.

Close and fasten all guards, shields, covers, plates or doors securely before power is reconnected.

An electrician must analyse the electrical system to determine the possible use of power retaining devices such as capacitors. Such power retaining devices must be disconnected, discharged or made safe before maintenance is performed.

Working space around electrical equipment must be clear of obstructions.

Provide adequate illumination to allow for proper operation and maintenance.

Materials Used with this Product

Always use Sabroe Refrigeration original spare parts.

Please note the type of refrigerant on which the compressor operates as well as the precautions that need to be taken as described in the following sections:

- First aid for accidents with ammonia.
- First aid for accidents with HFC/HCFC.
- First aid for accidents with HC.
- First aid for accidents with CO_2
- Protecting the operator as well as the environment.

First aid for accidents with ammonia

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

⚠ ***Warning!***

No plant can ever be said to be too safe - safety is a way of life.

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 as its own warning agent so that no person remains voluntarily in hazardous concentrations. 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 a very stable compound. At 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

Always call a doctor immediately.

Be prepared: Keep an irrigation bottle available containing a sterile isotonic (0.9%) NaCl-solution (salt water). A shower or a water tank should be available near all bulk installations with ammonia.

When applying first aid, the persons assisting must be duly protected to avoid further injuries.

First aid measures

Inhalation: Immediately, move affected personnel into fresh air and loosen clothing restricting breathing.

Call a doctor/ambulance with oxygen equipment.

Keep the patient still and warmly wrapped in blankets.

If mouth and throat are burnt (freeze or acid burn) and the patient is conscious, let him drink water in small mouthfuls.

If the patient is conscious and mouth and throat are **not** burnt, feed him sweetened tea or coffee (**never** feed an unconscious person).

Oxygen may be given to the patient, but **only** when authorised by a doctor. If the patient stops breathing, apply artificial respiration.

Eyes: In case of injuries from liquid splashes or concentrated vapour, immediately rinse with water (preferably using an eye rinser) and consult a doctor. Continue rinsing until otherwise stated by a doctor.

If the affected person wears contact lenses these must be removed before the rinsing.

Skin: In case of burns from liquid splashes or concentrated vapour, immediately wash with large quantities of water until the pain stops.

Consult a doctor about actual burns.

After washing, apply wet compresses - wetted with a sterile isotonic (0.9%) NaCl-solution (salt water) - to affected areas until medical advice is available.

First aid for accidents with HFC/HCFC

> ⚠ ***Warning!***
>
> *No plant can ever be said to be too safe - safety is a way of life.*

General

HFC/HCFC form colourless and invisible gasses which are heavier than air and smell faintly of chloroform at high concentrations.

Characteristics:

- non-toxic
- non-inflammable
- non-explosive
- non-corrosive

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

When affected persons are moved from low-lying or poorly ventilated rooms where high gas concentrations are suspected, the rescuer must wear a lifeline and be under constant observation from an assistant outside the room.

Do not use adrenaline or similar heart stimuli.

Inhalation: Immediately move affected persons into fresh air. Keep them still and warm and loosen clothing restricting breathing.

If the patient is unconscious, call a doctor/ambulance with oxygen equipment immediately.

Apply artificial respiration until a doctor authorizes other treatment.

Eyes: Immediately rinse with water (preferably using an eye rinser) and consult a doctor. Continue rinsing until otherwise stated by a doctor.

If the affected person wears contact lenses these must be removed before the rinsing.

Skin: In case of frost-bite, immediately rinse with luke-warm water (max. 37°C) and remove all clothes impeding blood circulation.

Consult a doctor.

Avoid direct contact with contaminated oil/refrigerant mixtures from electrically burnt-out hermetic compressors.

Protecting the operator as well as the environment

> ⚠ ***Warning!***
>
> *No plant can ever be said to be too safe - safety is a way of life.*

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

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

Pay extra attention to the following substances:

- refrigerants
- cooling media (brine, etc.)
- lubricating oils

Refrigerants usually have a natural boiling point considerably 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 can be suffocating when they displace air.

If high concentrations of refrigerant vapours are inhaled, they will attack the human nervous system.

When halogenated gasses come into contact with open flame or hot surfaces (over approx. 300°C), they will decompose to produce poisonous chemicals. These have a very pungent odour and will thus warn personnel of their presence.

At high concentrations R717 causes respiratory problems. When the amount of ammonia vapour in air is between 15 and 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 warn personnel before the concentration becomes dangerous.

The following table shows the values for the max. permissible refrigerant content in air measured in volume %. Certain countries may, however, have official limits different from the ones stated.

		Halogenated refrigerants						Ammonia	CO_2
		HFC					HCFC		
		R134a	**R404A**	**R407C**	**R410A**	**R507**	**R22**	**R717**	**R744**
TWA Time weighted average during a week	Unit Vol.%	0.1	0.1	0.1	0.1	0.1	0.1	0.005	0.5
Warning smell	Vol.%		0.2					0.002	

Furthermore, it can be said about refrigerants:

HFC/HCFC

- If released into the atmosphere, halogenated refrigerants of the types CFC and HCFC (e.g. R22) will contribute to the 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 CFC, HFC and HCFC are greenhouse gases which contribute to an intensification of the greenhouse effect. They must, therefore, **never** be released into the atmosphere. Use a separate compressor to draw the refrigerant into the plant condenser/receiver or into separate refrigerant cylinders.

Ammonia

- 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 into the atmosphere in large quantities.

Hydro carbons (HC)

- HC gasses are a group of B1 refrigerants characterized as very flammable.
- Hydro carbons are odourless and non-toxic gasses. Specific mixtures of air and gas create danger of explosion. As the gasses are heavier than air, they will be concentrated at the lowest possible level in case of leaks.

Carbon dioxide (CO_2)

- Carbon dioxide (CO_2) is a greenhouse gas with a GWP (Global Warming Potential) factor of 1. It is found in the atmosphere in a concentration of 0.036 vol. % (360 parts per million, ppm). As CO_2 is extracted from atmospheric air, it can safely be released into the atmosphere and does not contribute to enhancing the greenhouse effect.
- The boiling point for CO_2 is -78.5°C at 1.013 bar.
- CO_2 is an odourless, non-toxic non-inflammable gas. At concentrations higher than 5000 ppm the gas can be dangerous for humans. The gas is heavier than air and will thus be concentrated on the lowest level of the room in case of a leak. In closed rooms the gas can displace oxygen and cause suffocation.

Refrigerant evacuated from a refrigeration plant must 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 incineration 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 to observe the following:

- Refrigerants must not be released into the atmosphere (exept CO_2).
- When purging an R717 plant, use an approved air purger. The purged air must pass through an open container of water for any remaining R717 to be absorbed. The water mixture must be sent to an authorized incineration plant.
- Halogenated refrigerants **cannot** be absorbed by water. An approved air purger must be fitted to the plant. This must be checked regularly by use of a leak detector.

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

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 production of brine.

In general, all brines must be considered harmful to nature and they 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 incineration plant.

Lubricating oils

⚠ ***Warning!***

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

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

- Mineral oil (M oil)
- Hydro treated mineral oil (H oil)
- Semi-synthetic oil (mix of M oil and synthetic oil)
- Alkyl benzene-based synthetic oil (A oil)
- Polyalphaolefine-based synthetic oil (PAO oil)
- Mixed A and PAO oil (AP-oil)
- Polyalkylen Glycol-based synthetic oil (PAG oil)
- Ester oil (E oil)

See the section *Selecting lubricating oil for* Sabroe Refrigeration *compressors* in chapter 6, Technical Data.

When changing the oil in the compressor or draining oil from the vessel of the refrigeration plant, always collect the used oil in containers marked “waste oil” and send them to an approved incineration plant. It is **not** recommended to re-use oil.

Cooling water systems

⚠ ***Warning!***

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

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

4. Technical Description

The purpose of this chapter is to describe the intended purpose, the physical characteristics and the functions of the unit.

This chapter is primarily intended for designers, service engineers, prospective customers, sales personnel and personnel undergoing training.

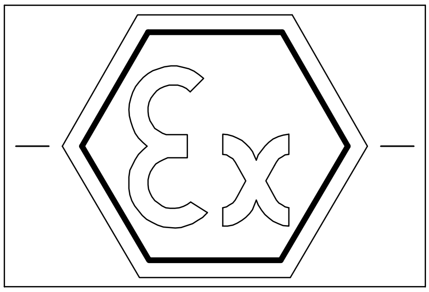
Areas of Application of the Reciprocating Compressor Unit

Application

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:

- As a refrigeration compressor with the number of revolutions pr. minute specified by Sabroe Refrigeration and the operating limits as stated in this manual or in a written agreement with Sabroe Refrigeration.
- Compressor types SMC 100 and TSMC 100 in an S or L execution can - as standard compressors - be used with the following refrigerants: **R717 - R22 - R134a - R407C - R404A - R507** - R600 - R600A - R290 - LPG. This manual only deals with the ones written in **bold** letters.
- Compressor types SMC 100 and TSMC 100 in an **E** execution are as standard compressors used with R717 only.
- The compressors can be used with other refrigerants, but only following a written agreement with Sabroe Refrigeration.
- SMC 100 and TSMC 100 compressors in S, L or E executions may be used at a max discharge design pressure of 25 bar. See *Test Pressure Levels for Standard Compressors and Components* in chapter 6.
- The compressors are approved for application in an explosion-prone environment, provided they have been fitted with explosion-proof equipment. This can be seen from the Ex nameplates, Fig. 4.1, fixed on each unit.

Fig. 4.1



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Please, note that specially made tools which cannot cause any sparks must be used in connection with maintenance work on the compressor.

Warning!

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.

⚠ ***Danger!***

Sabroe Refrigeration does not take any responsibility for injuries to personnel or damage to equipment resulting from using this equipment for other purposes than the ones stated above.

Application of Combustion Engines

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

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

Marine application

Special attention should be paid to the listing of the ship and consequently the inclination of the compressor. If the inclination is too large, the amount of oil charged will not be sufficient to keep the oil suction strainer fully submerged in oil. The result will be lack of oil pressure and potential bearing damage. The SMC 100 compressors will operate efficiently even below limits of inclination.

Fig. 4.2

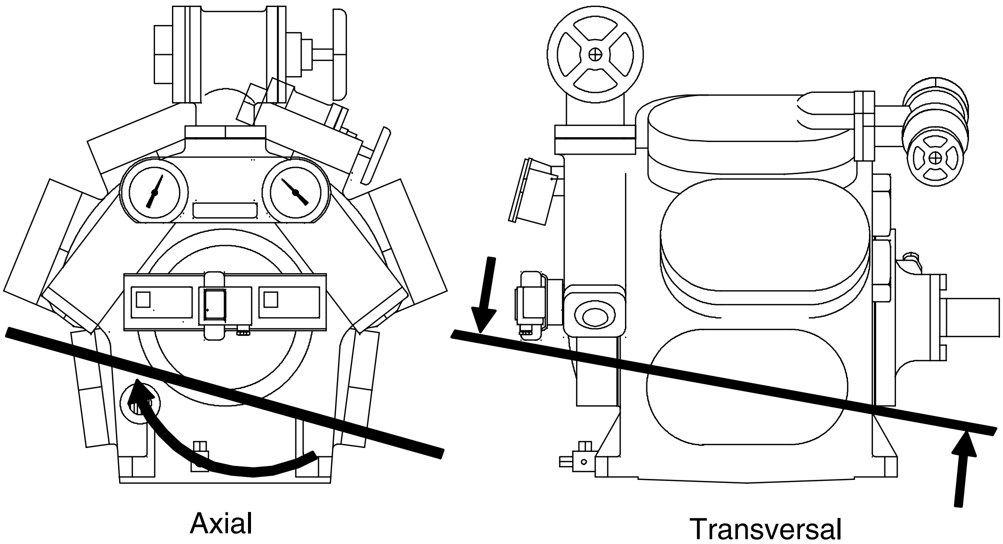


Table 4.1

Allowed inclination, degrees	Axial (rotation around crankshaft axis)		Transversal (rotation around axis perpendicular to crankshaft)	
	Static	Dynamic	Static	Dynamic
Short blocks SMC 104-106-108	15	22,5	10	15
Long blocks SMC 112-116	15	22,5	5	7,5

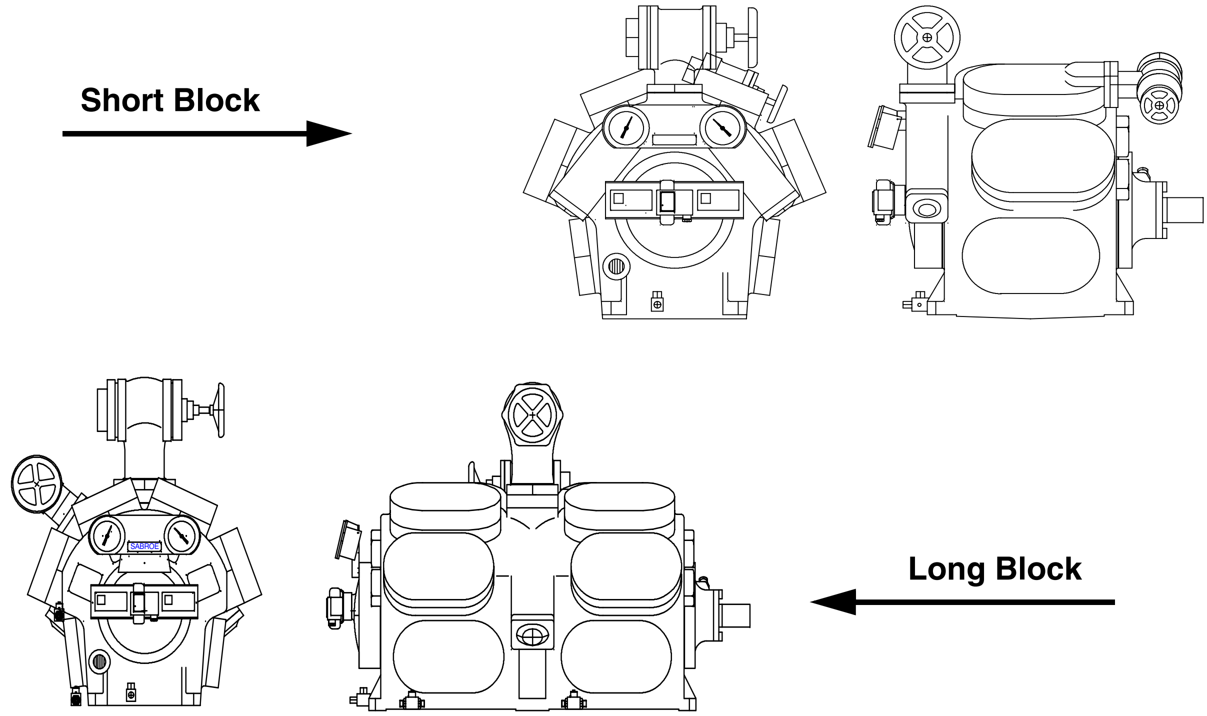
Usually, ships primarily list athwart; thus installation of the compressor with crankshaft in fore-and-aft direction is recommended.

Description of the Compressors Compressor Types

Reciprocating compressor types SMC 100 and TSMC 100 represent a series of open compressors with 4 to 16 cylinders in one and the same block. The cylinders are positioned in a V or W position and have the same internal diameter of 100 mm. The series comprises 15 single-stage and 6 two-stage compressors with the following type designations:

Compressors with 4, 6 and 8 cylinders are called short blocks whereas compressors with 12 and 16 cylinders are called long blocks.

Fig. 4.3



Single-stage compressors are designated **SMC** which is an abbreviation of **S**ABROE **M**ulti-cylinder **C**ompressor. As for the two-stage compressors the letter **T** has been added to indicate **T**wo stages.

Further, the compressors can be delivered with the following three strokes, designated S, L or E, respectively:

- **Type S** has an 80 mm piston stroke and is used with all approved refrigerants.
- **Type L** has a 100 mm piston stroke and is used with all approved refrigerants.
- **Type E** has a 120 mm piston stroke and is used only in connection with R717. The compressor has 50% more capacity than type **S.**

The operating limits (including number of revolutions) depend on the compressor type and refrigerant. As the extension of the operating limits is an ongoing process, please make sure that the diagram in question is the latest revision before making a conclusion.

Below are given some examples of type designations of the compressors:

Single-stage compressor **SMC 108 L**

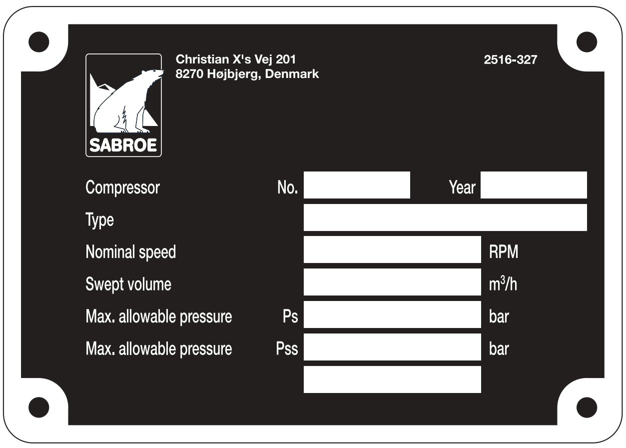
Compressor type: SMC
Cylinder Diameter: 100 mm
Number of Cylinders: 4-6-8-12 or 16
Stroke: S, L or E

Two-stage compressor **TSMC 116 S**

Compressor type: TSMC
Cylinder Diameter: 100 mm
Number of Cylinders: 8 or 16
Stroke: S, L or E

An entire list of the compressor series can be seen in the table *Technical Data for SMC 100 Series* in chapter 6, Technical Data.

The type and version of the various compressors can be read from the name plate shown below. A name plate is fixed on every compressor.



Similarly, the serial number of each compressor is stamped into the compressor block. The letter S, L or E, which refers to the compressor stroke, is stamped into the end surface of the crankshaft.

Whenever contacting Sabroe Refrigeration about a compressor, please state its serial number.

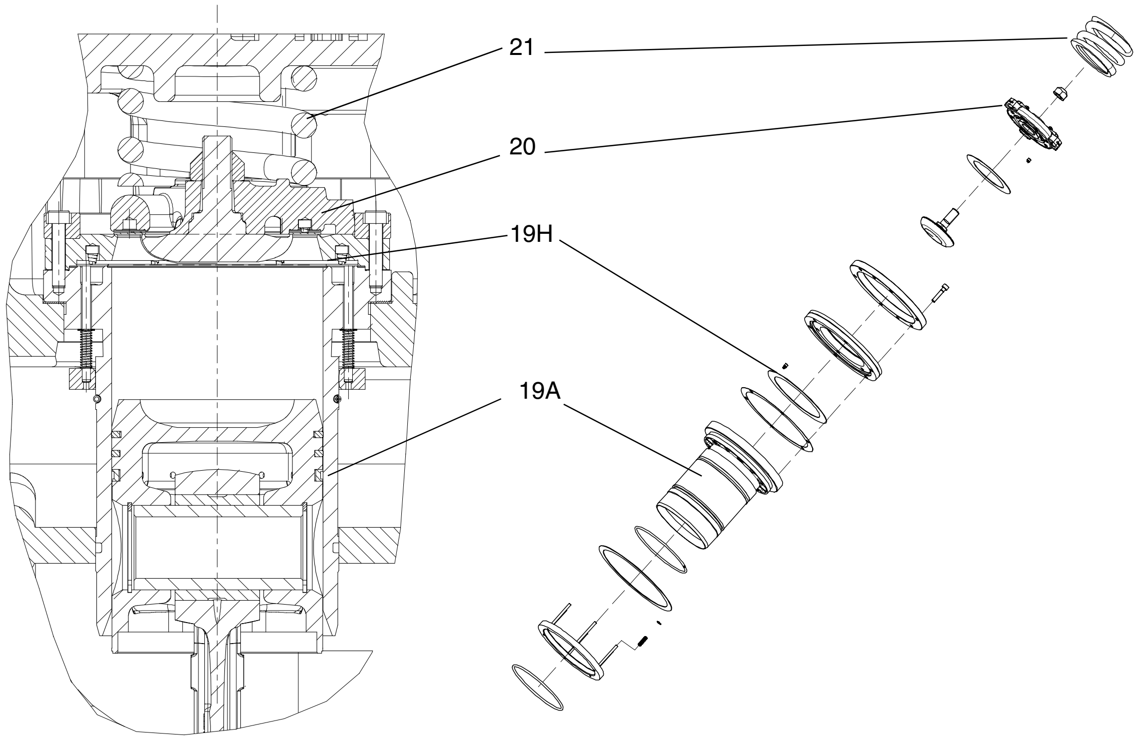
Compressor Description

With a few exceptions, all compressors of the SMC 100 or TSMC 100 types use the same spare parts as the ones described in the following section.

Single-stage Compressors

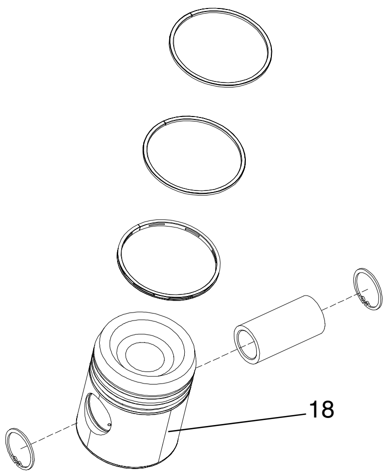
The compressors are equipped with replaceable **cylinder liners**, pos. 19A, Fig. 4.4, which are made of special cast iron and are easy to dismantle for inspection. They are honed and surface hardened, which makes them very wear resistant. Underneath each top cover there are always two cylinders.

Fig. 4.4 *SMC 100 Cylinder Liner Complete*



The pistons, pos. 18, are made of aluminium with two hard-plated piston rings and one oil scraping ring ensuring optimum tightness, low oil consumption as well as long life.

Fig. 4.5 Piston



Suction valve, pos. 19H, which is of the ring plate type, is fitted at the top of the cylinder liner and can be removed together with the cylinder liner.

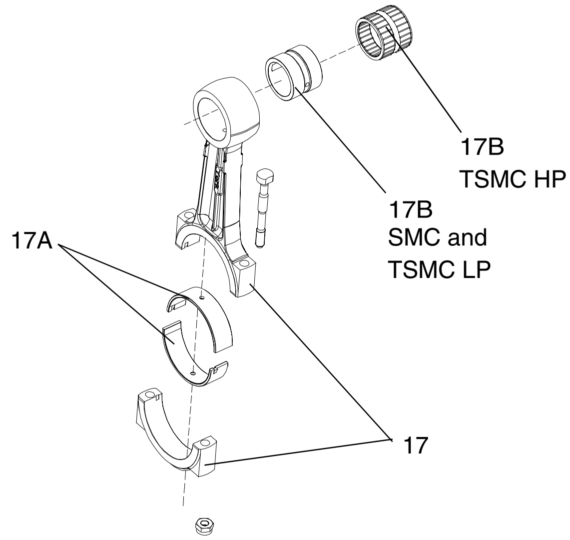
Discharge valve, pos. 20, forms the top of the cylinder and is kept in place by a powerful spring, pos. 21. This spring is also called the **safety spring** as it enables the complete discharge valve to lift a little at particularly high pressures in the cylinder due to liquid or oil in the compressed gas (liquid slugging). Thus overloading of the bearings in the connecting rod is avoided.

The compressor is designed for operation with liquid slugging for a short time only. If liquid slugging occurs (the sound of hard metal hammering), the compressor must be stopped and the cause must be removed.

Connecting rod, pos. 17, Fig. 4.6 is made of ductile cast iron. It has replaceable slide bearings, pos. 17A and B, at both ends on single stage compressors and on the first stage (LP) on TSMC. On the second stage (HP) on TSMC, the small end bearing is of the rolling element type.

The reason for this is that the top of the HP pistons are affected by the intermediate pressure, which is higher than the suction pressure, and thus gives a downward force during suction. This is different from the top of the LP pistons which are affected by a pressure lower than the suction pressure which gives the piston an upward force during suction.

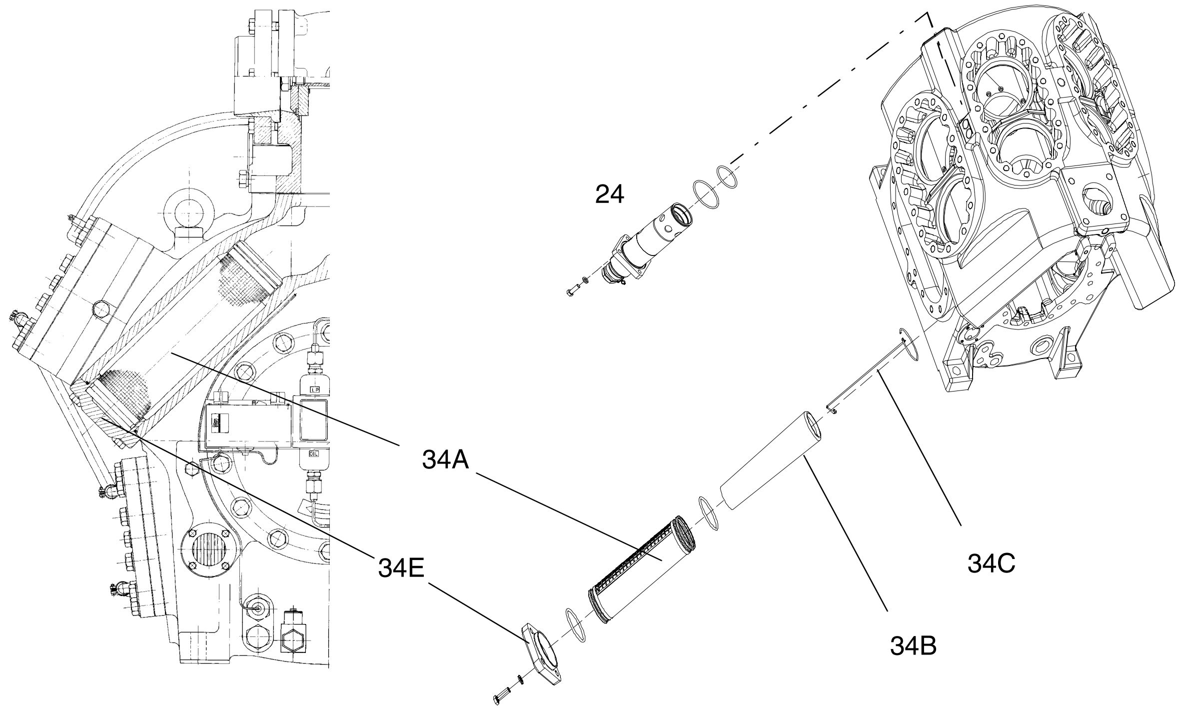
Fig. 4.6 Connecting Rod, SMC 100



Suction filter: All the compressors are equipped with very large built-in suction filters, pos. 34A, Fig. 4.7, with great filtering capacity which effectively filters off the dirt particles conveyed with the gas from the refrigeration plant to the compressor. The suction filters are made of stainless steel and, by dismantling the covers, pos. 34E, they are easy to pull out and clean.

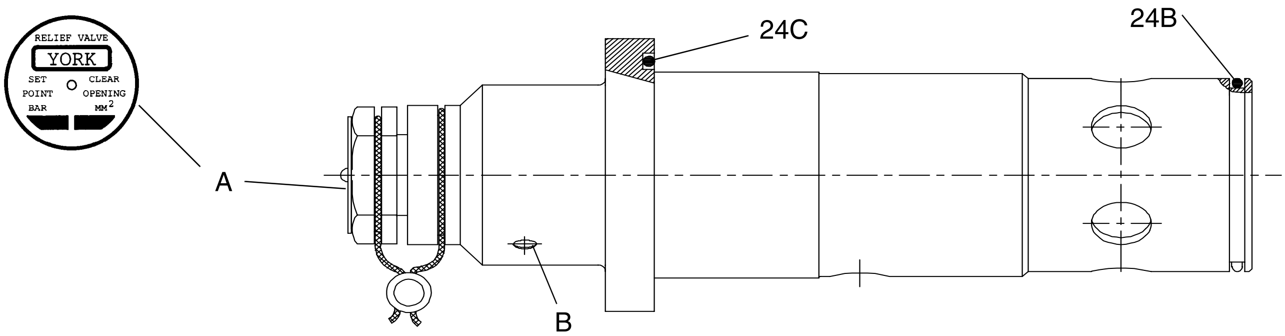
When a compressor is delivered, a fine-meshed **filter bag**, pos. 34B, has been fitted in the suction filters. The filter bag filters off the tiny rust particles that may pass the suction filters and is thus providing the compressor with considerable protection from dirt mixing with oil. The filter bags are used no longer than 50 hours after initial start up of the compressor. This also applies when changes, which may cause impurities in the suction gas, are made on the plant. After the 50 hours, the filter bags and the inserts for the filter bags pos. 34C must be taken out and discarded. Used filter bags must be disposed of according to existing environmental legislation, see also chapter 11 *Maintenance Instructions* and chapter 20 *Final Disposal*.

Fig. 4.7 *SMC 100 Filter Section and by-pass valve*



By-pass valve: The compressor is equipped with a built-in mechanical by-pass valve, Fig. 4.7 and Fig. 4.8, pos. 24, which safeguards the compressor against unintended over-pressure in case the electric safety equipment should fail. The bypass valve acts as a kind of over-pressure safeguard between the discharge and suction side of the compressor.

Fig. 4.8 *SMC/TSMC 100 - By-pass Valve*



The by-pass valve is delivered pre-set, sealed and adjusted to the following opening pressures:

- Standard for SMC and TSMC (HP stage) compressors: **24 bar** [348 psi].
- Special for SMC - and TSMC (HP stage) compressors: **22 bar** [319 psi]; this is only delivered following a specific order and applied in accordance with local rules and regulations concerning pressure vessels as e.g. oil separators. The current set pressure is stamped into the name plate pos. A.
- Standard for TSMC (LP stage) compressors: **12 bar** [174 psi].

The by-pass valve is of the **high-lifting type,** which makes it robust and durable.

Moreover, the by-pass valve is independent of the pressure on the suction side of the compressor. Consequently, it opens only when the pressure on the discharge side exceeds the set pressure compared to that of the atmosphere.

Note: The by-pass valve should not be considered a safety valve.

Fig. 4.9 *SMC 104-108 Short Block*

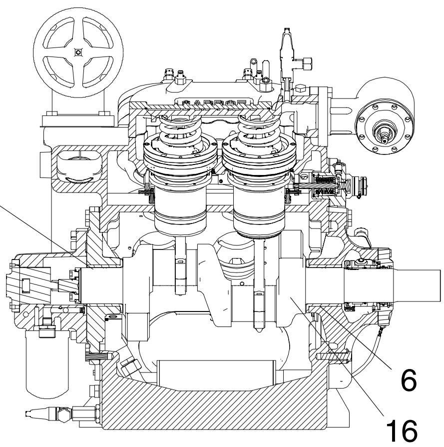
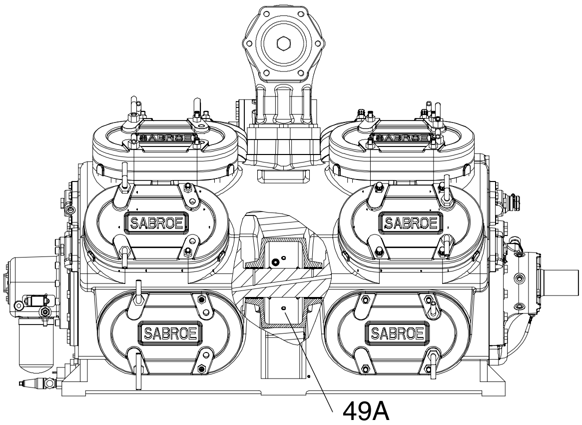
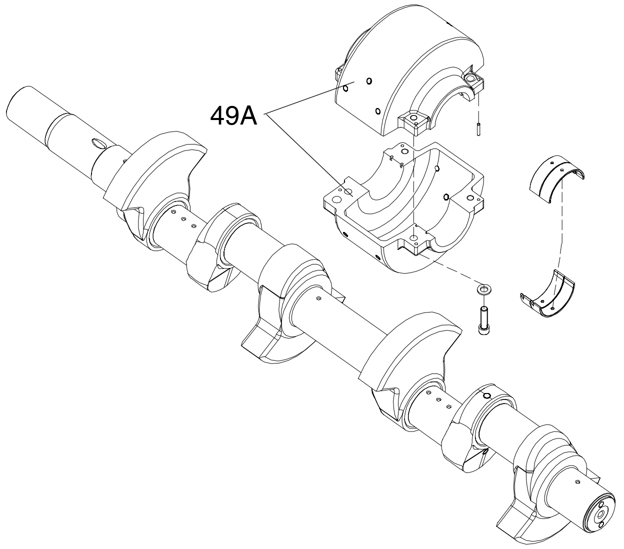


Fig. 4.10 *TSMC 112-116 Long Block*



The crankshaft, pos. 16, Fig. 4.9, rests in large slide main bearings pos. 5 and 6 which are able to absorb both radial and axial loads. Both the main bearings and the connecting rod bearings at the large end of the connecting rod are easy to replace in connection with an overhaul of the compressor and need no additional finishing after remounting. The bearings are available in 0.5 mm undersize to be used for crankshafts that are ground to 0.5 mm undersize during a renovation. After having been ground to undersize, the crankshaft needs no surface hardening or the like, but can be used directly as bearing surface. The crankshaft is dynamically balanced for a smooth and vibration free operation and need no further balancing after the above-mentioned machining to undersize. In the SMC 112-116 compressors the crankshaft is also supported by an intermediate bearing, pos. 49A, Fig. 4.10.

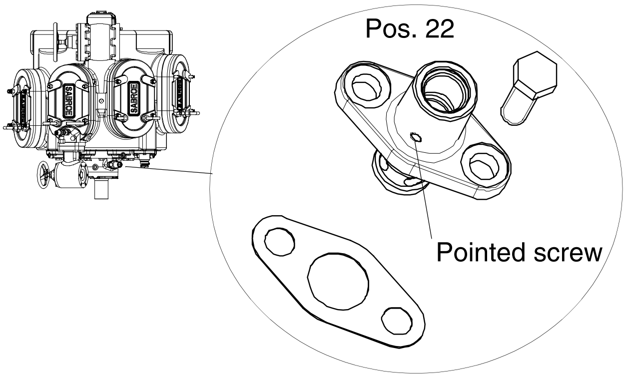
Fig. 4.11 *SMC 112 - 116 and TSMC 116*



The oil pump, pos. 11A, Fig. 4.14, is built into the compressor and driven by the crankshaft by means of a coupling. The oil pump is a self-priming gear pump which takes the oil from the oil sump through an oil suction strainer in the crankcase, pos 33A, Fig. 4.13 and forces it through the full flow filter into the lubricating system.

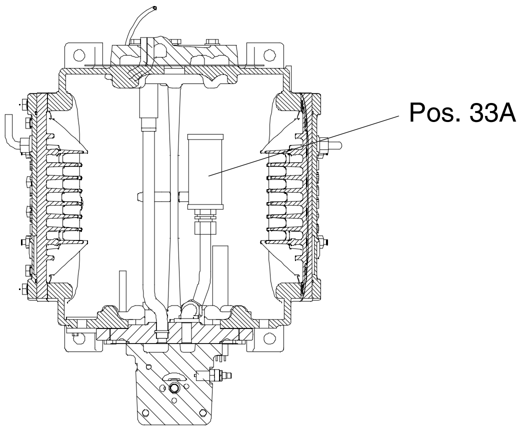
The oil pressure regulating valve, pos. 22, Fig. 4.12 regulates the oil pressure in the compressor lubricating system. It can be adjusted from the outside by means of a screw driver when the pointed screw, which locks the regulating screw, has been loosened. For variable speed driven compressors, the oil pressure has to be adjusted to the minimum oil pressure at minimum speed. Due to rising pressure drop at high oil flow, the pressure will rise when running at maximum rpm.

Fig. 4.12 *Oil pressure regulating valve*



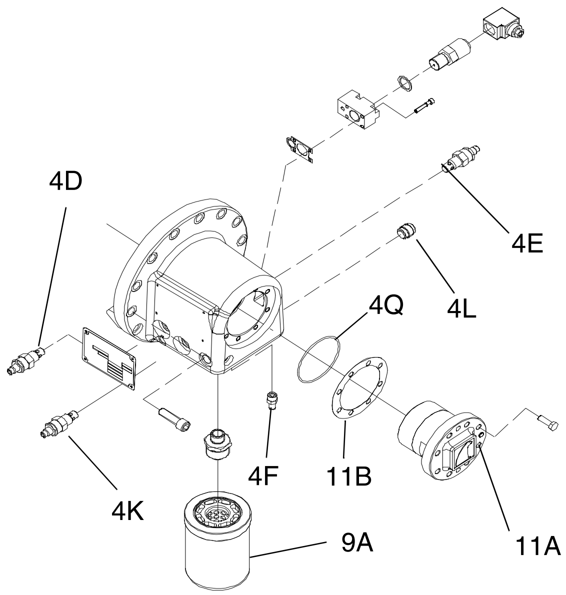
The oil suction strainer pos. 33A prevents dirt particles in the oil of the crankcase from entering the oil pump with a subsequent wear on the pump bearings. The filter is of the **full flow filter** type. The filter can be cleaned.

Fig. 4.13 *Oil suction strainer*



External oil filter, pos. 9A. After the oil pump, the oil is furthermore filtered in an external oil filter of the full flow filter type, pos. 9A, before it is led into the lubricating system. The filter element is a disposable filter and must be replaced by a new one as soon as its filtering ability has been used up. The replacement can be carried out without reducing the refrigerant pressure on the compressor.

Fig. 4.14 Oil pump cover assembly



Shut-off valves, pos. 4K and pos. 4D are used for dismantling the oil filter. The shut-off valves must be completely open during operation to avoid pressure drops in the oil system.
For additional information about function see oil diagram Fig. 4.16.

⚠ *Caution!*

Operating the compressor while pos. 4K and/or 4D are closed may damage the compressor (no lubricating oil supply to the compressor).

The air purge valve, pos. 4E is used to reduce the pressure in the oil filter before dismantling. **The valve pos. 4E further acts as a prelubrication valve**.

Prelubrication of the compressor must always be carried out before the initial start up and after a long period of standstill. See Maintenance Instructions.

This way the bearings and the oil system are lubricated and the oil pump is filled with oil. The hose from the prelubrication pump must be connected to the branch pos. 4F on the pump housing.

⚠ *Danger!*

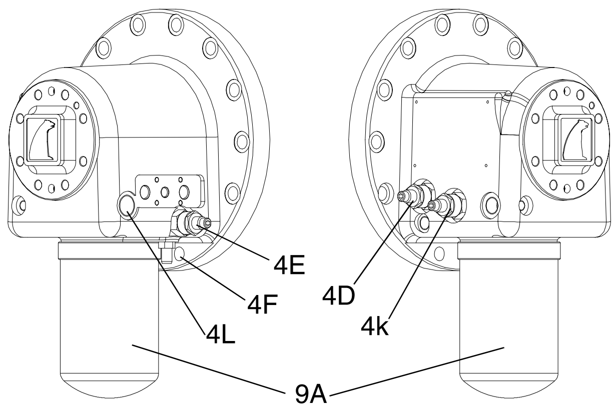
The oil filter pos. 9A is filled with oil (which may be hot) and is under pressure. It must not be loosened without the pressure being removed by means of the valves pos. 4K, 4D and 4E. See Maintenance Instructions.

⚠ *Danger!*

Operating valve pos. 4E without closing pos. 4K and 4D will cause oil and refrigerant leaks. See Maintenance Instructions.

The non-return valve, pos. 4L acts as a bypass valve when the differential pressure above the oil pump is too high.

Fig. 4.15 Valves and filter on oil pump cover



Differential pressure monitoring of the oil filter is carried out using a differential pressure switch mounted directly on the pump housing as standard. The signal serves as a warning to indicate that the filter must be changed. The filter has extra capacity in order to avoid using the signal for an alarm which forces the compressor to stop.

If required, the above mentioned switch can be replaced by a different type or by direct measurement of the oil differential pressure above the filter by connecting to port BT (inlet pressure) and BN (discharge pressure). Port BP must be blocked. (Regarding port connections, see chapter 5).

The shaft seal, pos. 10, is a sealing component which prevents oil and refrigerant from the compressor interior from leaking into the atmosphere. The shaft seal is of the slide ring type, consisting of a plane, lapped cast iron slide ring which rotates with the crankshaft and seals against a stationary spring-loaded slide ring made of special carbon. The shaft seal is of the balanced type and consequently serves a universal purpose in view of operating conditions, refrigerants and oil types used for the compressor.

The design of the shaft seal and coupling of the motor is such that the shaft seal can be removed from the compressor without removing neither compressor nor motor. This facilitates maintenance considerably.

Fig. 4.16 *Oil diagram*

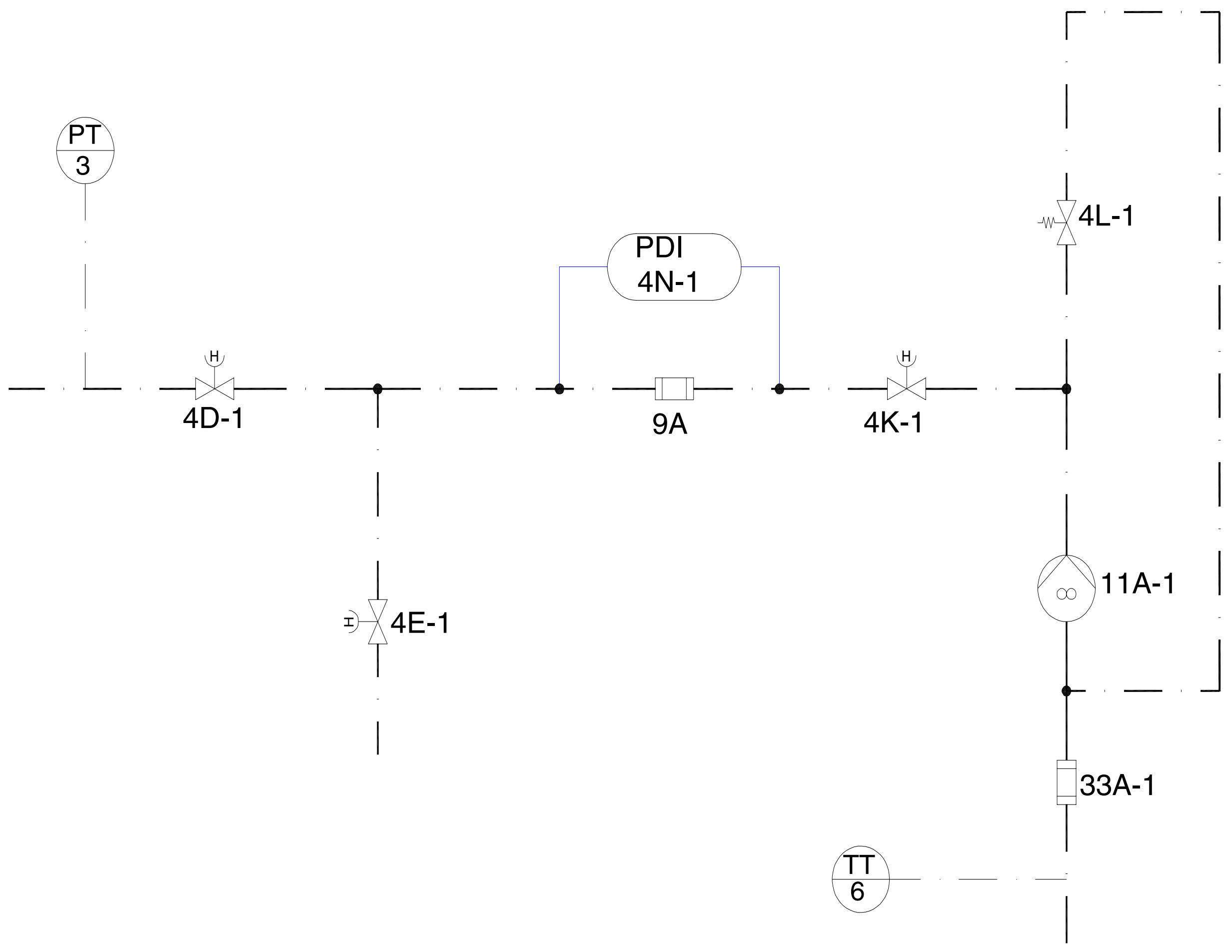


Fig. 4.17 *Shaft seal*

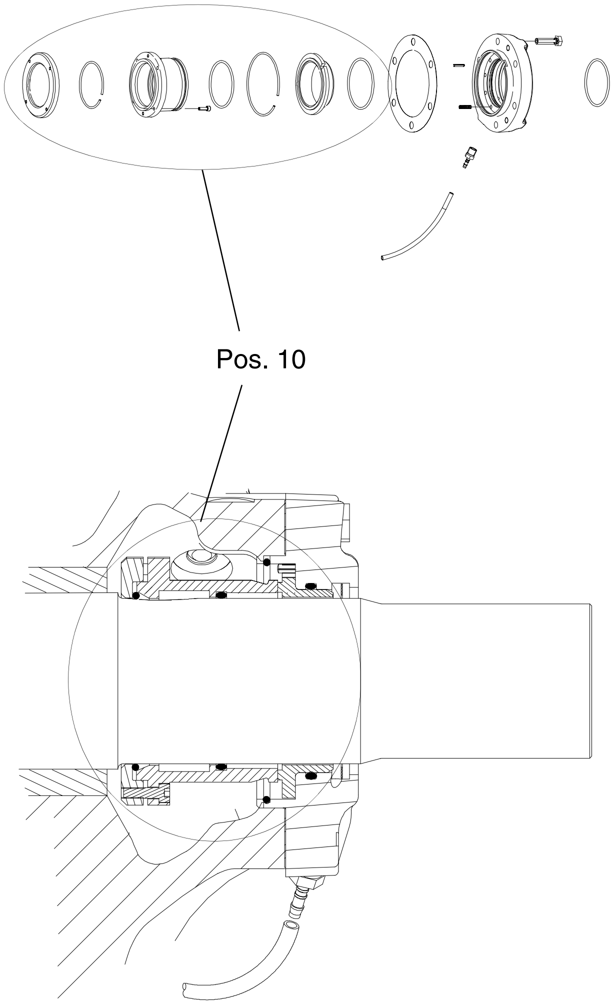
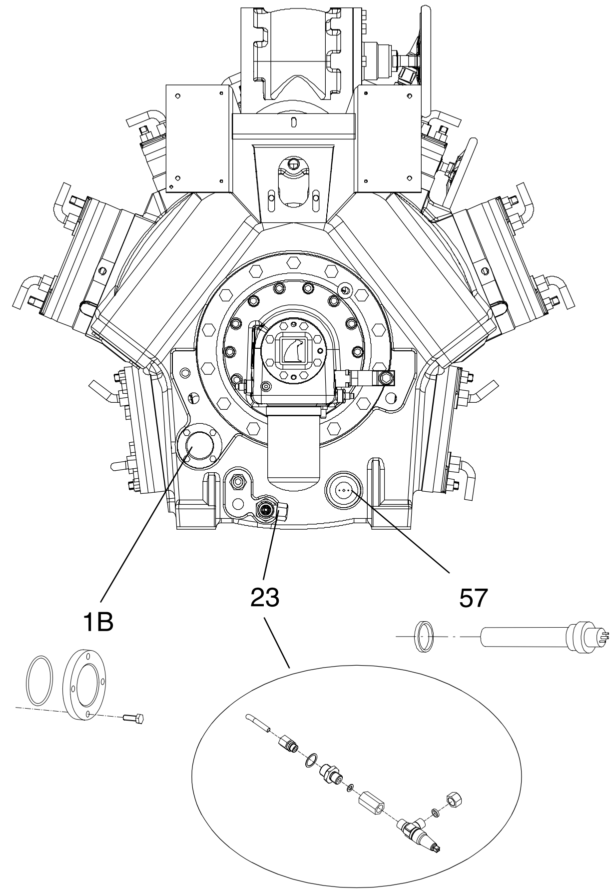


Fig. 4.18 *SMC 100 block Pump end*



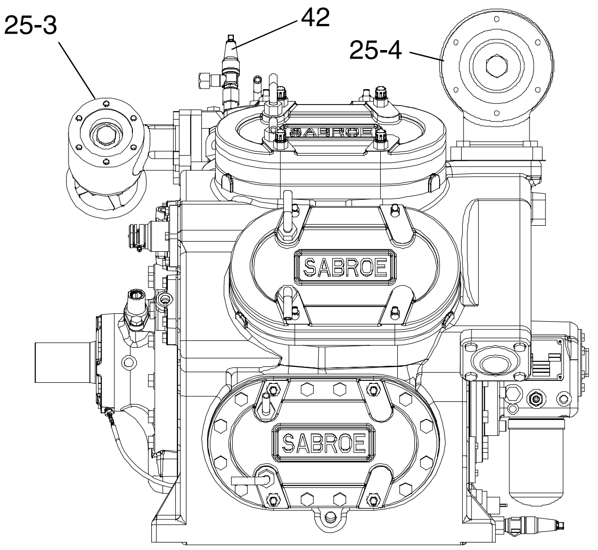
The heating rod, pos. 57, Fig. 4.18 keeps the oil warm when the compressor is not in operation. This reduces the refrigerant content in the oil and eliminates starting-up problems caused by oil foaming and subsequent insufficient oil pressure. While the compressor is operating, the heating cartridge can be switched off, but if it is problematic to maintain the oil temperature sufficiently high, it may be an advantage to keep the heating cartridge on during operation.

Oil draining valve, pos. 23, for draining and charging of oil. An inner socket at the draining valve ensures that the oil sump is properly drained so that the compressor does not have to be opened when changing oil and filters.

The oil level glass, pos.1B, indicates the prescribed oil level in the crankcase. See chapter 6, Technical Data - *Charging the Compressor with Oil.*

Evacuating valve, pos. 42, Fig. 4.19, for evacuating the compressor of refrigerant or air after service.

Fig. 4.19 *SMC 104 - 108 Short Block*

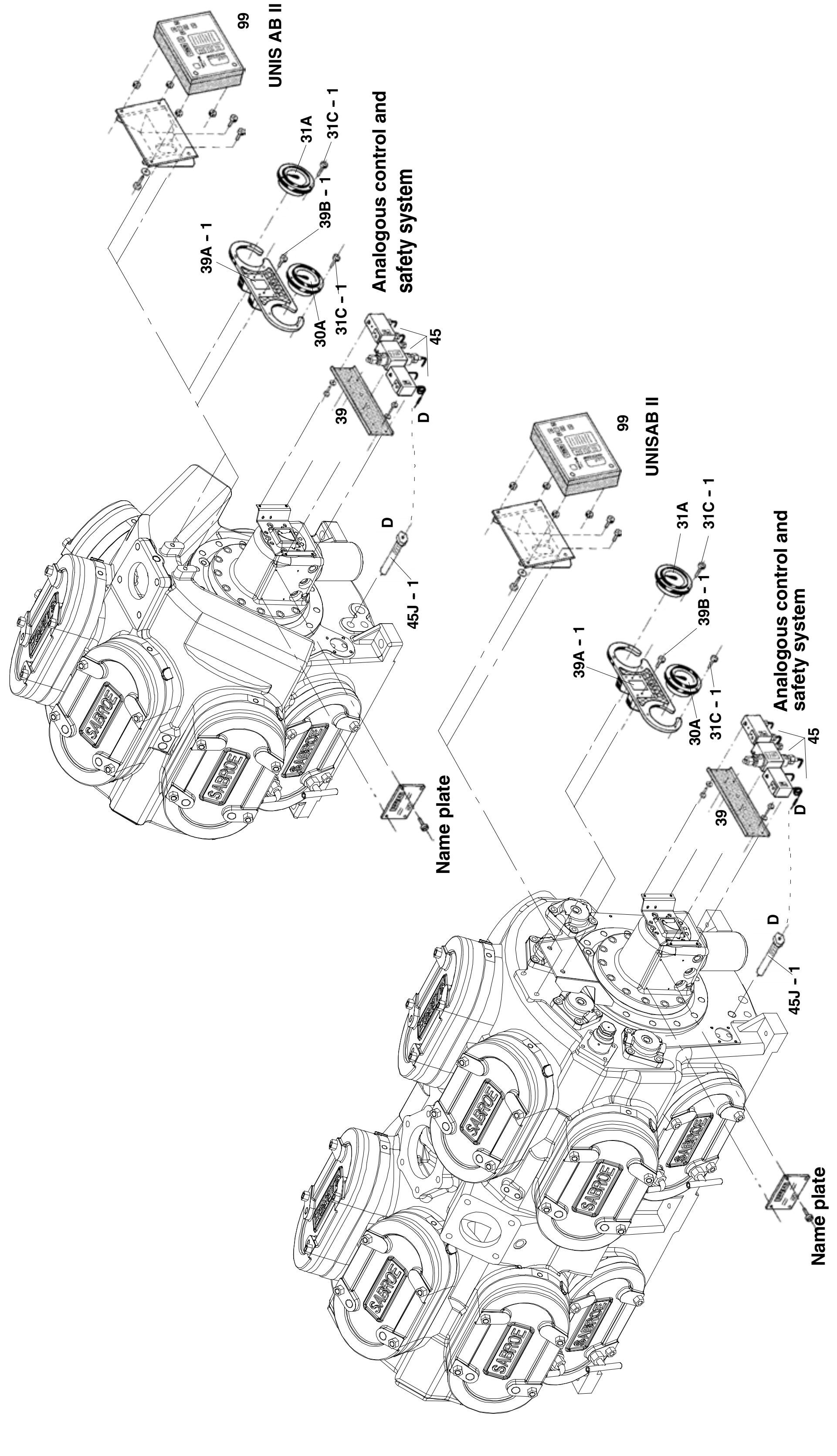


The stop valves, pos. 25-3 and 25-4, are fitted on the compressor discharge and suction flanges for efficient blocking off of the compressor from the refrigeration plant. The stop valves have welding flanges for connection to ISO and ASME standard pipes. Pipe dimensions are indicated on the dimension sketches in chapter 5, Physical and Connecting data.

Instrumentation: As standard equipment the compressors are fitted with either an **analogous** reading and safety system consisting of pressure gauges, pressure switches and thermostat, or with a SABROE microelectronic reading and control system, UNISAB II, as shown in Fig. 4.20. Both systems are described in detail later in this section.

Cooling of compressor and oil: On request the compressor can be delivered with a built-in cooling system with either water or refrigerant as described in the section, *Cooling Systems for Compressors.*

Fig. 4.20 *Instrumentation*



Two-stage Compressors Type TSMC 100

The TSMC compressors are so-called compound machines in which the refrigerant gas is compressed in two stages. The compressor is divided into a low-pressure section, LP, and a high-pressure section, HP. The cylinders in the low-pressure section compress the gas from evaporating pressure, PE, to intermediate pressure, PI.

During the compression the gas is heated and must consequently be cooled down in the intermediate cooling system before it reaches the high-pressure stage.

At the high-pressure stage, the gas is compressed from PI to the condensing pressure PC.

The system is described in detail in *Cooling of the intermediate discharge gas on TSMC compressors* later in this section.

The TSMC 100 compressors are available with 8 or 16 cylinders, divided as indicated:

TSMC 108:
6 low-pressure (LP) cylinder
2 high-pressure (HP) cylinder

TSMC 116:
12 low-pressure (LP) cylinder
4 high-pressure (HP) cylinder

TSMC 100 compressors are connected to installations where the compression ratio (PC/PE) is higher than the permissible compression ratio π for single-stage compressors. This is described in detail in chapter 6, Technical Data*, Operating Limits.*

As mentioned previously all compressor types in the SMC 100 and TSMC 100 series - with a few exceptions - are built up of the same components and with the same facilities.

However, the TSMC 100 compressors deviate on the following points:

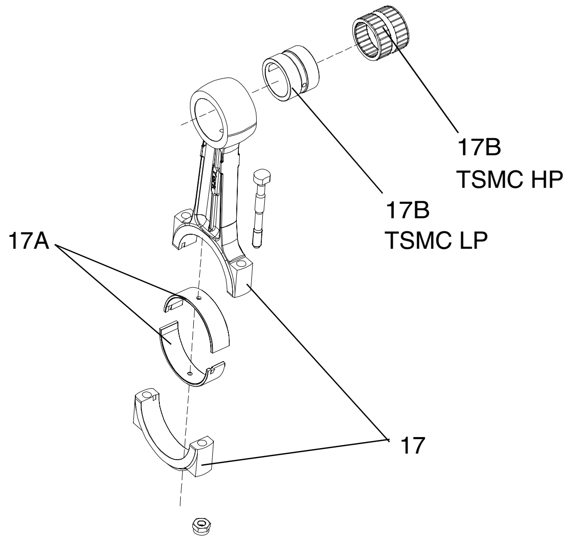
Compressor Block

The interior of the compressor block is constructed with suction chambers for both low pressure and high pressure stages. The pressure in the crankcase is the same as the suction pressure of the LP stage.

Piston Pin Bearing

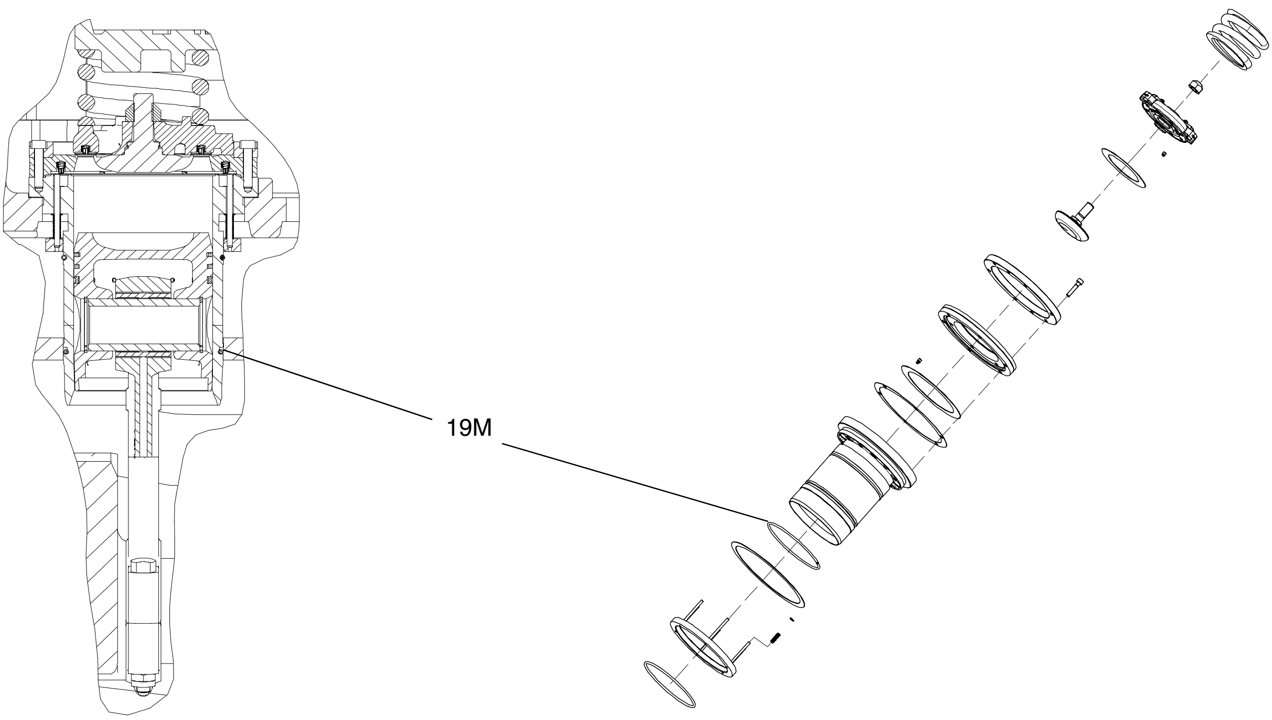
In the SMC and TSMC low-pressure stages the piston pin bearing consists of slide bearings, pos. 17B, Fig. 4.21. In the connecting rods of the high-pressure stage a **needle bearing**, pos.17B-2, has been fitted. This is because HP pistons on two-stage compressors - as opposed to single stage and LP pistons - are often subject to uni-directional force.

Fig. 4.21 *TSMC 100 Cylinder Liner Complete*



Similarly, an O-ring, pos. 19M, is used to seal the **intermediate pressure chamber** from the **crank-case** in which there is evaporating pressure.

Fig. 4.22 *TSMC cylinder liner*

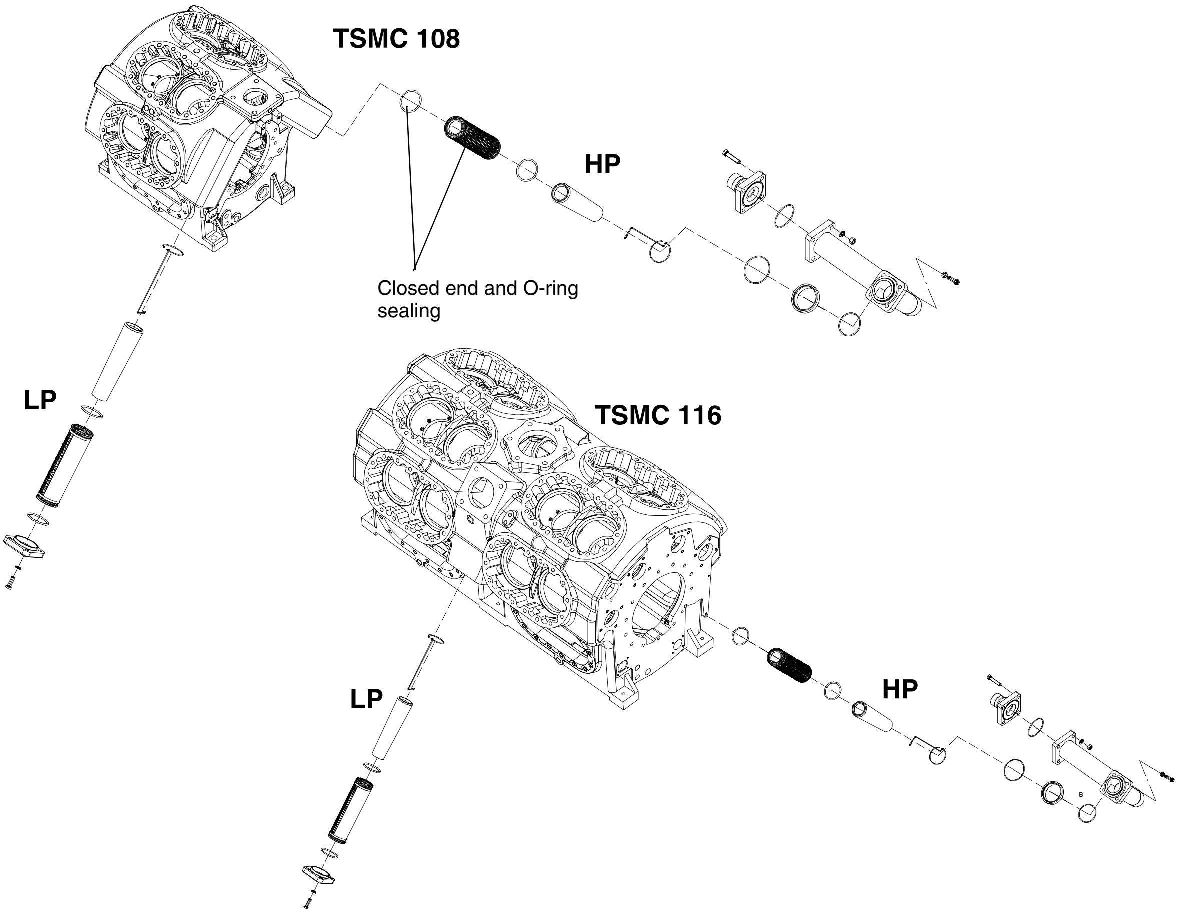


Suction Filters

In the TSMC compressors the two suction filters vary in design. The suction filter for the LP stage is of the same type as the ones for the SMC compressors and is characterised by **square holes** in the shell and openings at both ends.

In the high-pressure stage a suction filter of the same size as the one for the LP stage has been fitted, but this has **round holes** in the shell and is closed at one end.

Fig. 4.23



Depending on the type of refrigerant and the suction and discharge pressures, a **by-pass system** is sometimes used to regulate the intermediate pressure PI in order to prevent it from falling below the specified pressure.

The system is either built onto the compressor at the factory or mounted on the refrigeration plant if several two-stage compressors work in parallel.

The by-pass system is described in detail later in this section under *Cooling of the Intermediate Discharge Gas on TSMC Compressors.*

The TSMC 100 compressors can be delivered with one or two oil separators depending on the type of refrigerant and area of application. Otherwise, the terms of delivery are the same as the ones described for single-stage compressors.

Conversion of TSMC Compressors from Two-stage to Single-stage

If necessary, it is possible to convert a two-stage compressor into a single-stage compressor.

The following variations are possible:

a. Altering the compressor and using the same refrigerant

b. Altering the compressor and changing the refrigerant from R717 to HFC/HCFC at the same time

c. Altering the compressor and changing the refrigerant from HFC/HCFC to R717 at the same time

Generally, the conversion includes the following points:

1. Replacing the suction filter with a normal single-stage suction filter on the HP side.
2. Dismantling the pipe connection on the HP suction side and installing a standard cover, pos. 34 E.
3. Changing the pipe connections on the discharge side. As the built-in channel, which connects the top covers on a single-stage compressor, does not exist between the HP and LP top covers, this connection must be established externally.
4. Changing the HP stage connecting rods to the single stage type (journal bearing in small end). The piston pins must be changed.
5. Ensuring that the correct suction and discharge valves are fitted.
6. Installing the correct by-pass valves.
7. Adjusting the safety pressure controls.

Moreover, it is necessary to replace the compressor name plate and the name plates on the safety valves.

Please contact Sabroe Refrigeration’s After Market Sales Department for further information.

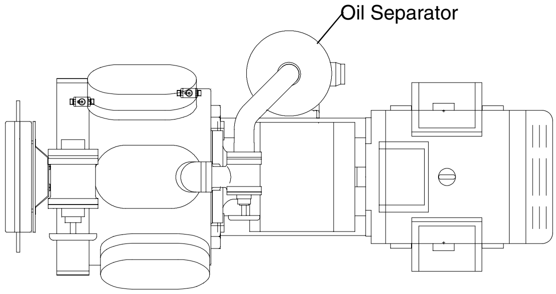
Oil Separator Type OVUR

The purpose of the oil separator is - under all kinds of operating conditions - to separate the oil which is conveyed with the disharge gas out of the compressor so that it will be led back to the compressor crankcase.

The oil separator is mounted on the compressor unit and connected to the discharge gas outlet of the compressor as indicated in the drawing, Fig. 4.24.

On some units the oil separator is not mounted.

Fig. 4.24 Standard Compressor Unit

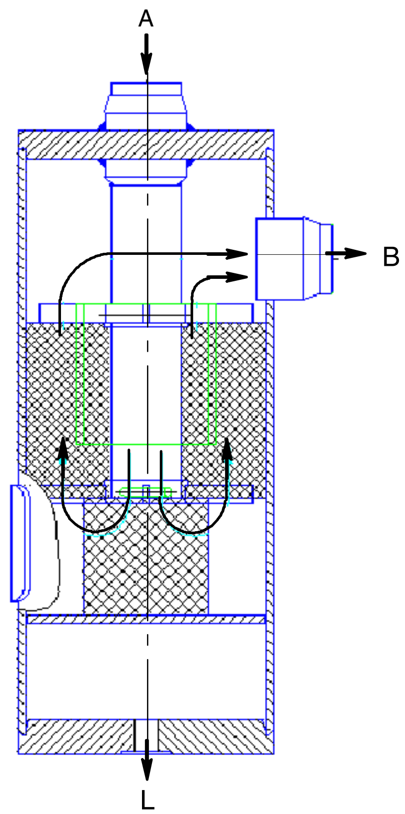


Mode of Operation

The discharge gas from the compressor flows through the oil separator, Fig. 4.25, from A to B, passing a number of filters in which the oil is separated from the discharge gas. The filters consist of a stainless steel wire mesh which usually needs no cleaning and which is not worn down. Consequently, the filters cannot be removed from the oil separator.

The oil separators are dimensioned for compressor full load and they ensure an oil carry-over of max. 35 ppm after the oil separator at full load.

Fig. 4.25 Oil Separator



A: Discharge gas inlet
B: Discharge gas outlet
L: Oil return to compressor

Selecting an Oil Separator

As the velocity through the oil separator affects the ability of the oil separator to separate the oil from the discharge gas, a series of oil separators of different sizes has been designed.

A special type of oil separator with a very low oil carry-over is available on request.

Oil Return to the Compressor

The oil separated in the oil separator is usually conveyed directly back to the compressor crankcase by means of the differential pressure between the pressure of the oil separator and that of the crankcase, PE.

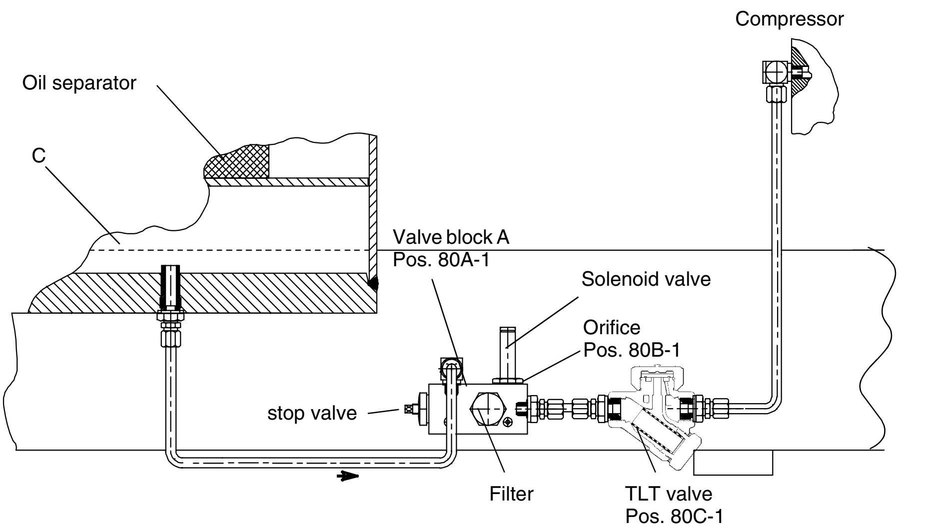
As the return of gas from the discharge side to the suction side will have a negative effect on the plant, it is desirable to lead only the separated oil back to the crankcase. This is controlled by using a thermodynamic liquid trap (TLT) combined with a reliable solenoid valve which blocks the system at standstill. Furthermore, it makes it possible to delay the opening of the oil return after start up and thus allowing condensed refrigerant, if any, in the oil separator to evaporate and not be led back to the crankcase.

For plants which do not allow solenoid valves, a reliable float valve controlled system can be delivered at an additional price.

A: Solenoid Valve Controlled Oil Return
As illustrated in the drawing, Fig. 4.26, the oil from the oil separator is led to the compressor crankcase via valve block pos. 80A and the TLT valve pos. 80C.

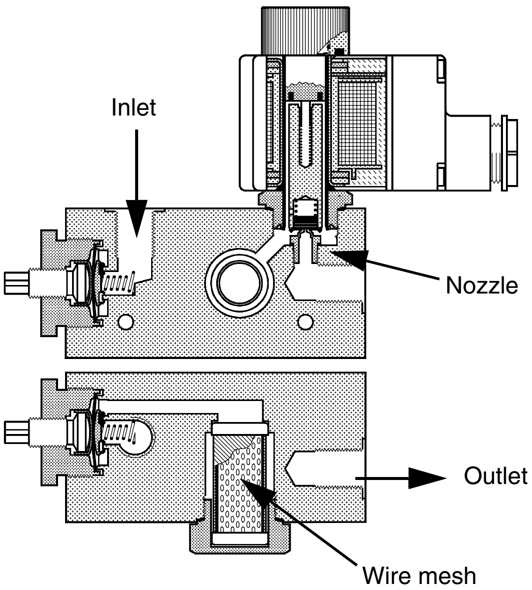
In the oil separator at position C the pipe is inserted 10 mm into the end plate whereby any sediment can settle at the bottom of the oil separator.

Fig. 4.26 *Solenoid Valve Controlled Oil Return*



In valve block, pos. 80A, Fig. 4.27, the oil first passes a stop valve which is normally completely open. This is **not** a regulating valve and it is closed only during maintenance work on the compressor and during cleaning of the filter in the valve block.

Fig. 4.27 *Valve Block, pos. 80A, Oil Return*



From the stop valve the oil passes a wire mesh, which can be removed and cleaned.The filtered oil now passes the solenoid valve, which must be **closed** at dead coil whenever the compressor is stopped. When the compressor is operating, the solenoid valve is **open**, allowing the oil to flow to the compressor.

As stated above it is recommended, however, to keep the solenoid valve closed for 20 to 30 minutes after start-up by means of a time relay (which may be ordered as an accessory part). Thus the oil is not returned to the compressor before the oil separator is warm and has evaporated any refrigerant which may have mixed with the oil at the bottom of the oil separator.

This time function is built into the UNISAB II system.

The solenoid valve seat is available with various boring diameters and nozzle sizes. For this purpose Ø3.3 mm must be used.

The coil for the solenoid valve can be delivered as a standard part with the following data:

Table 4.2

Coil Sizes		
220/230 Volt	50/60 Hz	10 Watt
115 Volt	50/60 Hz	10 Watt
240 Volt	50 Hz	10 Watt

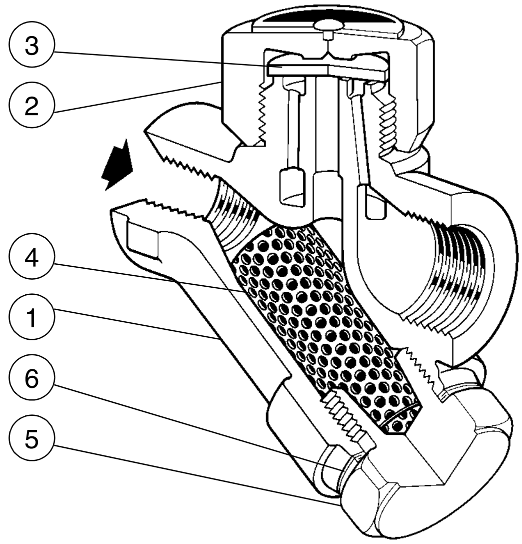
Caution!

The stop valve is a membrane valve. The membrane can be damaged if the valve is closed too tight.

Thermodynamic Liquid Trap (TLT)

The purpose of the TLT valve is to ensure that only oil is led back to the compressor as warm discharge gas mixed with the oil will cause the compressor capacity to decrease.

Fig. 4.28 *Thermodynamic Liquid Trap TLT*



1 : Housing
2 : Cap
3 : Disc
4 : Strainer
5 : Strainer Cap
6 : Gasket

The TLT valve works in the following way:

A thermodynamic liquid trap uses a disc to control the release of liquid and to trap gas. The trap cycles open and close to discharge liquid and closes tightly between discharges. The disc, which is the only moving part, rises and falls in response to dynamic forces produced by the gas flowing through the trap.

Liquid and/or gas enters the trap through the central orifice, lifts the disc and is discharged through the outlet orifice. The gas passes along the underside of the disc at high velocity and collects in the control chamber above. The resulting pressure imbalance forces the disc downward onto the seating surfaces and stops the flow.

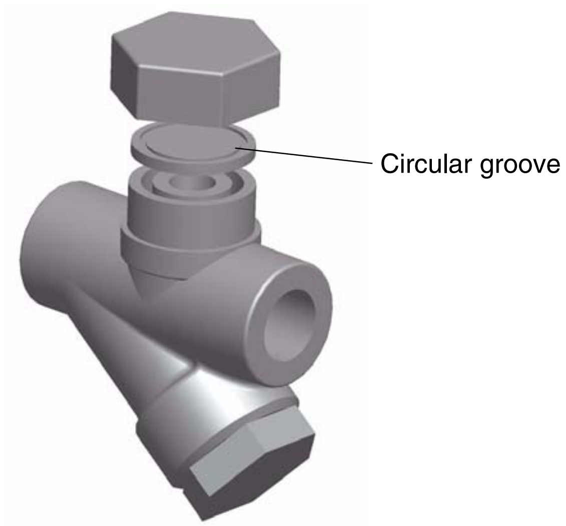
The trap remains tightly closed until the loss of heat through the trap body lowers the control chamber pressure, allowing the inlet pressure to raise the disc and repeat the cycle.

One side of the disc (3) is plain with a single scratch towards the outer edge, whereas the other side of the disc has a machined circular groove.

The trap is supplied with the single, radial scratch-side of the disc (3) towards the seating faces. If there are iregularities in the oil return, check that the scratch-side of the disc is towards the seating surface. Also check that the strainer (49 is free from impurities.

Also, if plant condensing temperature is equal to or lower than machine room temperature, the disc must be fitted with the bleed scratch towards the seating faces.

Fig. 4.29



Correct fit with circular groove upwards and radial scratch down towards seats.

Fig. 4.30

Side with single radial scratch must be towards seating faces.

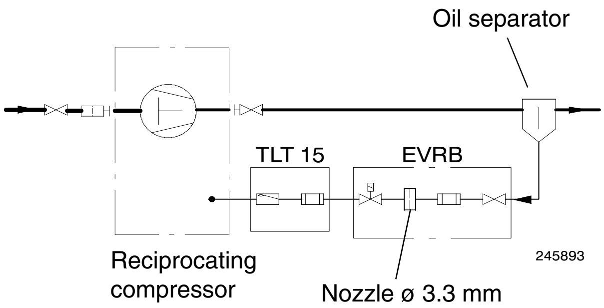
Replace the cap - no gasket is required but a suitable high temperature anti-sieze grease without copper should be applied to the threads.

Mounting

In principle, the liquid trap can function in all positions but to minimise uneven wear (and thereby achieving maximum life time) mounting it in a horizontal line with the cap up or down is recommended. See also Fig. 4.26.

The surface of the connection is machined to make a tight sealing using Al gasket.

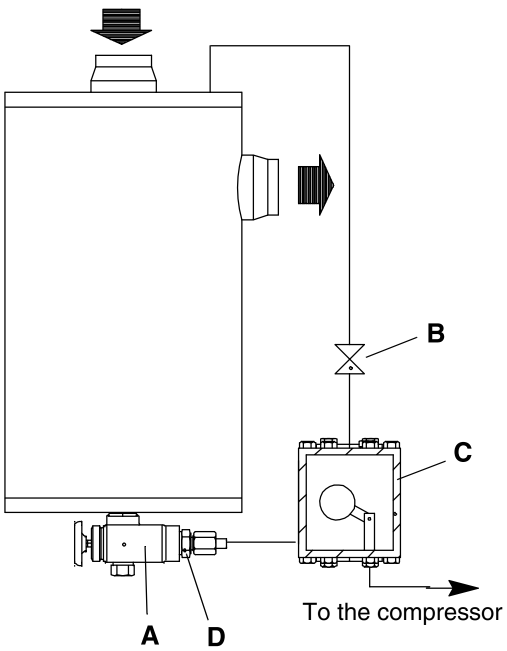
Fig. 4.31 *Principle piping diagram*



B: Float Valve Controlled Oil Return

The float valve is located in a separate float vessel, mounted on the side of the base frame and connected to the oil separator and compressor as illustrated on Fig. 4.32.

Fig. 4.32 *Float Valve Control Oil Return*



The separated oil is drained through stop valves A and filter D to the float vessel C, and here the float valve opens at an increasing oil level and returns the oil to the crankcase.

The pipe connection with valve B acts as a pressure equalizer between the two vessels. The float can be dismantled for servicing.

Oil Return in Connection with Parallel Operation

If several compressors are running in parallel on the same refrigeration plant, it is expedient to adjust their oil level in the crankcase by means of an automatic system. This is particularly necessary in the case of HFC and HCFC plants in which the oil is returned to the compressors with the suction gas as it is not distributed evenly on all the compressors.

However, also in modern, automated R717 refrigeration plants an automatic oil equalizing system can contribute to greater reliability, thus reducing the daily inspection tours.

The following passages **A, B** and **C** include a description of the three systems most commonly used.

The following passages describe each of the three systems in general. For more detailed information, please contact Sabroe Refrigeration.

System A

System A is used where two or more compressors are working in parallel and where either HFC, HCFC or R717 is used as the refrigerant. It is a condition, however, that the compressors keep working at the same suction pressure.

Principle diagram, Fig. 4.33, is an example of a plant with two compressors working in parallel on the same suction and discharge line.

Fig. 4.33 *Principle Diagram*

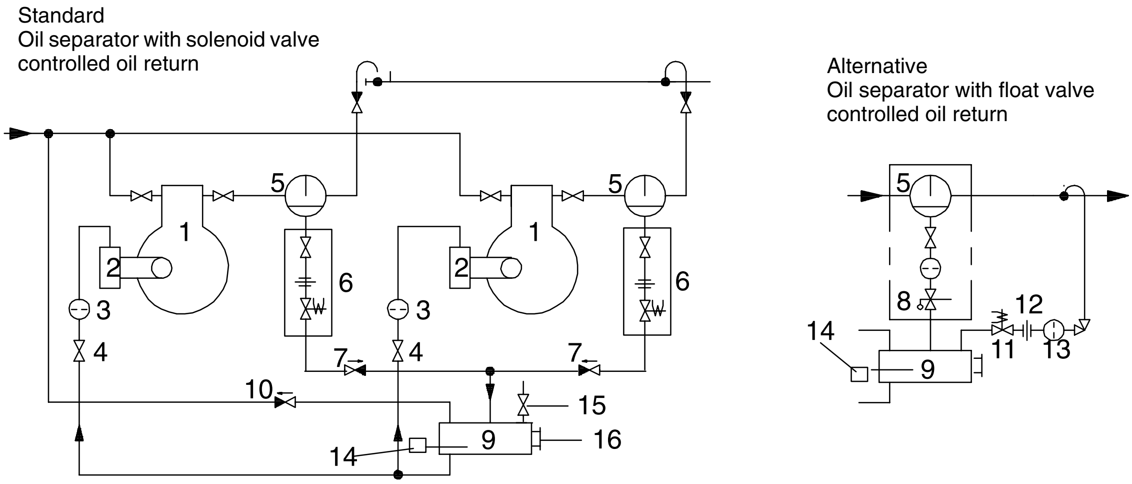
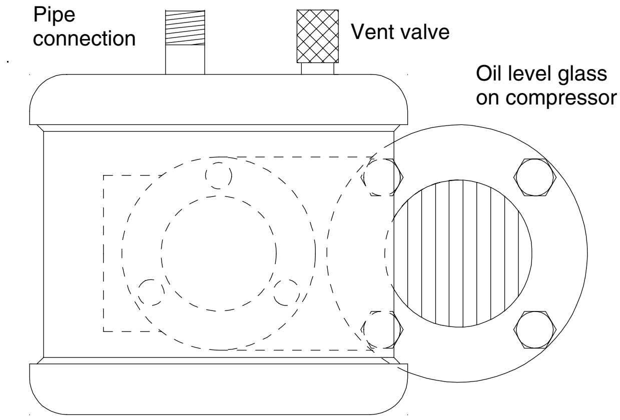


Table 4.3

1.	Compressor	9.	Oil vessel
2.	Float valve	10.	Non-return valve, 1 bar
3.	Filter	11.	Solenoid valve
4.	Stop valve	12.	Nozzle, dia. 3.3 mm
5.	Oil separator	13.	Filter
6.	Solenoid valve incl. nozzle (Fig. 4.33)	14.	Heating cartridge
7.	Non-return valve	15.	Oil charging valve
8.	Float valve	16.	Oil level glass

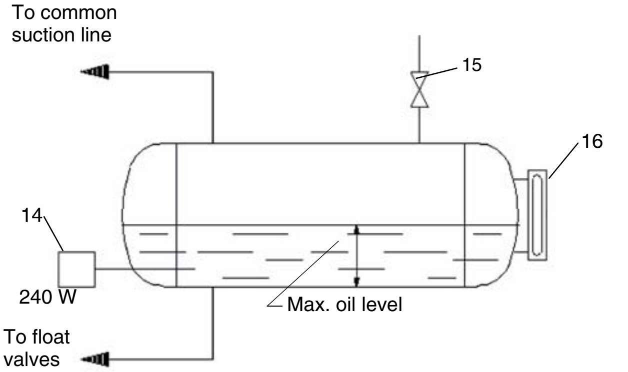
As illustrated in Fig. 4.34 a **float valve**, pos. 2, is fitted on each of the compressors in front of the oil level glass. This makes the oil level in the float house equal to that in the crankcase. This can be checked visually in the oil level glass.

Fig. 4.34 *Float Valve Housing with Float Valve*



The float controls a needle valve which opens at a **falling** oil level, letting the oil flow from the oil vessel, pos. 9, return to the compressor. This ensures a constant oil level in the compressor.

Fig. 4.35 *Oil Vessel, pos. 9*



The oil vessel, pos. 9, is illustrated by the principle drawing, Fig. 4.35. Its size is calculated so that an extra amount of oil is available to ensure the oil level in the compressor.

The total volume of the vessel should be approx. 50% of the oil volume in all the compressors, and the vessel should not be charged to more than 50%.

This means that the amount of oil in the vessel corresponds to 25% of the total amount of oil in the compressor.

The oil vessel must be equipped with:

- heating rod, 240 W, pos. 14
- oil charging valve, pos. 15
- oil level glass, pos. 16

From the top of the oil vessel, pos. 9, a pipeline is taken to the suction side of the plant.

A non-return valve, pos. 10, Fig. 4.33, has been inserted in the pipeline, and this valve opens at a differential pressure of 1 bar. This way the pressure in the oil vessel will be 1 bar higher than the suction pressure in the plant. This is sufficient in order to squeeze the oil through the float valves, pos. 2, without causing foaming in the float valve houses.

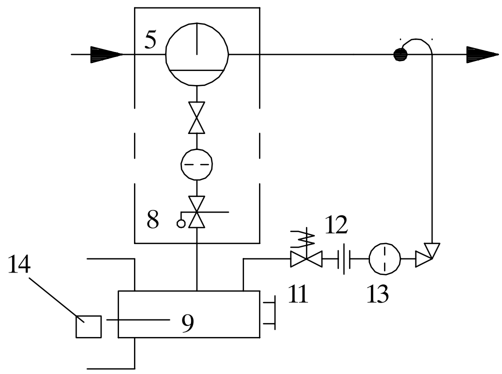
The Oil Return Systems from the Oil Separators are the same as the ones described in *Oil return to the compressor* in this section. The only difference is that the oil return system is not connected to the compressor but taken to the common oil vessel, pos. 9.

Solenoid valve, pos. 6, closes whenever the actual compressor stops.

In case the oil return system from the oil separators is controlled by a float valve, which is also described in this section, it will be necessary to mount a pipe connection to the discharge pipe as illustrated in Fig. 4.36.

This ensures a slight gas flow to the oil vessel, pos. 9, and consequently overpressure that presses the oil out to the compressors through float valves, pos. 2. Solenoid valve, pos. 11, closes when the plant stops and all the compressors are stopped.

Fig. 4.36 *Oil separator with float valve controlled oil return*



System B

System B is used where more than two compressors are working in parallel but where they do not have any joint suction line. The refrigerant may be HFC, HCFC or R717.

Principle diagram, Fig. 4.37, is an example of a plant with two compressors working in parallel but which do not have the same suction pressure, PE+, PE-.

Fig. 4.37

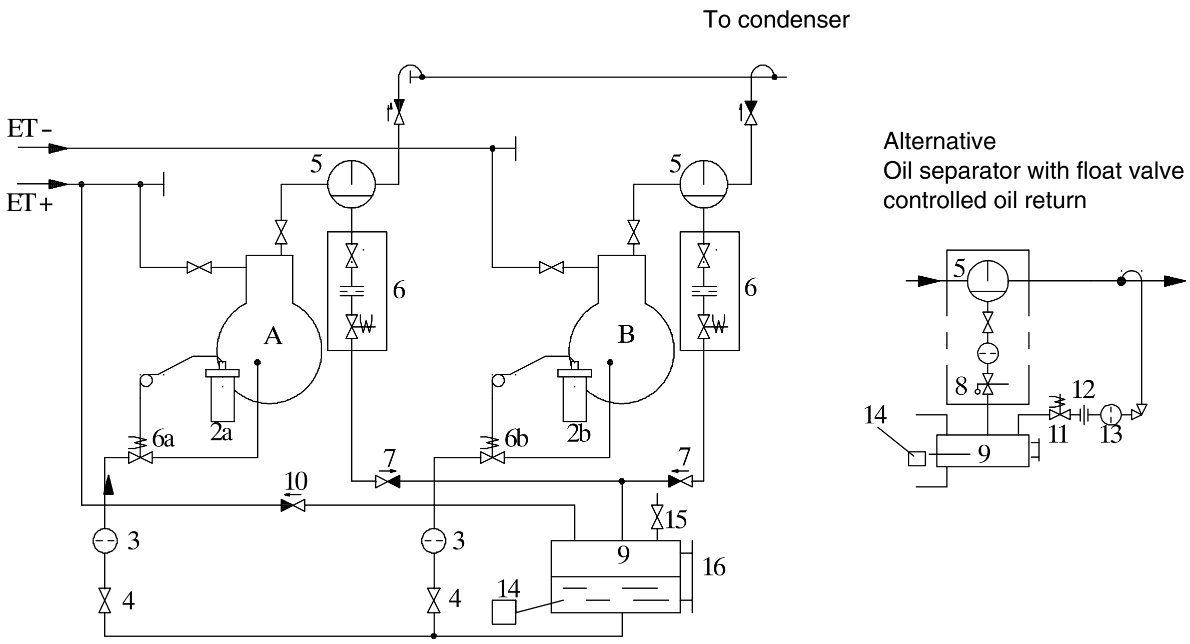


Table 4.4

A-B	Compressor	9.	Oil vessel
2a-2b.	Level Switch	10.	Non-return valve,1 bar
3.	Filter	11.	Solenoid valve
4.	Stop valve	12.	Nozzle, dia. 3.3 mm)
5.	Oil separator	13.	Filter
6a-6b.	Solenoid valve incl. nozzle (Fig. 4.37)	14.	Heating cartridge
7.	Non-return valve	15.	Oil charging valve
8.	Float valve	16.	Oil level glass

To be able to press the oil from the oil vessel, pos. 9, to the crankcase on the compressor, pos. A, which is working at the highest suction pressure PE+, the pipeline with the non-return valve (1 bar), pos. 10, is connected to the suction gas line for this compressor.

There is a risk, however, that the differential pressure between the oil vessel, pos. 9, and the crankcase on compressor B may become so great that the oil conveyed via the solenoid valve 6a starts foaming. Usually, this foaming does not cause any problems as the oil is supplied to the compressor above oil level. Any foaming that may occur will soon be dissolved in the crankcase.

The system has one further advantage as the oil does not pass the level switch vessels 2a and 2b. Should foaming occur, this is not going to interfere with the working of the level switch.

In case the oil return system is regulated by means of a float valve as described under **System A,** the same system as the one shown in Fig. 4.38 should be used.

System C

System C is a float regulated oil return system which is used when **only** two compressors are operating in parallel with the same condenser. It is not a requirement that the suction pressure is the same on the two compressors. The float valve is of the same type as the one used in system A.

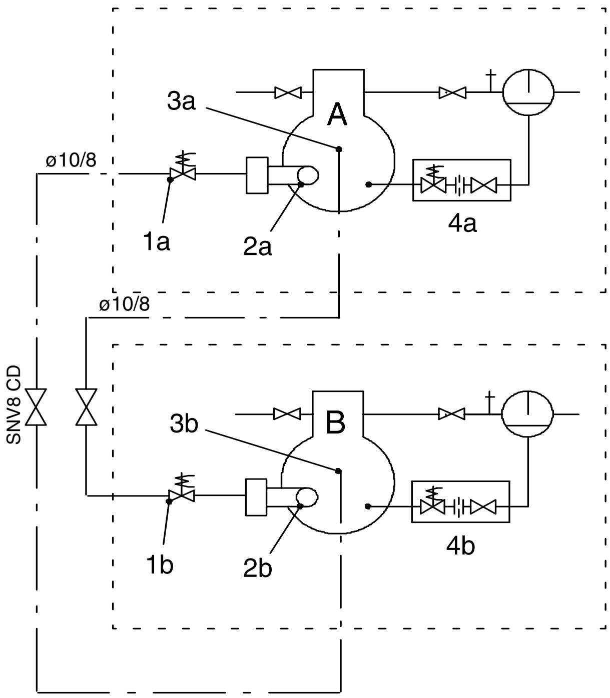
The oil level equalizing system is illustrated in Fig. 4.38.

It works by pressing the oil from one compressor to the next by means of the oil pump pressure (4.5 bar), pos. 3, in each of the compressors.

The oil level in the crankcase is regulated by a float valve, pos. 2a or 2b, which opens at a falling oil level in the compressor.

If e.g. the oil level in compressor A is too low, the float valve, pos. 2a, will open. The oil pump in compressor B will now supply oil through the solenoid valve (nozzle incl.), pos. 1a, until a normal oil level has been established, whereupon the float valve will close. The solenoid valve pos. 1 is open when the compressor in question is running.

Fig. 4.38

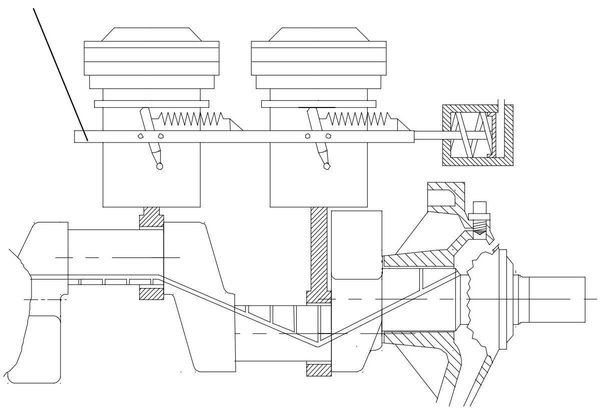


1a - 1b: Solenoid valve
2a - 2b: Float valve
3a - 3b: Connection to oil pump discharge
4a - 4b: Standard oil return system

Capacity Regulation of Compressor

All compressors have a built-in capacity regulating system which continually adjusts the compressor capacity to the cooling requirements of the plant. Even at reduced capacity the compressor works very efficiently. This makes it very well-suited for plants with reduced cooling requirements for lengthy operating periods.

Fig. 4.39 *Capacity Regulating Mechanism*



The capacity regulating system including the frame, pos. 13, is activated by the compressor oil pressure and controlled by means of solenoid valves fitted on the compressor. At a capacity reduction two suction valves are forced open at a time. In this case no compression takes place in the relevant cylinders as the sucked in gas in the cylinders is pressed back to the suction chamber through the suction valves.

The above forced opening of the suction valves is also used when starting up the compressor. The system works as follows: At compressor standstill all the suction valves are forced into an open position and cannot be closed until the compressor is in operation and the oil pump has built up the oil pressure in the lubricating system. With an open suction valve there is no compression resistance in the compressor and this reduces its starting torque considerably. Thus, a motor dimensioned to suit the operating conditions of the compressor can easily start up the compressor also by using the star/delta starting system.

For compressors fitted with extra capacity stages (extended unloading), one cylinder (SMC 104-106-108) or two cylinders (SMC 112-116) will be in operation all the time, also at start up.
See extended unloading.

Capacity Regulation and Unloading of Compressor

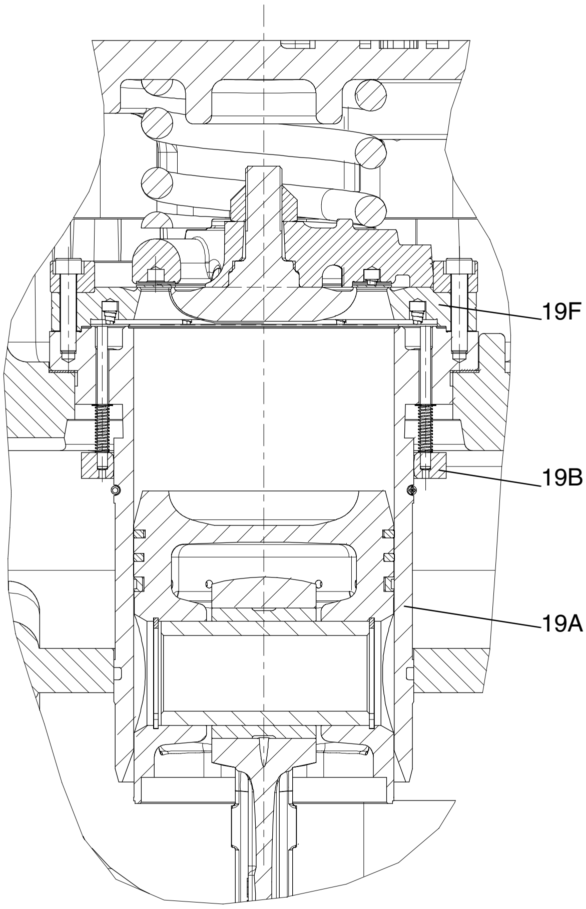
Capacity Regulation

As mentioned in the introduction to this section all SMC and TSMC compressors are fitted with a hydraulic capacity regulating system by means of which the compressor capacity can be adjusted to the refrigerating requirements of the plant.

When reducing the compressor capacity, two or more suction valves (on compressors with extended unloading: one or more suction valves) are forced open so that compression does not occur in the cylinders in question.

The suction valve is forced open when the unloading ring together with the pins, pos. 19B, are pressed up under the suction valve, thus keeping the valve in open position as shown in Fig. 4.40.

Fig. 4.40 *Cylinder Liner Complete*

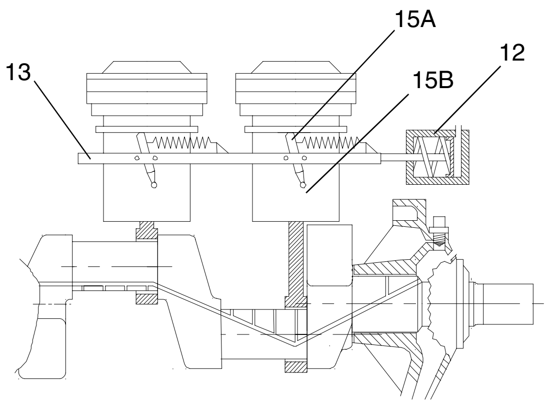


The unloading ring, pos. 19B, is activated by two rocker arms, pos. 15A, Fig. 4.41, one at each side of the cylinder liner. The rocker arms, which are placed in ball sockets, pos. 15B, are moved back and forth by the unloading frame, pos. 13.

The unloading frame, which is controlled by two brackets with guiding pins, does always activate two cylinders at a time. The unloading frame is moving back and forth by means of the unloading cylinder, pos. 12. If oil pressure is put on the cylinder during operation, the unloading frame will move to the left as shown in Fig. 4.41. Thus the angle of slope of the rocker arms is changed so that the unloading, ring pos. 19F, is able to move freely. Consequently, the cylinder is forced to work.

If the oil pressure to the unloading cylinder closes, the unloading frame, pos. 13, will move to the right, thereby raising the rocker arms. The unloading ring with pins, pos. 19B, are pressed up under the ring plate and the suction valve is forced open, thereby unloading the cylinder.

Fig. 4.41 *Unloading System*



Start Unloading

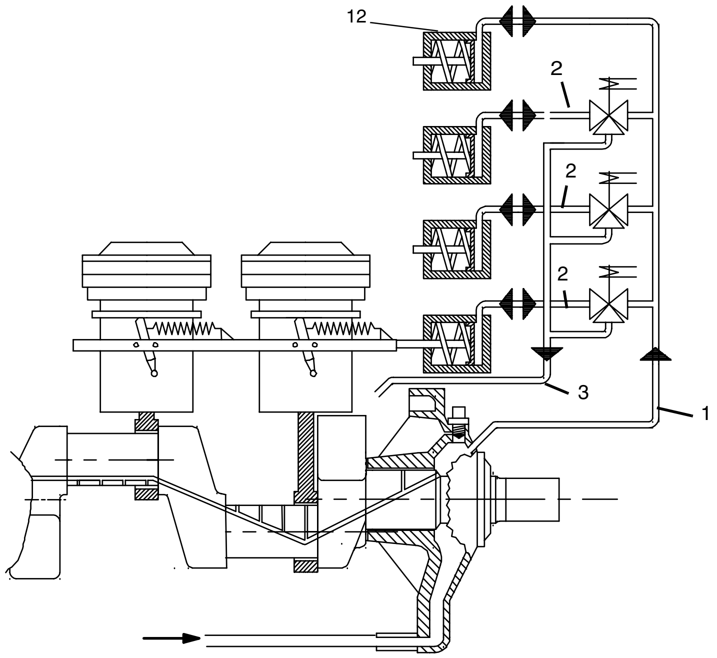
As already mentioned the compressor cylinders are unloaded when there is no oil pressure on the unloading cylinders. This means that when the compressor is stopped, i.e. without any oil pressure, all the unloading cylinders are unloaded and consequently there is no compression resistance during start-up.

This unloading during start-up reduces the starting torque of the compressor considerably.

This can be seen from the starting torque curves, in chapter 6, Technical Data.

Solenoid Valves for Capacity Regulation
The unloading cylinders are controlled by solenoid valves, Fig. 4.42, which receive opening and closing signals from a connected regulator. This could e.g. be a programme device or the Sabroe electronic control system, UNISAB II, as described later in this section under *Instrumentation*.

Fig. 4.42

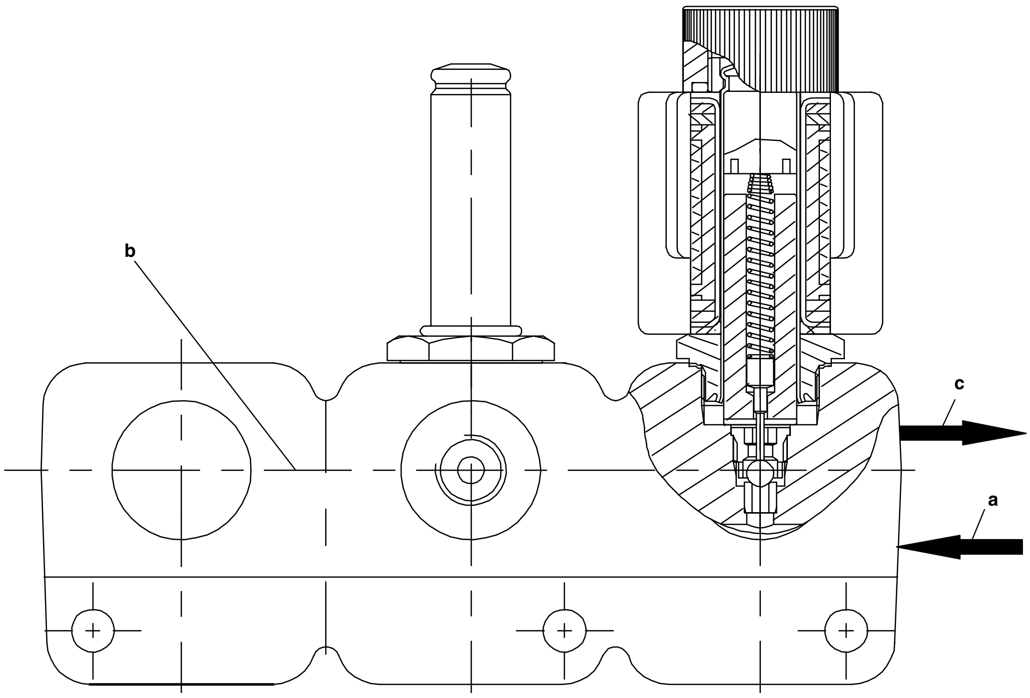


The solenoid control valve is an electromagnetic three-way valve which, with a dead coil, connects the unloading cylinder, pos. 12, with the crankcase (the passage of the oil flow from pipe 2 to pipe 3 is open), Fig. 4.42

If the coil is energized, the valve will reverse so that the passage of the oil flow from oil discharge pipe 1 to 2 is open and the connection to pipe 3 is closed.

The solenoid valves are mounted in joint blocks, Fig. 4.43, with one, two, three or four solenoid valves in each block.

Fig. 4.43 *Solenoid Valve Block*



In the block there is a common supply of pressure oil from the oil pump (pipe a) to the solenoid valves as well as a common connection to the crankcase (pipe c). Each solenoid valve has its own oil connection to the relevant regulating cylinder (pipe b).

Regulating Sequence

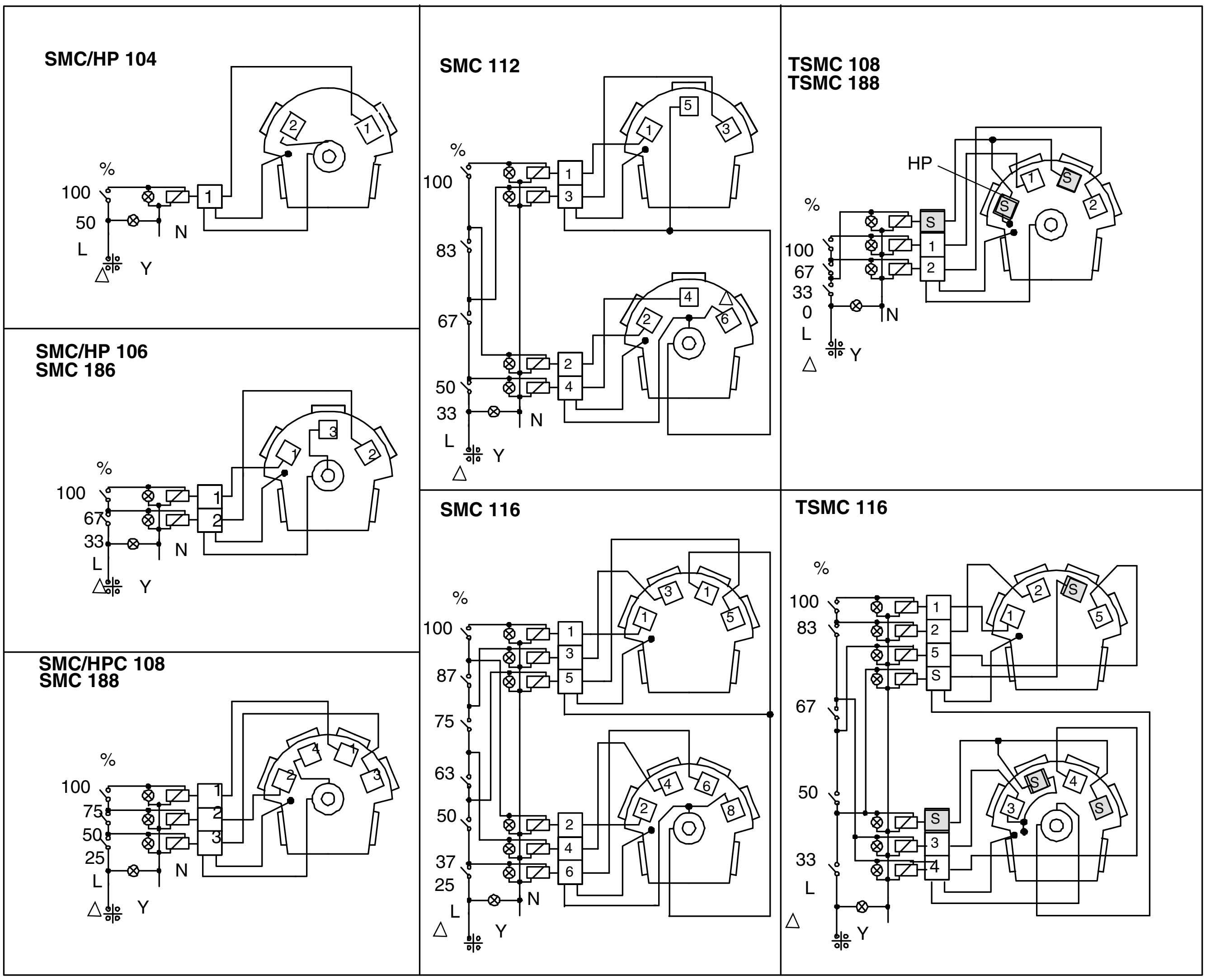
As described earlier, the compressors are always **completely unloaded** during start up exept for the compressor with extra capacity stages (extended unload), which will always have one or two cylinders loaded during start up (SMC104-108) and (SMC 112-116).

Standard compressors, however, with 2 cylinders on the SMC 104, 106 or 108 compressors or 4 cylinders on SMC 112 and 116 will be set to work when the compressor oil pump has worked up an oil pressure in the lubricating system.

The cylinders mentioned are connected directly to the oil system without any solenoid valve as shown in Fig. 4.44. This makes it the lowest capacity stage on the compressors.

The standard SMC 100 compressors can be regulated with the following capacity stages, represented by the hatched fields in Table 4.5.

Fig. 4.44 Schematic Drawings, Standard



The electric regulating system should be made in such a way that, after start-up, additional capacity cannot be loaded until the motor has reached its full torque.

The recommended run up time is 10 sec. The minimum speed according to the operating limit diagram is 5 sec (also applies to variable speed driven compressors).

Fig. 4.45 illustrates the regulating system in principle. The percentages indicate the compressor capacity at every stage.
When unloading a compressor without extra capacity stages, the solenoid valves are **unloaded** in numerical order: 1 -> 2 -> 3 -> 4.
When **loading**, the order is: 4 -> 3 -> 2 -> 1.

Note: On TSMC 116 compressors the solenoid valves nos. 3 and 4 must always be loaded simultaneously as they control both the LP and the HP cylinders.

Further, the TSMC compressors can, as standard equipment, be totally unloaded as described in the following.

Total Unloading
Besides the standard equipment as described in the previous passage the compressor can be fitted with a solenoid valve marked S (optional). Fig. 4.45.

The TSMC compressors, however, are always equipped with this S solenoid valve.

The S solenoid valve makes the total unloading of the compressor possible - i.e. the compressor idles at 0% capacity. The S solenoid valve must **never**, however, be part of a normal capacity regulation as the compressor will heat up excessively during a lengthy operating period at 0% capacity. The S solenoid valve must therefore only be used as follows:

- When total unloading is required until the motor has reached its maximum torque.
- When a refrigeration plant has sudden brief operational stops for a short time and compressor stop is not required. In this case the compressor must not be allowed to run for more than 5 minutes at 0% capacity. If the compressor is equipped with a refrigerant cooled oil cooler type OOSI (R717) or OOKH (HFC/HFCF) and liquid refrigerants are available so that the cooling system can operate, idling is allowed for up to 30 minutes.

The regulating sequence can be seen from the schematic drawings in Fig. 4.45.

Capacity Stages:
The SMC 100 compressors can be regulated with the following capacity stages, represented by the hatched fields in Table 4.5.

Fig. 4.45 Schematic drawings, Additional Equipment

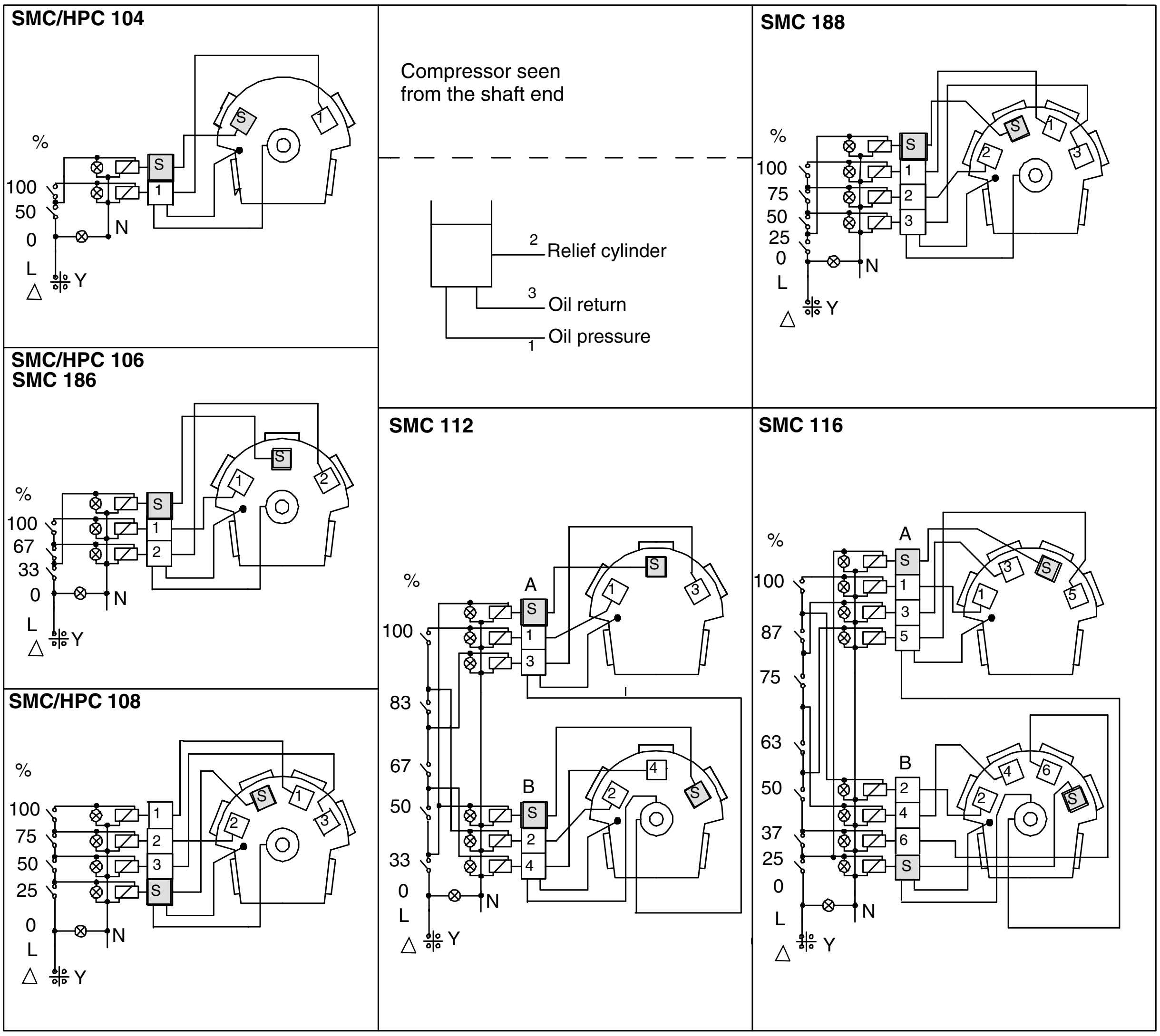


Table 4.5

Compressor Type	Capacity per Stage in %									
	25	33	37	50	63	67	75	83	87	100
SMC 104										
SMC 106										
SMC 108										
SMC 112										
SMC 116										
TSMC 108										
TSMC 116										

As illustrated in Table 4.5, the SMC 100 standard compressors can only be capacity regulated in steps of two cylinders, which is sufficient in most cases.

However, it will occasionally be required to feature more stages and for this reason a system called “extended unloading” has been developed to capacity regulate the compressor in steps of one cylinder per stage with the following capacity stages represented by the hatched fields in Table 4.6.

Table 4.7 displays the numbers of the solenoid valves which must be activated to obtain the stated capacity stages (load).

Table 4.6 *Extended unloading*

Base: Capacity step by one cylinder. For SMC 112 and SMC 116 min. load two cylinders.
TSMC not included.

Load	Type : SMC 100				
	104	106	108	112	116
12.5%					
16.7%					
18.8%					
25.0%					
31.3%					
33.3%					
37.5%					
41.7%					
43.8%					
50.0%					
56.3%					
58.3%					
62.5%					
66.7%					
68.8%					
75.0%					
81.3%					
83.3%					
87.5%					
91.7%					
93.8%					
100.0%					

The system is optional and can be ordered when an order for a new compressor is placed.

Already delivered SMC 100 compressors can be converted for extended or totally unloaded systems by means of reconstructing kits supplied by Sabroe Refrigeration's After Market Service Department.

Extended unloading, solenoid valve no. according to Fig. 4.45

Table 4.7

Load	Type : SMC 100				
	104	106	108	112	116
12.5%			0		0
16.7%		0		0	
18.8%					A
25.0%	0		S	A	AB
31.3%					6A
33.3%		S		AB	
37.5%			3		6AB
41.7%				4A	
43.8%					56B
50.0%	S	2	3S	4AB	56AB
56.3%					456A
58.3%				34B	
62.5%			23		456AB
66.7%		2S		34AB	
68.8%					3456B
75.0%	1		23S	234A	3456AB
81.3%					23456A
83.3%		12		234AB	
87.5%			123		23456AB
91.7%				1234B	
93.8%					123456B
100.0%	1S	12S	123S	1234AB	123456AB

Extended Unloading

The additional capacity stages are obtained by changing the unloading of one (SMC 104, 106 and 108) or two (SMC 112 and 116) cylinder pairs in such a way that the relief system only works the one cylinder while the other one is constantly connected.

Note: When the mentioned systems are used, the compressor **will not start up completely unloaded** but with capacity as shown in Table 4.8.

Table 4.8

104	106	108	112	116
25%	16.5%	12.5%	16.5%	12.5%

The change is obtained by removing the following pos. nos. from the constantly connected cylinder: both systems of rocker arms pos. 15A-1, bearing cup pos. 15B-1, spring retainer pos. 15C-1, spring pos. 15D-1 and tand washer for bearing cup pos. 15E-1.

The constantly connected cylinder is not mounted with unloading ring pos. 19B, washer pos. 19C-1, spring pos. 19D-1 and spring pos. 19E. It is marked “S” on the guide ring for the discharge valve pos. 19J-1. See the position of the cylinder in Fig. 4.47.

Fig. 4.46 *Cylinder Liner with Suction Valve*

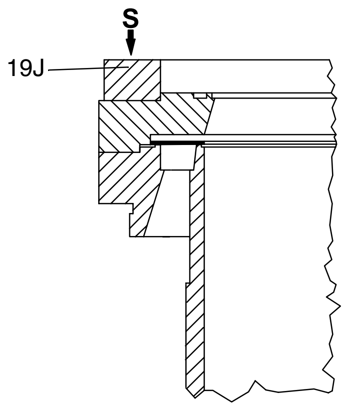
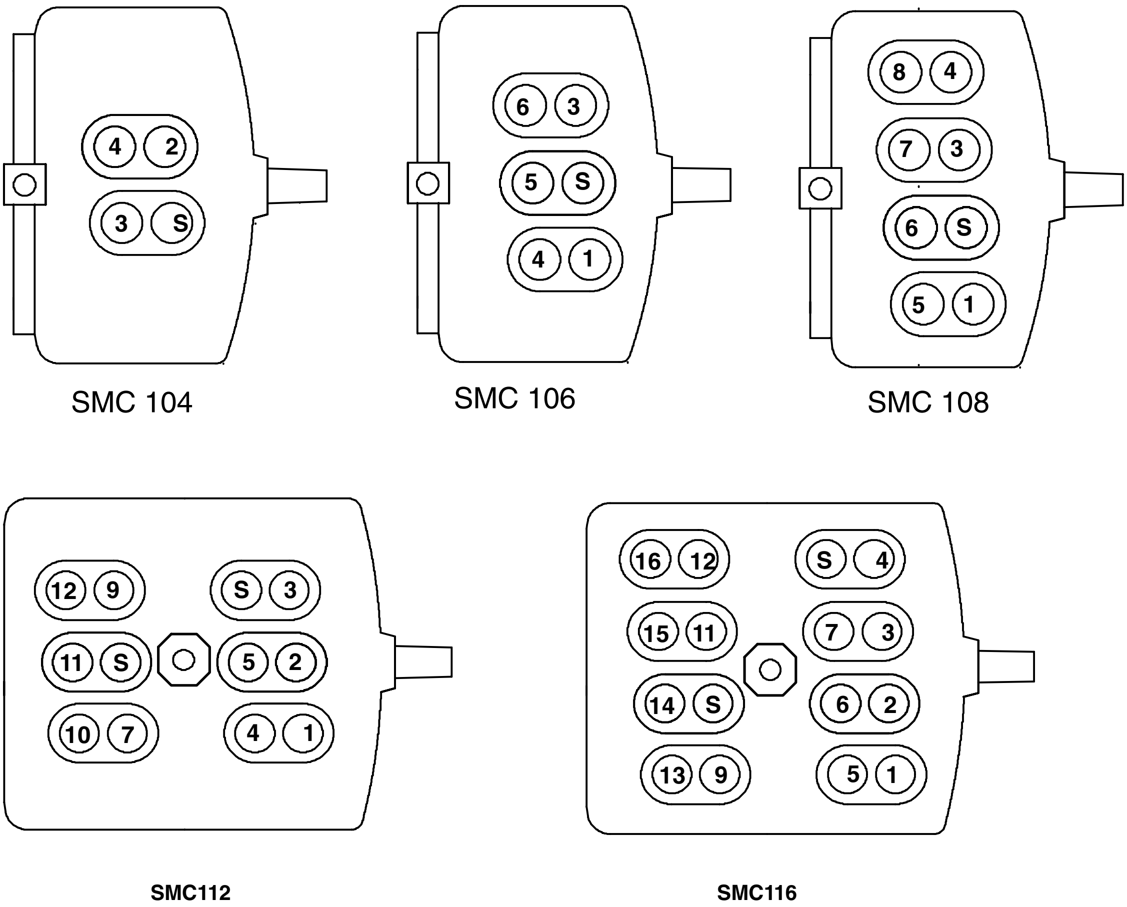


Fig. 4.47 *Position of cylinders in compressor frame*



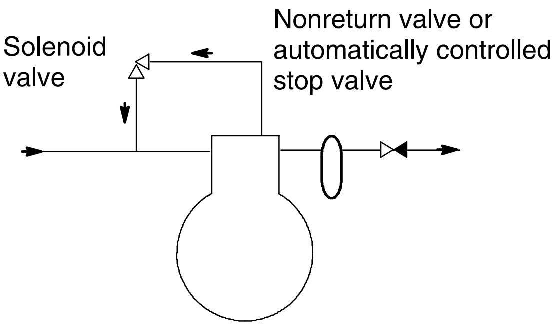
The valve body as for “Total unloading” is used to regulate the capacity stages instead of the standard valve body and the corresponding connecting pipes are mounted.

The increased starting torque must therefore be taken into consideration when choosing motor and start system.

For this purpose, the start up torque curves for R717 compressors and for HFC/HCFC compressors might be useful. These figures can be seen in chapter 6, Technical Data, *Starting torque of the compressor.* Please note that the max rpm is shown in the *Operating Limits Diagrams* in chapter 6.

Please note that if the motor is started up by means of a Y/Δ starter, the starting torque of the compressor may exceed the starting torque of the motor at a high differential pressure. In these cases the compressor must be equipped with a by-pass system which makes the pressure on the discharge side of the compressor equivalent to the suction pressure as illustrated in Fig. 4.48.

Fig. 4.48



After long operating hours at minimum capacity, the temperature of the compressor block and the oil will exceed the normal operating temperatures. It is therefore recommended to adhere to Sabroe Refrigeration's recommendations as to the cooling of the compressor. These recommendations can be found in the *Operating Limits diagrams*.

Variable speed drive (VSD)

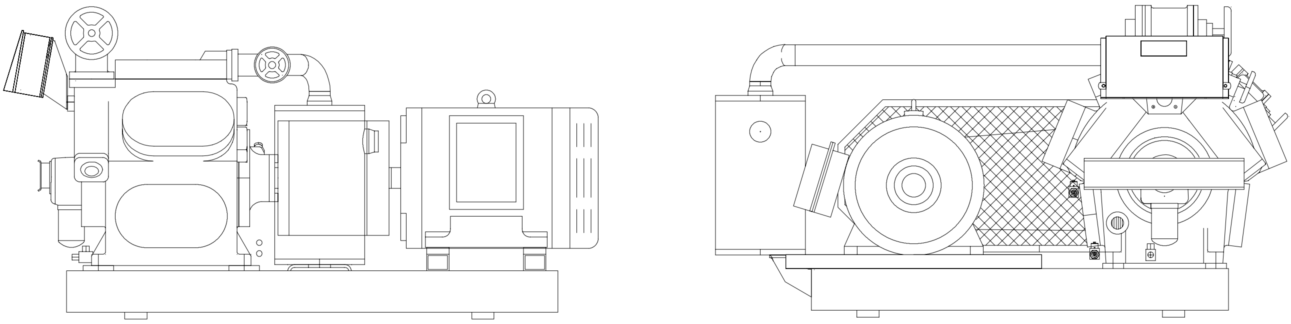
Further, the compressor can be driven by VSD as long as the rpm limits are not exceeded - see *Operating limits*. For the standard and total unloading compressor, UNISAB II is able to control the VSD combined with the mechanical capacity control in the most efficient way taking into consideration both energy consumption and wear.

Compressor Units

The compressor units can be delivered as standard units with base frames adapted to IEC electric motors. Against additional payment base frames can also be delivered for non-standard electric motors. On the base frame one oil separator can be mounted for the SMC compressors and two oil separators for the TSMC compressors. Oil return from oil separator to compressor is controlled by a system as described in the section, *Oil return to the compressor.*

Fig. 4.49

SMC 100 Unit - Direct Couple　　SMC 100 Unit - V-belt Driven



The compressors can be connected to an electric driving motor or a combustion motor. The transmission can be either direct through a coupling that is flexible in both radial and longitudinal direction but which is also rigid in its contorsion, thereby stabilising the compressor rotation. The transmission can also take place by means of a V-belt drive, which, through the selection of standard belt pulley diameters, is able to provide the compressor with the correct number of revolutions and consequently, the desired compressor capacity. For more information, read chapter 6, Technical Data.

Please note that the compressor must be modified in order to change the direction of rotation: the oil pump must be changed on Mk4.

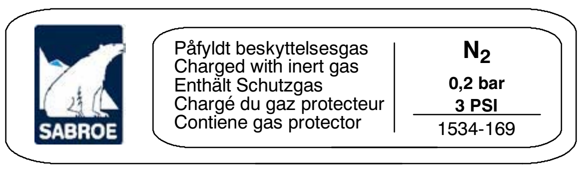
Extent of Delivery

The compressors can be delivered as **blocks only** in standard execution or mounted on a base frame as standard units as illustrated on dimension sketches in chapter 6, Technical Data, see also *Dimension and Piping diagrams.* Furthermore, it is possible to have compressors built into non-standard units following a specific agreement with Sabroe Refrigeration.

A standard compressor is delivered **without oil** in the crankcase but charged with Nitrogen N_2 to 0.2 bar [3 psi] overpressure.

A yellow label, Fig. 4.50, on the compressor indicates this Nitrogen charge.

Fig. 4.50



Instrumentation

In the standard version the compressors are available with one of the following two systems:

A: analogue reading and safety system

B: UNISAB II reading, safety and capacity regulating system

The compressors are designed so that either the analogue system or the UNISAB II system can be fitted without changing the compressor. They each have their own characteristics, however, as described in the following:

A: Analogue Reading and Safety System

The analogue system only has reading and safety functions and cannot control the compressor capacity.

Capacity control is handled by an external system built into the electrical switchboard and connected to the compressor on the mounting site. Some mounting costs must be expected.

The control system can be one of many types and makes. It must, however, be able to send out opening and closing signals to the solenoid valves of the compressor in the prescribed unloading and loading sequence as already described in this section, *Capacity Regulation and Unloading of Compressor.*

In special cases a manually operated switch system can be used instead of the automatic one. This makes it possible to regulate the compressor capacity by hand.

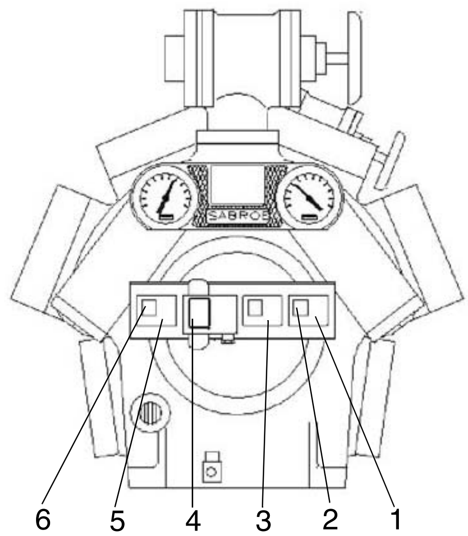
In its standard execution the analogue system consists of controls, built onto the compressor on delivery, but without electrical connections.

The controls are **not** factory adjusted and should therefore be adjusted before the initial start-up of the compressor.

As may be seen from the drawing Fig. 4.51 some of the controls have a dual function, i.e. the type designation KP15 indicates that 1 is the low pressure and 5 the high pressure cut-out function. KP98 e.g. has two temperature systems incorporated.

The specific controls are mentioned in the following, with reference to the numbers in Fig. 4.51.

Fig. 4.51



1. **High Pressure Cut-out KP15**

   Adjusted to stop the compressor if the discharge pressure rises to a pressure 2 bar [29 psi] lower than the setting pressure of the by-pass valve.

   The pressostat has a manual reset function.

2. **Low Pressure Cut-out KP15**

   Adjusted to stop the compressor if the suction pressure drops to a pressure corresponding to 5K lower than the lowest evaporating pressure.

   The pressostat has an automatic reset function

   and will therefore restart the compressor once the pressure rises again.

3. **Intermediate Pressure Cut-out KP5**

   Used only on TSMC compressors. Stops the compressor if the intermediate pressure has risen to 8 bar [116 psi].

   The pressostat has a manual reset function.

4. **Oil Differential Cut-out MP55**

   Adjusted to stop the compressor if the pressure in the lubricating system drops below 3.5 bar [51 psi] compared to the pressure in the crankcase.

   The pressure cut-out has a built-in time delay of 60 sec. which keeps it idle during the start-up of the compressor until the correct oil pressure has been established.

   The pressostat has a manual reset function

   as well as a yellow indicator lamp which, when illuminated, indicates that the electric circuits are working. Normal oil pressure in the compressor is 4.5 bar [65 psi] which is indicated on the manometer 9 on Fig. 4.52.

5. **Discharge Pipe Thermostat KP98**

   Adjusted to stop the compressor if the discharge gas temperature exceeds:

   150°C [302°F] for R717

   120°C [248°F] for HFC/HCFC

   This adjustment can, however, be set to 20°C [68°F] above the normal discharge gas temperature, once this is known from experience. This makes it possible to safeguard the compressor against excessive temperatures.

   The thermostat has a manual reset function.

6. **Oil Thermostat KP98**

   Adjusted to stop the compressor whenever the oil temperature in the crankcase exceeds 80°C [176°F].

   The thermostat has a manual reset function.

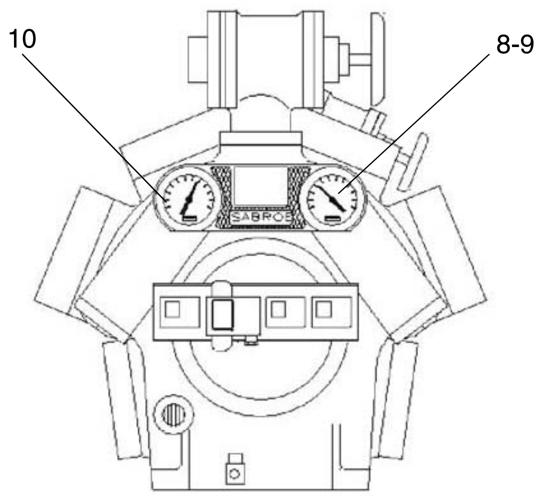
7. **Oil Filter Differential Pressostat**

   Indicates when oil filter pos. 9A needs to be replaced. Connections on the pressostat has a transparent housing and will indicate power supply with green LED and filter replacement with red LED.

Manometers

For reciprocating compressors the following three types of manometers are available:

Fig. 4.52



8. **High Pressure Manometer**

   High pressure manometer indicating the discharge pressure of the compressor and used in SMC compressors. Fig. 4.52

9. **High and Intermediate Pressure Manometer**

   High and intermediate pressure manometer indicating the discharge pressure for the HP and LP stages on TSMC compressors, Fig. 4.52.

   This manometer has two manometer works and two arrows, a red one for high pressure and a black one for intermediate pressure.

10. **Low Pressure and Oil Pressure Manometer**

    Low pressure and oil pressure manometer indicating the compressor suction pressure and oil pressure in the lubricating system of the compressor. Used in the SMC and TSMC compressors.

    This manometer has two manometer works which are interconnected so that one of the works indicate the suction pressure with an arrow whereas the oil pressure is indicated by means of a dial in the middle of the manometer and turned round by the other works. The figure on the dial right below the arrow indicates the oil pressure.
    This makes it possible to read the oil pressure directly from the manometer.

    The manometers can be used with several refrigerants.

- HFC/HCFC manometers for **R22, R134a, R404A**
- **R717** manometers
- **R410A, R744 (CO_2)** manometers

On delivery of compressors using other refrigerants the manometers are graded for that particular refrigerant. The standard units on the scale is bar/°C but others can be delivered on request.

B: UNISAB II Reading, Safety and Capacity Regulating System

UNISAB II is a computerized control and monitoring system which is specially developed to fit all Sabroe Refrigeration's SABROE reciprocating and screw compressors, i.e. the same UNISAB unit is used for both compressor types. It is only necessary to select type of compressor, refrigerant and a few other functions - and the UNISAB will be ready for operation. UNISAB II is based on Sabroe Refrigeration's extensive experience with design and operation of computerized compressor control systems.

Fig. 4.53 *Computerized Control and Monitoring*

UNISAB II is designed for safe control, monitoring and optimization of compressor operation and a minimum of unintended operation stops. In addition to efficient control and monitoring of single compressors UNISAB II is also designed for advanced control and monitoring of any combination of up to 14 compressors. It is thus possible to centrally control and monitor up to 14 compressors by using a COMSAB or PC COMSAB module.

Multi-lingual System

UNISAB II is available in 15 different languages, and it is possible to switch to the English version at any time.

Easy to Operate

UNISAB II has a systematic and easily accessible user interface which does not require any special knowledge or education.

Operational data and status appear from the distinct display which features four lines with twenty characters each. The user interface also has arrow keys for menu selection, set key for parameter changing as well as keys for selection of manual/automatic operation, start/stop, manual capacity regulation and resetting.

Safety Monitoring and Control

UNISAB II provides safe monitoring by means of warning and alarm values/settings for all measuring points. If a set value is exceeded, a red diode will flash slowly in warning situations without stopping the compressor, and quickly in alarm situations with compressor shut down. A display text will show the cause of the alarm. In both warning and alarm situations separate relays are activated for connection of a remote lamp, bell or alarm panel.

It is easy to find all the set values and their warning and alarm values through the straightforward menu system.

Besides monitoring the compressor pressures and temperatures, the UNISAB II also calculates the suction pressure vapour overheating, monitors the capacity slide position and oil flow, and calculates the oil filter differential pressure on screw compressors.

For correct fault diagnosis in case of a compressor shut down, the UNISAB II immediately stores the alarm situations in its memory which can be displayed and analyzed on the display at any time.

Instrumentation

Depending on compressor type the UNISAB II is equipped with a number of pressure and temperature transducers as well as position transmitters on the compressor. On single-stage reciprocating compressors three pressure and three temperature transducers are mounted while two-stage reciprocating compressors are equipped with four pressure and temperature transducers.

Screw compressors are fitted with four pressure and three temperature transducers as well as one or two slide position transmitters.

Furthermore, a thermistor input is available for motor protection.

Factory Test

Every UNISAB II is tested during the production process and when it is mounted on the compressor. A computer test is performed including a test certificate before the compressor leaves the factory.

Please note that UNISAB II cannot directly combine the capacity of compressors with extended capacity control; only SMC 104 can be controlled directly by UNISAB II when it is equipped with a simple box (this has to be configured as a HPC 108 or SMC 108).

Cooling of the Intermediate Discharge Gas on TSMC Compressors

At two-stage operation it is necessary to cool the discharge gas from the LP stage before it enters the HP stage. This intermediate cooling is carried out with the systems described below, depending on the type of refrigerant used.

Common for these intermediate cooling systems is that they must cool the intermediate pressure gas sufficiently and at the same time ensure that no liquid is admitted into the HP stage since liquid may result in liquid slugging in the HP cylinders and excessive wear on the moving parts. It is therefore important to check the systems as described 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. 4.54 The plant may also consist of one or more two-stage compressors as shown in Fig. 4.55.

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.

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.

Fig. 4.54 *SMC 100 compressor*

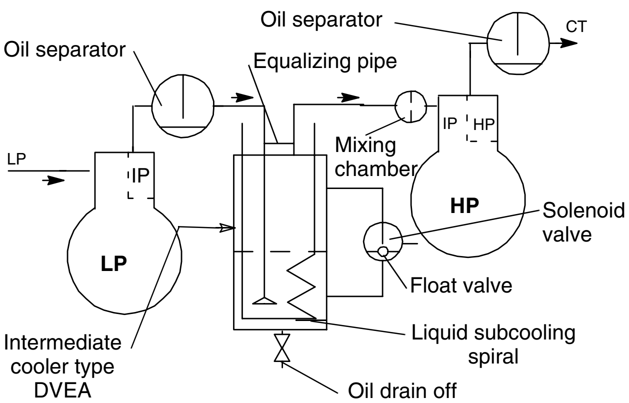
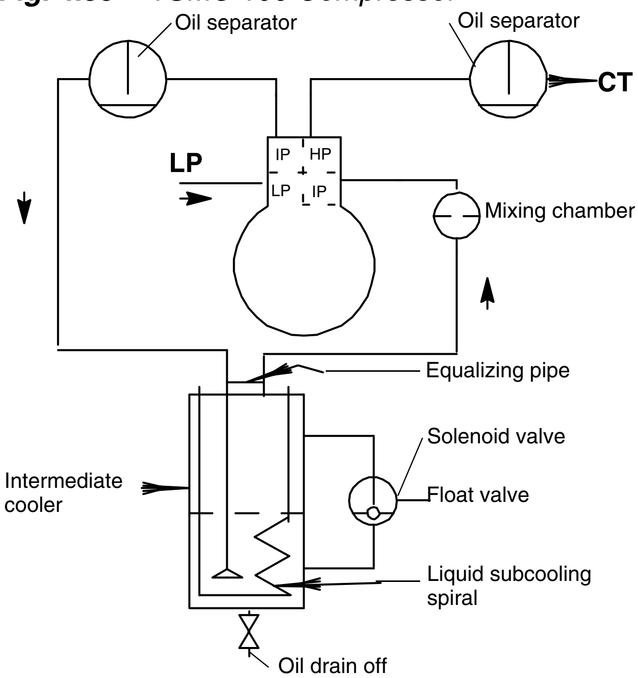


Fig. 4.55 *TSMC 100 Compressor*



In the liquid subcooling spiral the refrigerant flowing from the receiver to the evaporator in 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 operating correctly and keeping the liquid level constant. Frosting of the liquid level pipe on the intermediate cooler indicates the liquid level.

As a matter of precaution a **solenoid valve** should be used in the liquid line to the float so that it may shut off the liquid flow to the intermediate cooler whenever the system is stopped.

At regular intervals the intermediate cooler must be drained of oil through the oil drain valve.

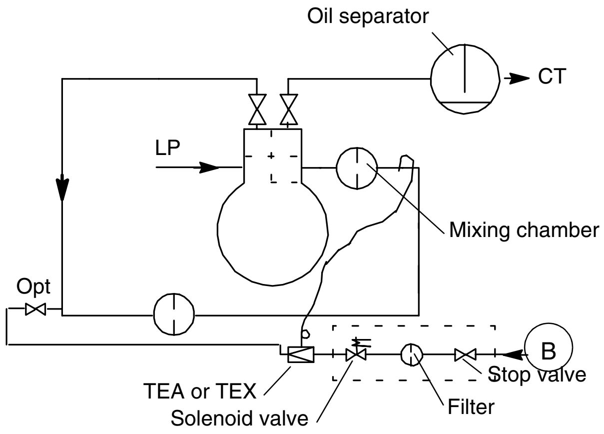
Intermediate Cooling System with Liquid Injection into the Intermediate Discharge Gas, R22 and R717

Two-stage compressors type TSMC can be equipped with a pipe connection from the LP stage discharge branch to the HP stage suction branch as shown in Fig. 4.56.

In the pipe connection the warm discharge gas from the LP stage is cooled by injection of liquid refrigerant into the intermediate pipe. This can be achieved with the following two systems:

1. **Intermediate Cooling with Thermostatic Expansion Valve Type:**
   TEA (R717) or TEX (R22)

Fig. 4.56
TSMC



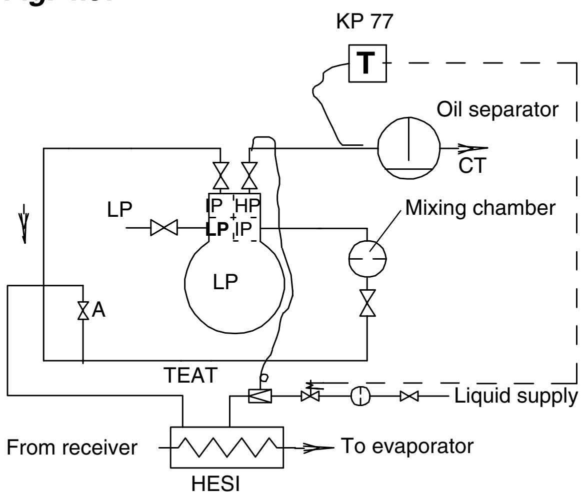
In the system in Fig. 4.56 the liquid refrigerant conveyed to the intermediate pipe is regulated by a **thermostatic expansion valve type TEA (R717) or TEX (R22)** with a sensor placed on the intermediate pipe close to the HP stage.

Connection, **pos. B**, pipe dimension OD 10 mm, emerges from receiver or priority vessel as described in *Cooling with thermopump - R717* later in this section. The intermediate discharge pipe is built onto the compressor on delivery as a block or a unit. On delivery of a compressor block the liquid system including the expansion valve must be mounted on site.

2. **Intermediate Cooling with Thermostatic Injection Valve Type:**
   TEAT (HCFC)

The intermediate cooling system is designed as illustrated in Fig. 4.57. Here the intermediate cooling is carried out by a thermostatic injection valve of the TEAT type and the subcooling takes place in a HESI heat exchanger.

Fig. 4.57



The sensor of the TEAT valve is placed in a sensor pocket at the HP 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 exceeds 55°C [131°F].

Automatic Regulation of Intermediate Pressure IP

In two-stage plants with reciprocating compressors it should be pointed out that the intermediate pressure is not allowed to drop excessively.

A low intermediate pressure reduces the damping effect of the gas on the valve plates in the LP stage discharge valves. The danger is that a breakdown may occur in the form of broken valve plates.

In order to prevent this it may be necessary to mount a by-pass system between the HP side and IP side. Thus a suitable amount of gas is led back to the IP side.
The system is illustrated in Fig. 4.58.

The lower limits for IP have been fixed at:

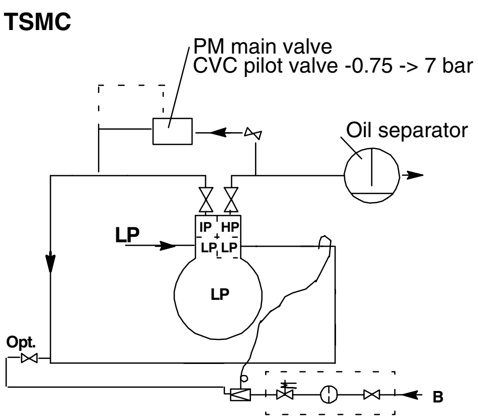
-15°C [5°F] for R717 plants

- 25°C [-13°F] for HFC and HCFC plants.

The by-pass system is additional equipment and is usually mounted by Sabroe Refrigeration directly on the internal pipe connections on the compressor block .

The diagrams, Fig. 4.54 to Fig. 4.57, do only show the principle of the different systems and must not, therefore, be used directly.

Fig. 4.58



Determining the Intermediate Pressure IP

The intermediate discharge temperature of the compressor is dependent on the evaporating temperature ET, the condensing temperature CT and of the ratio between the capacity at the LP and HP stages, corres-ponding to the number of cylinders that is working at each stage.

If a TSMC compressor is working at 100% capacity, the ratio between the number of cylinders is 3:1 as indicated in the Table 4.9.

When unloading the cylinders, this ratio is changed to 2:1 or 1:1 and the intermediate pressure will drop accordingly.

The intermediate discharge pressure is determined by entering the suction tempera-ture ET and the condensing temperature CT into the calculation programme COMP 1. The lower limits for the intermediate discharge pressure are the same as stated above:

-15°C [5°F] for R717 plants and

-25°C [-13°F] for HFC and HCFC plants.

To ensure correct operating conditions all partial load possibilities must be calculated. If the result of the calculation shows values below the stated limits, a by-pass must be fitted as described above.

However, it is also possible to connect the capacity regulating system in such a way that the compressor cannot operate at the capacity stages which produce suction temperatures lower than the limiting value of the refrigerant in question.

As described in the section *Capacity regulation* the TSMC compressors can be capacity regulated at the following stages:

Table 4.9

Compressor Type	Capacity %	Number of Cylinder Working		Ratios
		LP	HP	
TSMC 108	100	6	2	3:1
	66	4	2	2:1
	33	2	4	1:1
TSMC 116	100	12	4	3:1
	83	10	4	2.5:1
	67	8	4	2:1
	50	6	2	3:1
	33	4	2	2:1

Cooling Systems for Compressors

To preserve the optimum lubricating capacity of the oil it may become necessary to cool during compressor operation. Depending on the operating conditions and the type of refrigerant the plant uses, a number of cooling systems are available. See chapter 6, Technical Data, *Operating Limits Diagrams.*

The following standard cooling systems can be delivered for the compressors, depending on which type of refrigerant the compressor is operating with as well as the compressor type itself.

Standard Cooling Systems for Compressors

1. **R717**
   a. Air-cooled top and side covers and refrigerant-cooled oil cooler.
   b. Water-cooled top and side covers.
   c. Compressor cooling with thermopump
2. **R22-R134a-R404A-R507-R410A-R744**
   a. Air-cooled top and side covers.
   b. Air-cooled top covers and water-cooled side covers.
   c. Air-cooled top and side covers and refrigerant-cooled oil cooler.

Description

1a: Air-cooled Top and Side Covers with Refrigerant-cooled Oil Cooler R717

Air-cooled top and side covers are covers without cooling fins, but with a surface large enough to release any surplus heat in the compressor into the environment, see Fig. 4.59 and Fig. 4.60.

Fig. 4.59 *Air-cooled Top Cover*

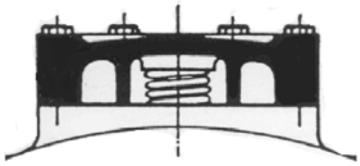
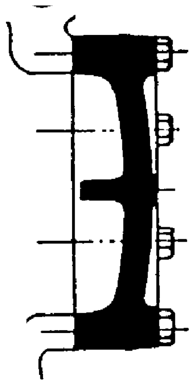


Fig. 4.60 *Air-cooled Side Cover*



There is therefore no need for forced cooling air flow past the covers.

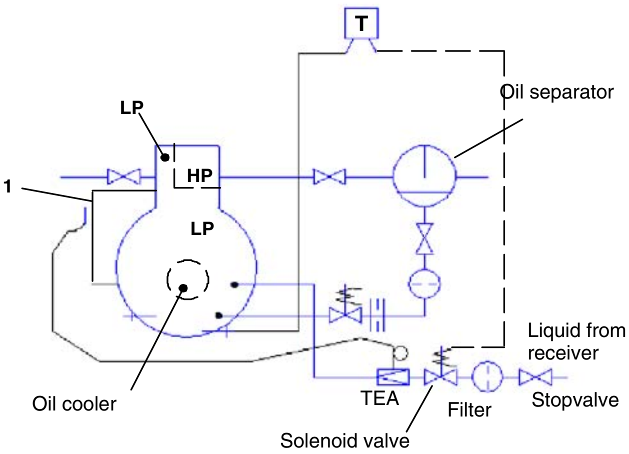
It is, however, necessary to cool the oil in the compressor by means of a built-in oil cooler, which is cooled by the refrigerant in the plant. The cooling system is built onto the compressor. It operates as illustrated in piping diagram, Fig. 4.61, for a normal single-stage compressor and in Fig. 4.62 for a booster compressor.

The cooling system consists of an oil cooler mounted on the oil pipe which connects the oil pump with the shaft seal. The oil cooler is dimensioned to maintain the oil temperature at 50-70°C [122 - 158 °F].

The expanding gas is led through pipe, pos. 1, Fig. 4.61, to the compressor suction side. On the outside of the pipe the sensor for the thermostatic expansion valve, type TEA, is fitted.

The expansion valve, type TEA, is particularly suited for R717. In the liquid line there is also a solenoid valve which closes when the compressor is stopped.

Fig. 4.61 Normal single-stage Compressor R717



The filter filters off any dirt particles in the liquid. The filter element can be removed and cleaned. **The stop valve** can block the cooling system from the refrigeration plant.

A thermostat T is connected to the cooling system and its sensor is placed in the oil of the crankcase. The thermostat is set to open the solenoid valve whenever the oil temperature exceeds 55°C [131°F]. In this way it is made sure that the oil heats up quickly and separates as much refrigerant as possible. UNISAB II controls the solenoid valve directly based on the measured oil temperature.

Booster Compressor

As illustrated in Fig. 4.61, the pipe pos. 1 is taken to the LP side of the compressor. This means that the compressor must compress the gas coming from the oil cooler which makes up only a very small part of the compressor capacity.

The pipe pos. 1 on the booster and two-stage compressor is led to the IP side as illustrated in Fig. 4.62 and Fig. 4.63. Thus the compressor capacity is not affected by the oil cooling system. The liquid supply is regulated by a thermostatic injection valve of the TEAT type whose sensor is placed on the discharge pipe of the compressor. This gives the cooling system two cooling functions. One is to cool the oil in the crankcase the other to cool the discharge gas and consequently the discharge side of the compressor.

Fig. 4.62 Booster Compressor R717

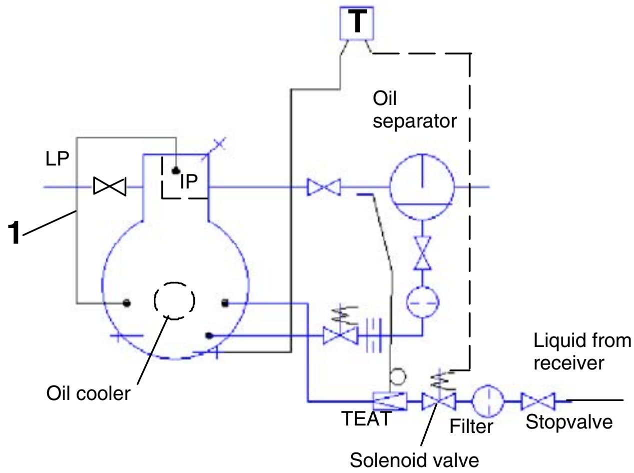
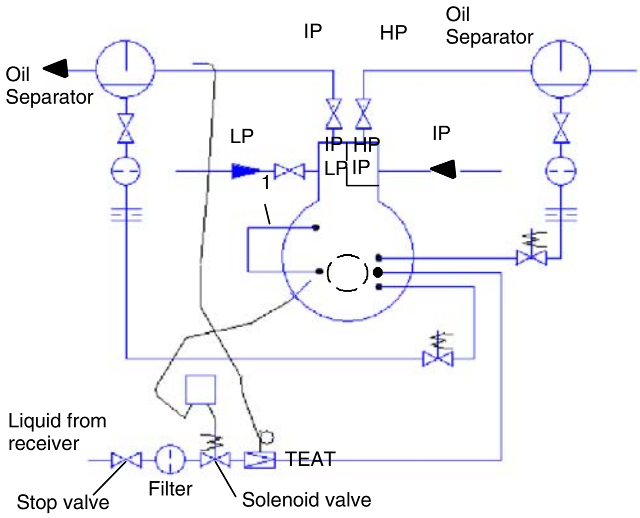


Fig. 4.63 Two-stage TSMC Compressor R717



The TEAT valve is set to inject liquid into the compression chamber of the compressor via the oil cooler in order for the discharge gas to maintain a temperature between +55°C and 95°C [131°F and 203°F].

The diagrams, Fig. 4.61 to Fig. 4.63, do only show the principle of the different systems and must not be used directly.

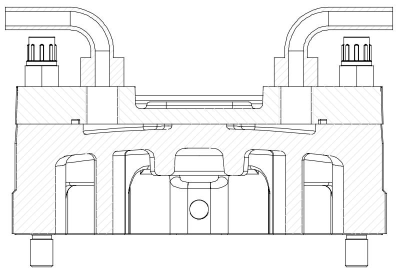
1b: Water-cooled Top and Side Covers - R717
The water cooling system must cool the entire compressor block. In principle, it consists of plane covers which are fixed on the top and side covers with a gasket in between as shown in Fig. 4.64 and Fig. 4.65.

A system of canals is thus created between the two covers in which the water is distributed evenly and cools effectively.

As the water covers can be dismantled without removing the top covers and depressurizing the compressor, the pipe system and the inner faces of the water cover can easily be cleaned of any impurities.

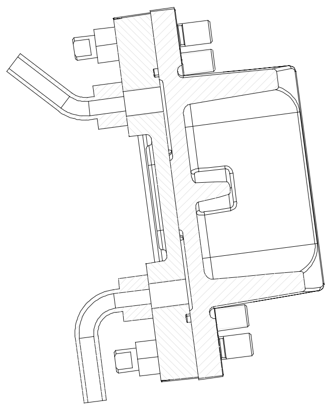
It is fairly easy to build this water cooling system on an air-cooled compressor. Note, however, that the air-cooled side covers must be replaced with covers with cooling fins on the inside. This may be seen by comparing Fig. 4.60 with Fig. 4.65.

Fig. 4.64 *Water-cooled Top Cover*



Note: *Do not use sea water as cooling water on top covers.*

Fig. 4.65 *Water-cooled Side Cover*

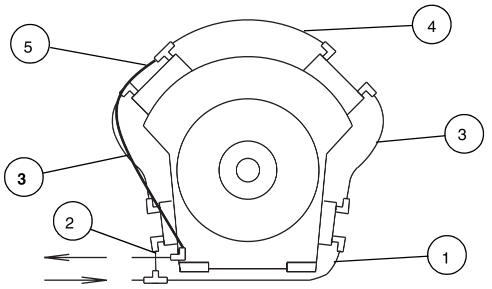


Mounting of Cooling Water Hoses

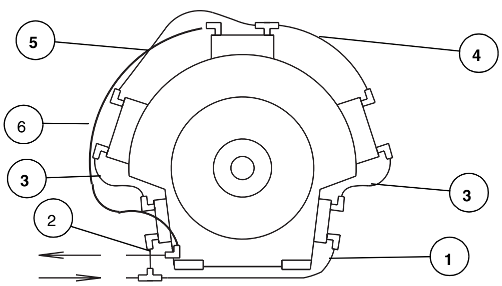
On delivery of the compressor, the cooling water covers are mounted, but they are **not** connected with water hoses. These are delivered separately to avoid damaging the hoses and connecting branches during transportation and mounting. The cooling water hoses are mounted as shown in the drawing which is delivered with the compressor. A copy of this drawing can be seen in Fig. 4.66.

Fig. 4.66 *Mounting of water hoses on top and side covers.*

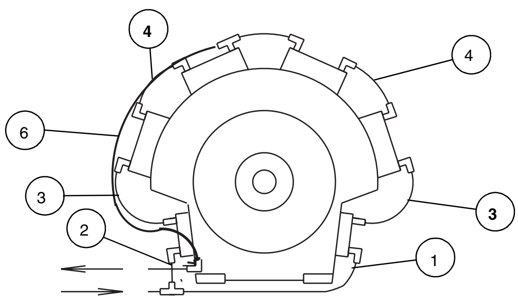
Cooling of top and side covers
SMC 104-106-108 and TSMC 108



SMC 104 3185-230		
Pos. No.	**Hose Type**	**L (mm)**
1	C	715
2	C	115
3	C	505
4	C	645
5	A	835



SMC 106 3185-231		
Pos. No.	**Hose Type**	**L (mm)**
1	C	730
2	C	125
3	D	335
4	C	375
5	C	515
6	C	1100



SMC 108 TSMC 108 3185-232		
Pos. No.	**Hose Type**	**L (mm)**
1	C	760
2	C	150
3	C	340
4	E	255
5	C	230
6	A	1090

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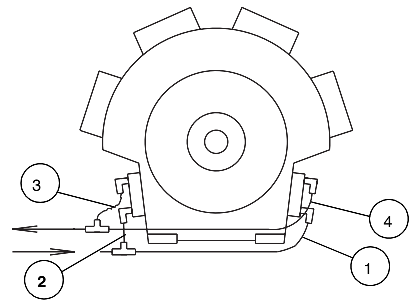
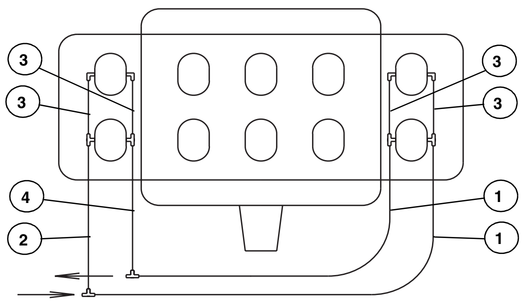
Fig. 4.67

Cooling of side covers only

SMC 104-106-108-112-116 and TSMC 108-116





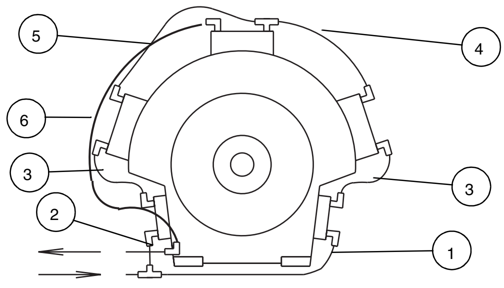
Side covers 3185-235 SMC 104-106-108 and TSMC 108		
Pos. No.	Hose Type	L (mm)
1	C	715
2	C	175
3	C	230
4	C	765

Side covers SMC 112 3185-246		
Pos. No.	Hose Type	L (mm) SMC 112
1	A	750
2	A	130
3	C	750
4	A	220

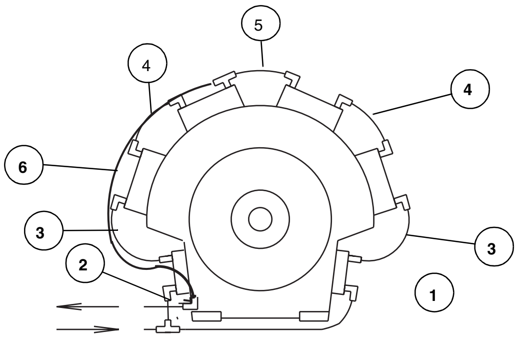
Side covers 3185-236 SMC 116 and TSMC 116		
Pos. No	Hose Type	L (mm) SMC 116 TSMC 116
1	A	740
2	A	160
3	C	770
4	B	215

Fig. 4.68

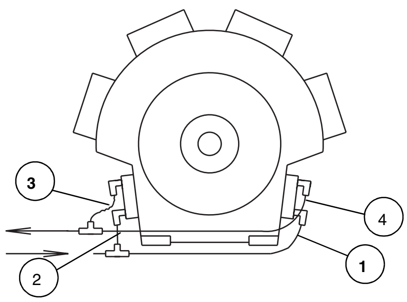
Cooling of top and side covers SMC 186-188 and TSMC 188



SMC 186 3185-242		
Pos. no.	**Hose type**	**L (mm)**
1	C	815
2	C	1830
3	C	605
4	C	245
5	C	1165
6	C	595



SMC 188/TSMC 188 3185-243		
Pos. no.	**Hose type**	**L (mm)**
1	E	335
2	A	1755
3	C	535
4	C	245
5	C	1175
6	C	340



Side covers only 3185-244		
Pos. no.	**Hose type**	**L (mm)**
1	C	1165
2	C	245
3	C	1315
4	C	410

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Note:

- The direction of the water flow is indicated in Fig. 4.66.
- The hose sections have been shortened to the lengths indicated from factory.
- In the supply pipe to the water system a solenoid valve must be fitted which **shuts off the water flow** in the refrigerating system when the compressor is not in operation. It is recommended, however, to continue the water cooling for approx. 10 minutes after the compressor has been stopped to protect the cooling water hoses against excessive temperatures.
- Dimensions of the inlet and outlet pipes for the cooling water system are indicated in chapter 5, Physical and Connection Data - *Table of Water Connection.*

Necessary Water Consumption

To achieve satisfactory distribution of cooling water and hence proper compressor cooling, the following limiting values should be followed.

Min. Water Flow

5.5 litres per hour per kW motor output. On water circulation plants greater water flow is recommended. See Fig. 4.69.

Max. permissible inlet temperature:

+40°C [104°F]

Min. permissible inlet temperature:

+10°C [50°F]

Max. permissible outlet temperature:

+55°C [151°F]

Max. permissible temperature rise from inlet to outlet on compressor:

15°C [59°F]

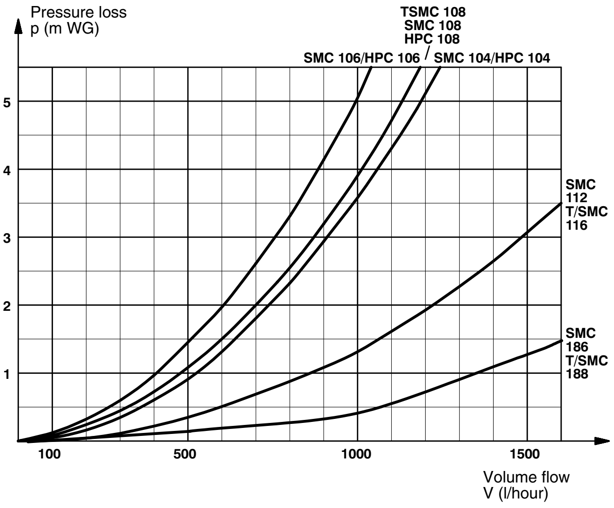
Max. permissible cooling water pressure:

8 bar.

Pressure Loss in the Cooling System in SMC/TSMC Compressors

Totally for Side and Top Covers

Fig. 4.69 Pressure loss diagram



Water Quality

Water that can be used as cooling water:

- Water from the water works or sea water
- Fresh ground water
- Water from cooling towers or condensers
- Closed water systems in which the water is cooled and recirculated
- Salt water (Brine)

Note: *Do not use sea water as cooling water on top covers.*

Obviously, it is very important that the water does not cause algae to grow or calcareous deposits to develop in the cooling system. This means that when water is recirculated in a closed system, a water treatment plant will usually be required. Sabroe Refrigeration can help you to choose the best treatment.

Please contact Sabroe Refrigeration for further information about water treatment.

Warning!

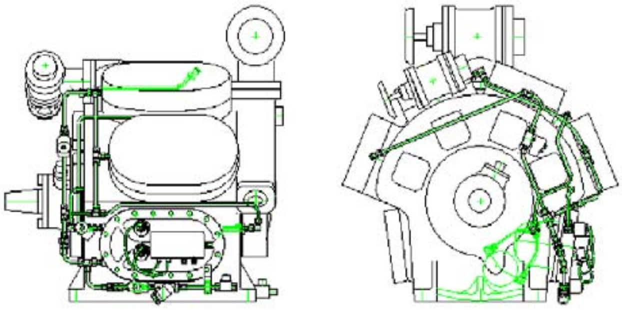
The recirculation water system may contain chemicals or biological contaminants, including legionella, which can be harmful if inhaled or ingested. Water systems should only be operated with an effective biological treatment programme.

1c: Cooling with Thermo Pump - R717

The thermo pump is a compressor cooling system which makes the compressor completely independent of the cooling water. The system is therefore very applicable in areas where there is a shortage of water resources or where the water quality is poor. The thermo pump system can only be used with R717.

The purpose of the thermo pump is both to cool the oil in the crankcase and to cool the compressor discharge gas in order to lower the temperature in the whole compressor.

Fig. 4.70 *Short Block with Thermopump*



The thermo pump is mounted as a side cover on the compressor and works by pressing the refrigerant into the canal system on the top covers and into the oil cooler which - depending on the operating conditions - is built into the crankcase.

On TSMC compressors cooling only takes place in the **high pressure stage top covers** and **no** oil cooler is used in the crankcase.

The thermo pump works under the influence of heat coming from the oil in the crankcase. In this way it also regulates its own pump capacity. This means that the thermo pump works slowly when the oil is cold, e.g. right after start-up of the compressor, but as the oil temperature gradually rises, the pump capacity will increase accordingly.

The thermo pump does not start, however, until the discharge gas temperature exceeds 80°C [176 °F].

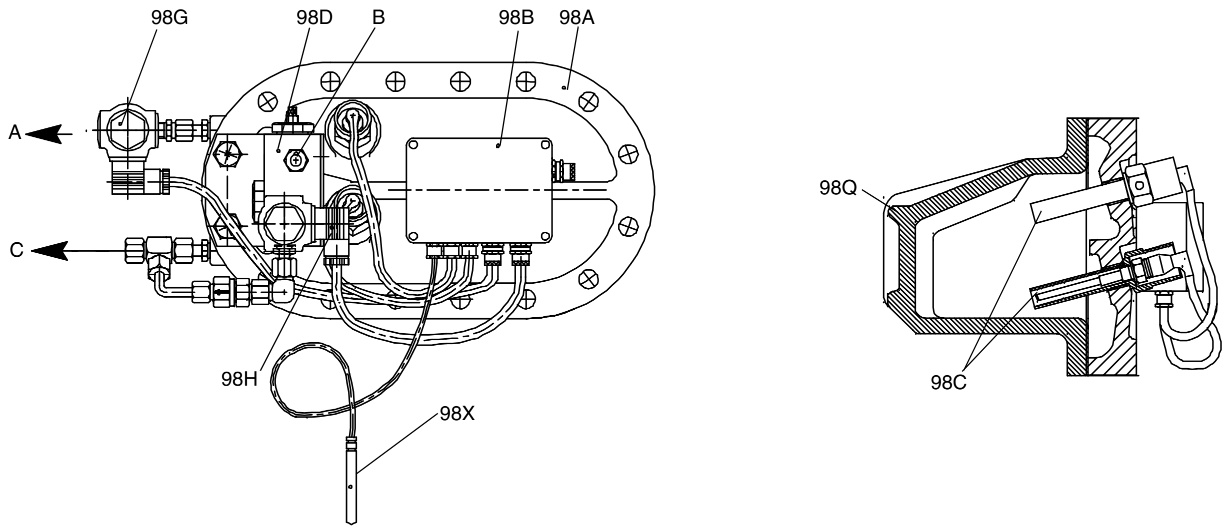
The pumping cycle of the thermo pump, i.e. a filling and an evacuation period, lasts between 4 and 8 minutes depending on the number of cylinders of the compressor, its capacity, the oil temperature in the crankcase and the operating pressure and temperatures of the plant. The filling period takes about 45 sec.

The thermo pump has an important advantage, namely that the refrigerant pumped by the thermo pump is led directly into the discharge gas of the compressor. Consequently, this **will have no influence on the compressor capacity**.

The Structure of the Thermo Pump

The side cover, see Fig. 4.71 pos. 98A, together with the cooling cover, pos. 98Q, constitute 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 ensure a proper thermal contact with the oil.

Fig. 4.71 *Side Cover with Thermo Pump*



As indicated in the principle drawings of the SMC 108,Fig. 4.72, and a TSMC, Fig. 4.73, the thermo pump has the following connections:

- Connection **pos. A,** which is linked to the compressor suction side and which can be blocked by means of solenoid valve pos. 98G, is used to lower the pressure in the pump vessel, pos. 98. This is part of the pumping cycle.
- Connection **pos. B** emerges from the plant receiver or the priority tank (will be described later) and goes right to the valve block pos. 80.
- Connection **pos. C** is connected to the bottom of the pump vessel pos. 98 as well as to the top covers and the oil cooler pos. 98T through a number of nozzles, pos. 98M.

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Fig. 4.72 *SMC 108*

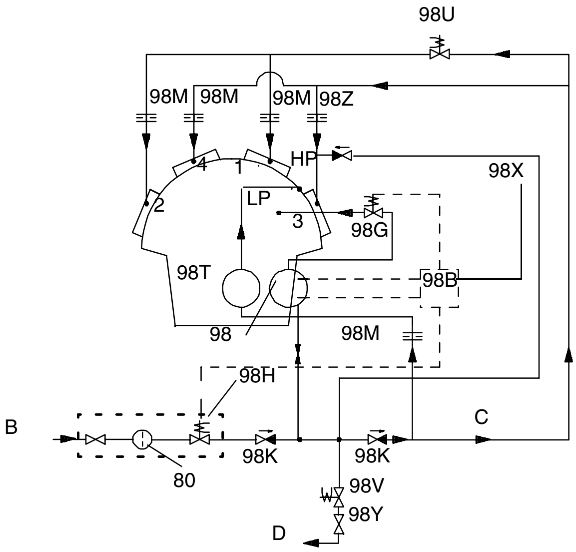
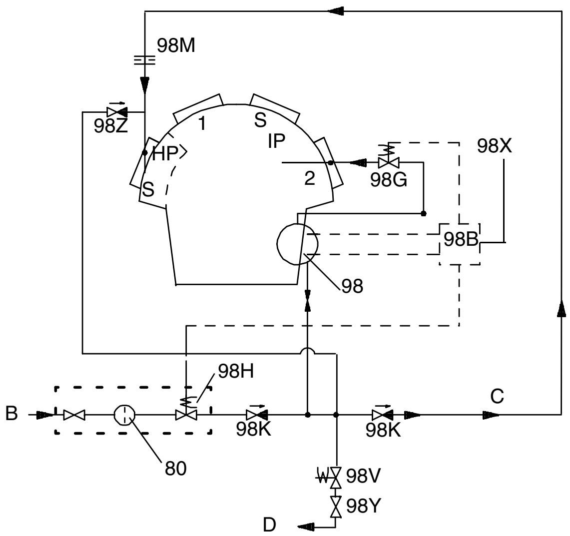


Fig. 4.73 *TSMC 108*



Filling and evacuation of the pump vessel is controlled by two level sensors, pos. 98C, Fig. 4.71. By means of the control box, pos. 98B, the sensors control the solenoid valves, pos. 98G and pos. 98H, so that they open and close simultaneously.

The thermo pump is safeguarded by the following systems as shown in Fig. 4.71, Fig. 4.72 and Fig. 4.73:

a. A thermostat built into the control box pos. 98B with sensors pos. 98X fitted on the compressor discharge pipe.

   The thermostat is factory set to start up the thermo pump once the discharge gas temperature is **above 80°C** [176 °F].

b. An evacuation system emptying the pump vessel through solenoid valve pos. 98V whenever the thermo pump stops.

   Please, note that the pipe connection pos. D to the plant evaporating side must be at a place where there is suction pressure and no risk of the liquid flowing back to the compressor through the suction line. Connection should e.g. be made to the liquid separator or the evaporator.

c. A safety circuit with a non-return valve, pos. 98Z, which opens for the flow in the pump vessel at a pressure **3 bar [44 psi] higher** than the one in the compressor discharge gas line.

Description of the Pumping Cycle

Filling the 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.

Thus 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.

Emptying the Pump Vessel

When the top sensor, pos. 98C, 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 will now rise as a consequence of the heat impact from the compressor oil and will - when it exceeds the pressure on the compressor discharge side - make the refrigerant flow through the pipe connection C 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, resulting in immediate cooling of the discharge gas.

The oil cooler OOSI (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 to 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

When reducing the compressor capacity, it will be necessary to reduce the cooling effect of the thermo pump as well. This is done as follows:

SMC 104-106-108, TSMC 116

The pipe connection from the pump vessel to the top covers is divided into two pipe lines. In one of these pipe lines a solenoid valve, pos. 98U, is fitted.

This solenoid valve is wired to the capacity regulating system of the compressor and it closes when the compressor capacity has been reduced as indicated in the following table, Table 4.10.

Table 4.10

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%

On the SMC 112-116 two thermo pumps have been mounted as shown in the principle drawings Fig. 4.74, Fig. 4.75 and Fig. 4.76.

Fig. 4.74 *SMC 112*

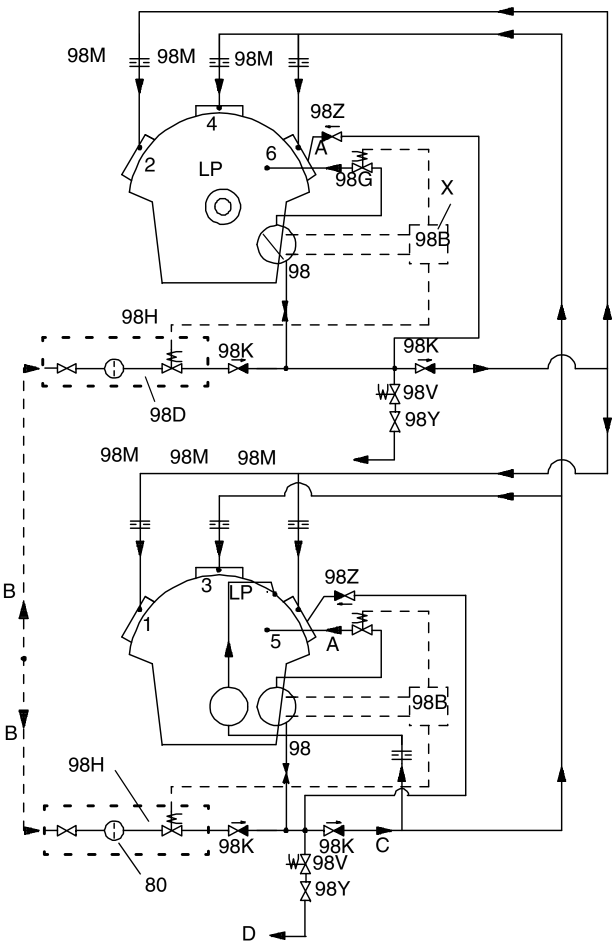


Fig. 4.75 *SMC 116*

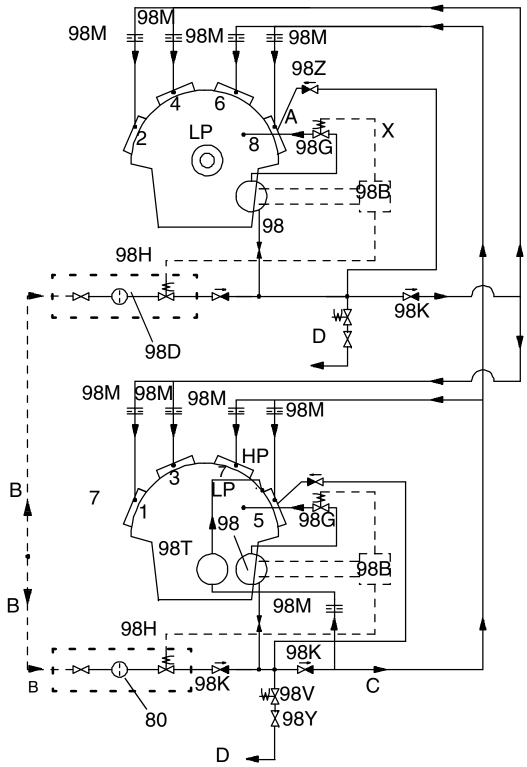
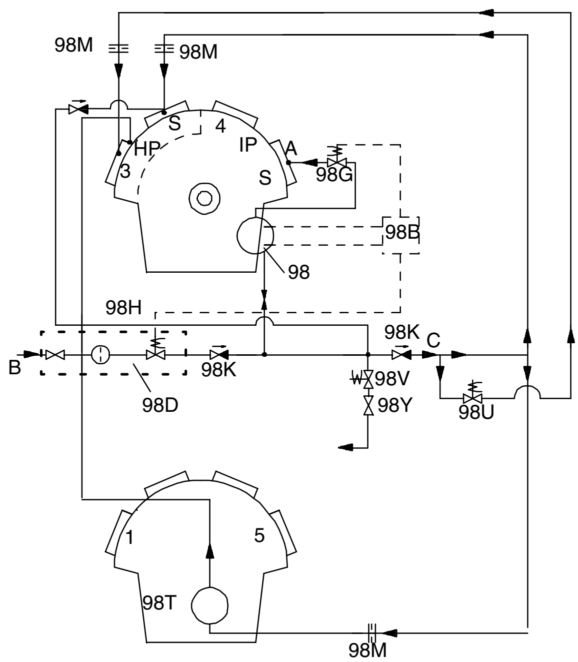


Fig. 4.76 *TSMC 116*



The total capacity of the thermo pumps is adapted to the compressor capacity by stopping and starting the thermo pump marked with an X on the principle drawing.

The stopping and starting is achieved through the wire 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 4.11.

Table 4.11

Compr. Capacity	Thermo Pump at Compressor Shaft End	
	Working	Not Working
SMC 112 SMC 116	100 - 83 - 67% 100-87-75-63%	50 - 33% 50 - 37 - 25%

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.**

Ensuring Liquid to the Thermo Pump

The thermo pump must always be ensured liquid from the plant, irrespective of whether the plant lacks liquid or if some other factor prevails.

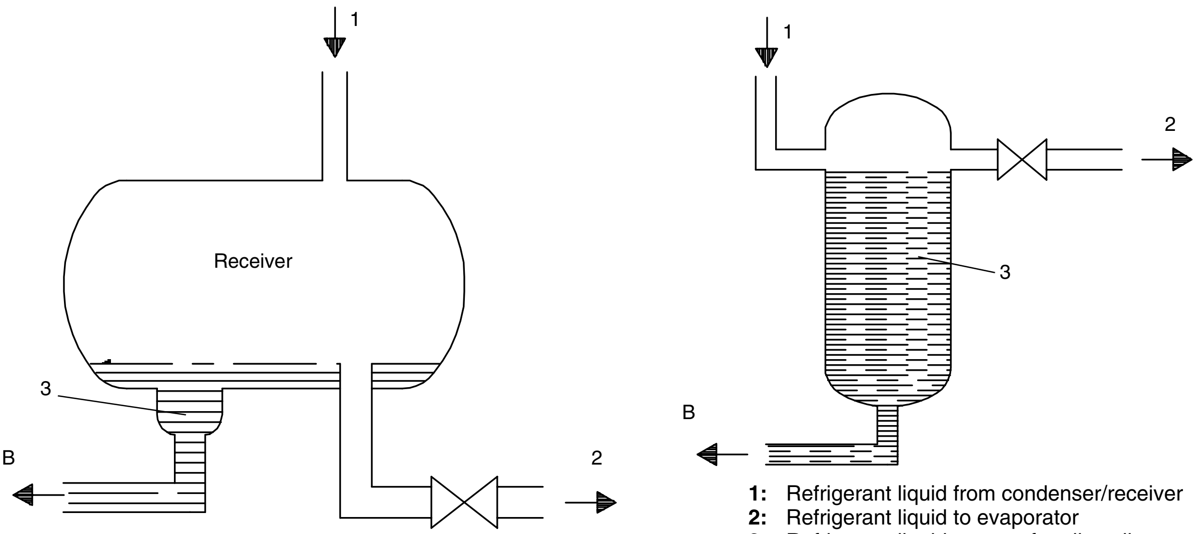
Thus, the thermo pump must also be ensured liquid during a possible pump down by means of the compressor.

In other words: *During operation the compressor must never be short of cooling.*

This safety is achieved either by taking the liquid directly from the receiver, pipe connection B, or by building a **priority tank** into the liquid line of the plant, Fig. 4.77.
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.

Fig. 4.77



1: Refrigerant liquid from condenser/receiver
2: Refrigerant liquid to evaporator
3: Refrigerant liquid reserve for oil cooling
B: Refrigerant liquid for oil cooling

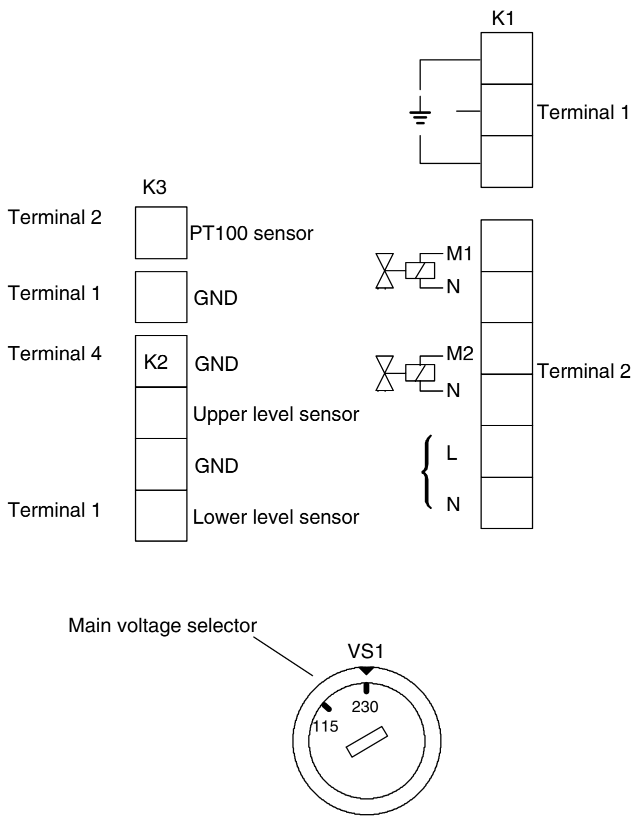
Power Connection

The control box is geared for the 3 voltages listed below.

Voltages:
110V - 50/60Hz
220V - 50/60Hz
240V - 50Hz

The control box contains a terminal strip as shown in Fig. 4.78.

Fig. 4.78



2a: Air-Cooled Top and Side Covers R22 - R134a - R404A - R507

Use the same cover mounting as described in paragraph 1a. As indicated in the *Operating Limits Diagrams* in Section 6, Technical Data, there is no need for oil cooling.

2b: Air-Cooled Top Covers and Water Cooled Side Covers R22 - R134a - R404A - R507

If water is available and a need for cooling exists according to the *Operating Limits Diagrams*, Section 6, Technical Data, this system is an excellent solution.

The water-cooled side covers are mounted as described in paragraph 1b, Fig. 4.67.

Fig. 4.79 *Cooling of Side Covers only*

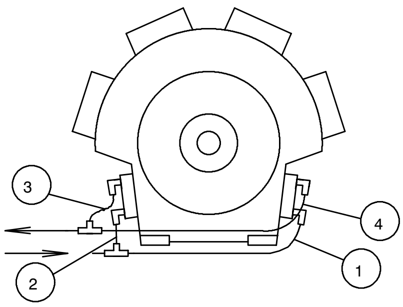


Table 4.12

Pos No	Hose type	Length (mm)
1	C	715
2	C	175
3	C	230
4	C	765

2c: Air-Cooled Top and Side Covers and Refrigerant-Cooled Oil Cooler R22 - R134a - R404A - R507

Use the same cover mounting as the one described in **paragraph 1a**.

In principle, the oil cooling system is constructed as illustrated in Fig. 4.61 for single-stage compressors, in Fig. 4.62 for booster compressors and in Fig. 4.63 for two-stage compressors.

Compressor Accessories

Following an order, the accessories listed below can be delivered for compressors or units:

- **Explosion-proof** instrumentation instead of the standard equipment.
- **Explosion-proof heating** cartridge for oil heating in the crankcase.
- **Explosion-proof solenoid valves** for capacity regulation.
- **Vibration dampers** to be inserted between unit and machine floor dimensioned to fit the unit in question.
- **Normal set of tools**, comprising special tools for dismantling and assembling the compressor.
- **Extended set of tools**. Besides the normal set of tools, this set contains all necessary standard hand tools.
- **Spare parts set** in various sizes.

When 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 Refrigeration service engineer to carry out the necessary service work without having to spend extra time on getting the spare parts required.

Spare parts can be delivered as described in the following. When contacting the local Sabroe Refrigeration representative, it is possible to receive a list of the spare part sets recommended by Sabroe Refrigeration.

Types of Spare Parts Set:

For the different compressor blocks:

- **Standard spare parts set:** Contains a suitable selection of O-rings as well as valve ring plates and valve spring.
- **Extended spare parts set:** In addition to the parts included in the **standard spare parts set,** the set contains a cylinder liner and discharge valve as well as an extended number and types of gaskets and fittings.
- **Certificate spare parts set:** In addition to the parts from the **extended spare parts set** this set contains a major number of components and wearing parts selected by the classification societies.
- **Special spare parts set:** This is a more comprehensive set than the **extended spare parts set** as almost all O-rings and gaskets are included and for the most wearing parts the number of parts have been extended.

For the different compressor units:

- **Standard spare parts set:** This is a set consisting mainly of O-rings and gaskets for some of the components included in the unit.
- **Certificate spare parts set:** In addition to the parts from the standard spare parts set this set contains other components selected in accordance with the requirements of the classification societies.

6. Technical Data

The purpose of this chapter is to provide the technical data of the equipment.
In this chapter technical data is defined as:

- Data for compressor
- Data for unit
- Working range
- Handling the compressor
- Area of application
- Noise level data
- Vibration data
- Test pressure for compressors
- Assessing the oil
- Selecting lubricating oil

This chapter is primarily intended for designers, service engineers, sales personnel and prospective customers.

Technical Data for the SMC 100 Series

Table 6.1

	Compressor type	Number of cylinders 1)	Bore mm	Stroke	Max/min speed nominal rpm 2)	Swept volume at max speed m^3/h	Weight of compressor block kg	Weight of compressor block lb
	SMC 104S	4				271	580	1279
	SMC 106S	6				407	675	1488
	SMC108S	8		80	1800/700	542	740	1631
	SMC112S	12				815	1250	2756
	SMC 116S	16				1086	1350	2976
	SMC104L	4				283	580	1279
	SMC106L	6				424	675	1488
Single stage	SMC108L	8		100		565	740	1631
	SMC112L	12				848	1250	2756
	SMC116L	16				1131	1350	2976
	SMC104E	4	100		1500/700	339	600	1323
	SMC106E	6				509	700	1543
	SMC108E	8		120		679	770	1698
	SMC112E	12				1018	1300	2866
	SMC116E	16				1357	1400	3086
	TSMC108S	6 LP + 2 HP		80		339	775	1709
	TSMC116S	12 LP + 4 HP				679	1400	3086
Two stage	TSMC108L	6 LP + 2 HP		100		424	775	1709
	TSMC116L	12 LP + 4 HP				848	1400	3086
	TSMC116L	6 LP + 2 HP		120		509	800	1764
	TSMC116E	12 LP + 4 HP				1018	1450	3197

1) LP = Low pressure cylinder
HP = High pressure cylinder
2) Permitted max. speed varies with operation conditions- and refrigerant.
See the Operating Limit Diagrams

Table 6.2 *Weight of Compressor Units*

Compressor Type	Direct driven		Belt driven		Remarks
	Kg	lb	Kg	lb	
SMC 104 SMC 106 SMC 108 SMC 112 SMC 116	830 925 990 1660 1400	1830 2039 2183 3660 3086	880 970 1030 1820 1920	1940 2138 2271 4012 4233	
TSMC 108 TSMC 108	1060 1400	2337 3086	1130 1410	2491 3109	Excl. intermediate cooler Incl. intermediate cooler
TSMC 116 TSMC 116	1900 2350	4189 5181	2080 2530	4586 5578	Excl. intermediate cooler Incl. intermediate cooler
The weight is exclusive of electric motor					

Table 6.3 Weight of Electric Motors

Sizes	MOTOR TYPE									
	SHORCH				LEROY SOMER					
	IP 23		IP 54		PLS		LS		FLS	
	kg	lb	kg	lb	kg	lb	kg	lb	kg	lb
IEC 160L			102	225	80	176	78	172	120	265
IEC 180M	190	419	173	381	98	216	100	220	135	298
IEC 180L	210	462	188	414	128	282	110	243	184	406
IEC 200M	240	529			165	364				
IEC 200L	265	584	235	518	190	419	170	375	260	573
IEC 225S			309	681			205	452	290	639
IEC 225M	355	783	340	750	240	529	235	518	388	855
IEC 250S	455	1003			335	739				
IEC 250M	480	1058	445	981	360	794	340	750	395	871
IEC 280S	625	1378	570	1257	460	1014	445	981	475	1047
IEC 280M	680	1499	630	1389	515	1135	490	1080	565	1246
IEC 315S	875	1929	900	1984			720	1587	850	1874
IEC 315M	945	2083	940	2072	730	1609	785	1731	1000	2205
IEC 315L	1050	2315	1200	2646	830	1830			1050	2315
IEC 355S			1500	3307						
IEC 355M	1790	3946	1600	3527			855	1885		
IEC 355L	2095	4619	1750	3858					1510	3329
IEC 355L			(LA)1900 (LB)2150						1550	3417

Compressor Capacity

Compressor capacity is calculated by means of the COMP 1 program in the Sabroe Match Master suite of programs.

Alternatively, contact your local dealer who can help dimensioning the compressor.

Dimension Sketches of Compressor Block

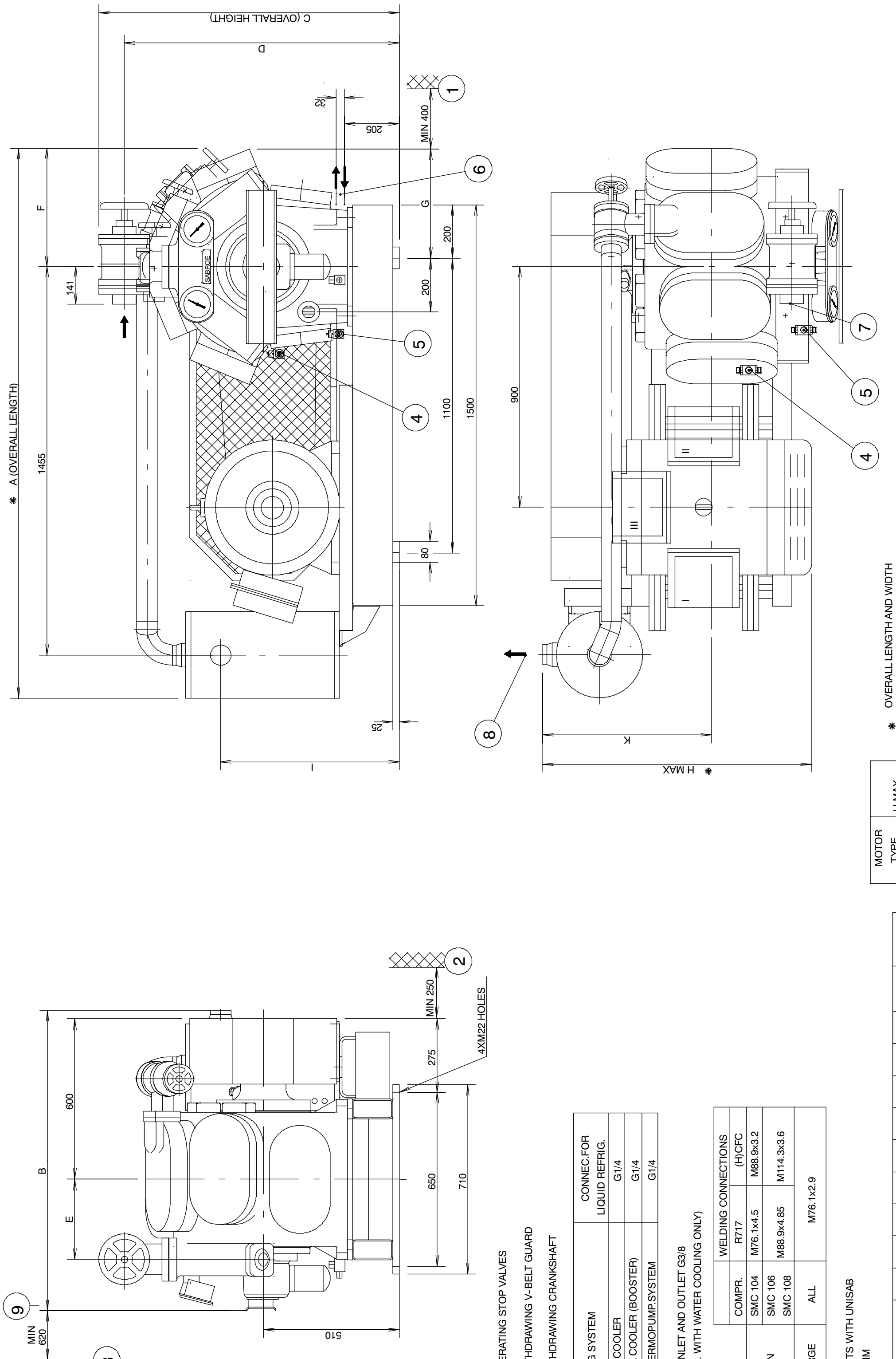
As standard execution the compressor block can be delivered with either an analog display and safety system, i.e. with pressure gauges, pressure sentive and thermostats, or with a UNISAB II system with display and safety facilities as well as capacity regulation of the compressor.

To illustrate the structure of the dimension sketches, three examples have been included, Fig. 6.1, Fig. 6.2 and Fig. 6.3. Moreover, reference is made to *Dimension and Piping Diagram*, which includes dimension sketches of all compressors and units.

However, during the final planning the latest dimension sketches from Sabroe Refrigeration are required.

6. Technical Data

Fig. 6.1 *SMC 100, V-belt Driven, Anolog System*



① FOR OPERATING STOP VALVES

② FOR WITHDRAWING V-BELT GUARD

③ FOR WITHDRAWING CRANKSHAFT

	COOLING SYSTEM	CONNEC.FOR LIQUID REFRIG.
④	R22 OIL COOLER	G1/4
④	R717 OIL COOLER (BOOSTER)	G1/4
⑤	R717 THERMOPUMP.SYSTEM	G1/4

⑥ WATER INLET AND OUTLET G3/8
(COMPR. WITH WATER COOLING ONLY)

			WELDING CONNECTIONS	
		COMPR.	R717	(H)CFC
⑦	SUCTION	SMC 104	M76.1x4.5	M88.9x3.2
		SMC 106 SMC 108	M88.9x4.85	M114.3x3.6
⑧	DISCHARGE	ALL	M76.1x2.9	

⑨ FOR UNITS WITH UNISAB
ADD 80MM

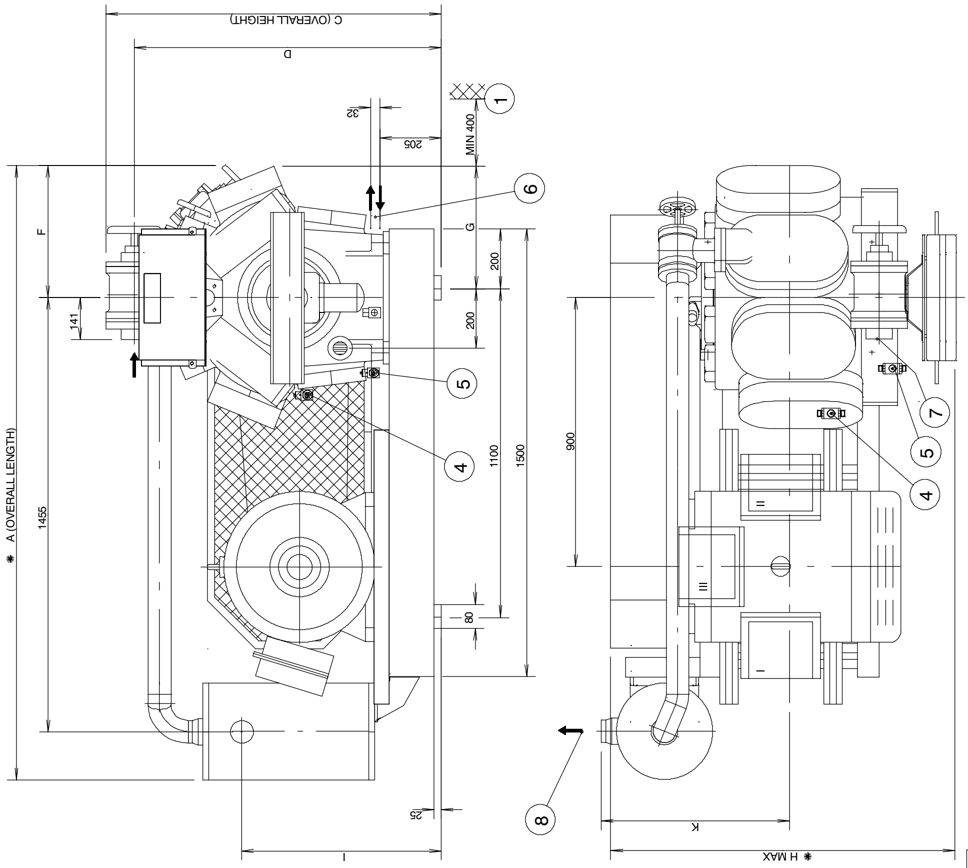
COMPR TYPE	MOTOR TYPE IEC	A MAX MM	B MM	C MM	D MM	E MM	F MM	G MM	I MM	K MM	FOUND. DRWG. NO.	WEIGHT OF UNIT EXCL. MOTOR
SMC104	200-315M	2050	1115	1095	1000	275	440	350	635	635	171438	880 KG
SMC106	200-315M	2010	1090	1130	1035	275	395	395	645	620	171438	970 KG
SMC108	200-315M	2020	1130	1125	1030	300	405	405	665	635	171438	1030 KG

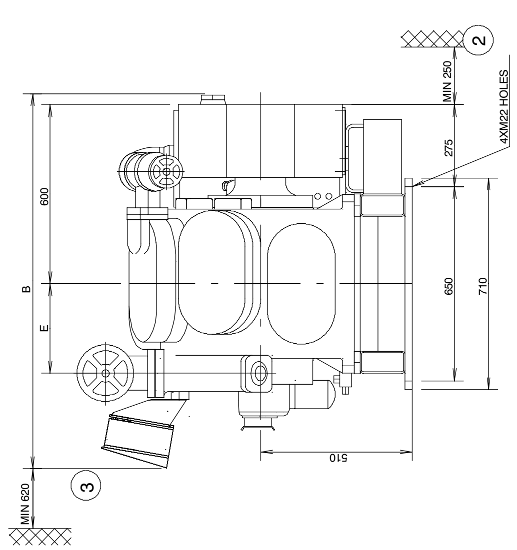
MOTOR TYPE IEC	H MAX
200	915
225	1015
250	1135
280	1235
315	1335

* OVERALL LENGTH AND WIDTH VARIES ACCORDING TO MAKE OF MOTOR AND TYPE
FOR EXACT LENGTH USE DIMENSION H IN TABEL

6. Technical Data

Fig. 6.2 *SMC 100, V-belt Driven, UNISAB II System*





1 FOR OPERATING STOP VALVES

2 FOR WITHDRAWING V-BELT GUARD

3 FOR WITHDRAWING CRANKSHAFT

	COOLING SYSTEM	CONNEC.FOR LIQUID REFRIG.
4	R22 OIL COOLER	G1/4
	R717 OIL COOLER (BOOSTER)	G1/4
5	R717 THERMOPUMP.SYSTEM	G1/4

6 WATER INLET AND OUTLET G3/8 (COMPR. WITH WATER COOLING ONLY)

			WELDING CONNECTIONS	
		COMPR.	R717	(H)CFC
7	SUCTION	SMC 104	M76.1x4.5	M88.9x3.2
		SMC 106 SMC 108	M88.9x4.85	M114.3x3.6
8	DISCHARGE	ALL	M76.1x2.9	

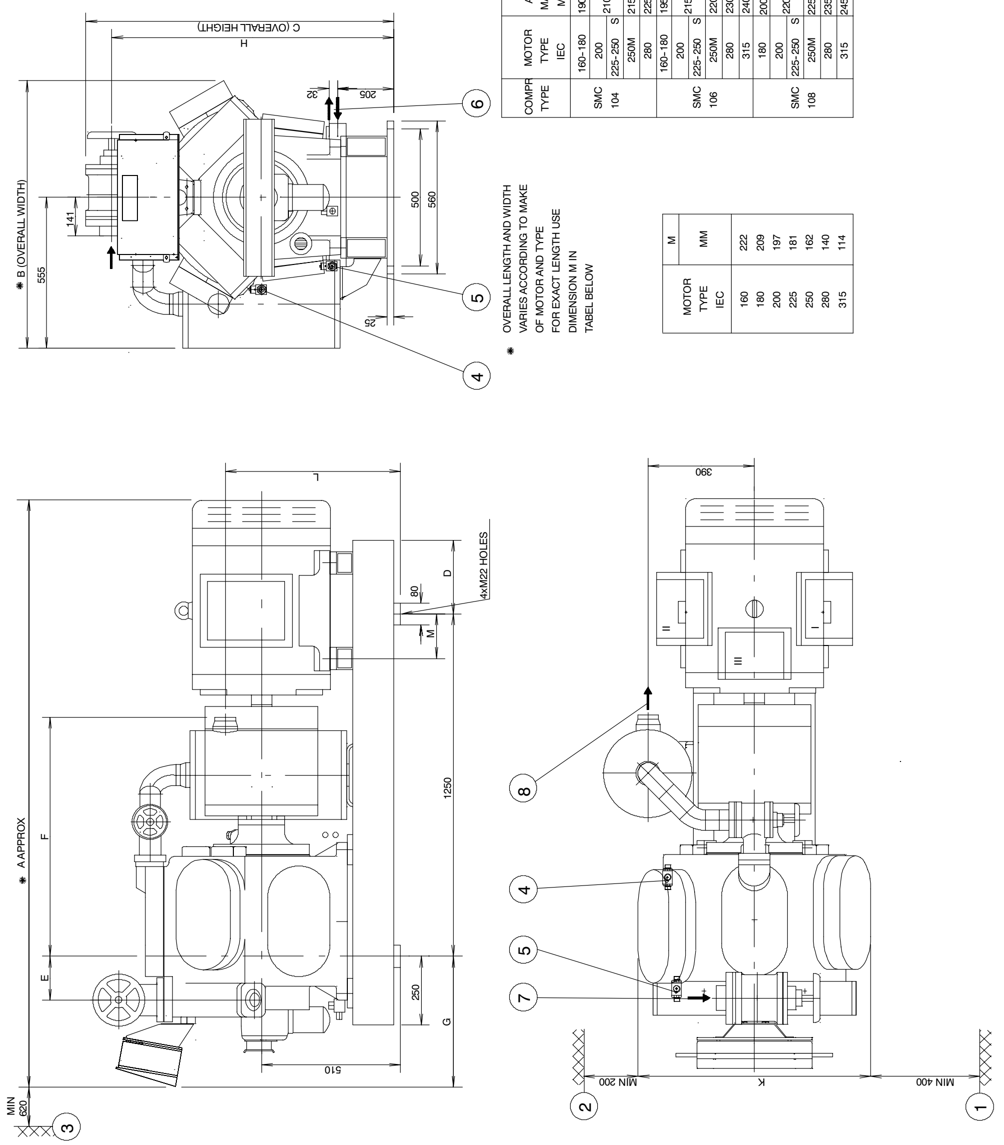
COMPR TYPE	MOTOR TYPE IEC	A MAX MM	B MM	C MM	D MM	E MM	F MM	G MM	I MM	K MM	FOUND. DRWG. NO.	WEIGHT OF UNIT EXCL. MOTOR
SMC104	200-315M	2050	1168	1095	1000	275	440	350	635	635	171438	880 KG
SMC106	200-315M	2010	1053	1130	1035	275	395	395	645	620	171438	[illegible]
SMC108	200-315M	2020	1193	1125	1030	300	405	405	665	635	171438	

MOTOR TYPE IEC	H MAX
200	1015
225	1115
250	1235
280	1335
315	1435

✱ OVERALL LENGTH AND WIDTH VARIES ACCORDING TO MAKE OF MOTOR AND TYPE FOR EXACT LENGTH USE DIMENSION H IN TABEL

6. Technical Data

Fig. 6.3 *SMC 100, Direct Driven, UNISAB II System*



① FOR OPERATING STOP VALVES

② FOR WITHDRAWING PISTONS AND SUCTION FILTER

③ FOR WITHDRAWING CRANKSHAFT

	COOLING SYSTEM	CONNEC.FOR LIQUID REFRIG.
④	R22 OIL COOLER R717 OIL COOLER (BOOSTER)	G1/4
⑤	R717 THERMOPUMP.SYSTEM	G1/4
⑥	WATER INLET AND OUTLET	G3/8

			WELDING CONNECTIONS	
		COMPR.	R717	(H)CFC
⑦	SUCTION	SMC 104	M76.1x2.9	M88.9x3.2
		SMC 106	M88.9x3.2	M114.3x3.6
		SMC 108		
⑧	DISCHARGE	ALL	M76.1x2.9	

✱ OVERALL LENGTH AND WIDTH VARIES ACCORDING TO MAKE OF MOTOR AND TYPE FOR EXACT LENGTH USE DIMENSION M IN TABEL BELOW

MOTOR TYPE IEC	M MM
160	222
180	209
200	197
225	181
250	162
280	140
315	114

COMPR TYPE	MOTOR TYPE IEC	A MAX MM	B MM	C MM	D MM	E MM	F MM	G MM	H MM	K MM	L MM	FOUND. DRWG. NO.	WEIGHT OF UNIT EXCL. MOTOR
SMC 104	160-180	1900	995	1095	270	135	900	393	1000	830	635	171427	830 KG
	200	2100											
	225-250 S											204847	
	250M	2150											
	280	2250			440							171426	
SMC 106	160-180	1950	995	1130	270	160	875	418	1035	875	645	171427	925 KG
	200	2150											
	225-250 S											204847	
	250M	2200											
	280	2300			440							171426	
	315	2400											
SMC 108	180	2000	1005	1125	270	185	875	443	1030	900	665	171427	990 KG
	200	2200											
	225-250 S											204847	
	250M	2250											
	280	2350			440							171426	
	315	2450											

Planning the Machine Room

When planning the machine room, make sure that there is enough space around the compressor. The minimum spacing is indicated below, see Fig. 6.4, Fig. 6.5 and Fig. 6.6.

Space 1:	500 mm [20”]
Space 2:	400 mm [16”]
Space 3:	
SMC 104-106-108, TSMC 108	600 mm [24”]
SMC 112-116, TSMC 116	1100 mm [43”]

Fig. 6.4

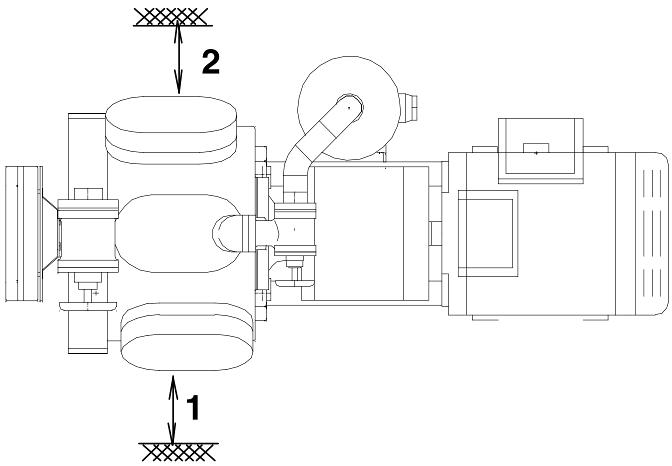


Fig. 6.5 *Compressor Block with Analog System*

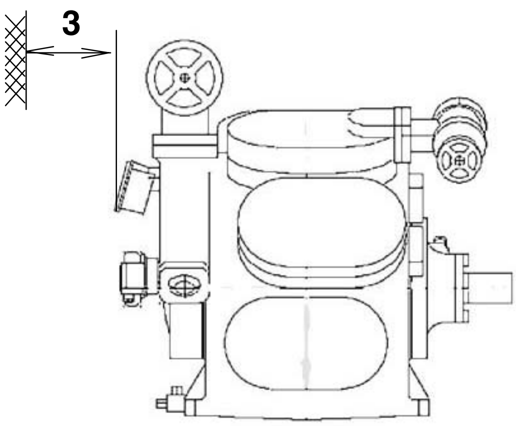
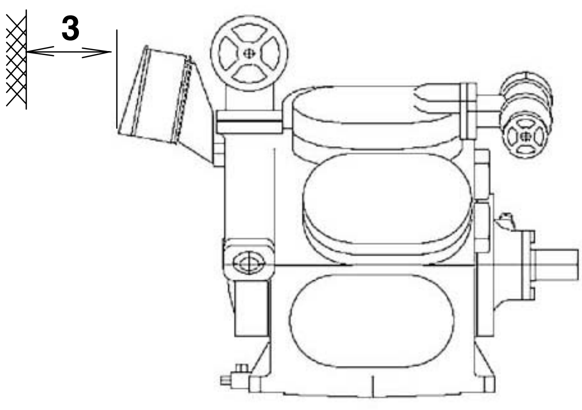


Fig. 6.6 *Compressor Block with UNISAB II System*



Enough room must be left around the compressor to allow the operating personnel to operate the compressor ①and carry out service work on the compressor ②. Space should be considered ③as sufficient space to make it possible to take out the crankshaft without dismounting the compressor from the base frame.

Operating Limits Diagrams

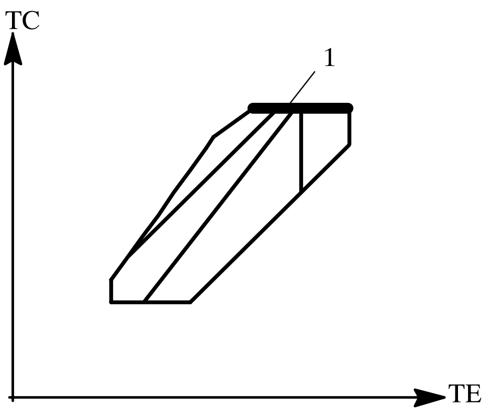
To make sure that Sabroe Refrigeration's customers experience a satisfactory compressor operation within the specified operating periods between the service intervals, it is essential that the operating conditions are kept within certain permitted operating limits.

The operating limits are specified in the following *Operating Limits Diagrams.* Sabroe Refrigeration is only liable in so far as the operating limits conditions of the compressor are kept within the limitation of the curvas. Similary, the recommendation concerning the number of revolutions and cooling of the compressor must be observed.

The limitation curves have been determined on the basis of both constructional and operating conditions.

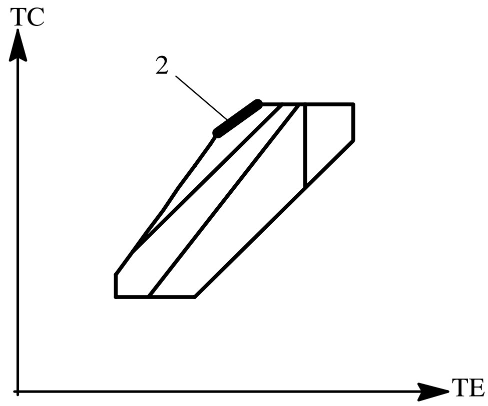
1. **Max Permissible Condensing Pressure:** The pressure limit corresponds to the test pressure which is applied to all compressors and as indicated under *Test Pressure* in this section.

Fig. 6.7



2. **Max Permissible Differential Pressure across the Pistons:**

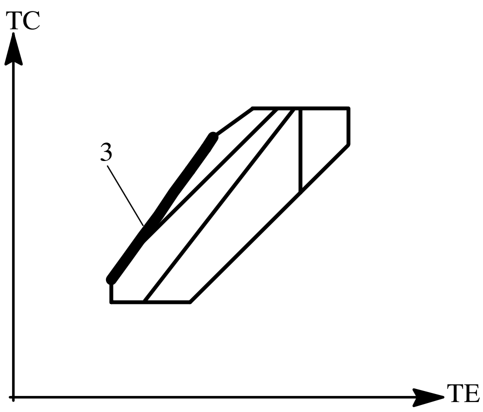
Fig. 6.8



3. **Permissible Compression Ratios π:** The compression ratio is calculated into the diagram with the following values:
Max. value or π for:

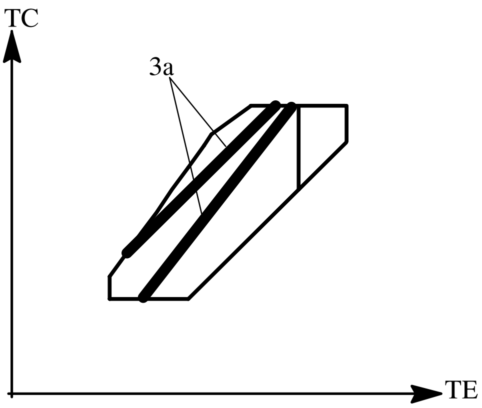
- R717	8 (7 for SMC 100 E)
- R134a	12
- R22	10
- R407C	10
- R404A	14
- R507	14

Fig. 6.9



3a. **Limitation of the Compressor rpm:** The limitation has been introduced in order to avoid excessive discharge gas and oil temperatures.

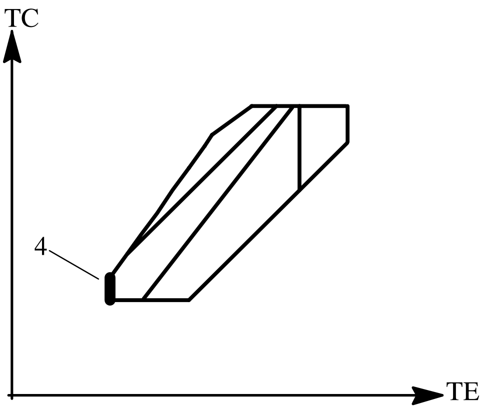
Fig. 6.10



4. The Lowest Permissible Suction Pressure:

The limit has been fixed at approx 0.5 bar and 5.6 bar for R744 (CO_2 triple point).

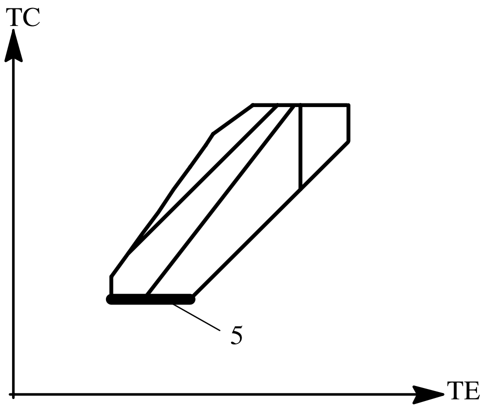
Fig. 6.11



5. The Lowest Permissible Condensing Pressure:

At condensing pressures lower than the ones specified, the dampening effect from the gas on the valve plates against the valve retaining plate is reduced. This increases the risk of valve breakdown.

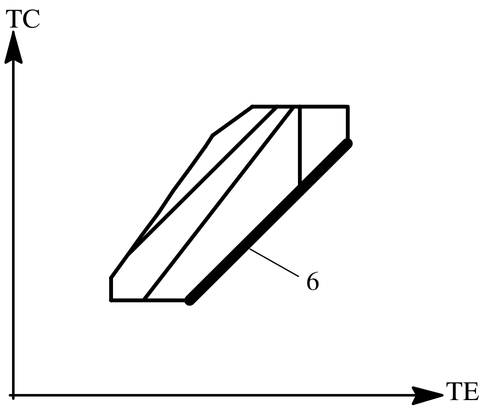
Fig. 6.12



6. Minimum Difference between Condensing and Evaporating Temperature:

If there is less difference than specified, the compressor will not get sufficiently warm. Lubrication problems may occur when the refrigerant content in the oil is too high with a subsequent risk of oil foaming in the compressor.

It should also be noted that some of the equipment in a refrigeration plant requires a certain pressure difference in order to function properly.

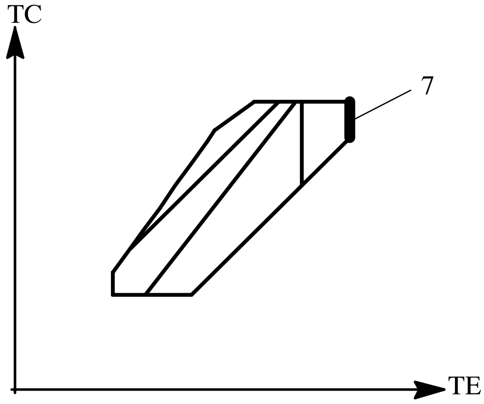


7. The Highest Permissible Evaporating Pressure:

In the crankcase there will always be an evaporating pressure. An increase in the evaporating pressure will increase the load on the thrust bearing at the crankshaft as well.

Furthermore, the refrigerant content in the oil is going to increase, primarily refrigerants used with soluble oil, and this may cause lubrication problems. The HFC and HCFC refrigerants, which are relatively heavy, will raise the pressure drop through the discharge and suction valves and this will impede the proper functioning of the valves.

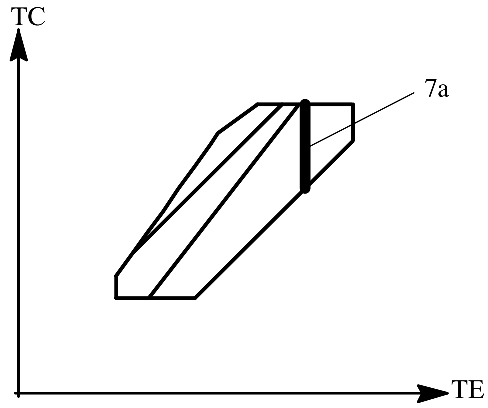
Fig. 6.13



7a. The Highest Permissible Evaporating Pressure:

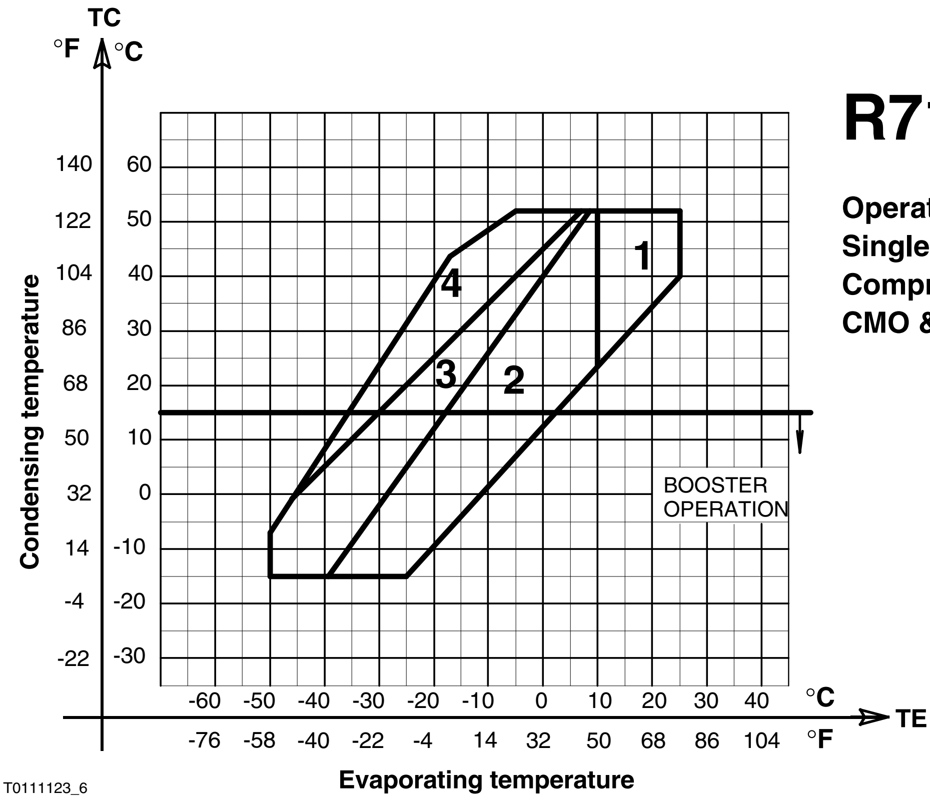
The limitation curves represent the highest permissible suction pressure without reducing the number of revolutions.

Fig. 6.14



The following *Operating Limits diagrams* include the refrigerants: R717, R134a, R22, R407C, R404a, R410A, R507 and R744.

The cooling systems for compressors which are mentioned in the *Operating Limits Diagrams* below are described in detail in chapter 4, Technical Description - *Cooling Systems for Compressors.*



R717

Operating Limits Single-Stage Compressor Type CMO & SMC

TYPE	AREA	rpm		COOLING	NOTE
		max.	min.		
CMO20/30	1 - 2	1800	900	Air cooled top- and side covers # or water-cooled	
	3			Thermopump or water-cooled	
	4				1)
SMC100S/L	1 - 2	1500	700	Air cooled top - and side covers # or water-cooled	
	3			Thermopump or water cooled	
	4				1)
SMC180	1	750	450	Water-cooled	
	2 - 3 - 4	1000*			

* SMC 188: 840 - 920 RPM not allowed.

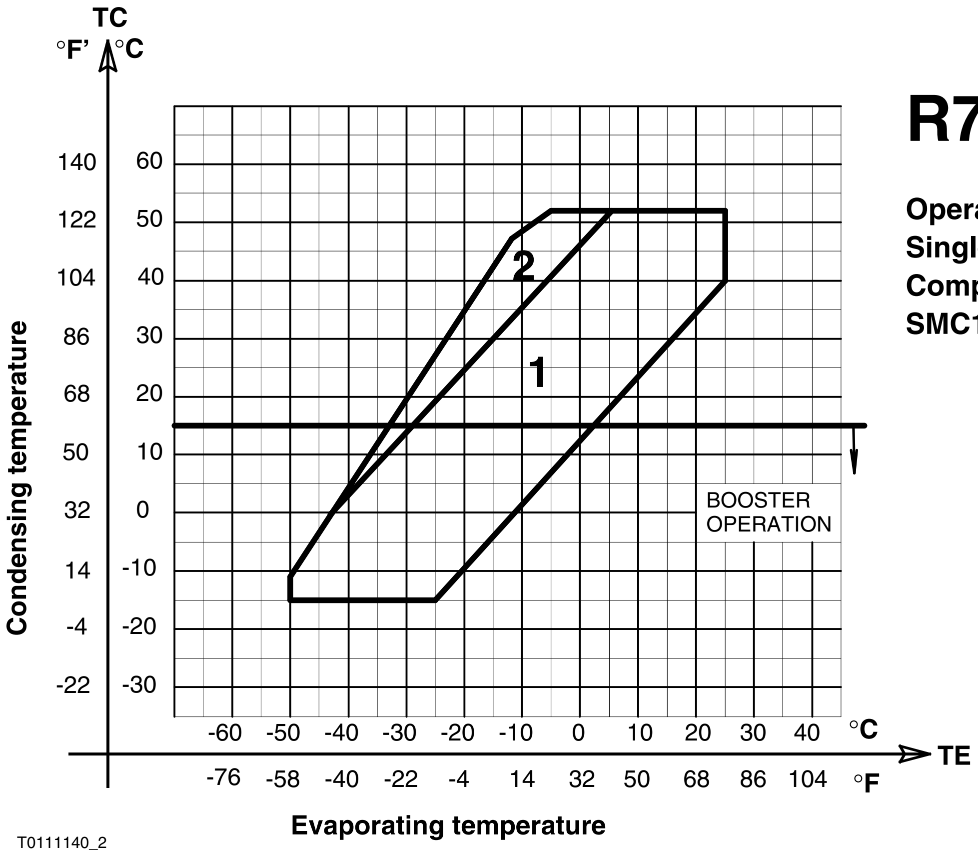
Included refrigerant cooled oil cooler.

Thermopump:
Top and side covers are cooled by injected refrigerant.
Oil cooling is included in the system.

Water-cooled:
Top and side covers are water-cooled.
Oil cooling is included in the system.

Discharge temperature must not exceed 150°C (302°F) at full load and at part load.

1) Discharge temperature at part load has to be checked.
Booster operation: Only water cooling available.



R717

Operating Limits
Single-Stage
Compressor Type
SMC100E

TYPE	AREA	rpm		COOLING		NOTE
		max.	min.	Booster	HP conditions	
SMC100E	1	1500	700	Water cooling only	Thermopump or water cooled	1)
	2					2)

Thermopump:
Top and side covers are cooled by injection refrigerant.

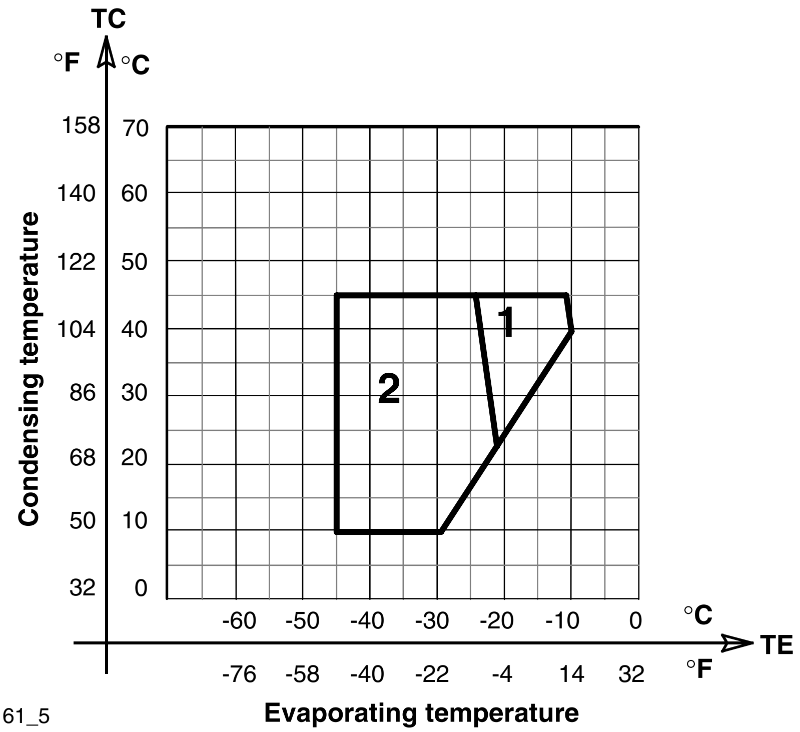
Oil cooling is included in the system.

Water-cooled:
Top and side covers are water-cooled.

Oil cooling is included in the system.

Discharge temperature must not exceed 150°C (302°F) at full load and at part load.

1) Discharge temperature at part load has to be checked.
2) In this area the compressor is not allowed to run at a capacity below 50%. For higher loads discharge temperature must be checked.



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R717

Operating limits
Two-Stage
Compressors
TCMO & TSMC

–

Type	Area	rpm		Cooling	Note
		max	min		
TCMO20/30	1	1800	900	Thermopump or water-cooled	
	2				2)
TSMC 100 S-L-E	1	1500	700	Thermopump or water-cooled	1)
	2				1) and 2)
TSMC 180	1	750	450	Water-cooled	1)
	2	1000			1) and 2)

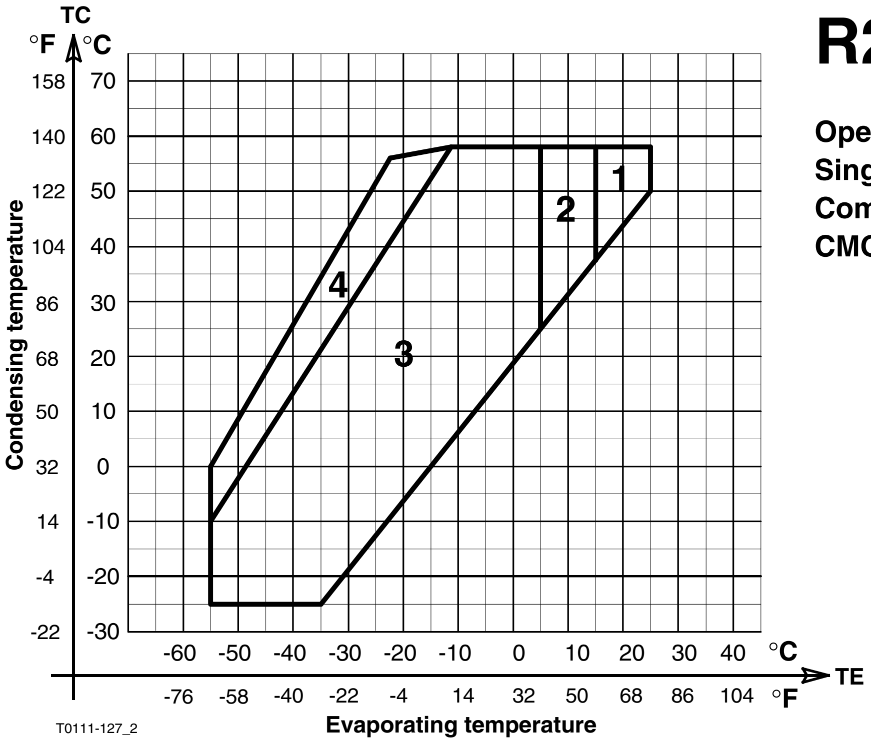
Thermopump:
High Stage Top covers are cooled by injected refrigerant
Oil cooling are included in the system

Water-cooled:
Top and side covers are water-cooled.
Oil cooling are included in the system.

Discharge temperature must not exceed 150°C (302°F) at full load and at part load.

Part-load operation:

1) Depending on the operating conditions and the pressure on the compressor, a by-pass system may be required.
2) Discharge temperature at part load has to be checked.



R22

Operating Limits
Single-Stage
Compressor type
CMO & SMC

TYPE	AREA	RPM		OIL COOLING REQUIRED1)	REMARKS
		MAX.	MIN.		
CMO20/30	1	1500	900	No	
	2			No	
	3	1800		At less than 50% capacity	
	4			Yes	
SMC100S	1	1000	700	No	
	2	1200		No	
	3	1800		At less than 50% capacity	
	4			Yes	
SMC100L	1				2)
	2	1000	700	No	
	3	1200		At less than 50% capacity yes	
	4			Yes	
SMC180	1-2				2)
	3	750	450	At less than 50% capacity yes	
	4			Yes	

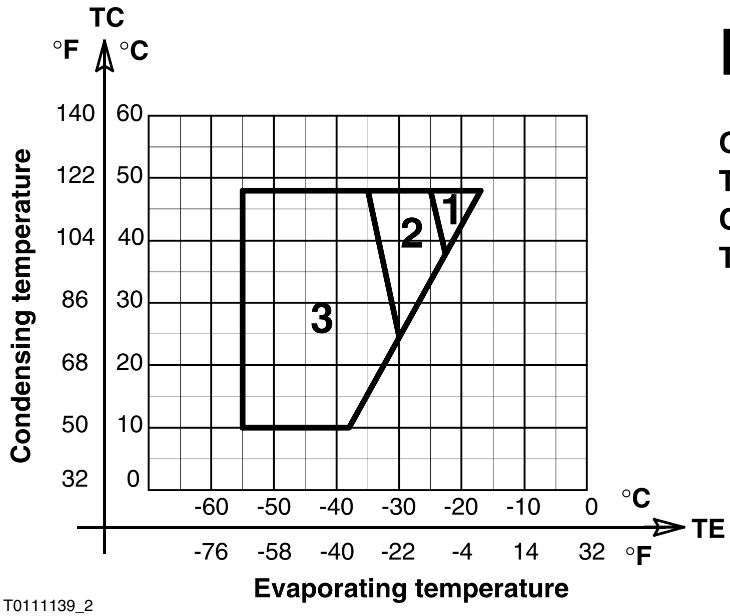
Top covers: Air-cooled only

1) When required, choose freely between **A** or **B** **<u>- except SMC180</u> where only A may be selected.**

A: Water-cooled side covers

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

2) Not applicable.



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R22

Operating Limits
Two-Stage
Compressor type
TCMO & TSMC

TYPE	AREA	RPM		OIL COOLING 1)	NOTE
		MAX.	MIN.		
TCMO20/30	1-2	1500	900	No	
	3	1800			
TSMC100S	1	1000	700	Yes	2)
	2	1200			
	3	1800			
TSMC100L	1				3)
	2	1000	700	Yes	2)
	3	1200			
TSMC180	1-2				3)
	3	750	450	Yes	2)

Top covers: Air-cooled only.

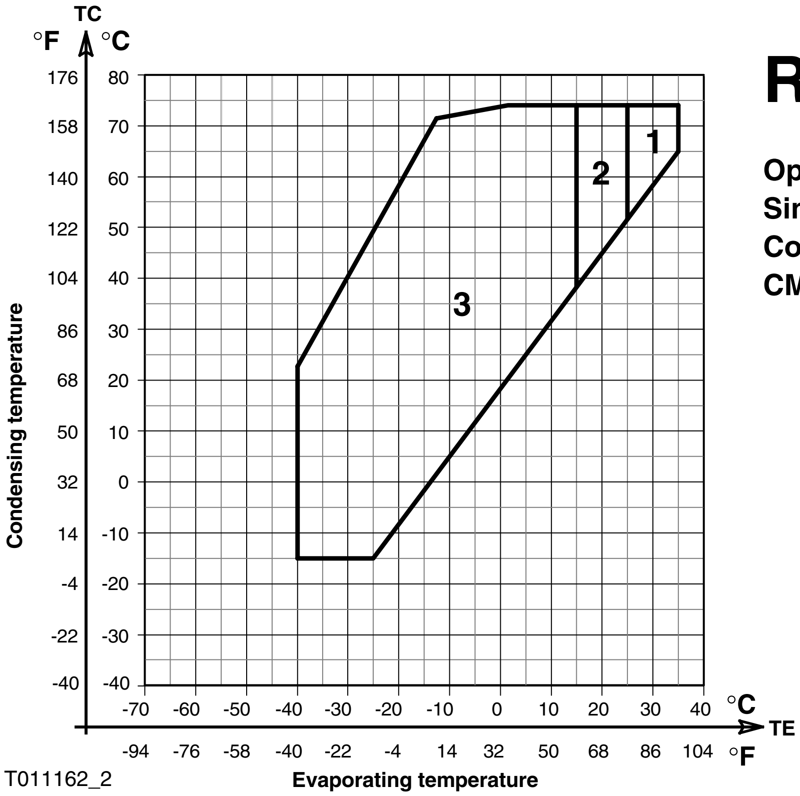
1) When required, choose freely between **A** or **B** **- except TSMC180 where only A may be selected.**

A: Water cooled side covers

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

2) By-pass equipment required to maintain intermediate temperature

3) Not applicable.



R134a

Operating Limits
Single-Stage
Compressor type
CMO & SMC

<table>
<tr><th rowspan="2">TYPE</th><th rowspan="2">AREA</th><th colspan="2">RPM</th><th rowspan="2">OIL-COOLING 1)</th><th rowspan="2">NOTE</th></tr>
<tr><th>MAX.</th><th>MIN.</th></tr>
<tr><td rowspan="4">CMO20/30</td><td rowspan="2">1-2</td><td>1200</td><td rowspan="4">900</td><td>No</td><td rowspan="4"></td></tr>
<tr><td rowspan="2">1500</td><td>At less than 50% capacity</td></tr>
<tr><td rowspan="2">3</td><td>No</td></tr>
<tr><td>1800</td><td>At less than 50% capacity</td></tr>
<tr><td rowspan="4">SMC100S</td><td>1</td><td>1000</td><td rowspan="4">700</td><td>No</td><td rowspan="3"></td></tr>
<tr><td>2</td><td rowspan="2">1200</td><td>No</td></tr>
<tr><td rowspan="2">3</td><td>No</td></tr>
<tr><td>1500</td><td>At less than 50% capacity</td><td></td></tr>
<tr><td rowspan="4">SMC100L</td><td>1</td><td colspan="3"></td><td>2)</td></tr>
<tr><td>2</td><td rowspan="2">1000</td><td rowspan="3">700</td><td>No</td><td rowspan="3"></td></tr>
<tr><td rowspan="2">3</td><td>No</td></tr>
<tr><td>1200</td><td>At less than 50% capacity</td></tr>
</table>

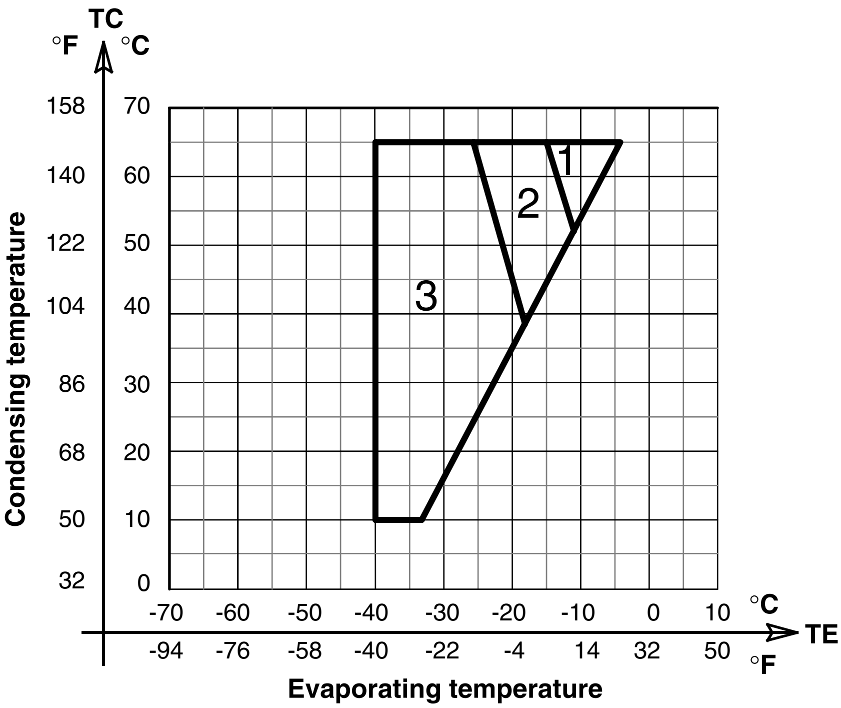
Top and side covers: Air-cooled

1) When required, choose freely between **A** or **B**

A: Water-cooled side covers

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

2) Not applicable.



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R134a

Operating limits
Two-Stage
Compressors
TCMO
TSMC 100 S-L

Type	Area	rpm		Oil-cooling required 1)	Note
		max	min		
TCMO20/30	1	1500	900	No	1)
	2	1800			
	3	1500			
TSMC 100 S	1	1000	700	No	1)
	2	1200			
	3	1500			
TSMC 100 L	1				2)
	2	1000	700	No	1)
	3	1200			

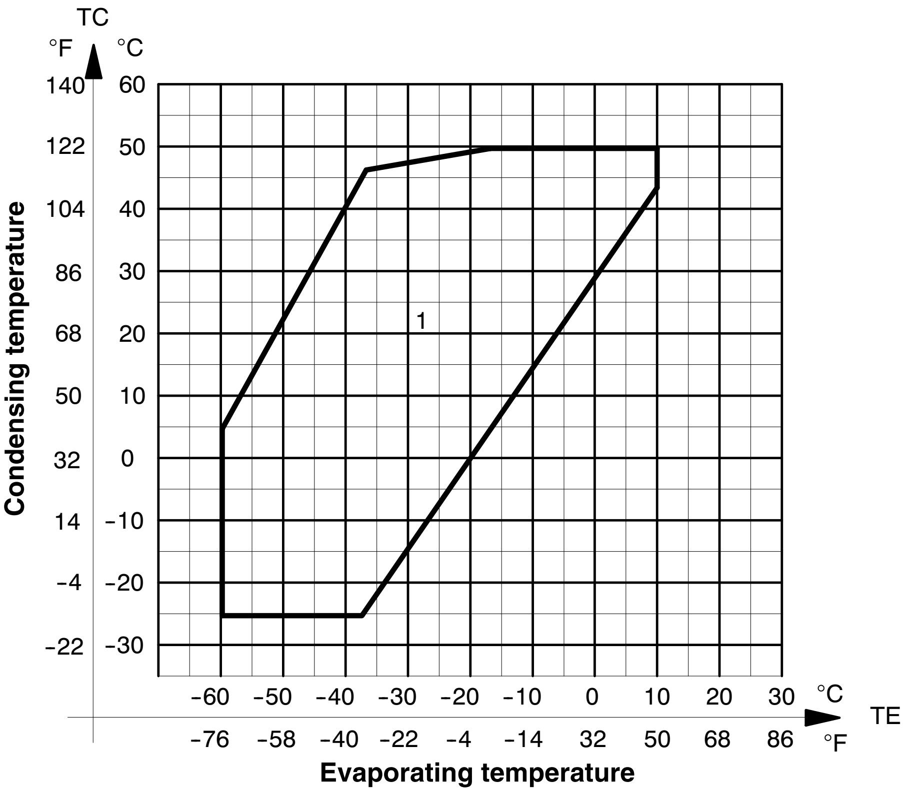
Top- and side covers: Only air-cooled.

1) **Part-load operation:**
By-pass equipment required to maintain intermediate temperature at minimum load.

2) Not applicable

R404A

Operating Limits
Single-Stage
Compressors type
CMO & SMC



T0111164_2

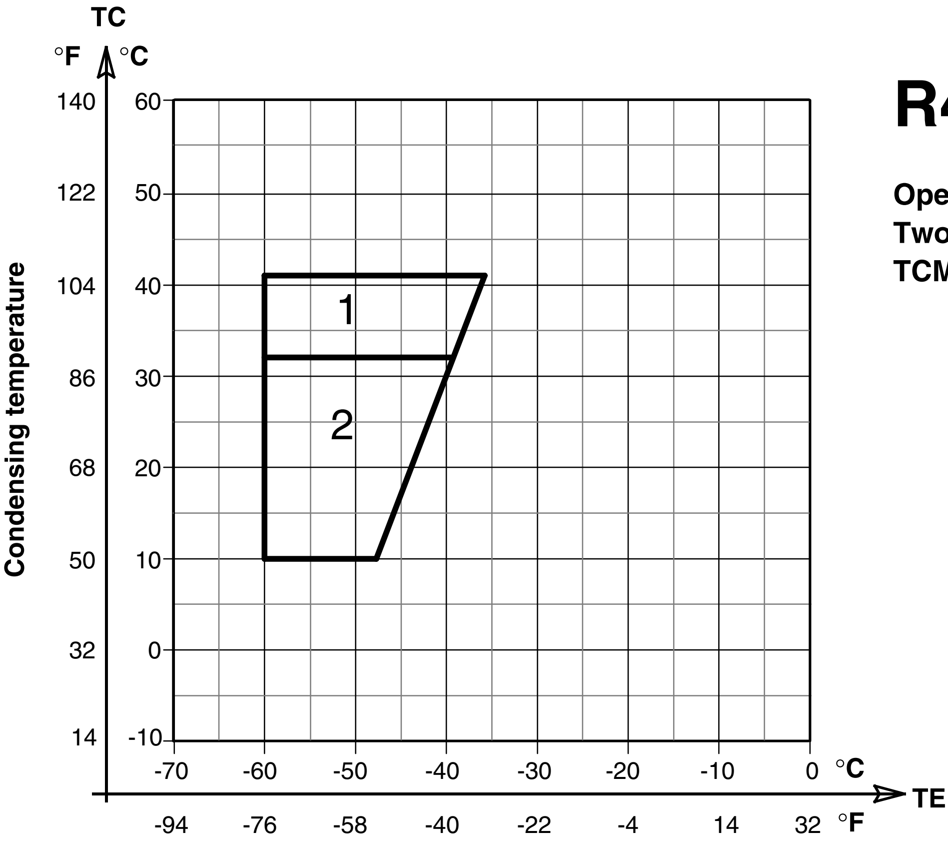
TYPE	AREA	RPM		OIL COOLING 1)	NOTE
		MAX.	MIN.		
CMO20	1	1500	900	No	
		1800		At less than 50% capacity	
SMC100S	1	1200	700	No	
		1500		At less than 50% capacity	
SMC100L	1	1200	700	No	

Top covers: Air-cooled design only.

1) When required, choose freely between **A** or **B**

A: Water-cooled side covers.

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



T0111165_1

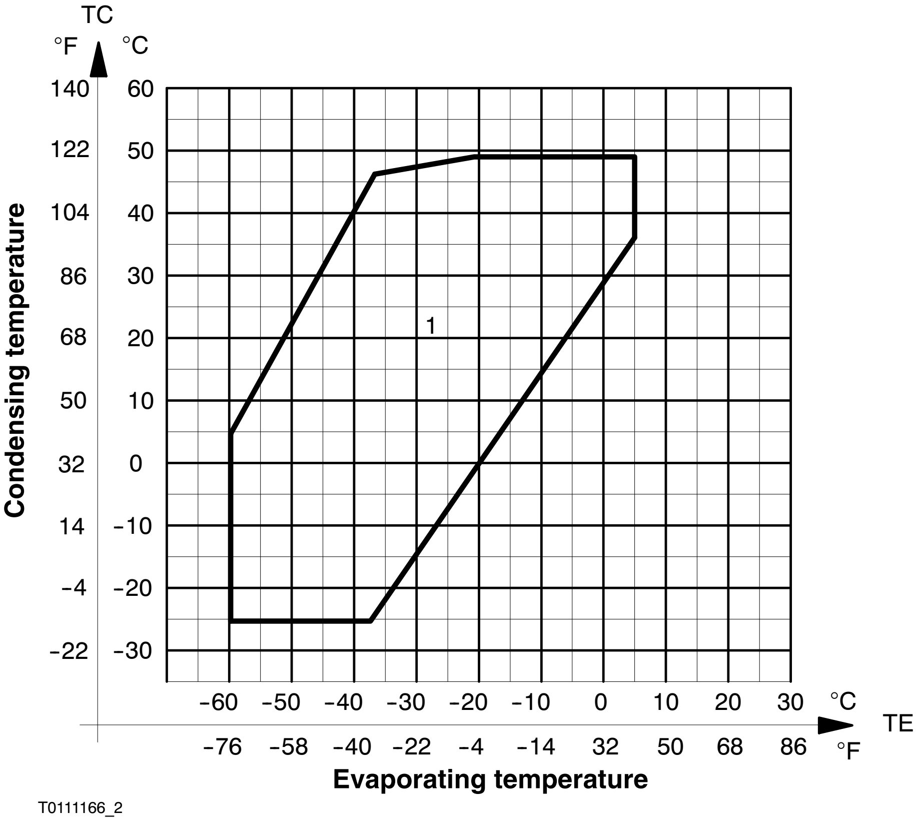
R404A

Operating Limits
Two-Stage
TCMO & TSMC

TYPE	AREA	RPM		OIL COOLING	NOTE
		MAX.	MIN.		
TCMO20	1	1800	900	No	
	2				
TSMC100S	1	1200	700	No	1)
	2	1500			
TSMC 100L	1	1000	700	No	1)
	2	1200			

Top and side covers: Air-cooled only.

1) **Part-load operation:**
By-pass equipment required to maintain intermediate temperature at minimum load.



R507

Operating Limits
Single-Stage
Compressor type
CMO & SMC

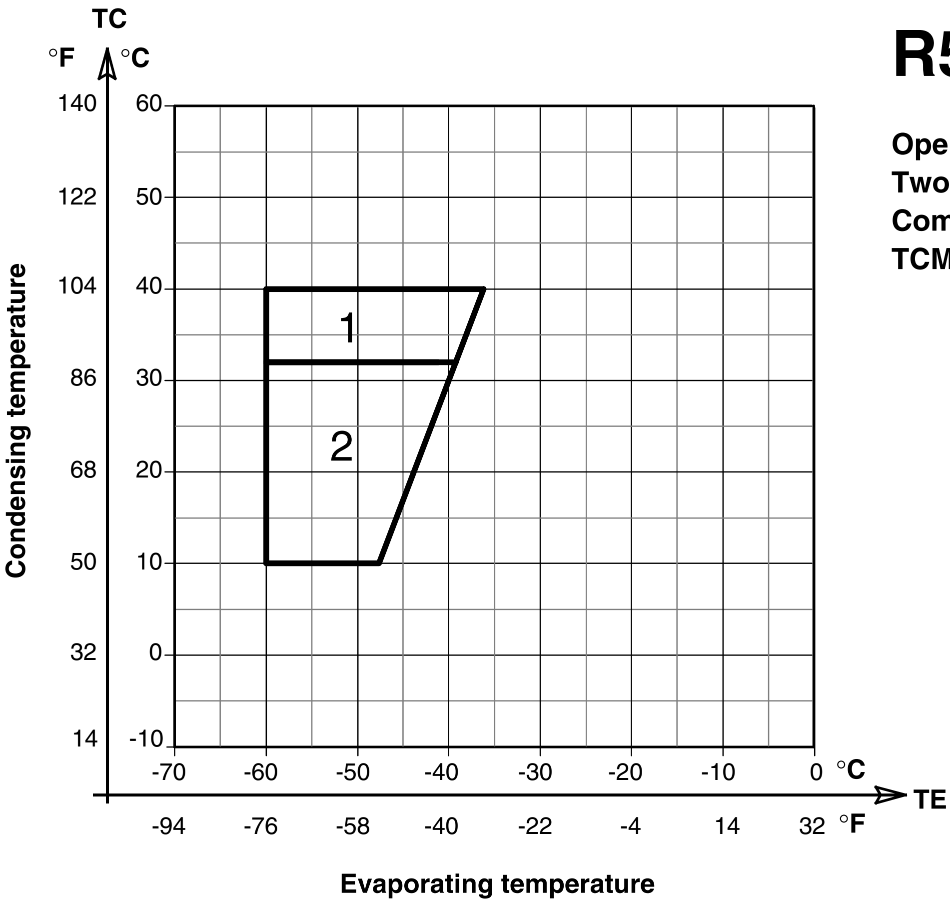
TYPE	AREA	RPM		OIL COOLING 1)	NOTE
		MAX.	MIN.		
CMO20	1	1500	900	No	
		1800		At less than 50% capacity	
SMC100S	1	1200	700	No	
		1500		At less than 50% capacity	
SMC100L	1	1200	700	No	

Top covers: Air-cooled only.

1) When required, choose freely between **A** or **B**

A: Water-cooled side covers.

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



T0111167_1

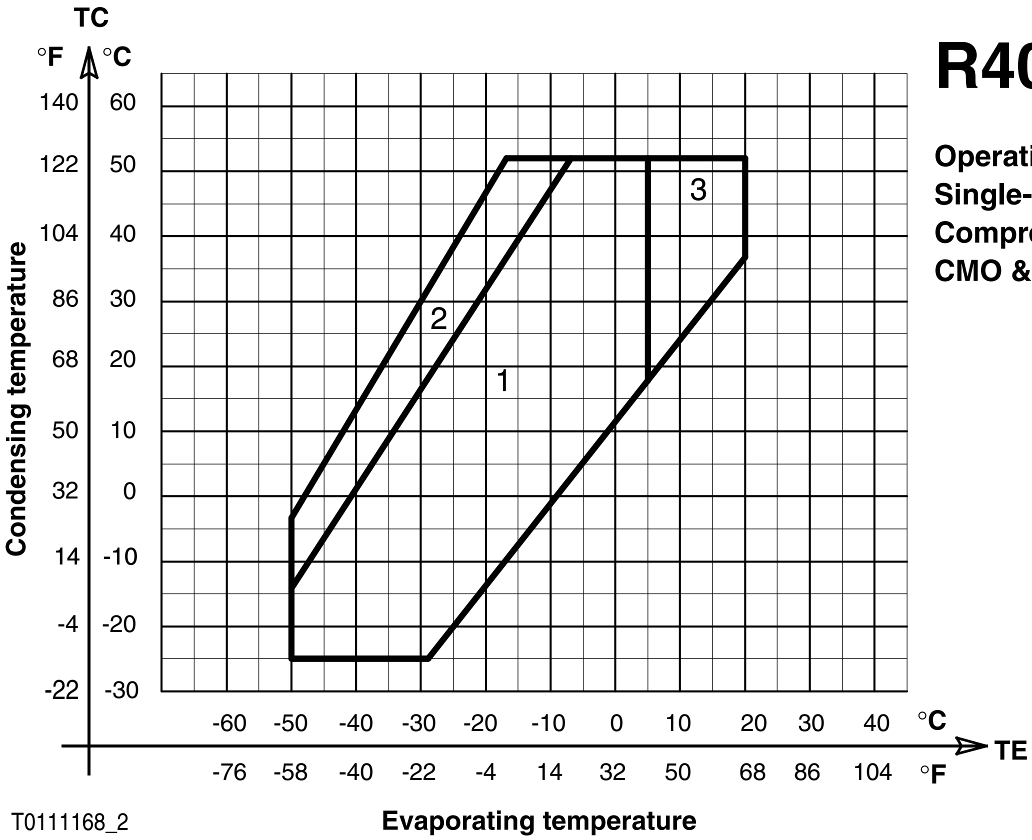
R507

Operating Limits
Two-Stage
Compressor
TCMO & TSMC

TYPE	AREA	RPM		OIL COOLING REQUIRED	NOTE
		MAX.	MIN.		
TCMO20	1	1800	900	No	
	2				
TSMC100S	1	1200	700	No	1)
	2	1500			
TSMC100L	1	1000	700	No	1)
	2	1200			

Top- and side covers: Air-cooled only.

1) **Part-load operation:**
By-pass equipment required to maintain intermediate temperature at minimum load.



R407C

Operating Limits Single-Stage Compressors CMO & SMC

TYPE	AREA	RPM		OIL COOLING 1)	NOTE
		MAX.	MIN.		
CMO20	1	1800	900	At less than 50% capacity	
	2			Yes	
	3	1500		No	
SMC100S	1	1500	700	At less than 50% capacity	
	2	1200		Yes	
	3			No	
SMC100L	1	1200	700	At less than 50% capacity	
	2	1000		Yes	
	3			No	

Top and side covers: Air-cooled only.

1) When required, choose freely between **A** or **B**

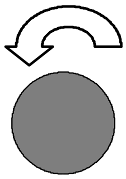
A: Water-cooled side covers.

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

Direction of Rotation of the Compressor

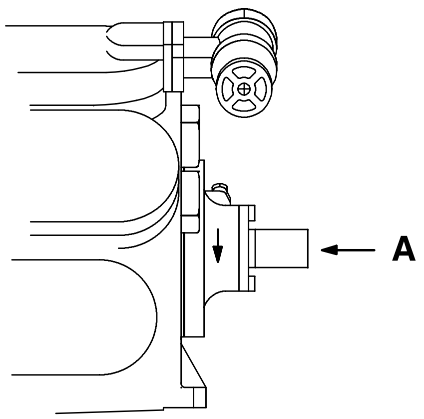
The normal direction of rotation for the compressors is **anti-clockwise** when looking at the compressor from the shaft end.

Fig. 6.15 *Direction of rotation for compressor seen from A*



An arrow cast into the bearing cover indicates the direction of rotation as shown in the picture.

Fig. 6.16



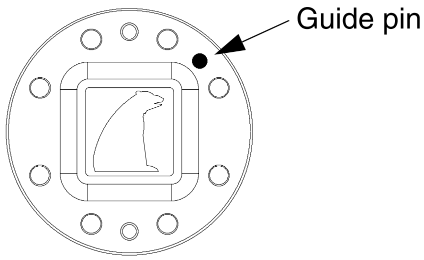
At times it may be necessary that the crankshaft rotates in the opposite direction, e.g. if the compressor is connected to a combustion motor with a specified direction of rotation.

In such cases the oil pump must be changed as it is uni-directional.

The direction of rotation for the pump is indicated by a guide pin.

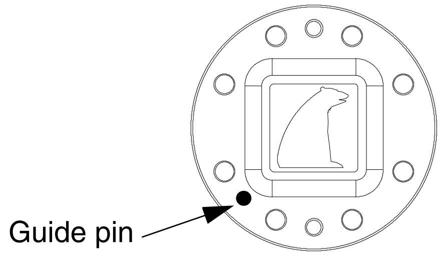
- Counterclockwise compressor rotation: Marking in cover to the right of the logo.

Fig. 6.17



- Clockwise compressor rotation: Marking in cover to the left of the logo.

Fig. 6.18

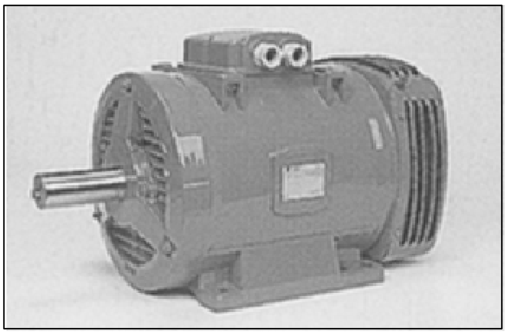


06 technical data.fm

Choice of Electric Motor

The IEC electric motors type IP23 or IP54 (55) (IP= Index of Protection) are normally used to drive the compressors, and the base frames are standard design for these motors.

Fig. 6.19 *IP23 Drip-proof Motor*



When selecting an electric motor, the following factors must be taken into consideration:

Motor Dimension

The size of the motor is determined on the basis of the power demands of the compressor under the current operating conditions calculated by means of the **Sabroe COMP1 PC** program.

However, for various reasons, always choose a motor a little bigger. The reason for this is explained in the following:

A. Generally speaking, the calculated power demand should be increased by one of the following factors in order to ensure that the motor has sufficient driving power, both during start-up, at minor deviations from the worked out operating conditions and with regard to mechanical transmission loss for instance in the V-belt drive:

1:	Air conditioning plant:	Factor 1.10
2:	Other refrigeration plants:	Factor 1.15
3:	For V-belt drive:	Factor 1.05

B. Do consider, however, which type of plant the compressor is going to work on, and then dimension the motor in accordance with the following rules:

a: For plants in which a higher ET may be expected, and consequently also a higher CT in the start-up phase, the motor must be dimensioned to meet the higher operating temperatures. Usually, this does not incorporate factor 1 and 2.

Likewise, special consideration should be given concerning the booster compressors.

b: Alternatively, the motor can be connected to a system for Ampere limitation which reduces the compressor capacity until the planned operating temperatures have been reached. This element is found in UNISAB II, which must be linked to the Amp. signal, however. In this case, factor 1 and 2 should also be omitted.

Note: Sabroe Refrigeration would like to point out that when using a motor with a class F insulation (105K) for operating conditions like for class B (90K), approx. 10% continual overloading of the motor will be acceptable in connection with the nominal effect.

As mentioned previously, all compressors are as standard **completely unloaded** during the start-up phase. This reduces the power consumption of the compressor considerably as may be seen from the starting torque curve, Fig. 6.20.

As standard, the SMC 100 can only be capacity regulated in steps of two cylinders, which is usually satisfactory. If required, extended unloading can be ordered when the order is placed or it can be mounted at a later time.

For more information on this subject, see chapter 4, Technical Description - Extended unloading of the Compressor.

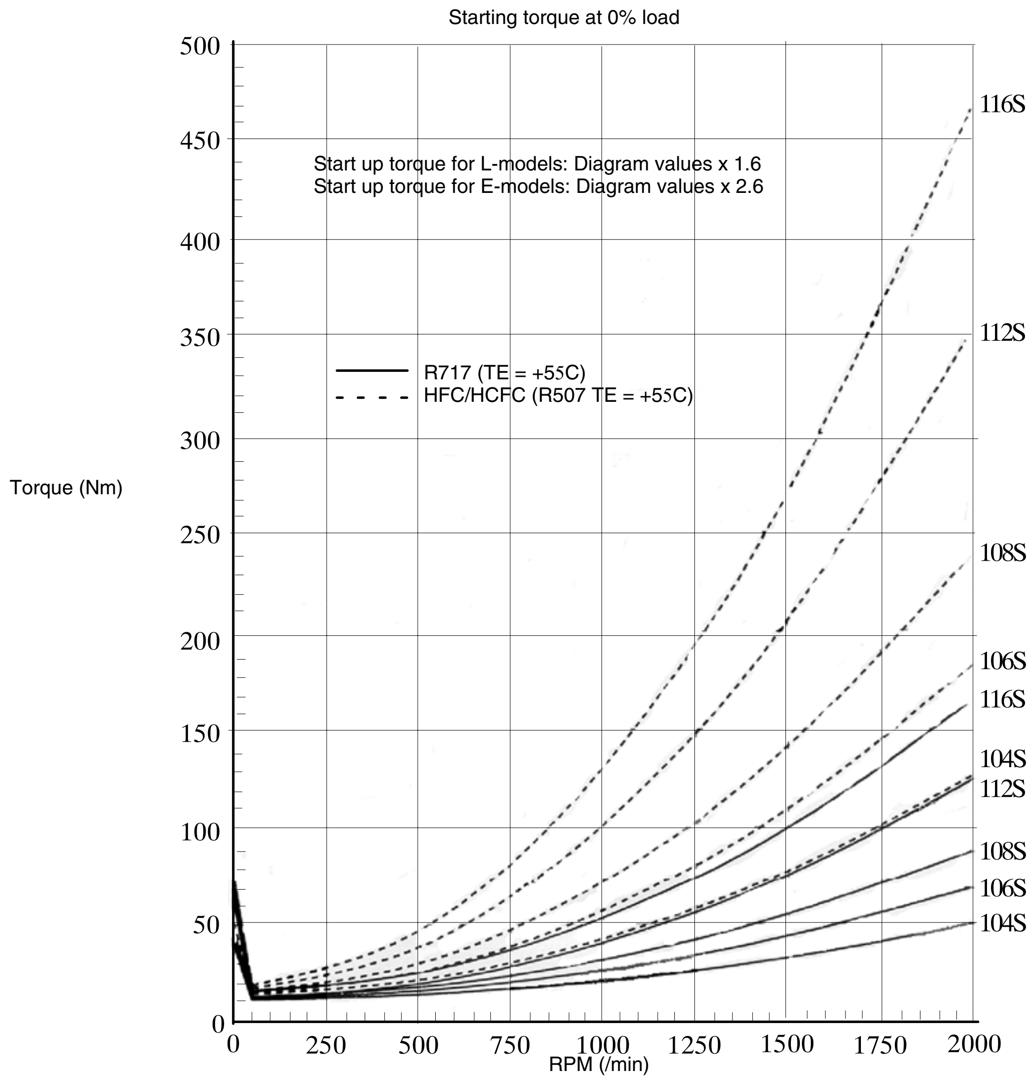
The starting torque for compressors with extended unloading appears from Fig. 6.22 and Fig. 6.23.

Please note that moment of inertia is not included in the diagrams. Further pay attention to the fact that the motor should reach its maximum torque before the non-adjustable cylinders are put into operation.

The maximum time for reaching minimum rpm (TSMC 100 : 750 rpm.) is 5 sec. and nominal speed should be reached after max. 10 sec.

For more information on this, see chapter 4, Technical Description - Capacity Regulation and Unloading of the Compressor.

Fig. 6.20



STARTING TORQUE FOR COMPRESSOR SMC/TSMC/HPC100

Starting torque of the compressor

The motor size is usually selected as described in the previous section. With all cylinders unloaded during the starting-up phase the motor generally has sufficient starting power in order to bring the compressor at full speed before the cylinders are loaded. Read more in chapter 4, Technical Description - *Capacity Regulation and Start Unloading of the Compressor.*

At times, however, it may be a good idea to compare the starting torque curve of the compressor to the starting curve of the motor (this information can be obtained from the motor manufacturer). Especially, when the compressor starts at a plant pressure below normal and when power limiting systems are used to start up the motor, e.g. a Y/ Δ starter, it may be necessary to work out a diagram as the one shown in Fig. 6.21. The hatched area represents the torque available to the motor when speeding up the compressor.

Fig. 6.21 *Starting Torque Curve for Electromotors*

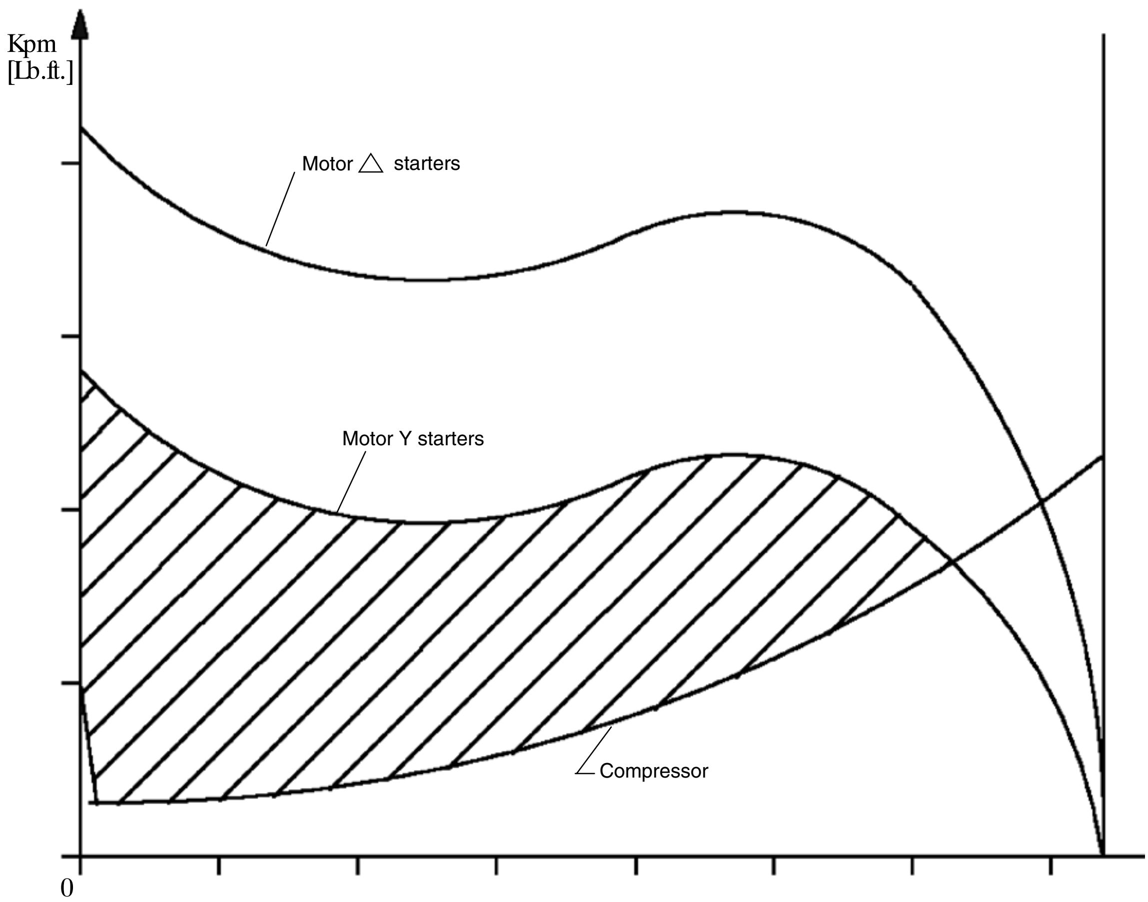
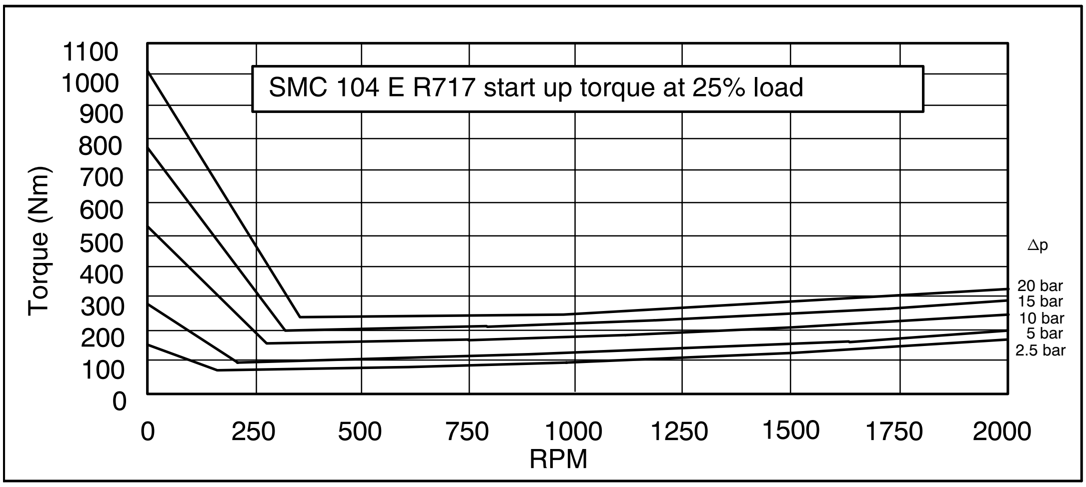
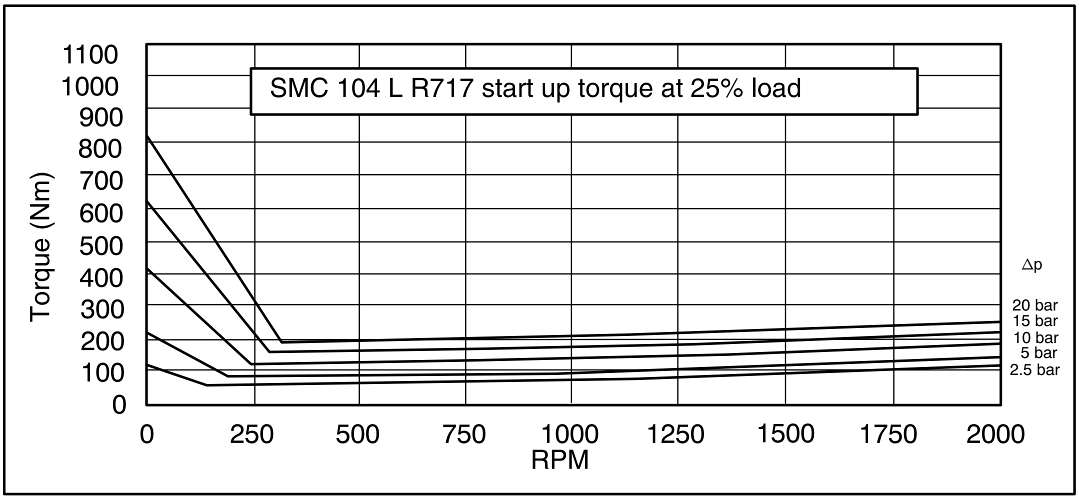


Fig. 6.22 *Start up torque SMC 100 R717 25% load*





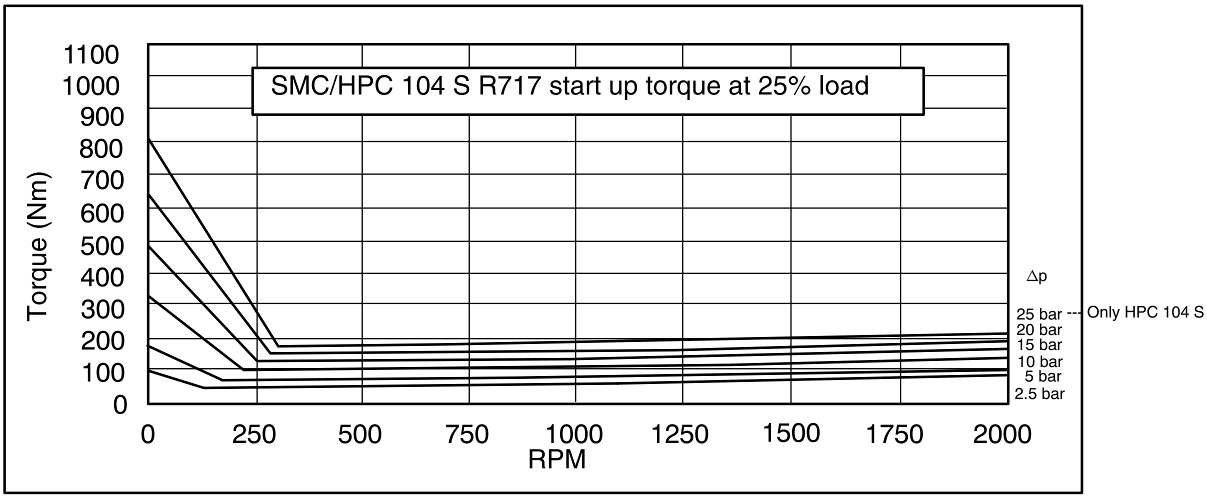
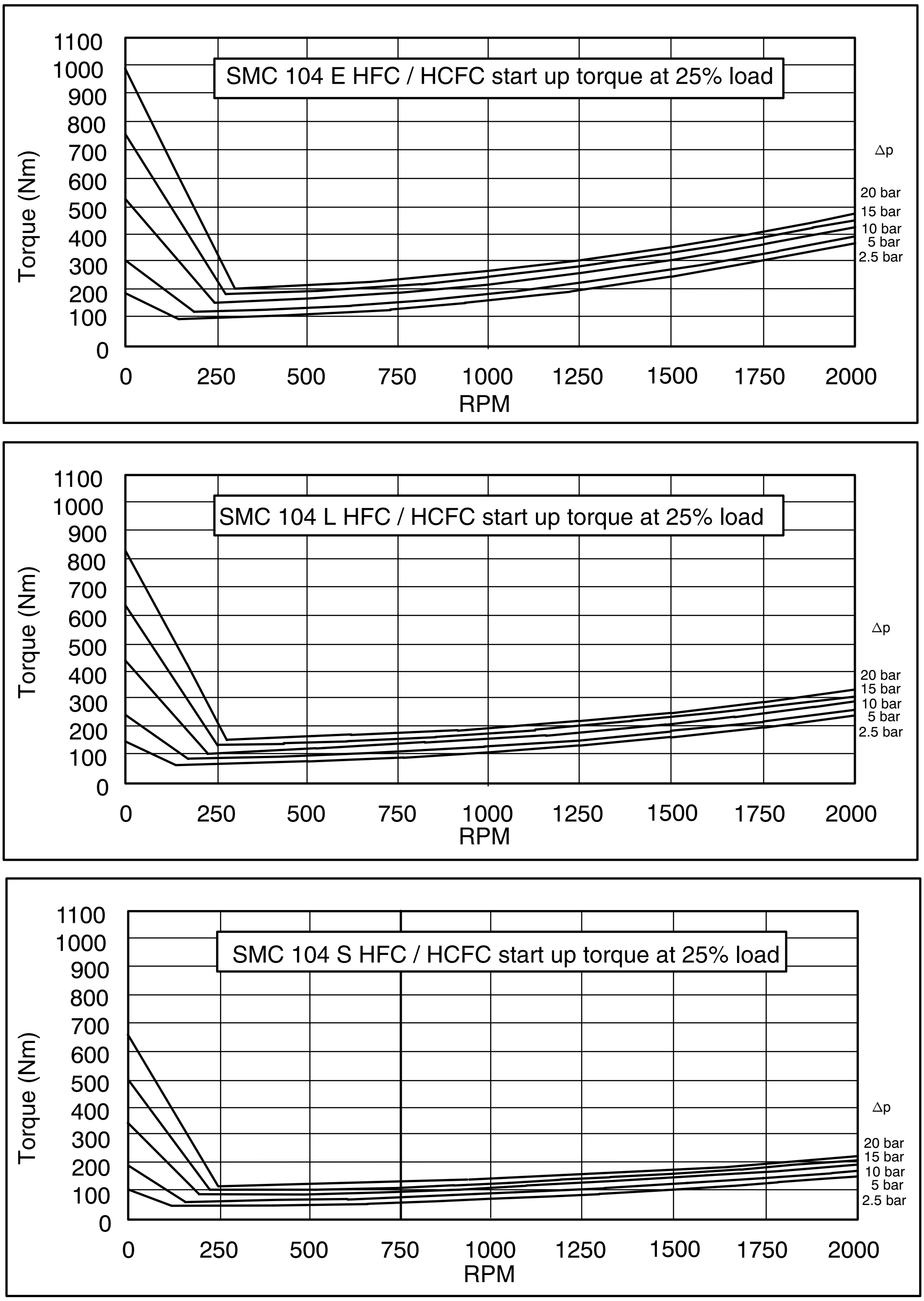


Fig. 6.23 *Start up SMC 100 - HFC/HCFC - 25% load*



Moment of Inertia

As to the moment of inertia, Table 6.4 and Table 6.5, the SMC/HPC/TSMC 100 compressors have the following values:

Table 6.4 *Moment of Inertia (kgm²) for SMC/HPC/TSMC 100 Compressors*

Type		SMC 100 S (80 mm stroke)					SMC 100 L (100 mm stroke)					SMC 100 E (120 mm stroke)				
No of cylinders: SMC/TSMC 100		4	6	8	12	16	4	6	8	12	16	4	6	8	12	16
HPC 100		4	6	8												
Compressor with free shaft end		0.154	0.189	0.218	0.376	0.427	0.196	0.234	0.269	0.464	0.579	0.254	0.321	0.340	0.593	0.705
V-belt driven compressor with shaft pulley	4	1.529	1.564	1.593	1.751	1.802	1.571	1.609	1.644	1.839	1.954	1.629	1.696	1.715	1.968	2.080
No of V-belts	6	1.404	1.439	1.468	1.626	1.677	1.446	1.484	1.519	1.714	1.829	1.504	1.571	1.590	1.843	1.955
Profil SPB	8	1.779	1.814	1.843	2.001	2.052	1.821	1.859	1.894	2.089	2.204	1.879	1.946	1.965	2.218	2.330
Direct driven compressor with complete AMR coupling		0.262	0.297	0.326	0.559	0.610	0.304	0.342	0.377	0.647	0.762	0.362	0.429	0.448	0.776	0.888

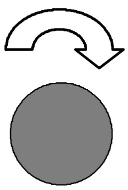
Table 6.5 *Moment of Inertia (lb.ft²) for SMC/HPC/TSMC 100 Compressors*

Type		SMC 100 S (80 mm stroke)					SMC 100 L (100 mm stroke)					SMC 100 E (120 mm stroke)				
No of cylinders: SMC/TSMC 100		4	6	8	12	16	4	6	8	12	16	4	6	8	12	16
HPC 100		4	6	8												
Compressor with free shaft end		3.66	4.49	5.18	8.93	10.14	4.66	5.56	6.39	11.02	13.75	6.03	7.62	8.08	14.09	16.75
V-belt driven compressor with shaft pulley	4	36.31	37.15	37.84	41.59	42.80	37.32	38.22	39.05	43.68	46.41	38.69	40.29	40.74	46.75	49.41
No of V-belts	6	33.35	34.18	34.87	38.62	39.83	34.35	35.25	36.08	40.71	43.44	35.72	37.32	37.77	43.78	46.44
Profil SPB	8	42.26	43.09	43.75	47.53	48.74	43.25	44.16	44.99	49.62	52.35	44.63	46.22	46.67	52.68	55.34
Direct driven compressor with complete AMR coupling		6.22	7.05	7.74	13.28	14.49	7.22	8.12	8.95	15.37	18.10	8.60	10.19	10.64	18.43	21.09

Direction of Rotation of Electric Motor

Sometimes the motor is equipped with specially designed ventilation wings to reduce the noise level. These motors have a **specified direction of rotation** which must be considered when connecting them to a compressor. If the motor is connected by means of a coupling, it must rotate clockwise when looking at it from the shaft end, Fig. 6.24.

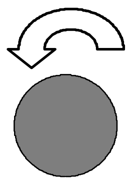
Fig. 6.24



If the motor is connected by means of a V-belt pulley, the direction of rotation should be as follows:

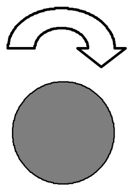
SMC 104-106-108 and TSMC 108
Anti-clockwise, Fig. 6.25.

Fig. 6.25



SMC 112-116 and TSMC 116
Clockwise, Fig. 6.26.

Fig. 6.26



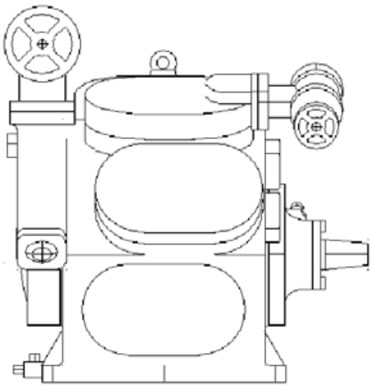
Note: The driving part of the V-belts must always be closest to the base frame.

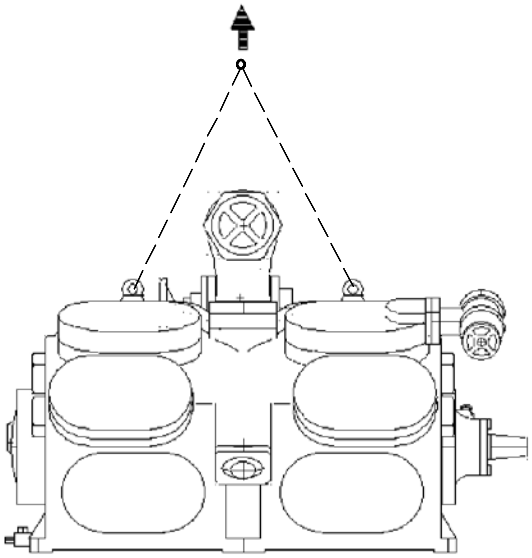
Handling of Compressor and Unit

When lifting the compressor, **only** use the lifting eyes **M20**, Fig. 6.27, which are fitted in the threaded holes at the top of the block. The weight of the compressor block is indicated in Table 6.1 in the beginning of this section.

Note: It is only the compressor block which may be lifted in the lifting eye. The same applies to the motor.

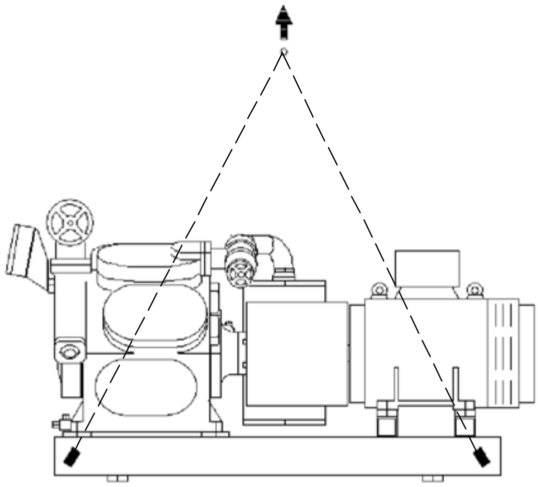
Fig. 6.27





The unit is lifted in the lifting eyes, which are welded onto the base frame and clearly marked with red paint. When the unit is lifted, make sure that the wires do not get stuck and thus damage the pipes or any other components on the unit.

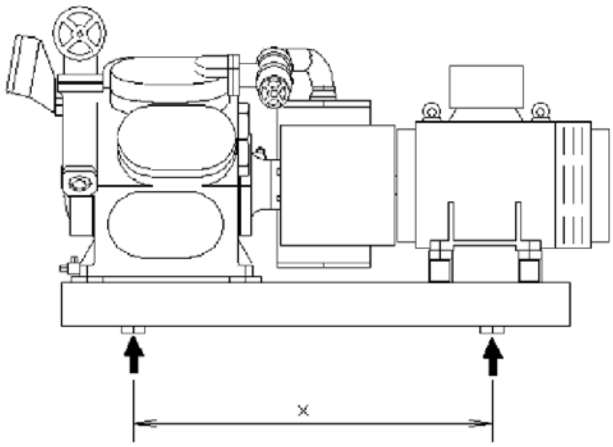
Fig. 6.28



Alternatively, the unit can be lifted with a forklift truck.

It is recommended to make the distance "x" as wide as possible yet still keeping it within the supports as illustrated in the Fig. 6.29. Be careful that the unit does not tip sideways as the point of gravity is rather high.

Fig. 6.29



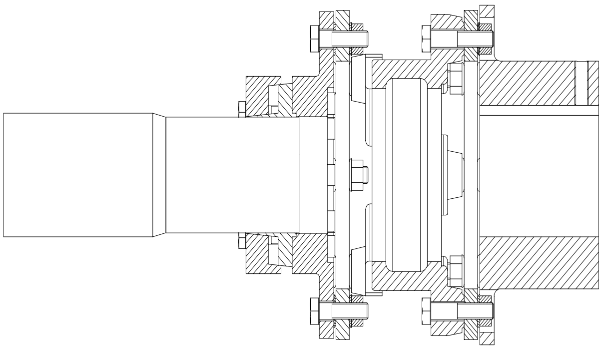
The weight of the unit can be seen in the shipping documents or in Table 6.2.

Compressor Shaft

All compressors have the same shaft size. On the shaft it is possible to mount either coupling flange or V-belt pulley as described in the following.

The coupling flange or the V-belt pulley is fixed by means of a cone clamping system.

Fig. 6.30



Boring of Hub
The coupling flange or the pulley is usually mounted on the compressor shaft on delivery of compressor units.

On delivery of compressor blocks where the customer prefers to bore the hub himself, the following procedure should be observed:

It is recommended to use the types of coupling as stated for SABROE compressors. If the necessary data is not known on delivery of the compressor, the coupling flange for the motor will be delivered pilot bored and the boring must be completed on site.

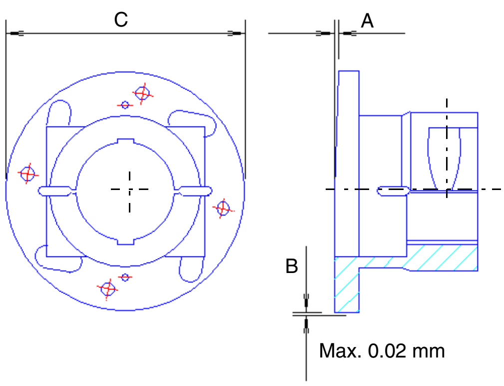
Coupling Types
AMR 312 for:
- SMC 104-106-108 and TSMC 108.
- HPC 104-106-108.

AMR 350 for:
- SMC 112-116 and TSMC 116.

Just like the flange to the compressor, the motor coupling flange has been duly balanced from factory. This makes special demands on the accuracy of the boring procedure.

Boring Procedure
The coupling flange is fixed in a lathe or a fine boring machine by tightening the outer diameter C of the flange, Fig. 6.31.

Fig. 6.31 *AMR Coupling Flange to Motor Shaft*



Alignment must be kept within the values stated in Table 6.6.

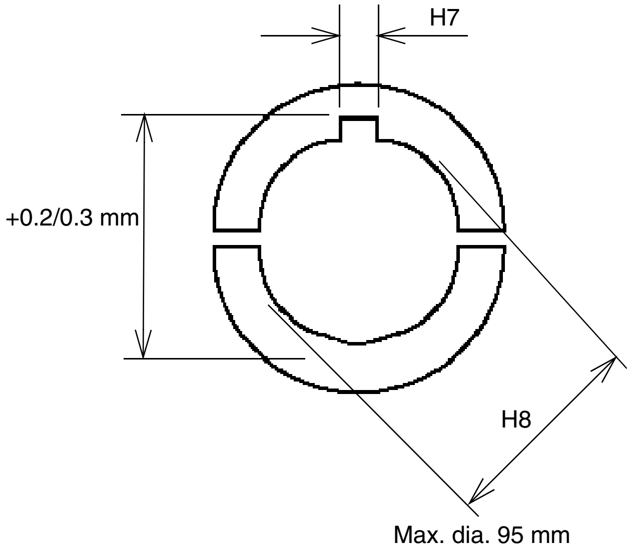
Table 6.6

Max. axial untruth measured at point A	0.02 mm
Max. radial untruth measured at point B	0.02 mm

Boring is carried out to the immediate motor shaft diameter with an H8 tolerance. Please, note that the max. boring diameter is **95 mm** and that **two** key grooves must be engraved in the key of the motor shaft in order to maintain balance.

The width of the key grooves is made with an **H7** tolerance, and the depth must be such as to create a distance between key and hub of 0.2-0.3 mm, Fig. 6.32

Fig. 6.32



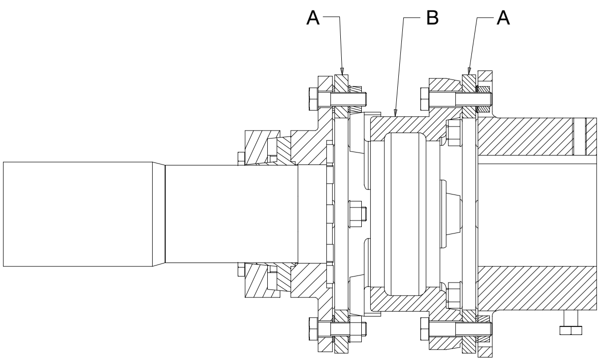
As seen in the above drawing, Fig. 6.31, the coupling hub is slit up axially and clamped to the motor shaft with two screws.

Read more about the coupling in the following section.

Coupling

An AMR coupling is used for Sabroe Refrigeration's Sabroe reciprocating compressors. This coupling is **resistant to torsional stress** but **radially and axially flexible**. Torsional resistance is achieved by a transmission of the rotational force of the motor through a number of thin laminated steel sheets (laminas) collected in two "parcels" (disc packs) A and fixed on the flanges with screws, Fig. 6.33.

Fig. 6.33



With the torsionally resistant coupling the oscillatory weight of the rotor in the electric motor works as a "flywheel", providing the compressor with a stable and vibration free operation during all kinds of operating conditions and capacity stages.

Radial flexibility is achieved by means of the intermediate piece B which, together with the two laminas "parcel A", creates a cardanic effect. In this way the two flanges are able to move a little radially in relation to each other, thus equalizing minor lateral movements of motor and compressor.

The compressor unit is delivered with coupling flanges mounted on the compressor and motor, provided that the motor comes from Sabroe Refrigeration. Intermediate piece and parcels with laminas are delivered separately and must be mounted on site. Remember that **compressor and motor must be aligned as described in chapter 7, Installation Instructions.**

Intermediate piece B also makes it possible to remove the shaft seal of the compressor without having to move motor or compressor. The length C of the intermediate piece (Fig. 6.34) and the lamina parcels cover a distance - after they have been dismantled - that makes it possible to dismount the coupling flange and the shaft seal of the compressor.

Fig. 6.34

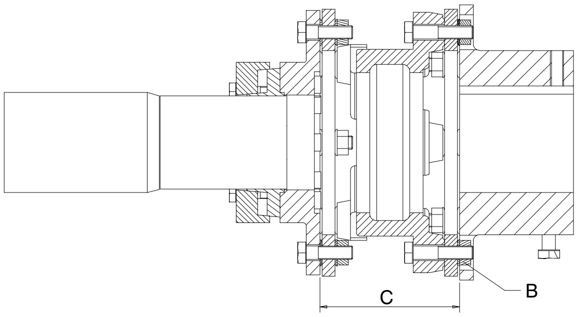


Table 6.7

Compressor	Distance C mm
HPC/SMC 104 - 106 - 108 TSMC 108	105
SMC 112 - 116 TSMC 116	116

The procedure for alignment of compressor and motor is described in chapter 7, Installation Instructions.

Balancing must be made before the key groove is engraved.

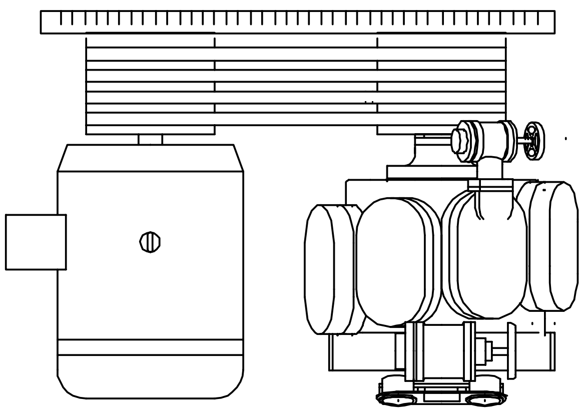
After boring, the coupling flanges are balanced. This is characterized by one or more holes on the side of the flange. Max. permissible imbalance can be seen from the table, Table 6.8.

Table 6.8

Compressor	HPC/SMC 104-106-108 TSMC 108	SMC 112-116 TSMC 116	Balancing Gmm
Coupling hub - motor	AMR 312 S	AMR 350 S	550
Coupling hub - compressor	AMR 312	AMR 350	400

V-belt drive for SMC/TSMC 100

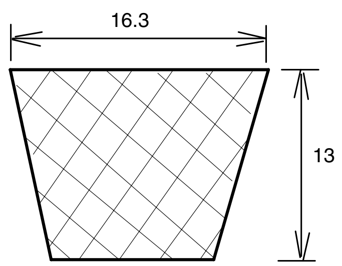
Fig. 6.35



By letting the electro motor drive the compressor through a V-belt drive, the speed of the compressor can be selected so that the max. capacity corresponds to the capacity requirements of the plant.

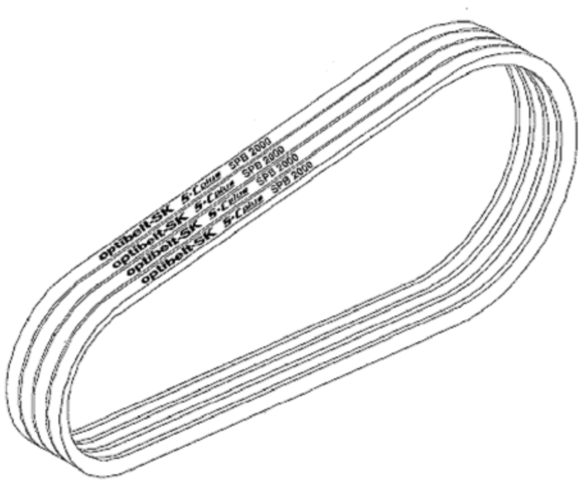
The V-belts are referred to as **SPB Red Power**. Their cross section dimensions are shown in Fig. 6.36

Fig. 6.36 *S = C plus SPB 2650*



The V-belts are of an excellent quality. Under normal operating conditions they do not require any service and are shape-permanent, which means that they can be characterised as **S = C plus**, which is stamped on the outside of the belts, see Fig. 6.37. Moreover, the V-belts are made with such narrow tolerances that they can be fitted immediately, which means that it is no longer necessary to check whether the belts match.
A V-belt drive which has been set up and adjusted correctly will usually have a long life time.

Fig. 6.37



Transmission Ratio

The required transmission of speed between motor and compressor is achieved by choosing the right combination of pulley diameters as stated in the Table 6.9. It appears from the table that there is only **one** pulley diameter for the compressors and that the transmission ratios are achieved by choosing among the standard motor pulleys.

Thus the Compressor Speed for Motor Speed 1460 rpm (50Hz) and 1760 rpm (60 Hz) stated in the table is achieved. The nominal V-belt length is stated in the column *Length of V-belt*, and the same length is stamped on the outside of the V-belts as in the example shown in Fig. 6.37.

Table 6.9 Standard Programme for V-Belts and Pulleys for SMC/TSMC 100

Standard V-belt pulley Diameter mm		Compressor speed compared to Motor speed		Length of V-belts mm	
Compressor	Motor	50 Hz 1460 rpm	60 Hz 1760 rpm	SMC 104- 106-108 TSMC 108	SMC 112- 116 TSMC 116
	180		792		1900
	190		836	2650	1900
	200	*730	880	2650	1900
	224	817	985	2650	2000
400	250	912	1100	2800	2000
	265	976	1166	2800	2000
	280	1022	1232	2800	2000
	315	1150	1386	2800	2120
	335	1273	1474	3000	2120
	355	1295	1562	3000	2240
	400	1460	1760	3000	2240

* SMC 104 - 108 and TSMC 108 only

Power Transmission

The number of V-belts which must be used to transmit the necessary power from the motor to the compressor - which usually corresponds to the nominal capacity of the motor - is stated in the following tables, Table 6.10 and Table 6.11.

Note: To obtain a smooth transmission, the number of V-belts must be chosen so that the belt drive loads at its maximum as stated in the table. **The motor pulleys** are always delivered with the number of grooves corresponding to the number of V-belts which must be used to transmit the maximum power of the motor to the V-belt drive in question, thus indicating how many V-belts **must** be fitted.

The compressor pulleys, however, are only delivered with the number of grooves shown below. Thus it may occur that there are more grooves on the compressor pulley than on the motor pulley.

SMC/TSMC 100

The compressor pulleys are always delivered with 4 - 6 or 8 grooves.

Table 6.10 *Max. Power Transmission SMC104-106-108 and TSMC108*

Number of V-belts	Motor speed 1460 rpm (50 Hz)								
	730	817	912	976	1022	1150	1295	1460	rpm
2	22	22	30	30	30	37	45	45	kW
3	30	37	45	45	45	55	55	75	
4	37	45	55	55	55	75	90	90	
5	45	55		75	75	90	110	110	
6	55	75	75	90	90	110	132	132	
8	75	90	106	110	118	132	150	169	

Number of V-belts	Motor speed 1760 rpm (60 Hz)									
	792	836	880	985	1100	1166	1232	1386	1474	rpm
2				26	36	36	36	44	44	kW
3	26	26	36	44	44	54	54	66	66	
4	36	44	44	54	66	66	66	90	90	
5	54	54	54	66		90	90	108	108	
6		66	66		90	108	108	132	132	
8	66	90	90	108	127	132	143	158	171	

Table 6.11 *Max. Power Transmission (kW) SMC112, 116 and TSMC116*

Number of V-belts	Motor speed 1460 rpm (50 Hz)								
	730	817	912	976	1022	1150	1295	1460	rpm
3						55	55	55	kW
4			55	55	55	75	75	90	
5		55		75	75	90	90	110	
6			75		90	110	110	132	
8		90	106	110	110	132	150	169	

Number of V-belts	Motor speed 1760 rpm (50 Hz)									
	792	836	880	985	1100	1166	1232	1386	1474	rpm
3							54	66	66	kW
4				54	66	66	66		90	
5		54	54	66			90	108	108	
6	54		66		90	90	108		132	
8	66	66	90	108	108	132	132	158	158	

Construction of V-Belt Drive

On standard units the nominal shaft distance between motor and compressor is **900 mm** for SMC/TSMC 104 to 108 as shown in Fig. 6.38, and **500 mm** on SMC/TSMC 112 and 116 as shown in Fig. 6.39.

Fig. 6.38 *SMC 104-106-108, TSMC 108*

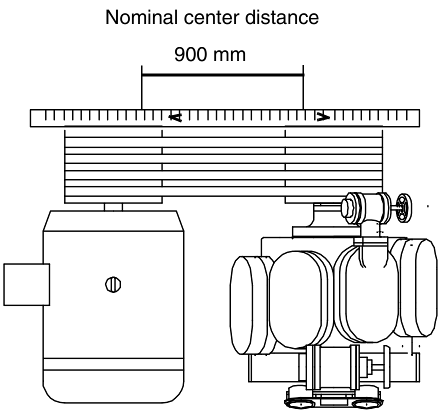
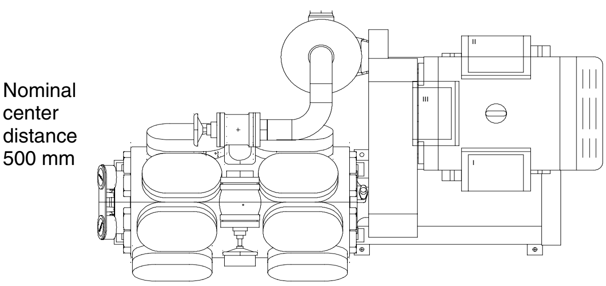
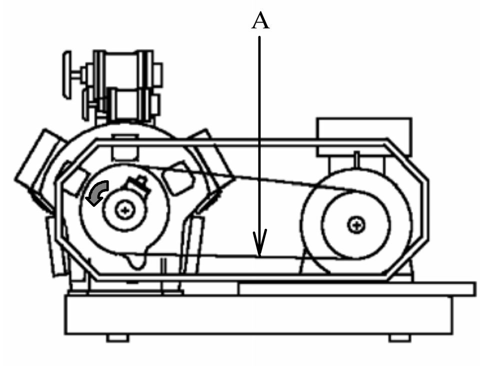


Fig. 6.39 *SMC 112-116, TSMC 112-116*



The driving part of the V-belts must always be closest to the base frame as shown with **A** in Fig. 6.40.

Fig. 6.40



The compressor pulley is bored with a cylindrical hole and is fitted to the crankshaft with a clamping unit. The end of the crankshaft and the outer face of the clamping unit must be aligned. Thus the belt pulley can be mounted on the crankshaft without previous adjustment. It must be tightened with the nine screws on the clamping unit, see fig. 6.41. The screws are tightened with a torque wrench.

Fig. 6.41

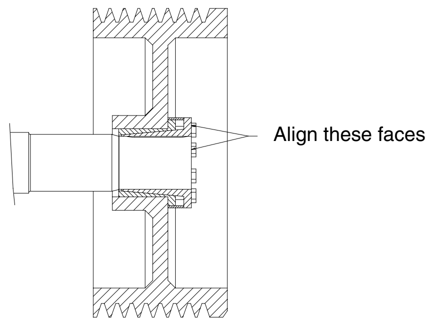
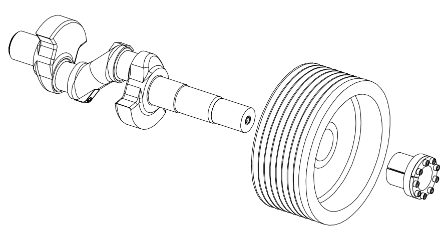


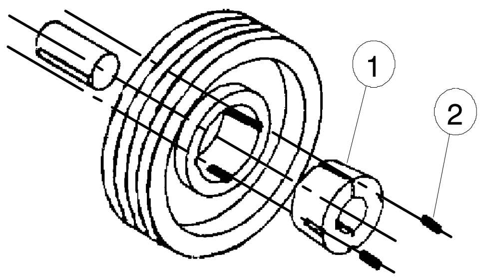
Fig. 6.42



When dismounting the belt pulley, loosen the screws on the clamping unit.

The motor pulley is tightened to the motor shaft by means of a conical bushing, pos. 1 in Fig. 6.43, which fits the conical boring of the belt pulley. The bushing is bored and equipped with a key, which fits the motor shaft in question. When mounting the pulley, first place the belt pulley and the bushing on the motor shaft, then fix the pulley to the bushing by means of two or three screws, pos. 2 in Fig. 6.43. Mount the screws in the holes where the thread **faces** the belt pulley. Thus the conical bushing is pressed around the motor shaft so that it both holds and centers the belt pulley. Before tightening, the belt pulley is placed on the motor shaft so that it is flush with the compressor belt pulley. Tighten the screws, pos. 2, with the torque as *indicated in chapter 21.*

Fig. 6.43



When **dismounting** the belt pulley, first dismount the two or three screws, pos. 2, and then mount one or two of the screws in the free hole/s where there is only a thread in the side which **faces** the bushing. By tightening the two screws evenly, it is now possible to press the belt pulley off the bushing. The bushing and the belt pulley can now be dismounted manually.

The V-belts must only be mounted and dismounted when the motor is placed close to the compressor to avoid damage of the belts.

Tightening and Adjusting the V-Belt Drive
When the necessary number of belts have been mounted **- corresponding to the number of grooves on the motor pulley** (max. 8) **-** the V-belt drive is tightened by moving the motor away from the compressor. For this purpose, use two washers which are part of the base frame and mounted at the feet of the motor.

For measuring the correct belt tension, use **Tension Gauge II, part no. 1622.003.**

Spare Parts
When delivering belt pulleys as spare parts, **the compressor pulley is always ready bored** and balanced. It can thus be fitted directly on the compressor.

The motor pulley is delivered balanced and with a conical bushing, which is ready bored for direct fitting on the motor shaft in question.

Service

A correctly aligned V-belt drive will have a long service life. After the first adjustment, the belt drive must be checked regularly. Checking and adjusting the V-belt drive is best carried out by means of the special tool (Tension Gauge) mentioned above, which is available from Sabroe Refrigeration *After-Market Service Department.*

When replacing the V-belts, the grooves in the V-belt pulleys should be checked for wear and tear by means of a **Belt and pulley groove gauge, part no. 1622.001**, which can also be obtained from our *After-Market Service Department.*

Noise from Compressors and Units

Noise is inevitable when a compressor or unit is working. However, by taking this into consideration during the project phase, it is possible to reduce noise pollution of the environment considerably.

Through the years Sabroe Refrigeration has been aware of this problem. As a consequence, we have designed the compressors and units with a view to meeting market demands concerning maximum noise levels.

Of course, modern compressor units are loud and must be expected to make noise, and this makes it the more important that the sound data stated for a compressor or unit should be evaluated correctly.

The above issue will be discussed in the following. In this connection Sabroe Refrigeration would like to point out that at a fairly low cost it is possible to make the machine room a pleasant work place. The use of noise absorbing materials could be one solution to the problem.

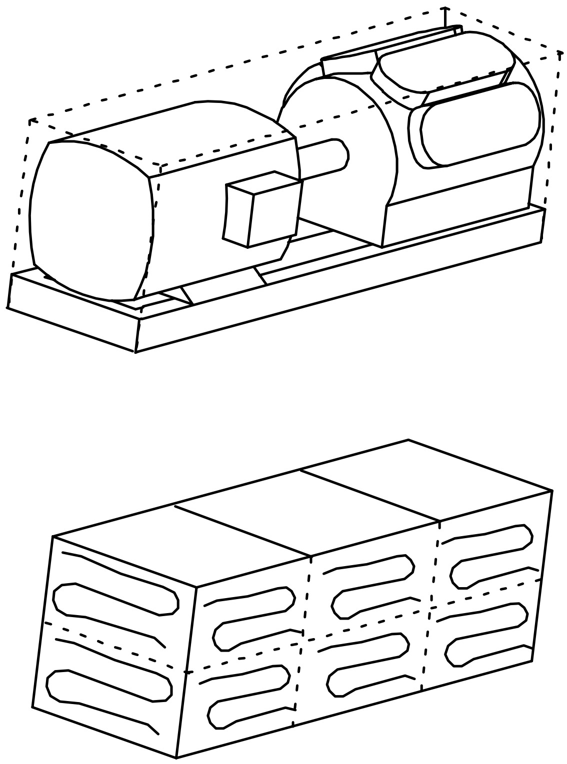
1. Sound Power and Sound Pressure

As seen in Table 6.13 sound data is indicated as **sound power level L_W or sound pressure level L_P.** It is essential to distinguish between these two values as they are stated in dB (decibel) and should be read as follows:

1.1. Sound Power Level L_W

According to ISO 9614-2 **L_W** is measured directly at the unit, Fig. 6.44, by installing a measuring grid as close to the unit as possible.

Fig. 6.44 *Unit covered with a measuring grid*



The measuring grid is divided into **fields of max.1 sq. m** each. The measuring is carried out by moving the sound level meter in a kind of back and forth movement, as illustrated in Fig. 6.44. The sound level meter now calculates the total sound power level **L_W** for the entire unit.

The sound power level L_W is, however, dependent on the surroundings of the noise source. Consequently, it is a somewhat theoretical value. Here, the **sound pressure level L_p** becomes of interest.

1.2. Sound Pressure Level L_p

It is actually the sound pressure level Lp that is measured by the sound meter. In the sound meter this is then automatically converted to the sound power level L_W by means of its built-in calculation programs.

The sound pressure measuring is, however, dependent on the room in which the measuring is carried out. As a consequence, this may yield different results from one room to another.

The arrangement of the room as well as building materials have a considerable influence on the results of the measuring.

This is why the measured values of the manufacturers for sound pressures are based on standard measures according to ISO 3989 which refers sound pressure level L_P to **a free field above a reflecting plane** at a distance of 1 meter from the measuring grid, as described in pt. 1.1.

Above facts should be taken into consideration during a check measuring on the plant in question as mentioned in points 2.1 and 2.3.

1.3. Frequency

Sound is fundamentally a pressure wave in the air at a given wave length (frequency).

From a compressor unit sound waves are emitted at many different frequencies due to the different movable parts.

The human ear can normally perceive frequencies in areas ranging from 20 Hz to 20 k Hz, but it does not perceive all frequencies equally well. Consequently, a sound meter must measure the sound pressure at various frequencies and then filter the measuring corresponding to the perceptual capacity of the ear (the A-weighting).

To this must be added the purely subjective perception of sound as most human beings feel considerable unease on hearing the so-called "pure" notes. If a frequency is followed by a sound pressure of 3-6 dB above the other frequencies, this feels annoying. In case of screw compressors, it is a fact that 300 and 600 Hz is normally felt to be annoying whereas reciprocating machines issue a more low-frequency (pleasant) sound.

2. Assessing the Measured Values

2.1.

As a consequence of the difference between the actually measured sound and the sound that the ear perceives, the measured values are weighted in the sound meter. Usually, the sound meter is set for A-weighted values called dB (A), based on a logarithmic scale.

That is why it is so important to apply the same unit of measure on comparing values from several different machines.

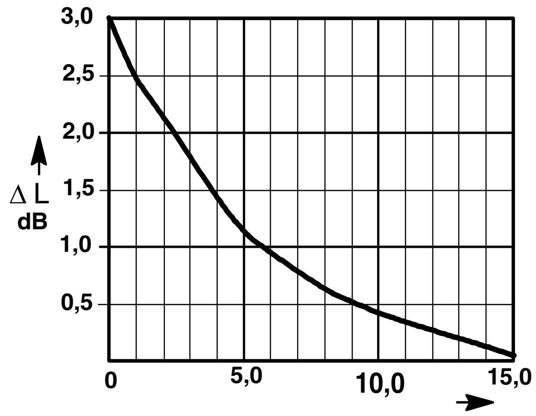
Further, we would like to point out that the sound pressure level L_P measured in the machine room as described under pt. 1.2 will always be above the one indicated in table, Table 6.13

The measured value will normally lie somewhere between the stated $\mathbf{L_P}$ and $\mathbf{L_W}$ values.

2.2.

In machine rooms with a number of compressors the total sound pressure level can be calculated by adding Δ L read on the curve in Fig. 6.45 to the sound pressure value for the unit with the highest sound pressure.

Fig. 6.45 *Curve for adding of logarithmic levels*



Difference (L_2-L_1) dB

Example 1:

With two compressors in the same room

Compressor 1,L_{P1}= 81 dB (A)

Compressor 2,L_{P2}= 86 dB (A)

Difference 5 dB (A)

Total sound pressure level:

L_P = 86 + 1.2 = 87.2 ≅ 87 dB (A)

Example 2:

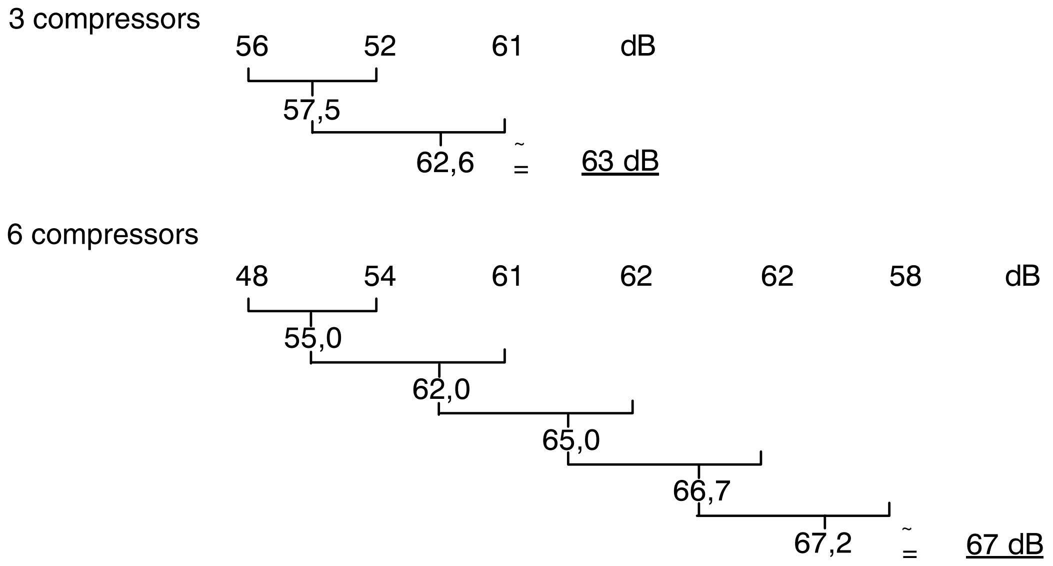
In case two compressors have the same sound pressure level, e.g. 86 dB (A) the difference will be 0.

total sound pressure level:

L_P = 86 + 3 = 89 dB (A)

Example 3:
With a number of compressors in the same room the sound pressure level is calculated by miner of the curve, Fig. 6.46, as follows:

Fig. 6.46



2.3.

It is essential that during a potential check measuring to carry out **more than one** sound pressure measuring, e.g. by measuring in fields as shown in Fig. 6.44 as a few local measures may result in incorrectly high measured values.

2.4.

Likewise, pay attention to the fact that the measured values stated for a certain unit should comprise a complete unit incl. compressor, motor, oil separator etc. which have all been covered by the measuring grid.

Thus, on assessing the measure results it is essential to know the extent of the measured surface area in the surrounding measuring grid.

2.5.

If the compressor is working at part load, this will generally lead to higher measured values than the ones indicated in the tables.

3. How to Check Sound Data

3.1.

The only correct method is the measuring of sound power L_W on the site itself and this requires the setting up of a measuring grid as well as the use of sound intensive equipment.

3.2.

If using sound pressure L_p meters only, an additional measuring of the reverberation period of the room will be required. This makes it possible to find a theoretical value of the emitted sound power **provided that the background noise is too low to be of any importance!**

Noise Data for Reciprocating Compressors

Single-stage

L_W and L_p values are measured at the following conditions:

Evaporating temperature TE = 5°C [5°F]

Condensing temperature TC = +35°C [95°F]

Refrigerant = R22/R717

Number of revolutions = **1450 rpm**

Heat Pump

Evaporating temperature TE = 20°C

Condensing temperature TC = +70°C

Refrigerant = R22/R717

Number of revolutions = **1450 rpm**

Table 6.12

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

Table 6.13

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

Two-stage

L_W and L_p values are measured at the following conditions:

Evaporating temperature TE= 35°C [-31°F]

Condensing temperature TC= +35°C [+95°F]

Refrigerant= R22/R717

Number of revolutions = **1450 rpm**

Table 6.14

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

4. Damping Acoustic Noise in a Machine Room

On planning or renovating a machine room, attention should be paid to the acoustic environment as a minor investment is sufficient to change an acoustically hard room to a noise damped room which is pleasant to work in.

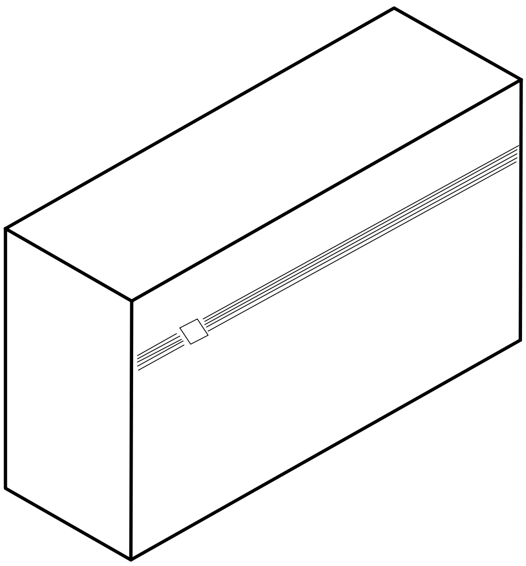
This is possible to achieve by choosing a sensible noise absorbing material, fitted on walls and ceiling or which is part of the building construction

It is recommended to seek advice from a consulting firm experienced in noise damping in order to obtain the solution best suited to your plant.

For this purpose computer calculated frequency analyses can be requested from
Sabroe Refrigeration for the compressor unit in question.

Another and **very efficient** solution would be to noise insulate the compressor unit itself.
Sabroe Refrigeration is able to deliver pre-fabricated and tested noise baffle boards.

Fig. 6.47



In General

The following paragraphs include a description of the factors that influence the acoustic quality of a machine room.

Reverberation Time

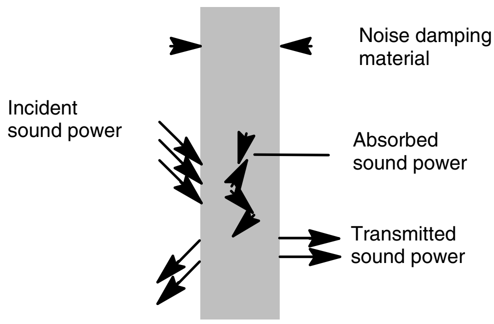
By a correct application of noise absorbing materials it is possible to change the **reverberation time** of a machine room which is defined as the time it takes for the sound pressure level $\mathbf{L_p}$ to drop 60 dB once the noise source stops.

The duration of the reverberation time depends on the volume of the room as well as the average absorption coefficient for the noise absorbing materials that are fitted in the room as they should be.

Absorption Coefficient

Usually the absorption coefficient α for noise absorbing materials is 0.5 to 0.8. See the following illustration, Fig. 6.48.

Fig. 6.48



$$X = \frac{\text{Reflected sound power}}{\text{Incident sound power}}$$

Subjective Perception of Noise Damping

With reference to table, Table 6.15, indicating how the human ear perceives the effect of noise insulation in a machine room, the following should be noted:

- By investing in a sensible noise insulation of the ceiling of the machine room this usually means reducing the reverberation time by half in the machine room with a subsequent great **subjective effect**.
- When using a pre-fabricated noise baffle board from Sabroe Refrigeration, the sound pressure in the machine room will typically be reduced by 20 dB. Naturally, this must be considered a great improvement - subjectively perceived.

Table 6.15

Reduction of sound pressure by noise insulation of compressor unit	Reduction of the average sound pressure level by noise insulation		Subjective perception of the improved acoustic quality of the room
dB	dB	Relative reverberation time	
0	0	1	-
1	0,5	0,9	Insignificant
3	1	0,8	Perceivable
6	2	0,6	Distinct
10	3	0,5	Considerable
20 *	6	0,25	Very considerable

*The Sabroe Refrigeration prefabricated **Version 2.0** noise baffle board for compressor units

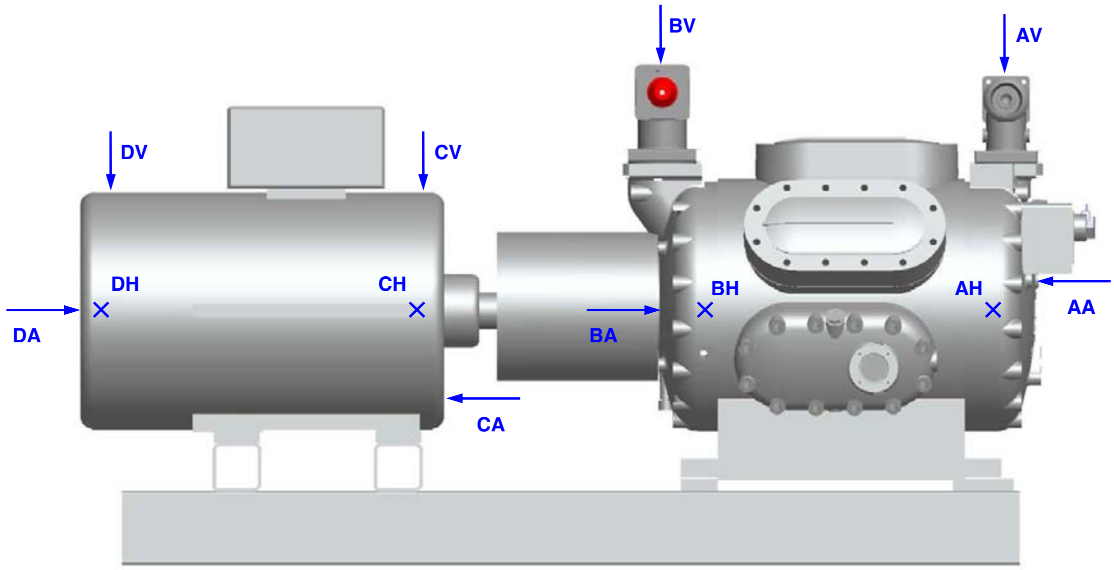
Vibration Data for Compressors - All Compressor Types

Vibration data for Sabroe Refrigeration's Sabroe **reciprocating** compressors comply with: **the ISO 10816, standard, Part 6, Annex A, group 4, AB,** which fixes max. permissible operating vibrations at 17.8 mm/s.

Vibration data for Sabroe Refrigeration's Sabroe **screw** compressors comply with: **ISO 10816 standard, part 1, Annex B, Class III, C,** which fixes max. permissible operating vibrations at 11.2 mm/s.

The measurements are made as illustrated in the figure below (points A-D).

Fig. 6.49



Pay attention to the following, however:

- Motors comply with EN 60034-14 (CEI/IEC 34-14) Class N.
- When placing the unit on the vibration dampers supplied by Sabroe Refrigeration (additional), the vibrations against the foundation are reduced by:
  - 85-95% for screw compressor units
  - 80% for reciprocating compressor units
- However, higher vibration level may occur if:
  - motor and compressor have not been aligned as described in the Instruction Manual**.**
  - the compressor runs at an incorrect V_i ratio. This applies to screw compressors.
  - the piping connections have been executed in a way that makes them force pull or push powers on the compressor unit or transfer vibrations to the unit caused by natural vibrations or connected machinery.
  - the vibration dampers have not been fitted or loaded correctly as indicated in the foundation drawing accompanying the order.

Specification of Compressor Materials

The materials to be used for the individual components of the compressors have been selected in view of a long life, wear resistance as well as resistance to the refrigerants and oils approved for the compressors.

The following table,Table 6.16, lists the most important components.

Table 6.16

Designation	Material	Form
Compressor frame SMC and TSMC	Cast iron	EN-GJL-250, EN 1561
Compressor frame HPC 100	Ductile cast iron	EN-GJS-500-7, EN 1563
Oil pump housing HPC 100, SMC and TSMC100	Cast iron	EN-GJL-250, EN 1561
Bearing cover pump end HPC 100, SMC and TSMC100	Ductile cast iron	EN-GJS-500-7, EN 1563
Water covers HPC 100, SMC and TSMC100	Cast iron	EN-GJL-250, EN 1561
All other covers SMC and TSMC	Cast iron	EN-GJL-250, EN 1561
All other covers HPC	Ductile cast iron	EN-GJS-500-7, EN 1563
Crankshaft HPC108	Ductile cast iron	EN-GJS-800-2, EN 1563
Crankshaft all other compressors	Ductile cast iron	EN-GJS-700-2, EN 1563
Connecting rod	Ductile cast iron	EN-GJS-700-2, EN 1563
Piston pin bushing	Phosphor bronze	BS1400, PB1-C
Half section of bearings for Connecting rod	White metal on a steel base	
Bolts for connecting rod	Cr-Mo steel	Cl, 12.9, DIN 898
Piston	Aluminium alloy	BS 1490/LM13
Piston rings and oil scraper ring	Cast iron	BS 1452 (W.CI7)
Piston pin	Cr-steel	17Cr3, DIN 17210
Cylinder liners	Cast iron w/special heat treatment	EN-GJL-250, EN 1561
Suction and discharge valve plates	Special steel	
Suction valve retaining plate	Ductile cast iron	EN-GJS-600-3, EN 1563
Safety head spring	Steel spring	54SiCr6, DIN 17221
Main bearings	White metal on a steel base	
Shaft seal carbon ring	Special carbon	
Shaft seal steel ring	Special steel	A62P
Suction filter	Stainless steel wire-mesh	AISI 316
Oil level glass	Glass in steel flange	
Oil strainer	Filter cartridge	AISI 304
By-pass valve	Various steel	C75, DIN 17222
Buffer springs	Spring steel	
Gaskets	Non-asbestos	
O-ring seals	CR Rubber (standard)	Compound 2347

Pressure Levels for Standard Compressors and Components

All components for refrigeration plants which are under the influence of gas pressure must be pressure tested to prove their strength and tightness.

The approving authorities determine the test pressure levels on the basis of various criteria. However, the test pressure requirements can be summarized into a number of standard pressure levels which in practice meet the requirements set up, and which can therefore be approved by most authorities involved.

Table 6.17 describes each step from strength test to transport.

Table 6.18 shows the standard pressure levels used by Sabroe Refrigeration. In case of specific applications, the authorities may, however, demand a higher test pressure level. Within certain limits such requirements can be met for SABROE compressors - against an additional price. Please, contact Sabroe Refrigeration for further information.

Units consist of components which have been pressure tested as described in the following table. This means that it is only necessary to leak test the unit. Leak testing is carried out with pressurized air at the pressure stated in the table. All weldings and connections are **covered with a frothing liquid** which will start foaming in case of a leak.

Allowable pressure

The pressures given in Table 6.18 under allowable pressure shall always be observed during plant design and operation. Pressure in the compressor are not allowed to exceed these values

Table 6.17

Step	Action	Reference	Description
1	Strength test	See Table 6.18	The test is carried out with air
2	Leak test 1	See Table 6.18	The test is carried out with air
3	Test run		Functional test of compressor.
4	Leak test 2	See Table 6.18	The test is carried out by spraying the compressor with a frothing liquid.
5	Charging of protective gas		Charging of protective gas, nitrogen (N_2). 0.2 bar [3 psi] overpressure.

Table 6.18 *Standard Test Pressure Levels*

Standard Test Pressure Levels										
	Max. allowable working pressure PS (High pressure side)		Max. allowable stand-still pressure PSs (Low pressure side)		Strength test pressure (High pressure side)		Strength test pressure (Low pressure side)		Leak test pressure	
	Bar	Psi	Bar	Psi	Bar	Psi	Bar	Psi	Bar	Psi
Compressor block : (T)SMC TCMO	28	411	18	265	42	617	27	397	7	103
Compressor block : HPC HPO	40	588	26	382	80	1176	40	588	7	103
Units : (T)SMC (T)CMO	24	353	18	265	27	397	27	397	7	103
Units : HPC HPO	39	573	26	382	43	632	40	288	7	103

Charging the Compressor with Oil

Usually, the compressor is delivered without any oil in the crankcase. As a principal rule, the amount of oil indicated in the table, Table 6.19, should be charged to the compressor.

Table 6.19 *Oil Charging*

Compressor		Amount of oil in crankcase	
Type	Size	Liter	US gal.
SMC/HPC	104	26	6.9
	106	28	7.4
	108	30	7.9
SMC	112	47	12.4
	116	50	13.2
TSMC	108	30	7.9
	116	50	13.2

After some hours of operation the compressor must be recharged with oil, however, as part of the oil has been absorbed by the refrigerant. This is especially the case for HFC and HCFC refrigerants.

The amount of oil to be recharged depends on the size of the refrigeration plant and the amount of refrigerant. Oil is charged to the middle of the oil level glass and the amount of oil needed in order to increase the oil level 10 mm is indicated in the table, Table 6.20.

Fig. 6.50 *Oil level glass*

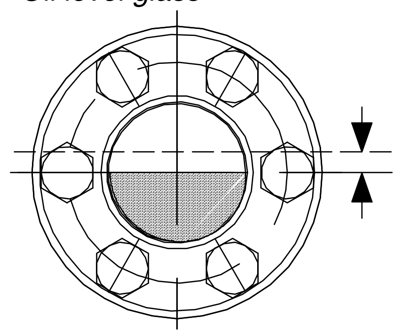


Table 6.20 *Oil level*

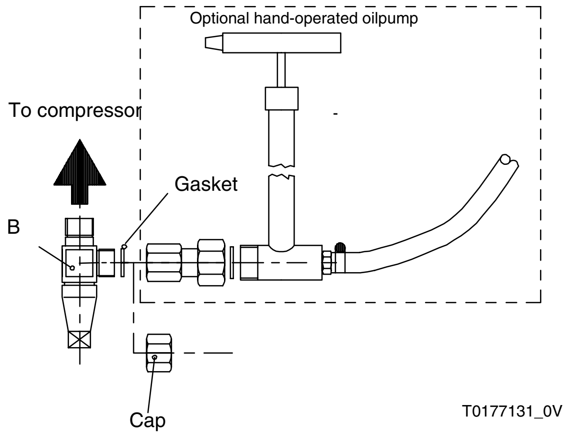
Compressor		Difference in oil level of 10 mm corresponds to:
Type	Size	
SMC/HPC	104	- 2 litres of oil [0.5 US gal.]
	106	
	108	
TSMC	108	
SMC	112	- 6 litres of oil [1.6 US gal.]
	116	
TSMC	116	

A manually operated pump connected to the oil charging valve pos. B can be used for the first as well as the following oil charges.
See chapter 5, Physical and Connection Data.

Note: On HPC 100 compressors with R717 and R744, the pressure must be relieved before oil charging.

06 technical data.fm

Fig. 6.51 Manually Operated Oil Pump



Oil Consumption

In refrigeration compressors there will always be a minor oil consumption, which means that a little oil is bound to follow the warm discharge gas out of the compressor.

In order to separate this oil, an oil separator is normally used. The separator is built into the discharge pipe, right next to the compressor. The separated oil is returned to the compressor as described in chapter 4, Technical Description *- Oil Separator.*

A minor part of the oil, however, present in the discharge gas as vapour, cannot be separated and will consequently continue into the plant, in which it is condensed in the condenser.

In R744, HFC and HCFC as well as in compact R717 refrigeration plants this oil will return to the compressor together with the suction gas.

In return, the oil in larger and ramified R717 refrigeration plants should be drained off and never reused in the compressor. This amount of oil represents the so-called oil consumption measured in ppm (**p**arts **p**er **m**illion) and is calculated by using the following formula:

$$\text{Oil consumption kg/h} = \frac{\text{Circulated amount of refrigerant Q (kg/h) x Oil consumption (ppm)}}{10^6}$$

The normal oil consumption is between 20 and 30 ppm for an SMC/HPC 100 compressor.

Selecting Oil Separator

As the velocity through the oil separator affects the ability of the oil separator to separate the oil from the discharge gas, an oil separator size has been designed for each compressor.

The maximum oil consumption for this oil separator is 35 ppm. Depending on the choice of lubricating oil, the oil consumption is normally much lower.

Selecting Lubricating Oil for SABROE Reciprocating Compressors

Refrigerant: R717

In a period from 1990 to 1995
Sabroe Refrigeration experienced a rising number of problems with the use of mineral oils, especially in R717 plants. The problems can be divided into two groups:

c. The oil changes viscosity within a few operating hours.

d. The oil dissolves (becomes very black).

The problems have been observed in connection with several different types of mineral oil and often occur within only a few operating hours. The consequences have been severe for both compressors and plants.

On the basis of the thorough investigation subsequently carried out by Sabroe Refrigeration, it was decided to introduce a series of synthetic oils complying with the requirements of modern refrigeration plants.

Mineral oils can, however, still be used in refrigeration plants, provided the lubricating quality is carefully monitored. For modern high-capacity refrigeration plants where a long service life for both lubricant and moving parts is expected,
Sabroe Refrigeration recommends the use of synthetic oils.

Areas of application and specifications for the synthetic oils mentioned are described in the following pages. Supervisors and/or users of plants are at liberty to choose between
Sabroe Refrigeration's own oil brands and alternative oil brands, provided they comply with the specifications required.

General
This recommendation will only deal with the lubrication of the compressor. The performance of the lubricant in the plant (receiver, evaporator, etc.) must, however, also be considered.

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

To achieve the best lubrication, the oil must:

- possess the correct viscosity under all operating conditions.
- possess acceptable viscosity at start-up.
- possess sufficient oxidation stability (the oil must be free of moisture when charged to the system).
- possess sufficient chemical stability when used together with R717.

Moreover, the extent to which different refrigerants dissolve in the oil must be determined so that the oil return system, etc. can be designed to perform at its optimum.

Stratification
Note that the oil in some plants is layered in refrigerant receivers and evaporators under certain operating conditions and at certain oil concentrations.

Plants with Several Different Compressor Types/Makes
In plants where several different compressor types/makes are connected, it is strongly recommended to use the same type of oil in all the compressors. This is very important where automatic oil return systems are used.

If you consider changing the type of oil, please read the section Oil Changing on SABROE Compressors carefully.

Selecting Lubricating Oil

The correct oil is selected by means of the following diagrams. When the **general** conditions concerning the lubrication of the compressor have been considered, the **specific conditions of the plant** must be taken into account.

Use the oil recommendation diagrams to select the correct **oil code number**.

The oil code number consists of letters indicating the oil type and viscosity number.

Table 6.21

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

In the *oil recommendation diagrams* it is possible to find the code number best suited for the operating conditions in question. With the code number it is possible to select the correct Sabroe oil for the application in question.

Oil Types and Oil Companies

Due to the large number of oil companies offering oil for refrigeration plants, it has not been possible for Sabroe Refrigeration to test all the different oil brands on the global market.

It is our experience that certain oil brands can change character during use and thus no longer correspond to the specifications stated by the oil companies on delivery. We have thus experienced changes in specifications as well as formula and performance without having received information on this beforehand from the oil company. This makes it extremely difficult for Sabroe Refrigeration to give a general approval of other oil brands.

In co-operation with a large, respected oil company Sabroe Refrigeration has therefore developed a series of three different oils covering most demands. Furthermore, a list of the oils which can be supplied through Sabroe Refrigeration has been prepared. Data for these oils is included in the table Data for Sabroe Oils. We recommend that you use these oils, which can be delivered in 20 litre pails or 208 litre drums. When ordering, use the part no. stated in List of Part Numbers for Available Sabroe Oils.

It is of course possible to use similar oils from other oil companies. If this is the case, use the table Data for Sabroe Oils.

Please note that Sabroe Refrigeration has not tested other oils than our own brand. Thus we cannot guarantee the quality, stability or suitability of other oils. The respective oil companies are thus responsible for the quality and suitability of the oil delivered, and if there are any problems with these oils in the compressor or the refrigeration plant, contact the oil supplier directly.

When selecting oils from other oil companies, special attention should be paid to the suitability of the oil in the compressor and the refrigeration plant as a whole.

Please note in particular the following points:

- Oil type
- Compressor type
- Miscibility between refrigerant and oil
- Operating data for the compressor
  - Discharge gas temperature
  - Oil temperature
  - Normal oil temperature in crankcase is 50-60°C

  - Max. permitted oil temperature = set point for alarm
  - Min. permitted oil temperature = set point for alarm - if there is any
- The viscosity of the oil in the compressor during operation:
  - Type of refrigerant and solubility of refrigerant in the oil
  - Operating temperatures
  - Vapour pressure in the oil reservoir
  - Suction pressure and oil temperature in the crankcase
  - Compatibility with neoprene O-rings: The aniline point indicates how the O-ring material reacts to the oil.
  - At an aniline point less than approx. 100°C the material has a tendency to swell, and at an aniline point higher than approx. 120°C it has a tendency to shrink
  - Thus it cannot be recommended to change the oil type from M to PAO without changing the O-rings at the same time as a leak may otherwise easily occur in the compressor or the plant. Sabroe Refrigeration recommends therefore the use of the Sabroe AP68 oil since this type of oil in this case reduces considerably the risk of leaks. Sabroe Refrigeration can supply a list of operating data on request.
- Please note the viscosity limits during operation:
  - Optimum viscosity limits = 20 to 50 cSt
  - Max. permitted viscosity = 100 cSt
  - Min. permitted viscosity = 10 cSt
  - Max. permitted viscosity during start-up of the compressor = 500 cSt
  - Max. refrigerant concentration in the oil during operation: 25% - also in case the viscosity requirements have been met.

Use of Mineral Oil

As described in the introduction, mineral oil in particular causes serious problems especially in R717 plants.

When using mineral oil, it is important to monitor the plant closely. The condition/colour of the oil must therefore be checked on a weekly basis and for each 1,000 to 2,000 operating hours oil samples must be taken for further analysis.

Sabroe Refrigeration recommends therefore only to use M oil under moderate operating conditions - see the following oil recommendation diagrams.

Sabroe Refrigeration is aware that several customers have used mineral oils for many years without any problems. The customers who wish to continue using mineral oil in existing as well as new compressors can do so, provided that the compressor type and the operating conditions are similar to the existing ones.

Sabroe Refrigeration has thus decided to market one brand of mineral oil which has been tested and found suitable for most of the general refrigeration purposes.

In case another brand of mineral oil is used, follow the specifications on the data pages in this recommendation as a guideline.

Mineral oil can be used in refrigeration plants, provided the lubricating quality is carefully monitored. Sabroe Refrigeration recommends, however, that you use synthetic oils for modern high-capacity *plants where a long service life for both lubricant and moving parts is expected.*

The advantage of using synthetic lubricating oils is a much lower oil consumption and longer oil changing intervals. Improved viscosity at low temperatures facilitates furthermore drainage at the cold parts of the plants.

How to Use the Diagrams in the Oil Recommendation:

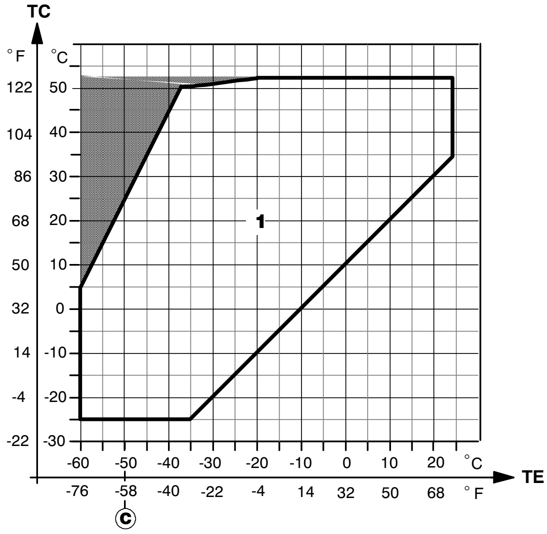
To find the correct **code number**, select refrigerant and compressor type in the oil recommendation diagram. Then insert the estimated operating conditions in the diagram.

Example (reciprocating compressors):

Refrigerant	**R717**
Condensing temperature:	**TC +35 °C**
Evaporating temperature:	**TE -20 °C**

Note: Sometimes plants operate under different conditions, e.g. different evaporating temperatures due to variations in the plant, or different condensing temperatures as a result of seasonal changes. By inserting TC and TE in the oil recommendation diagram, the recommended area is found. In this case it is oil area 1. If the intersection is outside the area, contact Sabroe Refrigeration for a detailed calculation by means of the calculation program COMP1.

Fig. 6.52



By using the table which is situated next to the oil recommendation diagram, select the recommended code number and thus the recommended oil. In the example above there are thus 3 possibilities: PAO3, AP1 or M1. However, M1 is only recommended for moderately loaded compressors.

Table 6.22

Code no.	Area no. 1
PAO3 AP1	▲ ☆/▲
M1	See note

Oil Change on Sabroe Compressors

Never change to another oil type without contacting the oil supplier. Nor is it advisable to recharge a compressor with another oil type than the one already used for the plant or compressor in question.

Mixing different oils may result in operating problems in the refrigeration plant or damage to the compressor. Incompatibility between different oil types may reduce the lubricating properties considerably and may cause oil residues to form in the compressor, oil separator or plant. Oil residues may block filters and damage the moving parts of the compressor.

Changing the oil type or brand should only be done following a thorough procedure involving drainage and evacuation of the refrigeration plant. Information on a suitable procedure can be obtained from Sabroe Refrigeration as well as a number of oil companies.

It is extremely important that the new unused oil is taken directly from its original container and that both the brand and the type correspond to the specifications of the plant.

Make sure that the original oil container is sealed properly during storage so that moisture from the air is not absorbed by the oil. Many oils, particularly polyolester oils, are extremely hygroscopic. It is therefore recommended only to buy the oil in containers whose size correspond to the amount to be used.

In case all of the oil is not used, make sure that the rest of the oil is sealed in the original container and stored in a warm, dry place. It is recommended to charge nitrogen to keep the water content below 50 ppm.

Ideally, oil containers should be equipped with a barrel tap to ensure an effective, airtight seal.

Oil Changing Intervals

A list of the recommended oil changing intervals is included in the instruction manuals of the compressors. This list is for guidance only. The actual oil changing intervals are often determined by a number of operating parameters in the plant.

It is strongly recommended to monitor the quality of the oil by performing oil analyses on a regular basis. This will also give an indication of the condition of the plant. This service can be supplied by Sabroe Refrigeration or the oil supplier.

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 Sabroe Refrigeration
Ⓒ	Min. suction temperature -50°C. At TE< -50°C superheating must be introduced.
*	Dry expansion systems only. Flooded systems to be considered individually: contact Sabroe 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 cSt 40°C	Viscosity cSt 100°C	Viscosity Index	Spec. grav. at 15°C	Flash p. COC °C	Pour p. °C	Anilin °C point	Acid no. mg KOH/g
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 great difference between polyolester-based lubricants from various suppliers, it is not possible to present any typical data for these oils. When using another oil brand than the one recommended by Sabroe Refrigeration, please contact the oil supplier to select the correct oil type.							
E5								
E9								
E11								
E85								

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

List of Part Numbers for Available Sabroe Oils

Oil brand	Oil code no.	Part no.	
		20 litre pail	208 litre barrel
Mobil Gargoyle Arctic 300	M1 (M68)	1231-264	1231-296
Sabroe Oil A100	A3 (A100)	1231-263	1231-262
Sabroe Oil AP68	AP1 (AP68)	1231-257	1231-260
Sabroe Oil PAO68	PAO3 (P68)	1231-256	1231-259
Mobil Gargoyle Arctic SHC 228	PAO5 (P100)	1231-282	1231-283
Mobil Gargoyle Arctic SHC 230	PAO9 (P220)	1231-284	1231-285
Mobil EAL Arctic 68	E3 (E68)	1231-272	1231-273
Mobil EAL Arctic 100	E5 (E100)	1231-274	1231-275
Mobil EAL Arctic 220	E9 (E220)		1231-279
Sabroe H oil	E11 (E370)	3914 1512 954 [1)]	9415 0008 000
FUCHS DEA Reniso C85E	E85 (85)	1231-304 [2)]	

[1)] 18.9 litre pail (5 US gallons)

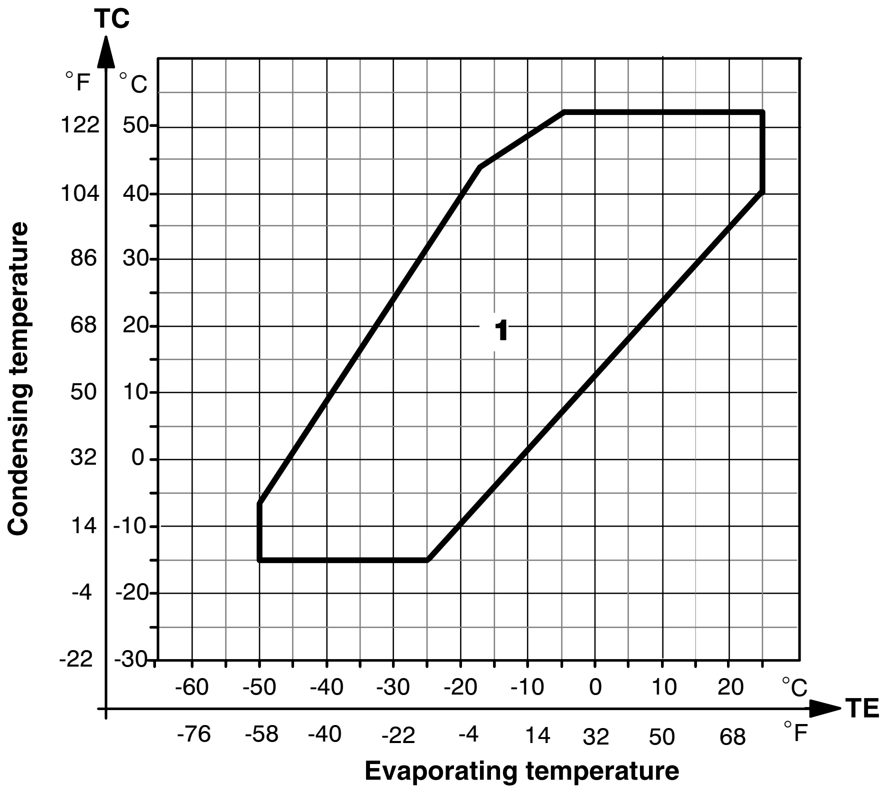
[2)] 10 litre

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

single-stage reciprocating compressor



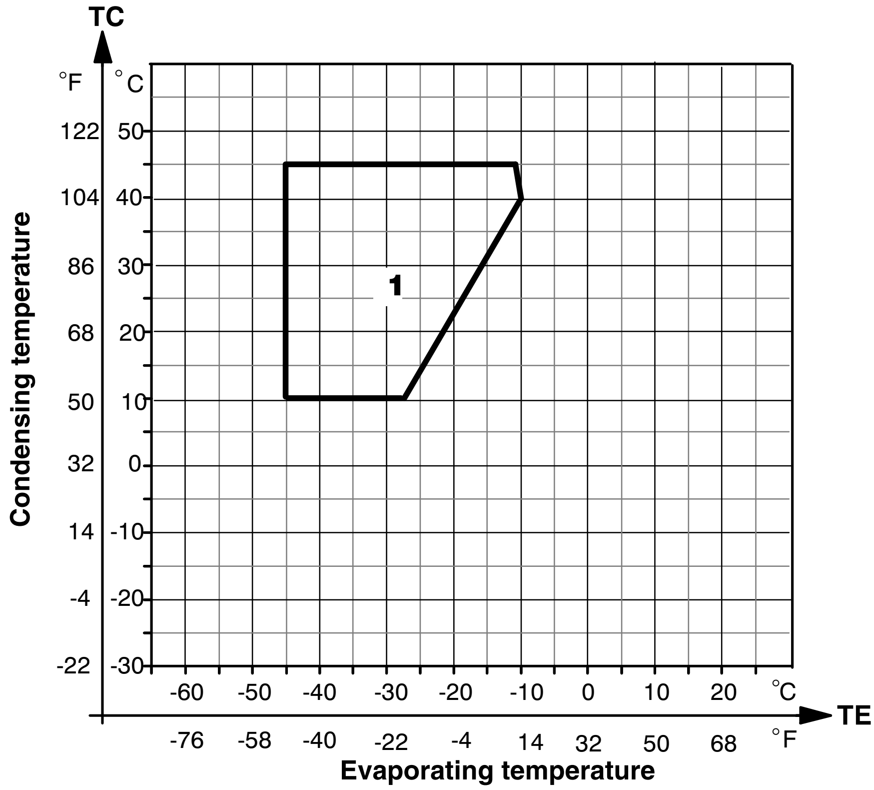
Code no	Area no 1
PAO 3	▲
AP 1	☆/▲
M1	See note

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

▲ : Very suitable in case of a new plant.
☆: In case you wish to change from mineral oil.

R717

two-stage reciprocating compressors



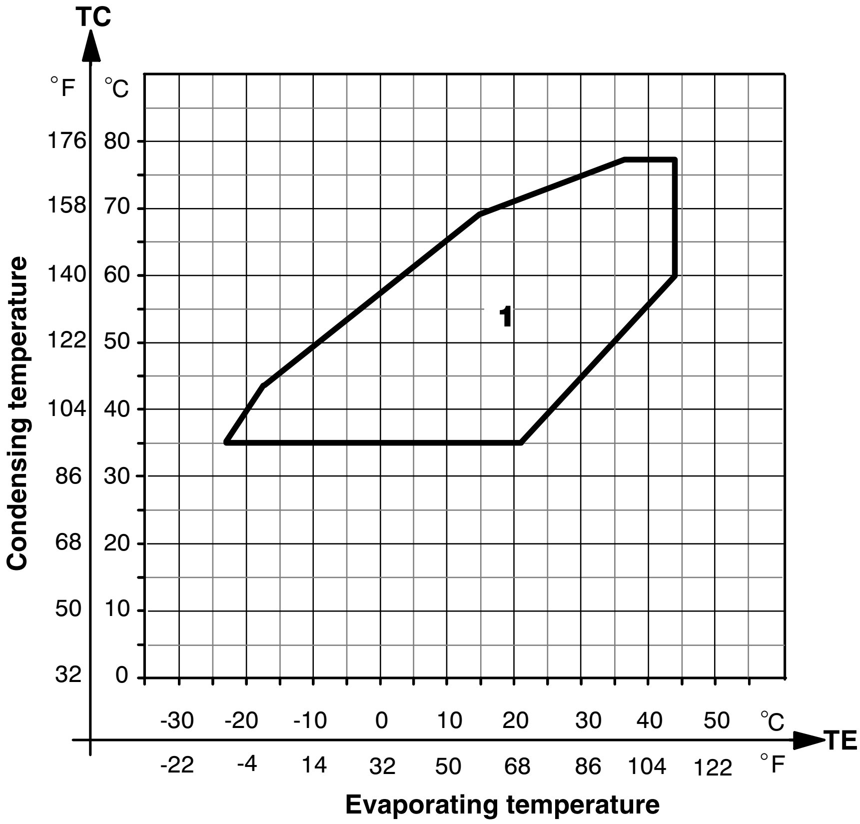
Code no	Area no 1
PAO 3	▲
AP 1	☆/▲
M1	See note

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

▲: Very suitable in case of a new plant.
☆: In case you wish to change from mineral oil.

R717

HPO and HPC reciprocating compressors



Code no	Area no 1
PAO 5	▲

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

▲: Very suitable in case of a new plant.

List of Major Oil Companies

The oil from the companies listed below are not tested by Sabroe Refrigeration and are therefore not approved by Sabroe Refrigeration. The following list includes the information provided by the oil companies. The oil companies are responsible for the information concerning the durability and suitability of their oils for specific purposes. Oils tested and approved by Sabroe Refrigeration are included 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	•		•		•
Elf / Lub Marine 1	•	•			•
Esso/Exxon	•	•	•		
Fina	•	•			•
FuchsDEA	•	•	•		•
Hydro-Texaco	•	•	•		•
ICI					•
Kuwait Petroleum (Q8)	•			•	
Mobil	•	•	•	•	•
Petro-Canada	•				
Shell	•	•	•		•
Statoil	•	•			
Sun Oil	•				•

Selecting Lubricating Oil for SABROE Reciprocating Compressors

Refrigerant: HFC/HCFC/R744

In a period from 1990 to 1995
Sabroe Refrigeration experienced a rising number of problems with the use of mineral oils, especially in R717 plants.
The problems can be divided into two groups:

e. The oil changes viscosity within a few operating hours.

f. The oil dissolves becomes very black).

The problems have been observed in connection with several different types of mineral oil and often occur within only a few operating hours. The consequences have been severe for both compressors and plants.

On the basis of the thorough investigation subsequently carried out by Sabroe Refrigeration, it was decided to introduce a series of synthetic oils complying with the requirements of modern refrigeration plants.

Mineral oils can, however, still be used in refrigeration plants, provided the lubricating quality is carefully monitored. For modern high-capacity refrigeration plants where a long service life for both lubricant and moving parts is expected, Sabroe Refrigeration recommends the use of synthetic oils.

Areas of application and specifications for the synthetic oils mentioned are described in the following pages. Supervisors and/or users of plants are at liberty to choose between Sabroe Refrigeration's own oil brands and alternative oil brands, provided they comply with the specifications required.

General

This recommendation will only deal with the lubrication of the compressor. The performance of the lubricant in the plant (receiver, evaporator, etc.) must, however, also be considered.

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

To achieve the best lubrication, the oil must:

- possess the correct viscosity under all operating conditions.
- possess acceptable viscosity at start-up.
- possess sufficient oxidation stability (the oil must be free of moisture when charged to the system).
- possess sufficient chemical stability when used together with HFC/HCFC.

Moreover, the extent to which different refrigerants dissolve in the oil must be determined so that the oil return system, etc. can be designed to perform at its optimum.

Stratification

Note that the oil in some plants is layered in refrigerant receivers and evaporators under certain operating conditions and at certain oil concentrations. This applies in particular to HFC/HCFC plants.

The oil recommendation diagrams for SABROE compressors with HFC and HCFC refrigerants indicate the limits for Sabroe oils where stratification occurs. The oil concentrations stated in these diagrams must not be exceeded. This makes it possible to adjust the oil rectification/return systems to the oil consumption of the compressor so that the maximum concentration is not exceeded. For area A in the diagrams, the oil concentration in the liquid phase must not exceed 2%. For the other areas, the oil concentration must not exceed 5%. For area B, please contact Sabroe Refrigeration.

Plants with Several Different Compressor Types/Makes

In plants where several different compressor types/makes are connected, it is strongly recommended to use the same type of oil in all the compressors. This is very important where automatic oil return systems are used.

If you consider changing the type of oil, please read the section Oil Changing on SABROE Compressors carefully.

Selecting Lubricating Oil

The correct oil is selected by means of the following diagrams. When the general conditions concerning the lubrication of the compressor have been considered, the specific conditions of the plant must be taken into account.

Use the oil recommendation diagrams to select the correct oil code number.

The oil code number consists of letters indicating the oil type and viscosity number..

Table 6.23

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

In the oil recommendation diagrams it is possible to find the code number best suited for the operating conditions in question. With the code number it is possible to select the correct Sabroe oil for the application in question.

Oil Types and Oil Companies

Due to the large number of oil companies offering oil for refrigeration plants, it has not been possible for Sabroe Refrigeration to test all the different oil brands on the global market.

It is our experience that certain oil brands can change character during use and thus no longer correspond to the specifications stated by the oil companies on delivery. We have thus experienced changes in specifications as well as formula and performance without having received information on this beforehand from the oil company. This makes it extremely difficult for Sabroe Refrigeration to give a general approval of other oil brands.

In co-operation with a large, respected oil company Sabroe Refrigeration has therefore developed a series of three different oils covering most demands. Furthermore, a list of the oils which can be supplied through Sabroe Refrigeration has been prepared. Data for these oils is included in the table Data for Sabroe Oils. We recommend that you use these oils, which can be delivered in 20 litre pails or 208 litre drums. When ordering, use the part no. stated in List of Part Numbers for Available Sabroe Oils.

It is of course possible to use similar oils from other oil companies. If this is the case, use the table Data for Sabroe Oils.

Please note that Sabroe Refrigeration has not tested other oils than our own brand. Thus we cannot guarantee the quality, stability or suitability of other oils. The respective oil companies are thus responsible for the quality and suitability of the oil delivered, and if there are any problems with these oils in the compressor or the refrigeration plant, contact the oil supplier directly.

When selecting oils from other oil companies, special attention should be paid to the suitability of the oil in the compressor and the refrigeration plant as a whole.

Please note in particular the following points:

- Oil type
- Refrigerant type
- Compressor type
- Miscibility between refrigerant and oil
- Operating data for the compressor
  - Discharge gas temperature
  - Oil temperature
  - Normal temperature in the crank case is 50-60°C
  - Max. permitted oil temperature = set point for alarm.
  - Min. permitted oil temperature = set point for alarm - if there is any
- The viscosity of the oil in the compressor during operation and under the influence of:
  - Type of refrigerant and solubility of refrigerant in the oil
  - Operating temperatures
  - Vapour pressure in the oil reservoir
  - Suction pressure and oil temperature in the crankcase
  - Compatibility with neoprene O-rings: The aniline point indicates how the O-ring material reacts to the oil.

  At an aniline point less than approx. 100°C the material has a tendency to swell, and at an aniline point higher than approx. 120°C it has a tendency to shrink.

  Thus it cannot be recommended to change the oil type from M to PAO without changing the O-rings at the same time as a leak may otherwise easily occur in the compressor or the plant. Sabroe Refrigeration recommends therefore the use of the Sabroe AP68 oil since this type of oil in this case reduces considerably the risk of leaks.

  Sabroe Refrigeration can supply a list of operating data on request.
- Please note the viscosity limits during operation:
  - Optimum viscosity limits = 20 to 50 cSt
  - Max. permitted viscosity = 100 cSt
  - Min. permitted viscosity = 10 cSt
  - Max. permitted viscosity during start-up of the compressor = 500 cSt
  - Max. refrigerant concentration in the oil during operation: 25% - also in case the viscosity requirements have been met.

Use of Mineral Oil

As described in the introduction, mineral oil in particular causes serious problems especially in R717 plants.

When using mineral oil, it is important to monitor the plant closely. The condition/colour of the oil must therefore be checked on a weekly basis and for each 1,000 to 2,000 operating hours oil samples must be taken for further analysis.

Sabroe Refrigeration recommends therefore only to use M oil under moderate operating conditions - see the following oil recommendation diagrams.

Sabroe Refrigeration is aware that several customers have used mineral oils for many years without any problems. The customers who wish to continue using mineral oil in existing as well as new compressors can do so, provided that the compressor type and the operating conditions are similar to the existing ones.

Sabroe Refrigeration has thus decided to market one brand of mineral oil which has been tested and found suitable for most of the general refrigeration purposes.

In case another brand of mineral oil is used, follow the specifications on the data pages in this recommendation as a guideline.

Mineral oil can be used in refrigeration plants, provided the lubricating quality is carefully monitored. Sabroe Refrigeration recommends, however, that you use synthetic oils for modern high-capacity plants where a long service life for both lubricant and moving parts is expected.

The advantage of using synthetic lubricating oils is a much lower oil consumption and longer oil changing intervals. Improved viscosity at low temperatures facilitates furthermore drainage at the cold parts of the plants.

How to Use the Diagrams in the Oil Recommendation:

To find the correct code number, select refrigerant and compressor type in the oil recommendation diagram. Then insert the estimated operating conditions in the diagram.

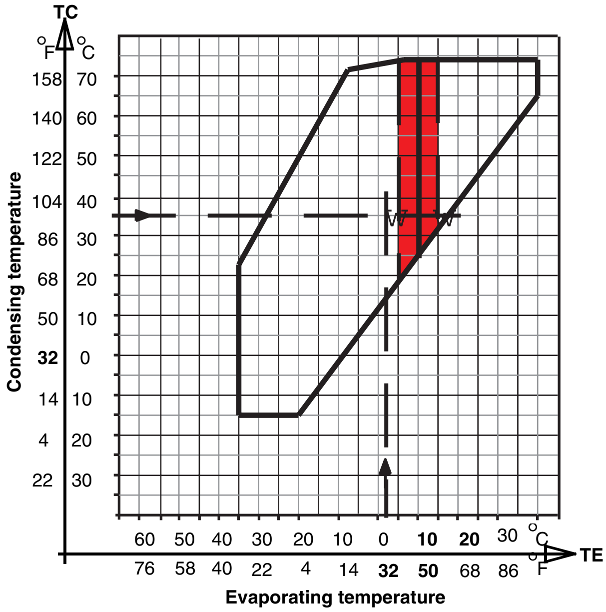
Example (reciprocating compressors):

Refrigerant	**R134a**
Condensing temperature:	**TC +35 °C**
Evaporating temperature:	**TE -3°C**

Note: Sometimes plants operate under different conditions, e.g. different evaporating temperatures due to variations in the plant, or different condensing temperatures as a result of seasonal changes. By inserting TC and TE in the oil recommendation diagram, the recommended area is found. In this case it is oil area 1. If TC should change, e.g. from -3°C to +7°C, use oil area 2. As +7°C is within the marked area, oil area 1 can, however, also be used at this TE.

Fig. 6.53

R134a



By using the table which is situated next to the oil recommendation diagram, select the recommended code number and thus the recommended oil. In the example above an oil with code number E5 can be used.

Table 6.24

Code no.	Area no.	
	1	2
E5	▲	
E9		▲

Oil Change on Sabroe Compressors

Never change to another oil type without contacting the oil supplier. Nor is it advisable to recharge a compressor with another oil type than the one already used for the plant or compressor in question.

Mixing different oils may result in operating problems in the refrigeration plant or damage to the compressor. Incompatibility between different oil types may reduce the lubricating properties considerably and may cause oil residues to form in the compressor, oil separator or plant. Oil residues may block filters and damage the moving parts of the compressor.

Changing the oil type or brand should only be done following a thorough procedure involving drainage and evacuation of the refrigeration plant. Information on a suitable procedure can be obtained from Sabroe Refrigeration as well as a number of oil companies.

It is extremely important that the new unused oil is taken directly from its original container and that both the brand and the type correspond to the specifications of the plant.

Make sure that the original oil container is sealed properly during storage so that moisture from the air is not absorbed by the oil. Many oils, particularly polyester oils, are extremely hygroscopic. It is therefore recommended only to buy the oil in containers whose size correspond to the amount to be used.

In case all of the oil is not used, make sure that the rest of the oil is sealed in the original container and stored in a warm, dry place. It is recommended to charge nitrogen to keep the water content below 50 ppm.

Ideally, oil containers should be equipped with a barrel tap to ensure an effective, airtight seal.

Oil Changing Intervals

A list of the recommended oil changing intervals is included in the instruction manuals of the compressors. This list is for guidance only. The actual oil changing intervals are often determined by a number of operating parameters in the plant.

It is strongly recommended to monitor the quality of the oil by performing oil analyses on a regular basis. This will also give an indication of the condition of the plant. This service can be supplied by Sabroe Refrigeration or the oil supplier..

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 Sabroe Refrigeration
Ⓒ	Min. suction temperature -50°C. At TE< -50°C superheating must be introduced.
*	Dry expansion systems only. Flooded systems to be considered individually: contact Sabroe 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** cSt 40°C	cSt 100°C	**Viscosity** Index	**Spec.** grav. at 15°C	**Flash p.** COC °C	**Pour p.** °C	**Anilin** °C point	**Acid no.** mg KOH/g
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 great difference between polyolester-based lubricants from various suppliers, it is not possible to present any typical data for these oils. When using another oil brand than the one recommended by Sabroe Refrigeration, please contact the oil supplier to select the correct oil type.							
E5								
E9								
E11								
E85								

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

List of Part Numbers for Available Sabroe Oils

Oil brand	Oil code no.	Part no.	
		20 litre pail	208 litre barrel
Mobil Gargoyle Arctic 300	M1 (M68)	1231-264	1231-296
Sabroe Oil A100	A3 (A100)	1231-263	1231-262
Sabroe Oil AP68	AP1 (AP68)	1231-257	1231-260
Sabroe Oil PAO68	PAO3 (P68)	1231-256	1231-259
Mobil Gargoyle Arctic SHC 228	PAO5 (P100)	1231-282	1231-283
Mobil Gargoyle Arctic SHC 230	PAO9 (P220)	1231-284	1231-285
Mobil EAL Arctic 68	E3 (E68)	1231-272	1231-273
Mobil EAL Arctic 100	E5 (E100)	1231-274	1231-275
Mobil EAL Arctic 220	E9 (E220)		1231-279
Sabroe H oil	E11 (E370)	3914 1512 954 1)	9415 0008 000
FUCHS DEA Reniso C85E	E85 (85)	1231-304 2)	

1) 18.9 litre pail (5 US gallons)

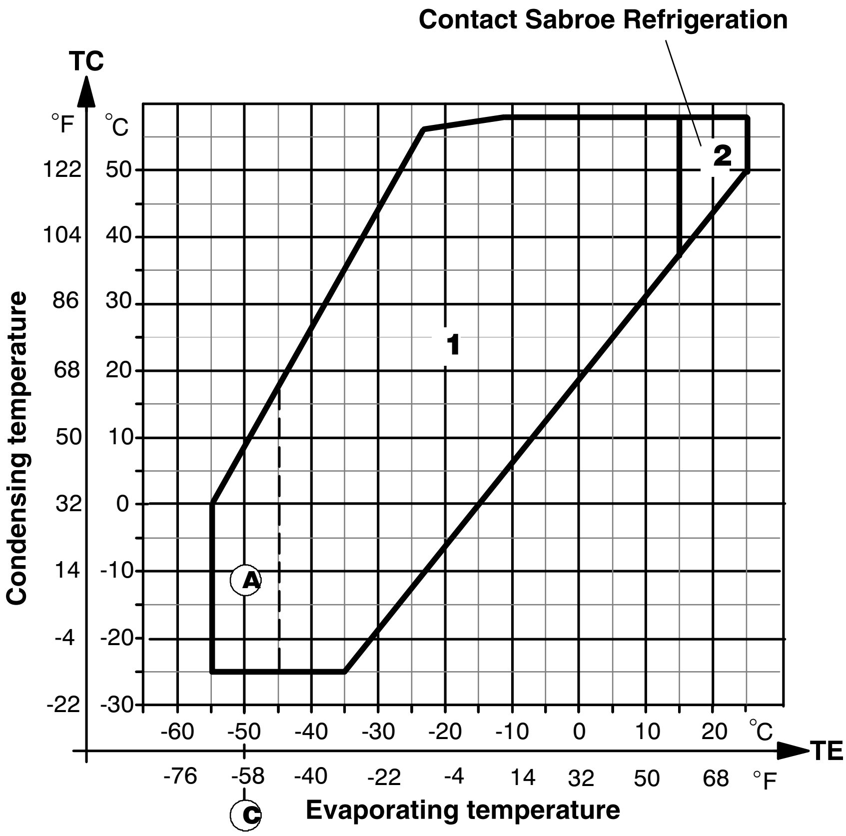
2) 10 litre

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)

R22

single-stage reciprocating compressors



Code no	Area no 1
A 3	▲

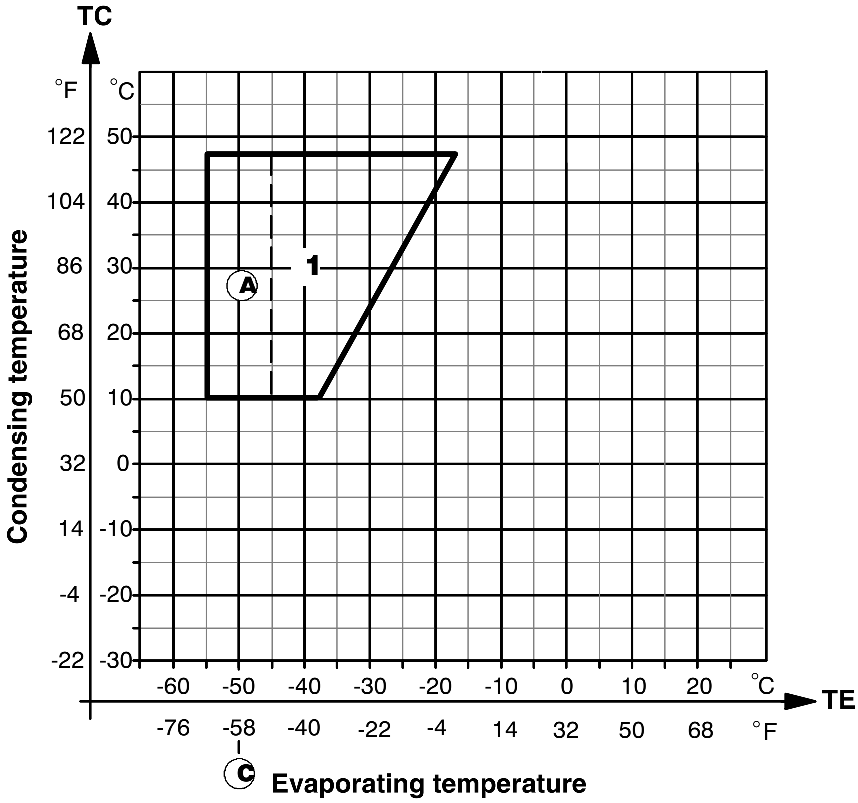
▲: Very suitable in case of a new plant.

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

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

R22

two-stage reciprocating compressors

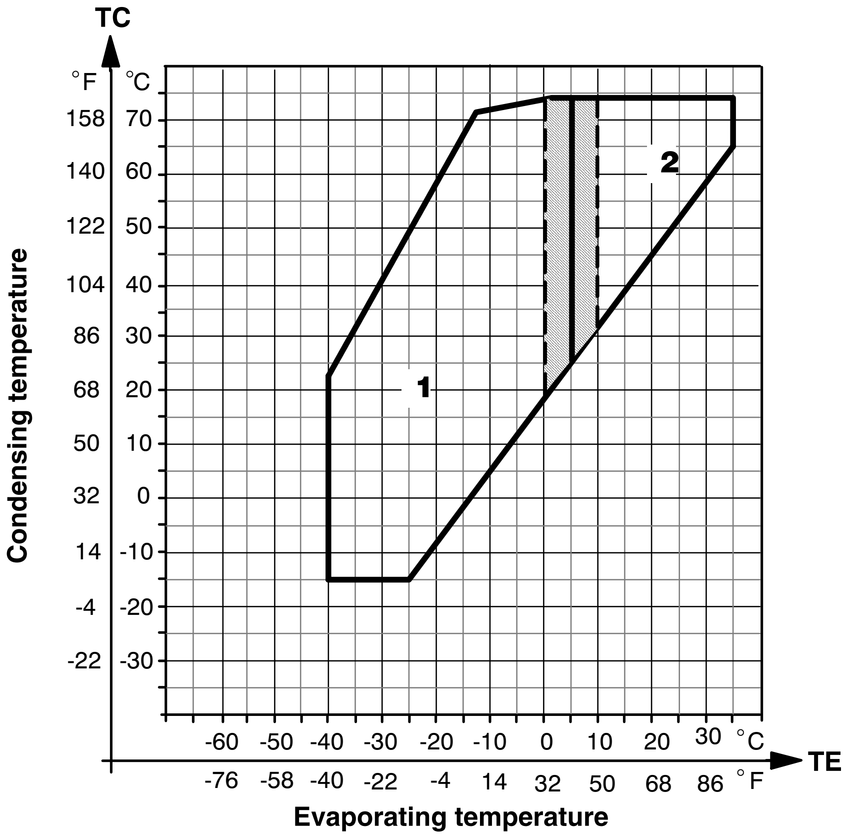


Code no	Area no 1
A 3	▲

▲: Very suitable in case of a new plant.
Ⓐ: Max oil concentration in liquid phase at TE: 2% W.
Ⓒ: Min suction temperature -50°C. At TE<-50°C superheating must be introduced.

R134a

single-stage reciprocating compressors



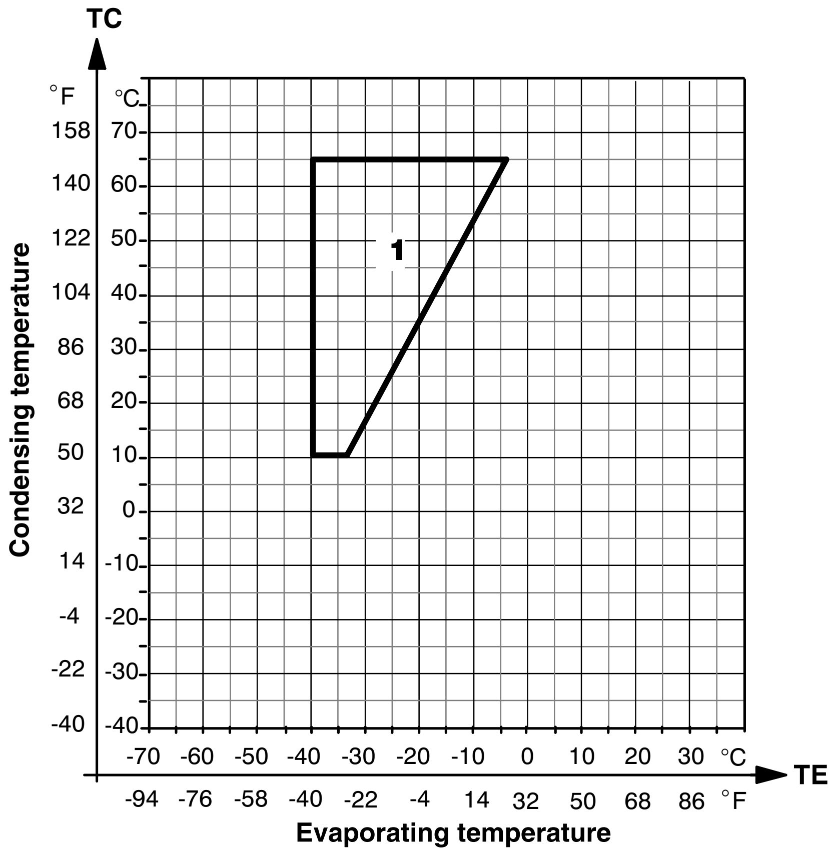
Code no	Area no	
	1	2
E 5	▲	
E 9		▲

▲: Very suitable in case of a new plant.

▧: Zone in which both oils are applicable.:

R134a

two-stage reciprocating compressors

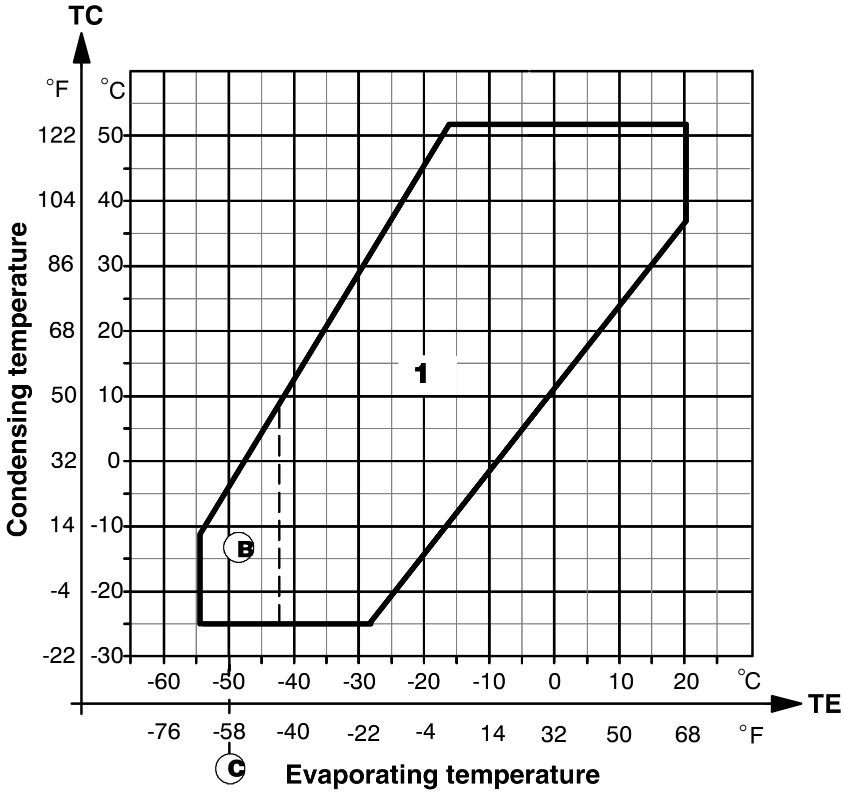


Code no	Area no 1
E 5	▲

▲: Very suitable in case of a new plant.

R407C

single-stage reciprocating compressors



Code no	Area no 1
E 3	▲

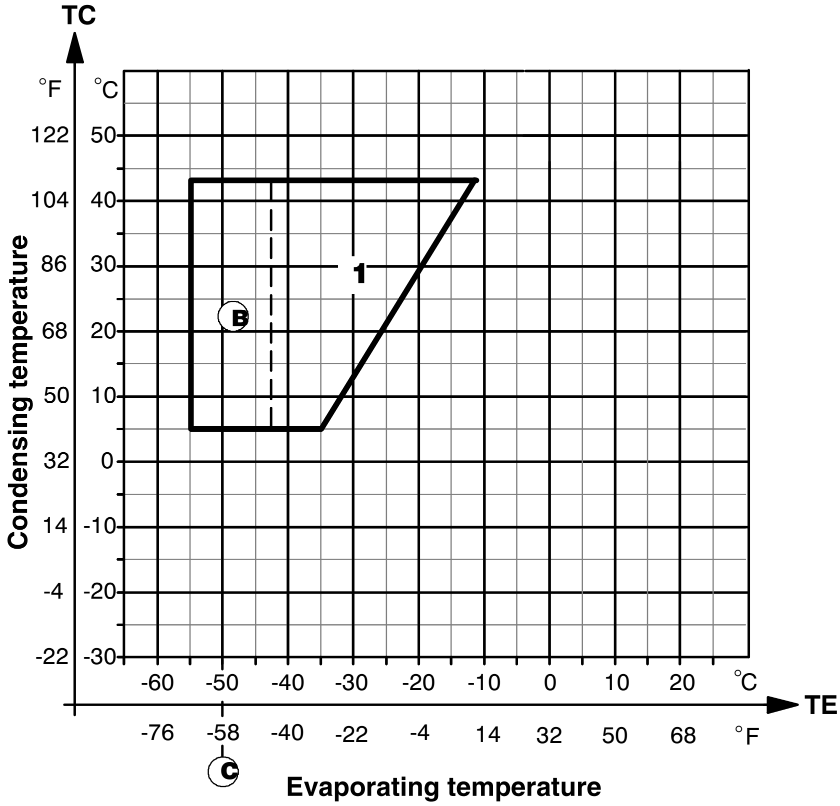
▲: : Very suitable in case of a new plant.

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

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

R407C

two-stage reciprocating compressors



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Code no	Area no 1
E 3	▲

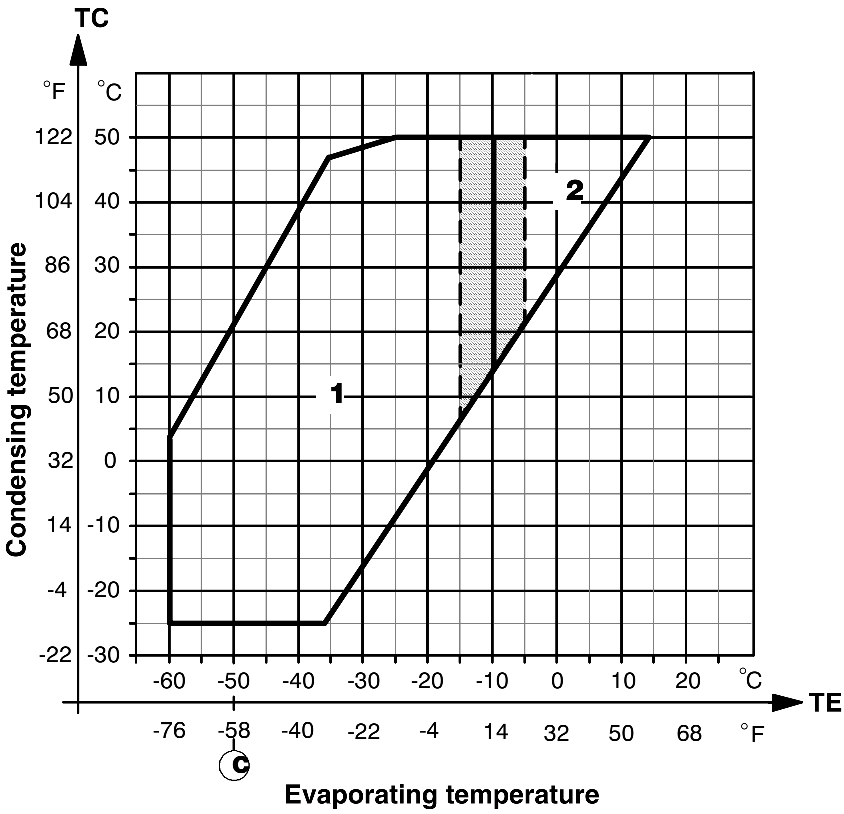
▲: : Very suitable in case of a new plant.

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

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

R404A

single-stage reciprocating compressors



Code no	Area no	
	1	2
E 3	▲	
E 5		▲

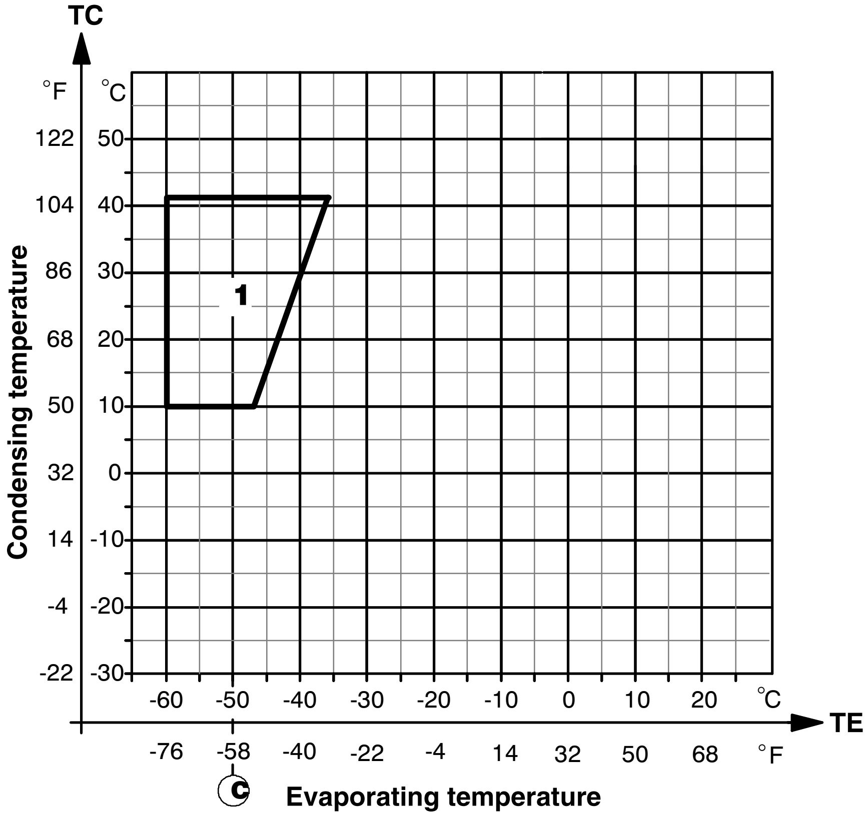
▲: : Very suitable in case of a new plant.

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

▨: Zone in which both oils are applicable.

R404A

two-stage reciprocating compressors



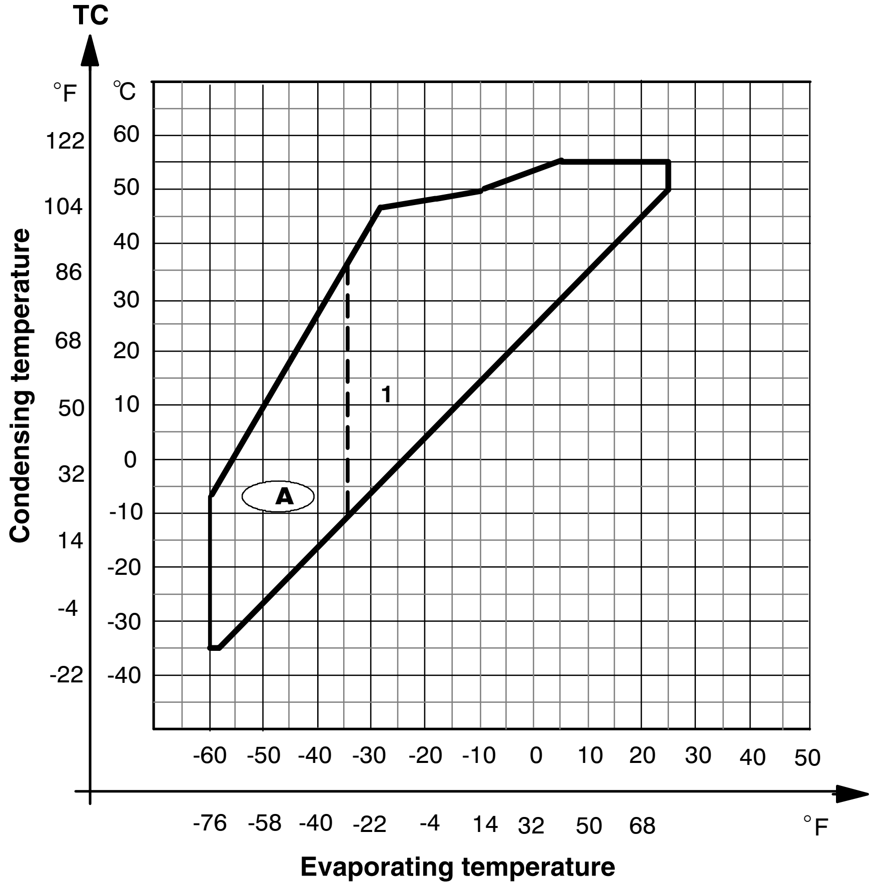
Code no	Area no 1
E 3	▲

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

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

R410A

HPO and HPC reciprocating compressors



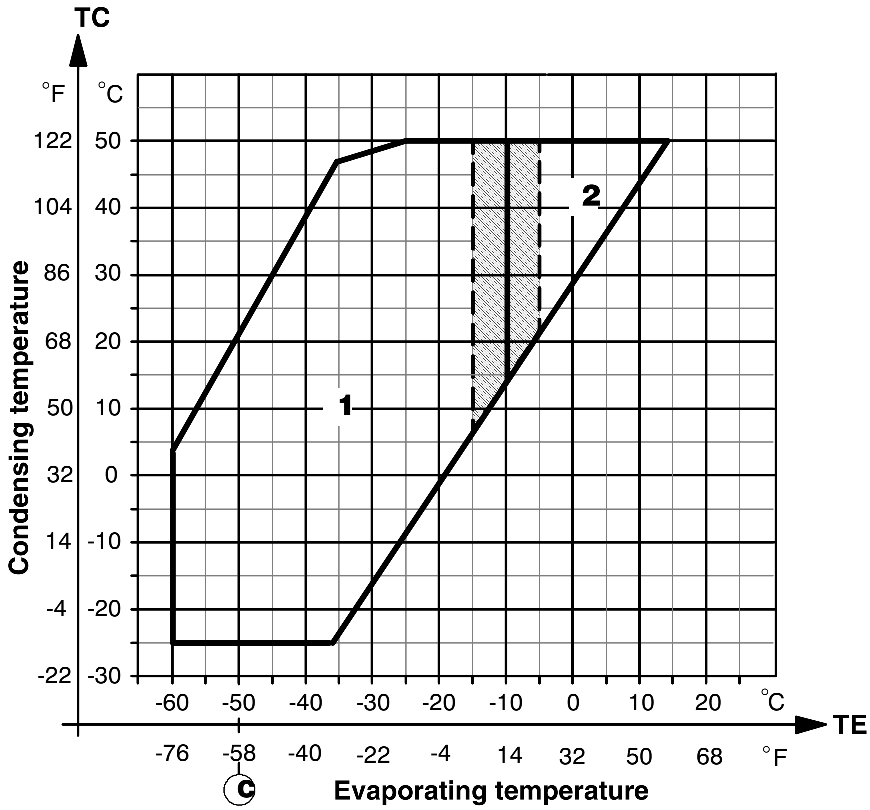
Code no.	Area no 1
E 5	▲

▲: very suitable in case of a new plant.

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

R507

single-stage reciprocating compressors



Code no	Area no	
	1	2
E 3	▲	
E 5		▲

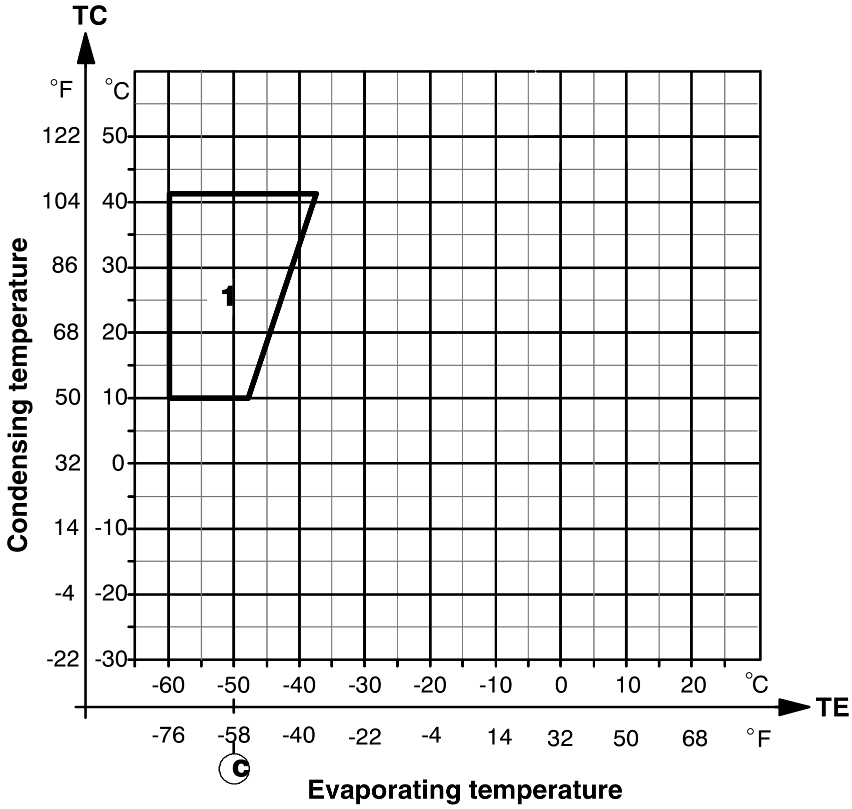
▲: : Very suitable in case of a new plant.

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

▧: Zone in which both oils are applicable.

R507

two-stage reciprocating compressors



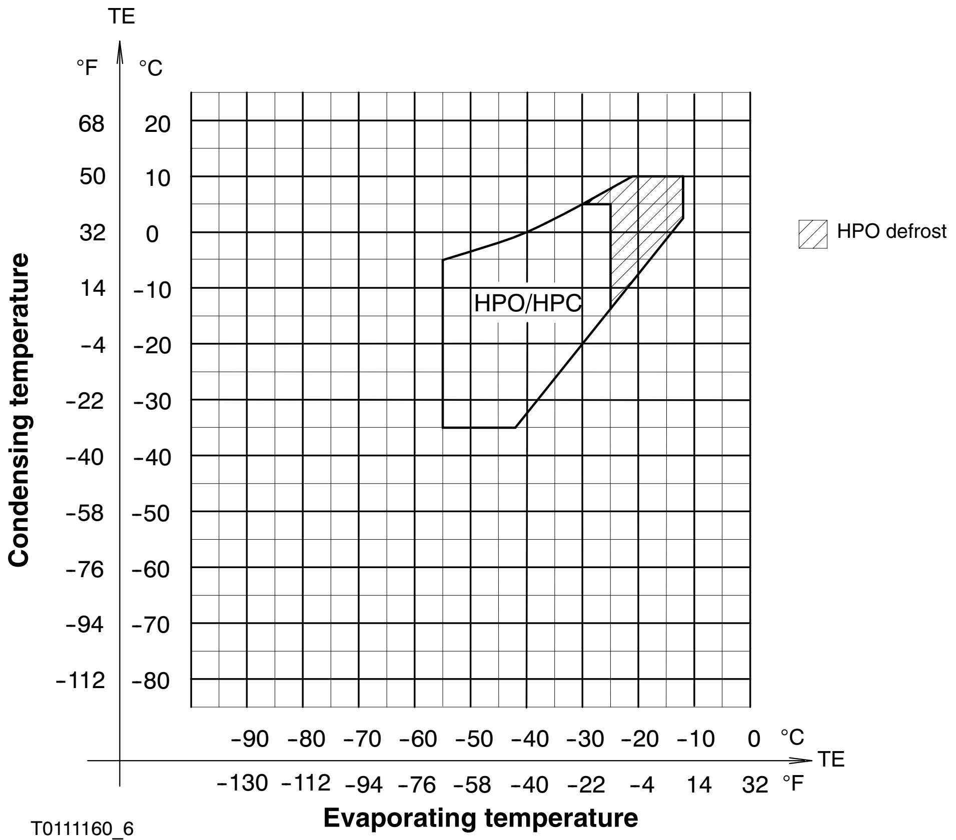
Code no	Area no 1
E 5	▲

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

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

R744

single-stage reciprocating compressors



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Code no	Area no
	1
E 85	▲

▲: Very suitable in case of a new plant

List of Major Oil Companies

The oil from the companies listed below are not tested by Sabroe Refrigeration and are therefore not approved by Sabroe Refrigeration. The following list includes the information provided by the oil companies. The oil companies are responsible for the information concerning the durability and suitability of their oils for specific purposes. Oils tested and approved by Sabroe Refrigeration are included 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	•		•		•
Elf / Lub Marine 1	•	•			•
Esso/Exxon	•	•	•		
Fina	•	•			•
FuchsDEA	•	•	•		•
Hydro-Texaco	•	•	•		•
ICI					•
Kuwait Petroleum (Q8)	•			•	
Mobil	•	•	•	•	•
Petro-Canada	•				
Shell	•	•	•		•
Statoil	•	•			
Sun Oil	•				•

9. Settings

The purpose of this chapter is to provide information about the factory settings of the safety and control equipment, how to change the settings and the effect of a change.

This chapter is primarily intended for installation and service engineers.

Safety Precautions

⚠ ***Danger!***

Risk of injury to personnel and damage to equipment! In addition to the safety precautions in this chapter, always read the safety precautions belonging to this equipment before changing the settings. Failure to comply with safety precautions may cause death or injury to personnel. It may also cause damage to or destruction of the equipment.

Qualification Requirements

Changes in the factory settings must only be carried out by an authorised refrigeration company.

Moreover, it is required that the personnel is able to follow a detailed description in English.

Factory settings for analogous control and safety system appear from Table 9.1. In connection with fault-finding in case of irregularities in the operation, the table should include own settings to make it easier for the supervisor to identify the error in question. The same applies to UNISAB II control.

Compressor control systems

Compressors are delivered with an analogue control and safety system or the UNISAB II reading, safety and capacity regulating system.

With regard to compressors delivered with the UNISAB II system, the system is described in the Operating Manual located in the UNISAB II cabinet.

Furthermore, a UNISAB II Engineering Manual (version 2.04) is available. This manual describes the control system in more detail. Consequently, setting of set points etc. is not described in this section.

Table 9.1 Pressure and Temperature Settings for Compressor Type SMC/TSMC

Analogous control and safety system			Refrigerant							
			R22	R 134	R 404A	R 507	R 717		Min. setting (own setting)	Max. setting (own setting)
Safety Equipment	Safety valve on compressor	HT	X	X	X	X	X	24 bar (standard)		
			X	X	X	X	X	22 bar (special)		
		MT	X	X	X	X	X	12 bar		
	High and intermediate-pressure cut-out	KP5 (KP15)	X	X	X	X	X	Set so that the compressor stops at a pressure 2 bar lower than the safety valve set- ting.		
	Low-pressure cut-out	KP1 (KP15)	X	X	X	X	X	Set to a pressure with saturation temp. 5° K lower than the lowest evaporating temperature.		
	Oil pressure cut-out	MP55	X	X	X	X	X	3.5 bar		
	Discharge pipe thermostat	KP98	X	X	X			* 120° C		
							X	* 150° C		
	Oil thermostat	KP98	X	X	X	X	X	80° C		
Control Equipment	Thermostat for compressor cooling	KP77	X	X	X	X	X	55° C		
	Thermo valve for compressor cooling	T (E) X T (E) N T (E) S	X	X	X	X		Normally set at 4° C su- perheat Change to min. 10° C superheat		
	Injection valve for intermediate cooling	TEAT		X	X	X		Factory setting 45° C. See NB		
			X				X	Factory setting 75° C. See NB		
		T (E) X TEA	X					Set at min.10° C superheat		
							X	Set at min.10° C superheat		
	By-pass valve	PMC+ CVC		X	X	X		-25° C		
							X	-15° C		
	Oil filter differential pressure	KZD4/M3	X	X	X	X	X	2,0 bar		
	Oil pressure regulating valve		X	X	X	X	X	4.5 bar		

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

** Adjust the TEAT valves so that the expected discharge pipe temperature (-5° C/+10° C) is achieved at 100% compressor capacity. Increase the opening temperature 10° C by turning the spindle 5 turns clockwise. 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. For detailed descriptions concerning setting and adjustment of automatics, see chapter 21, Appendices.

Fig. 9.1 *Expected Discharge GasTemperatures*

HFC HCFC

R134a – Evaporating temperature or intermediate temperature C° – Discharge gas temp.° C

Suction gas superheat °C	Condensing temp. °C	Condensing pressure bar	+10	0	-10	-20	-30
10	20	5.7	38	41	43	48	55
	25	6.6	44	45	48	52	59
	30	7.7	49	50	53	58	66
	35	8.8	53	54	58	64	74
	40	10.1	57	59	63	69	79
	45	11.5	61	63	67	74	82
20	20	5.7	48	51	53	58	65
	25	6.6	54	55	58	62	69
	30	7.7	59	60	63	68	76
	35	8.8	63	64	68	74	84
	40	10.1	67	69	73	79	89
	45	11.5	71	73	77	84	92
30	20	5.7	58	61	63	68	75
	25	6.6	64	65	68	72	79
	30	7.7	69	70	73	78	86
	35	8.8	73	74	78	84	94
	40	10.1	77	79	83	89	99
	45	11.5	81	83	87	94	102

R22 – Evaporating temperature or intermediate temperature C° – Discharge gas temp.° C

Suction gas superheat °C	Condensing temp. °C	Condensing pressure bar	+10	0	-10	-20	-30
10	20	8.2	37	48	61	76	91
	25	9.5	47	57	69	84	101
	30	11.1	55	65	77	92	108
	35	12.7	68	74	85	99	115
	40	14.5	72	82	94	106	120
	45	16.5	81	90	100	112	126
20	20	8.2	48	59	72	88	103
	25	9.5	57	68	80	95	110
	30	11.1	65	76	88	102	117
	35	12.7	73	84	96	109	123
	40	14.5	82	92	103	115	128
	45	16.5	90	98	109	121	133
30	20	8.2	59	70	83	97	113
	25	9.5	69	78	91	105	120
	30	11.1	75	86	98	111	125
	35	12.7	84	95	106	118	131
	40	14.5	92	101	111	123	135
	45	16.5	99	108	117	128	139

R404A/R507 – Evaporating temperature or intermediate temperature C° – Discharge gas temp.° C

Suction gas superheat °C	Condensing temp. °C	Condensing pressure bar	0	-10	-20	-30	-40
10	20	11.0	40	42	46	53	62
	25	12.5	44	47	51	58	67
	30	14.3	49	52	56	63	71
	35	16.2	54	57	61	67	75
	40	18.2	59	62	66	72	79
	45	20.5	65	67	71	77	83
20	20	11.0	50	52	56	63	72
	25	12.5	54	57	61	68	77
	30	14.3	59	62	66	73	81
	35	16.2	64	67	71	77	85
	40	18.2	69	72	76	82	89
	45	20.5	75	77	81	87	93
30	20	11.0	60	62	66	73	82
	25	12.5	64	67	71	78	87
	30	14.3	69	72	76	83	91
	35	16.2	74	76	81	87	95
	40	18.2	79	82	86	92	99
	45	20.5	85	87	91	97	103

R717 – Evaporating temperature or intermediate temperature C° – Discharge gas temp.° C

Suction gas superheat °C	Condensing temp. °C	Condensing pressure bar	+10	0	-10	-20	-30
10	20	7.6	53	71	91	110	131
	25	9.1	65	83	102	121	142
	30	10.7	77	95	113	133	151
	35	12.6	89	106	123	141	160
	40	14.6	101	117	133	151	170
	45	16.9	110	126	143	161	-
20	20	7.6	65	83	103	122	143
	25	9.1	77	95	114	132	153
	30	10.7	89	106	125	142	162
	35	12.6	100	116	134	152	-
	40	14.6	111	127	144	162	-
	45	16.9	121	136	154	171	-
30	20	7.6	78	96	115	134	153
	25	9.1	90	106	126	144	163
	30	10.7	102	118	136	154	-
	35	12.6	112	128	146	163	-
	40	14.6	123	138	155	-	-
	45	16.9	132	148	165	-	-

10. Operating instructions

This chapter is included in the separate manual 'Operating instructions'; please consult this manual if you need information about operating the compressor.

11. Maintenance Instructions

The purpose of this chapter is to describe:

- Dangers resulting from failure to comply with safety precautions when performing maintenance tasks.
- Scheduled maintenance tasks for this equipment and how to carry them out safely.
- When these scheduled maintenance tasks should be performed.

This chapter is primarily intended for operators and service engineers.

Danger!

Risk of injury to personnel and damage to equipment! Always read the safety precautions belonging to this equipment before start. Failure to comply with safety precautions may cause death or injury to personnel. It may also cause damage to or destruction of the equipment.

Safety Precautions

Danger!

Risk of injury to personnel and damage to equipment! In addition to the safety precautions in this chapter, always read the safety precautions belonging to this equipment before start. Failure to comply with safety precautions may cause death or injury to personnel. It may also cause damage to or destruction of the equipment.

Safety Measures

Danger!

The paragraphs that follow present some important safety considerations for this type of compressor unit. Before starting maintenance work, study carefully the general safety instructions/regulations that apply to this series of compressor units. Failure to follow these instructions/regulations can lead to personal injury and even death. Moreover, the equipment can be damaged or destroyed.

Maintenance of the Compressor Unit

General

To make certain that the compressor unit operates without problems throughout a long service life, follow the system of maintenance presented in the following instructions.

Maintenance can be divided into three groups:

1. **Daily Maintenance**
   This consists of visual inspections. When familiar with the normal noise and vibration of the unit, compare each day's performance with previous observations. Make comparisons with the available diagrams etc. to make certain that the operating data lie within the permissible ranges.
   - Inspect the compressor unit and check that both noise and vibration are normal.
   - Enter the observed operating data into the operations log, see Table for Monitoring Operation in chapter 10, Operating Instructions. Check that all operating values are within the permissible ranges. Compare them with previous values to detect trends. If necessary, submit a report so that a closer check can be made.
   - Check the oil level in the oil separator (Screw compressor unit).
   - Check the oil level in the compressor (Reciprocating compressor unit).
   - Check oil pressure.
   - Check the refrigerant charge.
   - Search for leaks if there is even the slightest suspicion that there may be a leak. Conducting a manual check right at the compressor unit itself is always the best way to check for:
     a) leakage of oil and/or refrigerant,
     b) leakage of cooling water or brine,
     c) abnormal vibrations.
   - Do not wait for the monitoring equipment to issue an alarm. Searching for leaks is explained in greater detail later in this chapter.

⚠ ***Warning!***

Daily maintenance is normally conducted by operating personnel. Other maintenance and service tasks which require the refrigeration system to be opened must only be conducted by authorized personnel.

2. **Periodic maintenance**
   Motor lubrication and other routine maintenance tasks are usually based on running time. Note, however, that these can be conducted more frequently if necessary.
3. **Major overhaul**
   For major maintenance tasks such as compressor overhauls, the usual procedure is to call in the supplier's service personnel.

The different parts of the compressor unit that require regular periodical maintenance are indicated below.

Service intervals

The service interval for a reciprocating compressor should be determined as follows:

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

Service interval diagrams

Fig. 11.1 ***R717*** *- SMC 100 S-L*
E-type: Multiply by 0.75

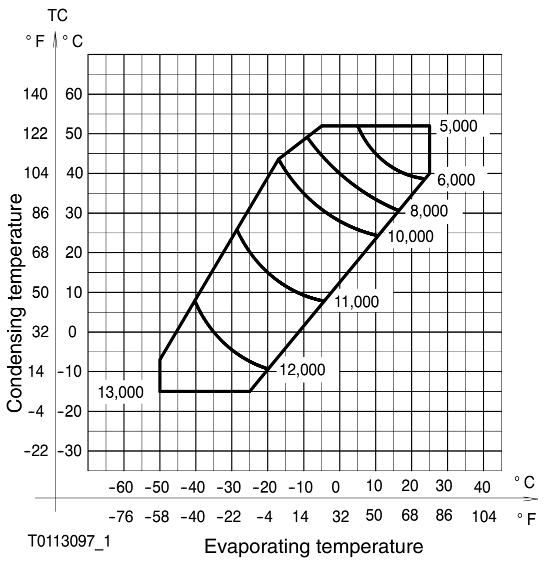


Fig. 11.2 ***HCFC/HFC/R290*** *- SMC 100 S-L*

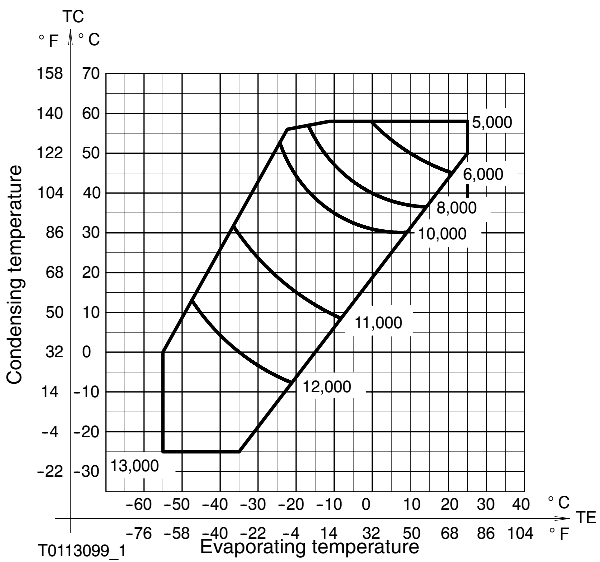


Fig. 11.3 ***R717*** *- TSMC 100 S-L*
E-type: Multiply by 0.75

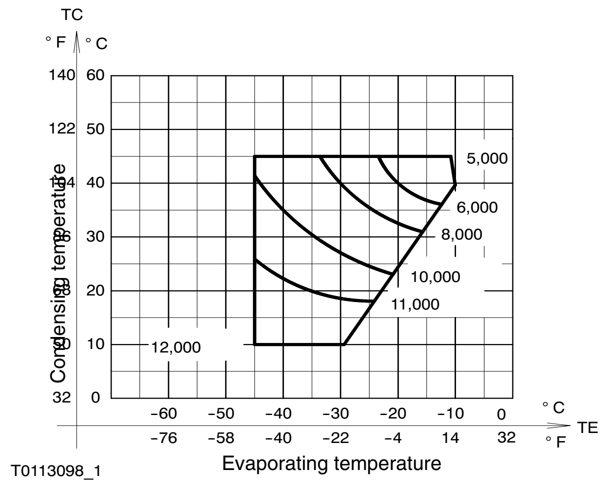
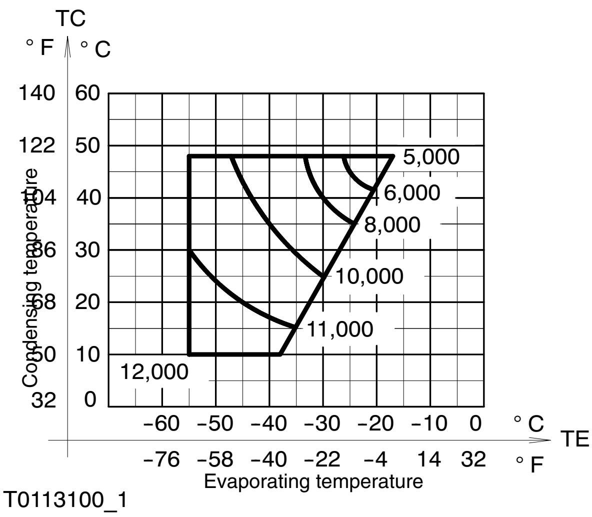


Fig. 11.4 ***HCFC/HFC/R290*** *- TSMC 100 S-L*



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

Table 11.1

Rpm	970	1,170	1,460	1,760
Correction factor	1.5	1.25	1.00	0.83

Correction may also be calculated according to the formula below:

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

Example

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

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

Note: Always replace oil filter when changing oil or when indicated by control lamp or UNISAB II.

The scope of the overhaul must follow the scheme below:

- 1 x service interval: Use service set “A”
- 2 x service interval: Use service set “B”
- 3 x service interval: Use service set “A”
- 4 x service interval: Use service set “C”

The service sets include parts which should always be replaced regardless of appearance when compressor is opened. The above cycle is repeated as long as the compressor is in operation.

After first 200 hours of operation,
use service set “0”.

Inspection parts

In addition to the predetermined replacement according to above service sets, certain parts must be inspected. Inspection and replacement criteria for inspected parts are shown in separate instruction.

Nice-to-have part sets

A list of recommended parts supporting the parts inspection is available. The list contains all parts necessary if the inspected parts must be replaced. In other words, these sets tell the service technician what to bring to the inspection.

Measures to be taken

The following sections describe the measures which must be taken. They include information about tools, materials, preparations and implementation.

Noise and Vibration

No special requirements are imposed regarding equipment and materials. Inspect the unit and check that there is no abnormal noise and vibration. Listen for any knocking or other abnormal noise caused by poorly clamped pipes or faulty valves.

Evaporating Pressure and Condensing Pressure

No special requirements are imposed regarding equipment and materials. Check on the operator's panel or manometers that the pressures comply with what is set forth in the specifications issued for the reciprocating compressor unit in question and that they are within the permissible operating ranges.

Evaporating Pressure

The terms “evaporating pressure” and “suction pressure” refer to the pressure on the suction side of the compressor.

Usually the pressure is the same at the evaporator outlet as at the compressor inlet. The only difference is the pressure drop in the line. Because of this pressure drop, the pressure at the evaporator outlet is a little higher than at the compressor. The non-return valve in the suction line will also contribute to the pressure drop.

Normal Evaporating Pressure

According to fundamental refrigeration engineering principles, the refrigerant absorbs heat from the medium that is being chilled.

In order for heat to be transferred to the refrigerant, it must boil at a lower temperature than the temperature of the medium being chilled in the evaporator. A basic rule is thus that the evaporating temperature is lower than the temperature of the medium that is being chilled in the evaporator. This rule sets a maximum value for the suction pressure.

Condensing Pressure

The terms “condensing pressure” or "high pressure" as used here refer to the pressure that prevails at the compressor outlet side. Usually the pressure is the same at the condenser inlet as at the compressor outlet. The only difference is the pressure drop in the line

Because of this pressure drop in the line the pressure is a little higher at the compressor than at the inlet to the condenser. The oil separator and stop valve mounted in the discharge line will also contribute to the pressure drop.

Normal Condensing Pressure

In the condenser the absorbed heat energy in the refrigerant is released to the surroundings.
The heat energy in the refrigerant is the sum of the heat energy absorbed in the evaporator and the energy supplied to the compressor via the electric motor taking oil cooling system in account.

During the condensing process the refrigerant vapors are again transformed into liquid. To give off the energy (heat) from the condenser, the temperature of the medium (air, water) to which the heat is to be transferred must be lower than the condensing temperature. Since there is a connection between the temperature and the pressure in the condenser, there is a minimum value for how much the condensing temperature must fall; a too low condensing pressure level will result in operational failures.

Visual Inspection

Inspect the reciprocating compressor unit in order to make sure that there are no refrigerant or oil leaks.

Oil Pressure

Check that the oil pressure complies with the recommended cut-out pressure, see chapter 9, Settings.

Oil level

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

Chapter 6, Technical Data - *Charging the Compressor with Oil* includes table values for oil charging and oil level. If the oil level is below the lowest part of the oil level glass, oil must be recharged.

Recharging of oil ("topping up") can be carried out during operation either by means of a hand-operated oil pump or as described later in this section under *Charging Compressor with Lubricating Oil.* **Only** use the recommended oil.

When the oil level is too low, check the plant for leaks. If it is not possible to find the error, call for service assistance.

General Rules for Use of Lubricating Oil in Refrigeration Compressors

- 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.**
- Use grade of oil originally prescribed for compressor.
- 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.
- If it is necessary to switch to another brand of oil, please contact the supplier of the new oil for instructions. Note that some of the old oil may be left in the piping system.
- 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.

Chapter 6, Technical Data - *Charging the Compressor with Oil* includes a detailed description of lubricating oils as well as directions for selecting the correct oil.

Caution!

Never add oil until the reason for the drop in the oil level has been found and remedied.

Warning!

Corrosive oil is a hazardous substance. It can cause irritation and other injuries.

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, but 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 drain off some oil. This is done to prevent any impurities which may have accumulated in the valve or the piping from mixing with the oil sample.

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 Refrigeration 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:

- Whether or not the oil is still usable, if necessary after filtering.
- 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.
- Each report will include the corresponding measuring results from **the previous 3 oil analyses**. In this way it is possible 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 representative.
- 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.

Analysing the Oil

The following table states some average values that can be applied in practice. However, 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.

Limiting Values

Parameter	Unit	Method	Sabroe Oil PAO 68			Sabroe Oil AP 68			Sabroe Oil A 100		
			Taget Spec.	Max.	Min.	Taget Spec.	Max.	Min.	Taget Spec.	Max.	Min.
Viscosity @40 °C	cSt	ASTM D 445	66	76	53	64	74	51	100	115	80
TAN *1)	mg KOH/g	ASTM D 664	0.03	0.2	-	0.01	0.02	-	0.05	0.02	-
SAN *2)	mg KOH/g	ASTM D 665	-	0	-	-	0	-	-	0	-
Water	ppm	Karl Fisher	-	100	-	-	100	-	-	100	-
Apperance	-	-		report			report			report	
Colour	-	ASTM D 1500		report			report			report	
Pentane Insolubles	Wt%	MM 490 (5 µm)	-	0.05	-	-	0.05	-	-	0.05	-
Oxidation	abs/cm	IR, 1700-1720/cm	-	5	-	-	5	-	-	5	-
Nitration	abs/cm	IR, 1627-1637/cm	-	5	-	-	5	-	-	5	-
Nitro Compounds	abs/cm	IR, 1547-1557/cm	-	0.5	-	-	0.5	-	-	0.5	-
Maximum values for metal content in the oil											
Lead	ppm	ICP	-	10	-	-	10	-	-	10	-
Copper	ppm	ICP	-	10	-	-	10	-	-	10	-
Silicium	ppm	ICP	-	25	-	-	25	-	-	25	-
Iron	ppm	ICP	-	100	-	-	100	-	-	100	-
Chromium	ppm	ICP	-	5	-	-	5	-	-	5	-
Aluminium	ppm	ICP	-	10	-	-	10	-	-	10	-
Tin	ppm	ICP	-	10	-	-	10	-	-	10	-

1) TAN (Total Acid Number) is only reported for non-ammonia applications
2) SAN (Strong Acid Number) is only reported for non-ammonia applications

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 from 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 also be sent to Sabroe Refrigeration so that we are in a position to advise our customers if required.

Charging Compressor with Lubricating Oil

Since all SABROE reciprocating compressors are supplied with a special oil charging valve on the crankcase, refrigeration oil may be charged while the compressor is in operation.

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

Oil charge and oil level are shown in Table 11.2 and Table 11.3.

Note: When charging for the first time, use the oil pump. The compressor must never be started unless it is charged with oil.

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

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

When in operation, the compressor may be recharged with oil using the **hand-operated 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. Therefore, it is often necessary to recharge with refrigeration oil after starting up for the first time and after charging with fresh refrigerant.

Therefore, the oil level in the compressor must be watched closely after start up.

Table 11.2 *Oil Charge*

Compressor		Amount of oil in crankcase	
Type	**Size**	**Liter**	**US gal.**
HPC 100	104	26	6.9
SMC 100	106	28	7.4
TSMC 100	108	30	7.9
Mk4 S-L-E	112	47	12.4
	116	50	13.2

Table 11.3 *Oil level*

Compressor		Difference in oil level of 10 mm corresponds to:
Type	**Size**	
HPC 100	104	-2 litres of oil [0.5 US gal.]
SMC 100	106	
TSMC 100	108	
S-L-E	112	-6 litres of oil [1.6 US gal.]
	116	

Searching for Leaks

Searching for leaks can be carried out in many ways. The most frequently used method is to use a leak detector. After finding a leak, a good way to find its exact location is to apply soapy water.

In case of large leaks, divide the system into sections by closing the valve to prevent needless amounts of refrigerant from leaking out.

Proceed as follows to search for leaks:

- Ascertain whether there is a shortage of refrigerant by checking the level of the refrigerant in the condenser or the receiver.
- Also check that the measuring equipment is functioning properly and do not give false readings.
- Search for drops of oil at couplings, flanged joints, valve spindles, shaft seals, safety valves, oil filter and the like.
- Ventilate in advance to remove any gaseous refrigerant from the searching area.
- Check that the required refrigerant pressure is present in the part of the system in question.
- Conduct the search systematically to make certain that all possible sources of leaks are checked.

Do not forget any of the following:

- Threaded joints and flanged joints
- Valve spindles
- Shaft seals
- Relief equipment
- Expansion valves
- Pressure transducers and pressure gauges
- Safety valves

Method of Searching for Leaks

HFC/HCFC
Move the leak-detection probe slowly along the places where leaks are possible and move all the way around couplings and the like.

Continue searching for leaks even after finding one (the system may be leaking at other places).

Before proceeding, wipe away any oil that is present after fixing a leak. Write all observations into a log book (searching, fixing, topping up the refrigerant etc.).

After concluding maintenance or repairing tasks, check that the reciprocating compressor unit is tight. The air that remains must be removed with a vacuum pump before putting the unit back in operation.

Ammonia
Leak detection with ammonia is carried out in the same way as with HFC/HCFC, using sulphur sticks instead of the leak-detection probe.

Motor Lubrication

For electric motors it is absolutely essential to lubricate the bearings in the right way and use the correct type of grease.

For correct service, please follow the instructions of the motor manufacturer.

Replacing Motor Bearings
Contact Sabroe Refrigeration's service organization.

Major Overhaul of the Compressor
Contact Sabroe Refrigeration's service organization.

12. Fault-finding Instructions

The purpose of this chapter is to:

- Describe the dangers resulting from failure to comply with instructions and safety precautions during the fault-finding process.
- Provide a list of common problems.
- For each problem, suggest cause(s) and recommend actions to solve the problem.

This chapter is primarily intended for service engineers.

Danger!

Risk of injury to personnel and damage to equipment! Always read the safety precautions belonging to this equipment before start. Failure to comply with safety precautions may cause death or injury to personnel. It may also cause damage to or destruction of the equipment.

Safety Precautions

Danger!

Risk of injury to personnel and damage to equipment! In addition to the safety precautions in this chapter, always read the general safety precautions belonging to this equipment before starting the fault-finding process. Failure to comply with safety precautions may cause death or injury to personnel. It may also cause damage to or destruction of the equipment.

Qualification Requirements

Fault-finding requires highly skilled, qualified personnel with extensive knowledge of the system in question. The formal requirements include a knowledge of refrigeration engineering and familiarity with the system in question.

How to Carry Out Fault-finding

Fault-finding is necessary in three general situations:

- **When acute problems arise**
  To find out what caused the reciprocating compressor unit to malfunction.
- **Maintenance**
  During scheduled maintenance to detect operational deficiencies that can lead to future disturbances or uneconomical operation.
- **Starting up after repairs**
  After a damaged component has been replaced (for example) to find external reasons why the component failed.

Reciprocating Compressor Unit as Part of the Overall System

The functions performed by a reciprocating compressor unit — and thus the errors that may occur — are often linked to the overall system (plant) in which it is operating.

On the low pressure side, the reciprocating compressor unit is connected to an evaporator as well as to a system used for distributing the chilled medium.

On the high pressure side, it is connected to a condenser as well as to a system used for the coolant.

A control system performs monitoring, control and regulation. Most of the errors which occur are indicated by the control system.

Personnel who carry out fault-finding must take into account all of the above mentioned system parts to obtain a clear picture of what is happening.

Systematic Fault-finding

Fault-finding should be carried out systematically. The personnel will often know what the problem is, and find the error immediately. If the personnel has a thorough knowledge of the unit in question, they will often know the cause of the problem.

If this is not the case, consider the situation quietly. Do not change any settings immediately. Spend some time working out a systematic approach.

Operating Condition

Experience shows that pressure and temperature variations in a refrigeration system can provide information about the refrigeration plant operating conditions.

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

Considerable changes in the operating conditions can often be produced by only very small changes in the variable pressure and temperatures.

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

Using the Troubleshooting Chart

In the following chart each individual error possibility is indicated by a code number in the left hand column, with the error briefly described in the second 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: *Too low discharge pipe temperature* - error code 15.

Cause Codes:

26 (liquid in suction line)
32 (too much coolant/air to condenser)
39 (Expansion valve provides too little superheating).

Table 12.1

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 continuosly	8, 21, 22, 24, 41, 46, 52, 53, 5,6 60.
5	Abnormal noise from compressor	16, 17, 18, 19, 26, 48, 49, 50, 51, 52, 53, 54, 56, 57, 58.
6	Insufficient capacuty 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	Slugging in compressor during start up	16, 18, 26, 37, 38, 39, 44, 56, 61.
8	Slugging 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.

Table 12.2

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

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 re-starting.
1.12	Oil-pressure cut-out has cut	Compressor starts at reset. Check oil level. If oil foams in crankcase, see 18.

2. Compressor starts and stops too often

2.9	High-pressure cut-out cuts at high pressure	High condenser pressure - see 9. Check condenser cooling and adjust pressure cut-out to correct breaking pressure - see table *Pressure and temperature settings.* Replace defective pressure cut-out.
2.10	Low-pressure cut-out cuts at too low suction pressure.	Low suction pressure - see 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 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 unsufficient	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 13.
5.26	Liquid refrigerant in suction line	Liquid stroke. See 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 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 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	Reduce compressor capacity or start with throttled suction stop valve.
	Sudden reduction in pressure across the oil sump (suction pressure) produces foaming	Follow instructions in 18.
7.26	Refrigerant has condensed in suction line or crankcase	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.
	Suction line has free fall towards compressor	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 *(see pressure testing),* 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/coling 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 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 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:** **The oil level must always be visible in the oil level sight glass on the compressor.**	
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 super heating 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 18.

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.

13. Service Instructions

The purpose of this chapter is to describe:

- Dangers resulting from failure to comply with safety precautions when performing maintenance tasks.
- Scheduled maintenance tasks for this equipment and how to carry them out safely.

This chapter is primarily intended for service engineers.

Danger!

Risk of injury to personnel and damage to equipment! Always read the safety precautions belonging to this equipment before start. Failure to comply with safety precautions may cause death or injury to personnel. It may also cause damage to or destruction of equipment.

Danger!

Risk of injury to personnel and damage to equipment! In addition to the safety precautions in this chapter, always read the safety precautions belonging to the equipment before changing the settings. Failure to comply with safety precautions may cause death or injury to personnel. It may also cause damage to or destruction of the equipment.

Safety Measures

Danger!

The paragraphs that follow present some important safety considerations for this type of compressor unit. Before starting service work, study carefully the general safety instructions/regulations that apply to this series of reciprocating compressor units. Failure to follow these instructions/regulations can lead to personal injury or even death. Moreover, the equipment can be damaged or destroyed.

General Preparations before Service

Ventilation

Before servicing the unit, always check that the ventilation system used in the area where the reciprocating compressor unit is located (machine room) is functional and operating at full capacity.

The safety instructions explain the risks associated with the refrigerant and oil being used. Pay close attention to the fact that large amounts of escaped (or released) refrigerant entail risk of suffocation.

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

Pressure

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

Hot and Cold Surfaces

A reciprocating compressor unit contains both hot and cold system parts. Always wear and use the recommended safety items.

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

Qualification Requirements

Before carrying out the measures set forth in this manual, all personnel must have studied the instructions issued for the reciprocating compressor unit carefully.

The personnel must also fulfil all national requirements for authorization.

Main Power Supply

Before servicing the compressor, switch off the power on the main disconnect switch of the plant. To prevent the compressor from starting up inadvertently, dismantle the main fuses of the plant.

Tools and Accessories

Servicing the compressor correctly requires a lot of special tools. The tools can be ordered from Sabroe Refrigeration.

Tools set for compressor

The tool set comprises the tool set for Mk3 and a supplementary tool set for Mk4.

Version	Tool set	Description	Part of: Service Manual Spare Parts Manual
Mk3	Normal Extended	See document 0661-684	Chapter 18
Mk4	Supplementary tool set	See document 0662-061	Chapter 18

Servicing the piston compressor

Good and careful servicing of compressor and unit is of great importance for their proper functioning and service life.

It is therefore recommended that these service instructions be followed. Based on the number of operating hours, they indicate the service tasks to be carried out.

The servicing schedules also depend on the speed of the compressor. If the compressor is running at less than 1200 rpm, Sabroe Refrigeration permits extended service intervals. However, the compressor must always operate within the speed recommended by Sabroe Refrigeration.
See chapter 4, *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.

Consequently, operating conditions must be checked on a daily basis and registered in an operating log.

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:

- Immediately after stopping the compressor, read the pressure on discharge and suction side of compressor.
- Close the discharge stop valve quickly and, from the moment of closure, time how long it takes for the pressure to drop on the high pressure side of the compressor. Normally, the pressure drop should not be more than 3 bar over a period of approx. 5 minutes.
- If the pressure drops more quickly, this is due to internal leakage, which may occur:
- where the pressure valve ring plates are in bad contact with their seats (Pos. 20C against Pos. 20A and 19H);
- with defective seal Pos. 19T;
- with defective seal Pos. 19K;
- because cylinder lining and top cover have been tightened without a long mounting stopper being fitted. Cylinder lining is thus resting on rocker arms, Pos. 15A;
- on the by-pass valve, because the valve cone does not fit tightly against the seat, or outer O-ring Pos. 24B or inner O-ring Pos. 24C is defective.

During pressure drop testing, pay attention to any piping connections to the discharge side of the compressor, which may influence 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:

Step	Activity	Remark
1	Run compressor at lowest capacity stage and then 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 lower than normal.	
3	Close discharge stop valve and other piping connections to compressor.	
4	Remove remaining refrigerant gas using a pump-down compressor connected to purge valve (pos. 42) see Fig. 13.1	Only HFC and HCFC
5	Connect the purge valve (pos. 42), see Fig. 13.2 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 dispatch for proper destruction. The moment the pressure is equalized the valve must be closed in order to prevent that water is being sucked back into the compressor.	Only R717
6	In connection with R744 (CO_2) compresosrs, refrigerant may be blown out into the open as CO_2 is naturally occuring and harmless in low concentrations.	R744

Fig. 13.1

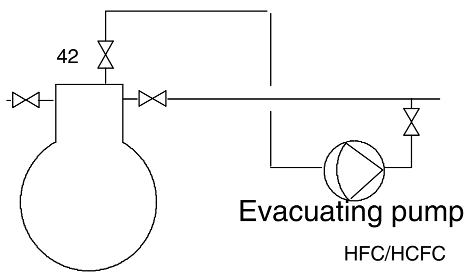
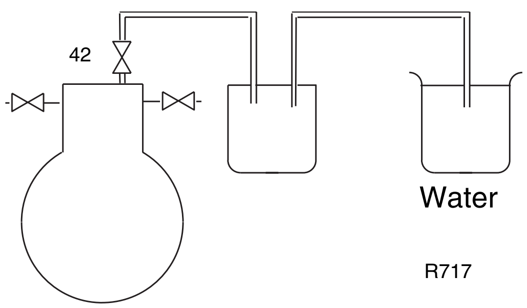


Fig. 13.2



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 Refrigeration *can supply ready-made spare-part sets, which will be helpful in carrying out the scheduled service.*

Servicing the refrigeration plant

During start-up as well as operation, it must be ensured 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. Make sure that:

- 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 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 condensing pressure implies a risk of restricting the refrigerant supply to the evaporator.
	Discharge pipe temperature		Normal discharge pipe temperature according to instructions.
Filters	Filter in - liquid line - thermostatic valve - suction line - oil return	Clean when required	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 required	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.
Refrigerant	Refrigerant charge	Periodically	Inadequate charging results in reduced plant capacity and it often leads to an excessively high discharge pipe temperature.
	Leak detection		The plant must be searched regularly for leaks. Flanges and joints settle during the initial operation period of the plant. 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.

	Check	Interval	Activity
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 with 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 required	Unproblematic operation is conditioned by 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

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 that it has lost its flexibility and cannot be refitted.
All seals and gaskets used are resistant to oil, HFC/HCFC and ammonia. All O-rings are made of neoprene rubber.

Preparation for maintenance

Pump-down

Before opening up the compressor for inspection, the pressure inside must be lowered to slightly above atmospheric pressure. This can be done in one of the following ways, 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 barg.

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 may be pressure equalized with atmospheric air and opened.
- Remove all fuses, if any.

2. If the compressor is inoperative

- Leave heating rod in crankcase connected for a couple of hours before the 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.
- Having ensured that power to compressor motor cannot be inadvertently connected, the compressor may be pressure equalized with atmospheric air and opened.
- Remove all fuses, if any.

Dismantling and assembly

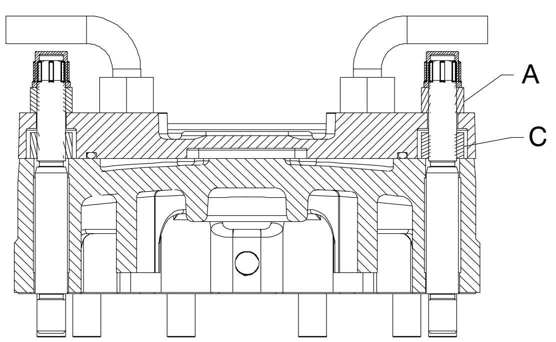
The following sections describe the individual components. When dismantling and assembling, parts should generally be fitted in the same position from which they were taken, and should therefore be marked as they are removed. Further they should be thoroughly cleaned, checked and lubricated prior to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

Water covers

Dismantling water covers

The water covers may be dismantled even with pressurised compressor, as the water covers are mounted with four independent nuts. Always make sure, however, that the compressor cannot start while the water covers are being dismantled. To dismantle the water covers, first shut off the water supply. Also, to avoid scalding when dismantling, make sure that the water temperature inside the system does not exceed +70°C [158°F]. First remove the hoses connecting the individual water covers. Then loosen the four nuts (A) on top of each water cover and the water covers can be lifted away. If the water cover sticks to the top cover underneath, loosen it with a blow from a soft hammer on the side.

Fig. 13.3



Fitting water covers

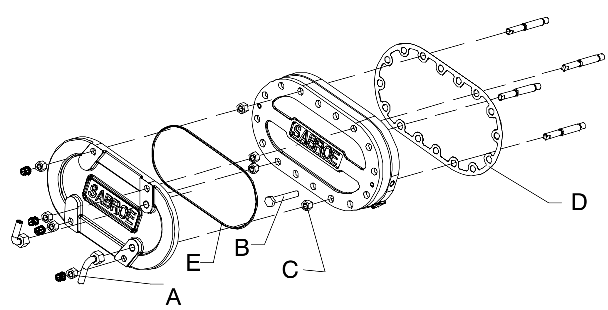
Before assembling the water cover check that the o-ring gaskets are not damaged. If so, they must be replaced. Also thoroughly clean the o-ring groove and the gasket surface on the top cover. To keep the o-ring in place, a small amrount of grease may be applied in the groove for the o-ring. Gently place the water cover in position, using the four staybolts as guides. The covers should be positioned with the water inlet and outlet at the shaft end. This means that the "SABROE" logo is correctly oriented. Before tightening the nuts, check that the o-ring is still in its place in the groove. The gab between the water and top cover should not exceed 0.5 mm before tightening. Then tighten the four nuts. Refit the water hoses, open the water supply and check that there are no leaks.

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. Also, the water covers should be removed according to the above instruction, if equipped so. Remember to depressurise the compressor if not already done. Loosen and remove screws (B), except for the four nuts on the staybolts (C), see figure.

Fig. 13.4

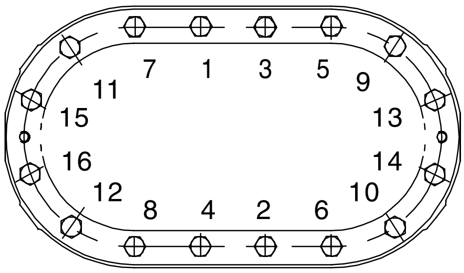


These nuts (C) should be loosened approx. 1 mm and then it must be checked that the cover lifts off the gasket. If, on the contrary, it remains fastened to the gasket, loosen it with a blow from a soft hammer on the side **while keeping the four nuts fitted**. This is important because of the powerful spring pressure beneath the top cover. After dismantling the four nuts - 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. Also check that the gasket (D) is intact and, if necessary, that the **clearance volume** and **lifting reserve** have been adjusted as described later in these instructions. If the gasket (D) needs to be replaced at all, the graphitized side must face the compressor frame. Place the top cover loosely on top of the springs Pos. 21, using the four staybolts as guides. Before tightening the four nuts (C) on the staybolts, all screws must be mounted by hand. Tighten the top cover firmly first with the four nuts mentioned above then with the remaining screws. Finally, cross-tighten all the screws and nuts to the prescribed torque in the following sequence:

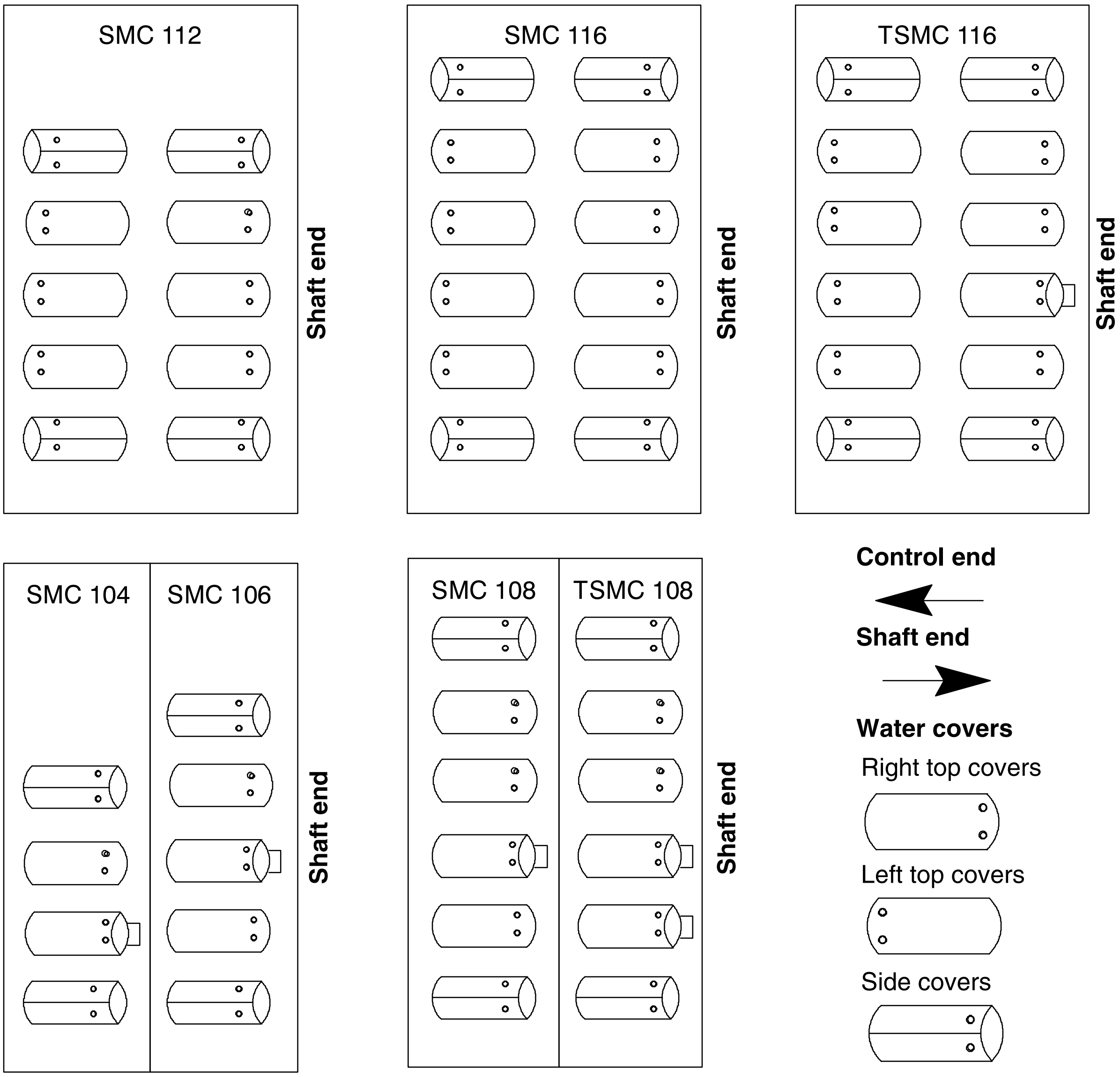
Fig. 13.5



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

Mounting top and water covers

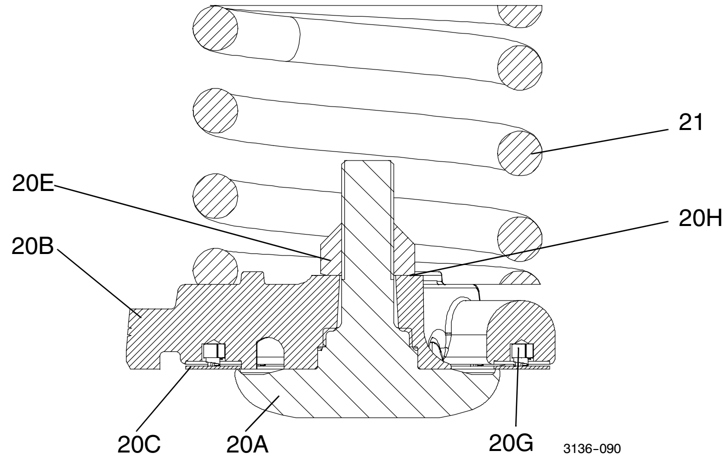
Fig. 13.6



Discharge valve

Fig. 13.7

Pos. 20



As shown in 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 through the valve with the discharge gas - also called liquid stroke. Such stroke should not normally occur, as liquid cannot pass through 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 raise a little under the strain of increased pressure.

If liquid strokes can be 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.

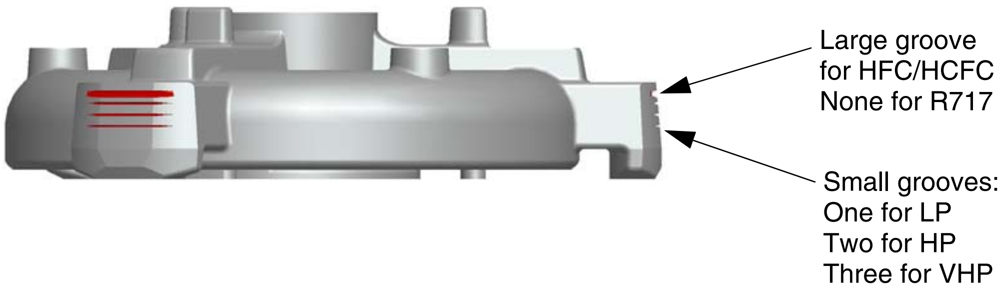
The discharge valves are selected as shown in the diagram below on the basis of the condensing or intermediate pressure temperature.

<table>
<tr><th>Refrigerant</th><th colspan="2">Conditions</th><th>Valve type</th></tr>
<tr><td rowspan="2">R717</td><td colspan="2">TC < 15°C</td><td>LP</td></tr>
<tr><td colspan="2">TC < 15°C</td><td>HP</td></tr>
<tr><td rowspan="7">R22
R134a
R404A
R507</td><td colspan="2">TC < 15°C</td><td>LP</td></tr>
<tr><td rowspan="3">15°C ≤ TC <</td><td>45°C R404A - R507</td><td rowspan="3">HP</td></tr>
<tr><td>50°C R22</td></tr>
<tr><td>70°C R134a</td></tr>
<tr><td rowspan="3">TC ></td><td>45°C R404A - R507</td><td rowspan="3">VHP</td></tr>
<tr><td>50°C R22</td></tr>
<tr><td>70°C R134a</td></tr>
<tr><td>R410A
R744</td><td colspan="2">TC = all</td><td>HP</td></tr>
</table>

Note:
Thus same valve type name, valves are not identical in above table. Valve type are refering to refrigerant as well.

Marking
All pressure valves supplied by Sabroe Refrigeration today are marked as described below and shown on the sketch.

Fig. 13.8



Refrigerants HFC/HCFC
All discharge valves are marked with a large groove near the upper edge of the valve feet.

Refrigerant R717
There is no large groove at the upper edge of the valve feet.

Conditions

The valve type is marked with one, two or three small grooves below the large groove (if any).

One small groove: LP

Two small grooves: HP

Three small grooves: VHP

Dismantling

- When the top cover has been removed, spring Pos. 21A and discharge valve Pos. 20B can be lifted out by hand. See dismantling of top cover.
- Tighten discharge valve in a soft-jawed vice, then dismantle the nut Pos. 20E, and remove the lock washer Pos. 20H.
- Valve seat Pos. 20A, discharge valve Pos. 20B and ring plate Pos. 20C can now be disassembled by hand.
- Remove valve springs Pos. 20G by hand.

Assembly

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

Assemble the discharge valve in reverse order of the one described above. Note the following, however:

- Tighten nut Pos. 20E
  See Torque for screws and bolts in Chapter 21

Tightness testing of discharge valve

This is done by means of the pressure drop test as described later in this 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.

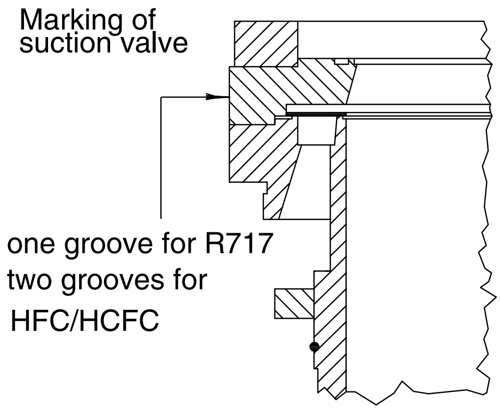
It is difficult to give altogether precise times for such replacements, as the durability of the valve ring plates depends on the following factors:

- 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 considerably 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:

Fig. 13.9



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 the 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 that 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

When dismantling the screws Pos. 19N, the guide ring Pos. 19J, suction valve stop Pos. 19H and ring plate Pos. 19F can 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, make sure that the valve springs Pos. 19G are in good condition and firmly fixed in their apertures.

Perform the assembly in reverse order of the one described above. Note the following, however:

- Change paper gasket.
- Before tightening screws 19N, make sure that suction valve plate can be moved freely in its guide. Tighten screws Pos. 19N to torque of 1.4 Kpm ≅ 14 Nm.

Inserting cylinder lining

- Rotate crankshaft to position the piston at top dead centre.
- Check that the long plug from the 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, after having checked the 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.

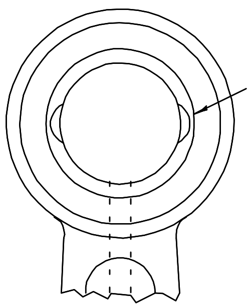
The connecting rod Pos. 17 is equipped with independent bearings at both ends. **The big end** is fitted with two bearing half bushes Pos. 17A, consisting of a half-cylindrical steel plate internally coated with white metal. These bearing half bushes are secured in the connecting rod, partly through 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 corresponding 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. 13.10



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

Fitting connecting rod

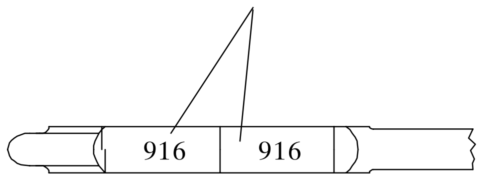
Before fitting the connecting rod in the compressor stand, piston and piston rings must be fitted onto the connecting rod. See the following sections. In addition, the two connecting rod bolts Pos. 17C must be fitted as shown on the spare parts drawing.

- Fit bearing bushes into both parts of connecting rod.
- Introduce connecting rod down through top cover opening in frame and manually guide into position on crankshaft. Be careful 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 *(see Fig. 13.11)*.

Fig. 13.11

Note:
Stamped number on the same side on assembly



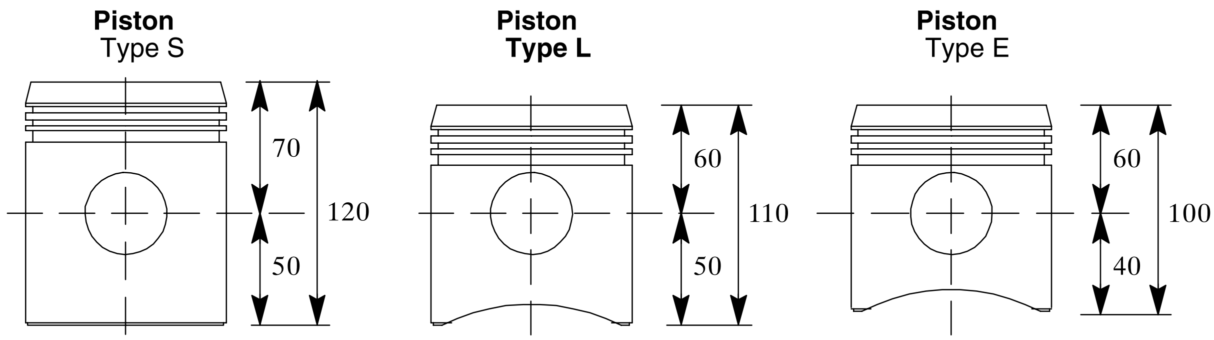
- Tighten nuts Pos. 17D alternately with increasing torque and finish off with torque wrench.
  Torque: 4.4 Kpm ≅ 43 Nm.

Piston

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

There are three versions of pistons:
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. 13.12.

Fig. 13.12



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

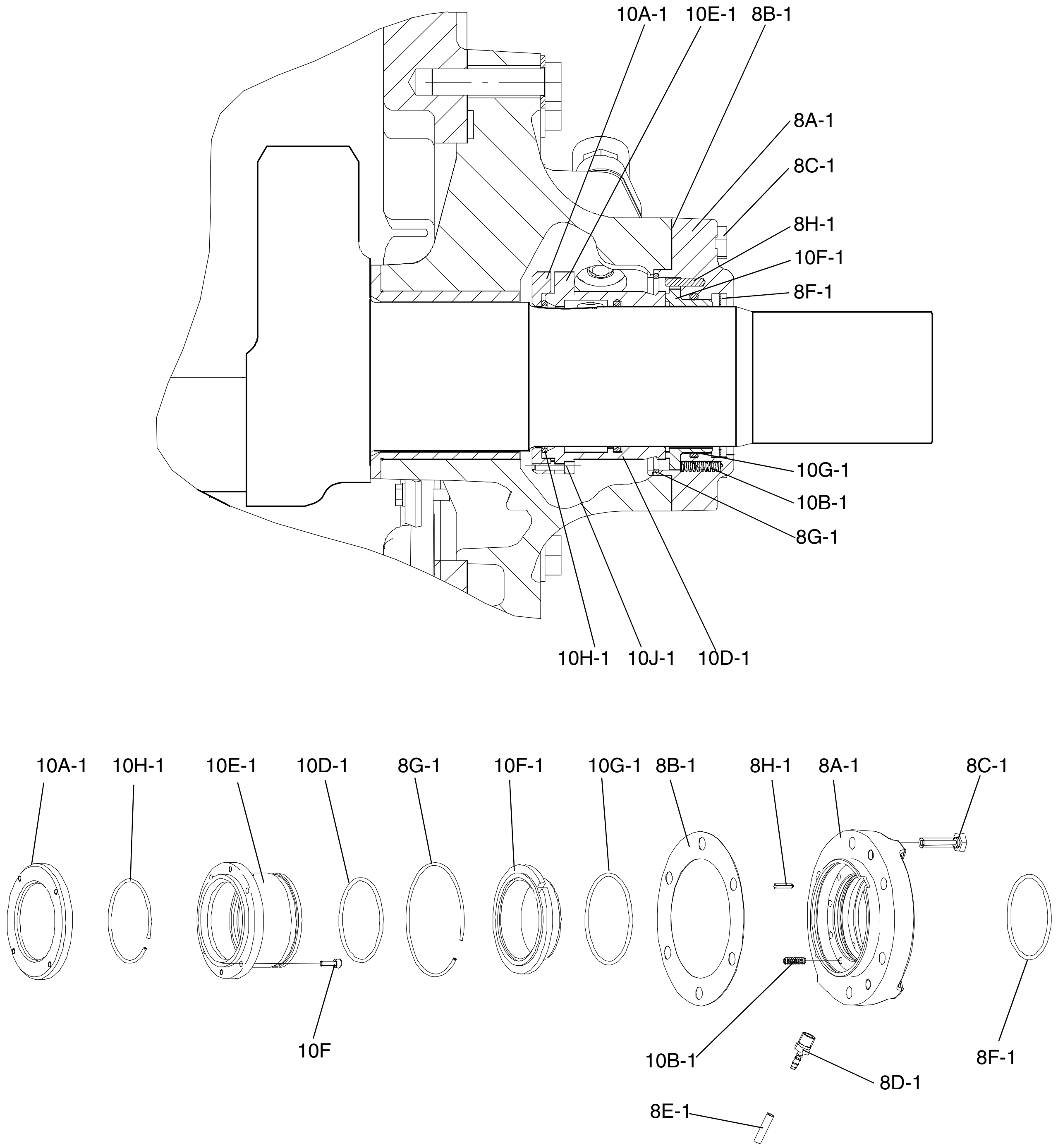
Adopt the following procedure when assembling piston and connecting rod:

- Fit one of the circlips pos. 18D into bore reserved for piston pin.
- Heat piston to 70°C [158°F] 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 using 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

Fig. 13.13



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

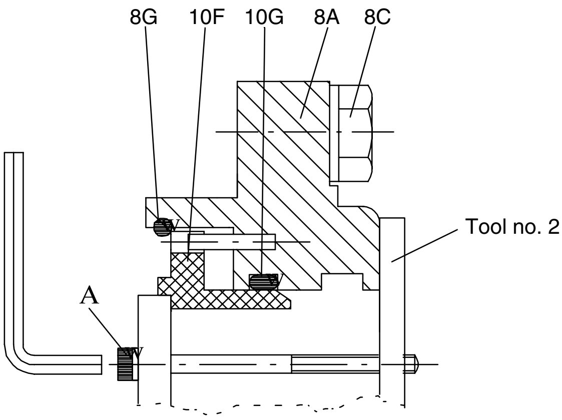
1. Once the gas pressure in the compressor has been eliminated and the motor safeguarded against inadvertent start-up, dismantle coupling or V-belt disk.

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.

2. Dismantle shaft seal cover Pos. 8A by loosening bolts Pos. 8C alternately so as to displace shaft seal cover outwards without jiggling. This will avoid damage to internal parts of the shaft seal.
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 that no damage is done to the carbon slide ring Pos. 10F which comes out with it.
4. The carbon slide ring Pos. 10F can be extracted by dismounting circlip pos. 8G as follows:

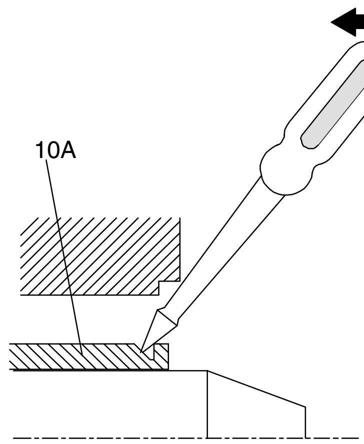
5. Mount tool no. 2 as illustrated in Fig. 13.14 and tighten screw A so that the carbon slide ring does not touch the locking ring.
6. Take care not to tighten screw A too much as this could damage the carbon ring.
7. Circlip pos. 8G is now easily extracted by means of a screw driver without damaging the slide surface of the carbon slide ring.
8. After removing tool no. 2, the carbon slide ring pos. 10F, O-ring pos. 10G and springs pos. 10B, Fig. 13.14 can now be dismantled.

Fig. 13.14



9. Dismantle slide ring 10E by turning the four Allen screws 10J max. 2-3 turns; the entire unit can then be taken out with the fingers or by 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. 13.15.

Fig. 13.15



10. 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.

1. **Unit with slide ring, Pos. 10E**
    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 its correct position.
    2. Position slide ring Pos. 10E on shaft and make sure that tightening flange makes contact with shaft shoulder.
    3. Crosswise, tighten screws Pos. 10J alternately with Allen wrench from tool kit. The torque is specified in the instruction manual.
    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.
2. **Unit with shaft seal cover Pos. 8A**
    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 that slot fits in over the retention pin Pos. 8H.
    2. With tool no. 2 fitted as shown *(see Fig. 13.14)* 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. 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.
    4. By 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.
    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.
    6. Mount oil throw ring, as shown in drawing.
    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 strokes (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 check 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 part 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 of 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*: **0.3mm, 0.5mm, 0.75mm, 1.0mm, 1.3mm, 1.5mm, 1.75mm, 2.0mm**

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.

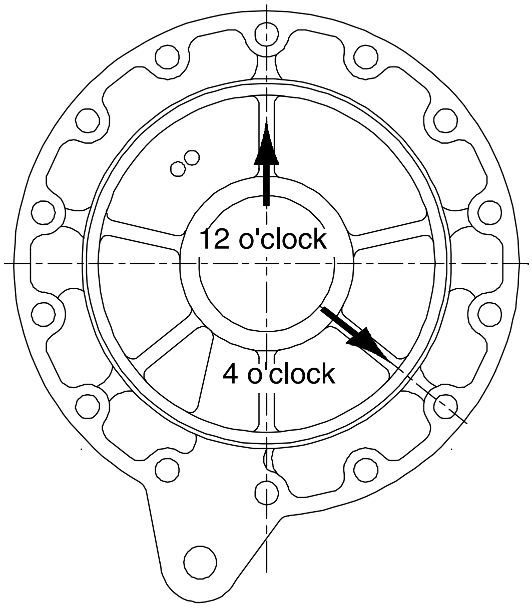
The bushing can be pressed out and replaced by new ones and needs no further machining after mounting.

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 in fig. 1 below.
The bearing bushing pos. 5C is positioned with in- and outlets in a **12 o'clock** position.

Fig. 13.16

Mounting of bearing bushing pos. 6C



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

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

Fig. 13.17

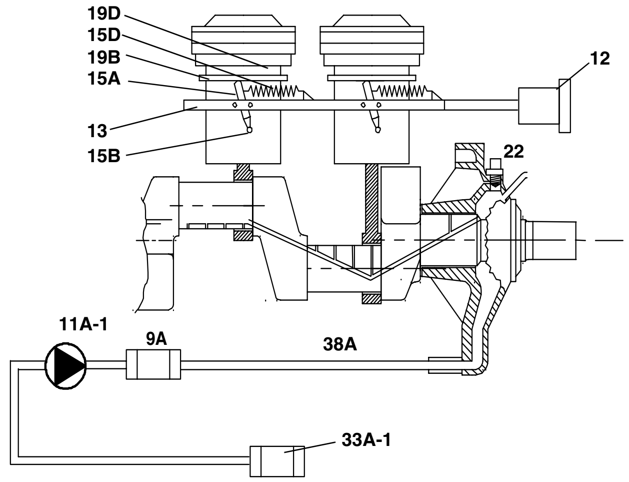
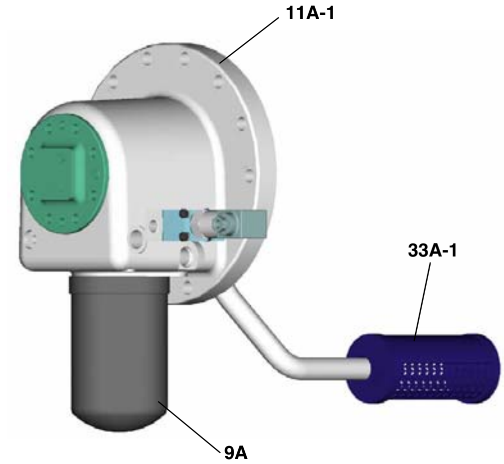


Fig. 13.18



The oil pump pos. 11A-1 sucks the oil from the crankcase through the strainer. The pump presses the oil to the shaft seal housing through a pipe pos. 38A.

The strainer pos. 33A-1 is made of a wire mesh which can be cleaned.

See description of the strainer later in this section.

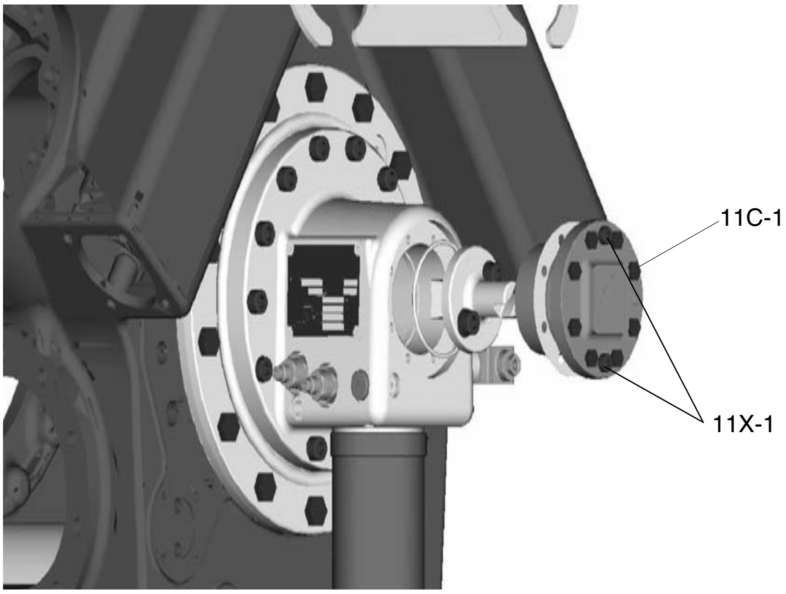
The shaft seal housing forms a distribution chamber for the oil. The oil pressure in the shaft seal housing is adjusted by means of the oil pressure regulating valve Pos. 22, which is mounted in the shaft seal housing. The regulating valve can be adjusted from the outside by means of a screwdriver. Clockwise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

Fig. 13.19



The oil pump is a gear pump which is run by the crankshaft by means of a guide. The oil pump direction of rotation is marked on the cover.

If the compressor direction of rotation is changed from counterclockwise (standard) to clockwise, the oil pump must be replaced by a pump with oppossite direction of rotation.

In that case, the arrow on the compressor end cover by shaft seal pos. 6A should be erased and replaced by a painted arrow indicating the new compressor direction of rotation.

Dismantling of oil pump

When the compressor has been drained from refrigerant and secured against unintentional start-up, the following should be carried out:

- Dismantle eight M8 bolts pos. 11C-1
- To be able to pull the oil pump out of the housing, the remaining two M8 bolts pos. 11X-1 must be dismantled
- Two M8 bolts from pos. 11C-1 are screwed in and used to pull out the oil pump.
- After dismounting the oil pump, the original two bolts pos. 11X-1 should be mounted in the oil pump.

Note: Normally, the oil pump has a very long service life and therefore, instead of repairing it in case of breakdown, it is recommended to replace it by a new one.

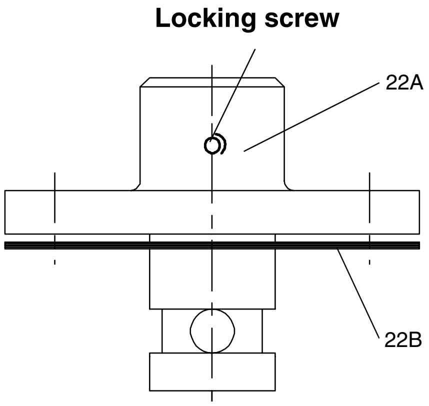
Oil pressure valve

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 is adjusted by turning an adjusting screw at the valve end. Use a screw-driver for this purpose.

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

Fig. 13.20



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, *(see Fig. 13.20)*, 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, *(see Fig. 13.21)*, which secures 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 is released, the compressor must be stopped immediately 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.

Therefore, take care that the hole pos. B does not get covered or clogged.

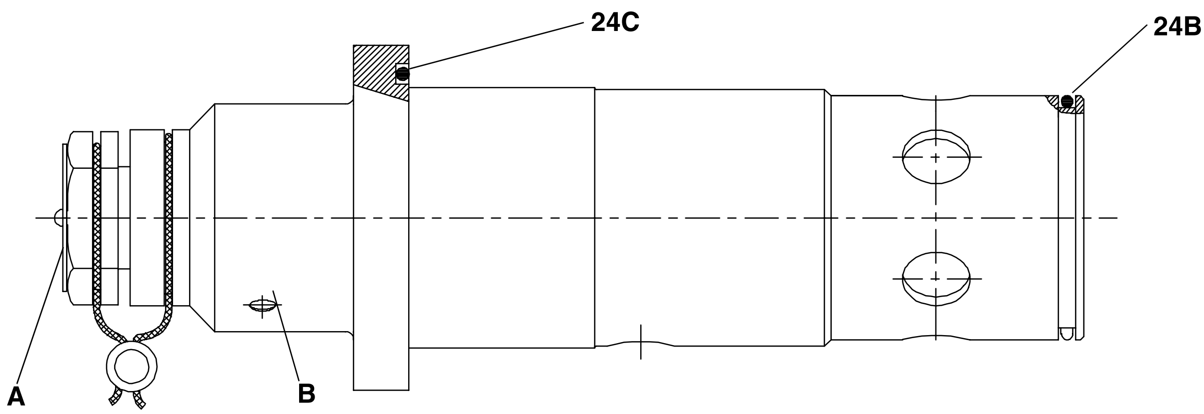
In case the pressure on the discharge side exceeds the set pressure so that the by-pass valve opens, the valve will remain open until the pressure on the discharge side has fallen to approx. half the set pressure. The valve then closes automatically. However, at great differential pressures across the 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 restarted.

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. 13.21

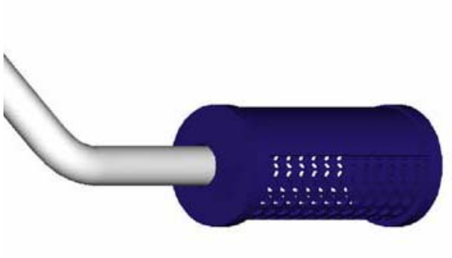


Strainer

All oil to the compressor lubricating system is filtered through a strainer pos. 33A-1 which is mounted in the crankcase.

As shown in Fig. 13.22, the strainer is a unit consisting of a 100 μ stainless primary filter and a shield covering half the filter.

Fig. 13.22 *Strainer*



Oil filter

After oil pump and strainer, the oil is further filtered in a full flow filter pos. 9A. The filter element is a disposable filter and must be replaced with a new one when the filter capacity is used up.

The filter element pos. 9A is a unit consisting of a 13 μ filter. Replacement of the filter is carried out as described in the following, see also oil diagram Fig. 13.23.

- Stop the compressor
- Close shut-off valve pos 4K-1. Remove the cap and turn the spindle clockwise.
- Close shut-off valve pos 4D-1. Remove the cap and turn the spindle clockwise.
- Open purge valve pos 4E-1. Remove the cap and turn the spindle counterclockwise.

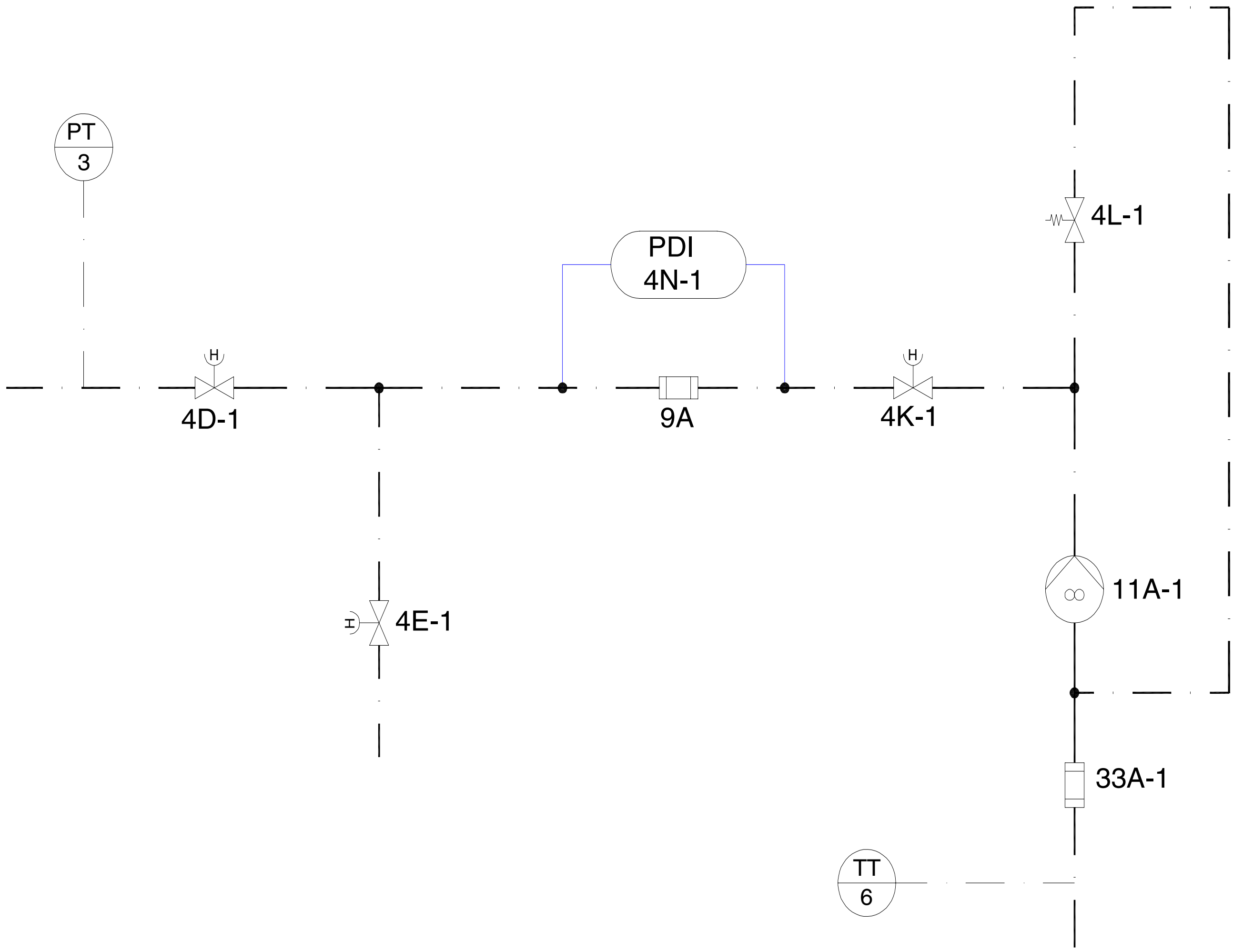
  Bleeding ensures pressure equalizing of the filter element before it is changed.
- The filter element can be removed when there is no longer any oil running from the branch pos 4F -1.
- Dismount the filter by turning it counterclockwise.
- Then close purge valve pos. 4E-1.
- Mount the new filter. Follow instructions on filter.
- Open shut-off valve pos. 4K-1. To open the valve completely, turn the spindle counterclockwise. Then put on cap.
- Open purge valve pos. 4E-1 and fill up the filter with oil. Evacuate the system of air until oil is running through the branch pos. 4F-1. Always check this to avoid air in the plant.
- Close the purge valve pos. 4E-1 and put on cap.
- Open shut-off valve pos. 4D-1. To open the valve completely turn the spindle counterclockwise

> ⚠ ***Danger!***
>
> Oil filter contains refrigerant under pressure

Important! Be sure that both valves pos. 4K-1 and 4D-1 are completely open at start up.

The valves in the oil system are replaceable. Before replacing, all preparations concerning opening of compressor must be carried out in accordance with the description in this manual.

Fig. 13.23 Oil diagram



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 they 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.

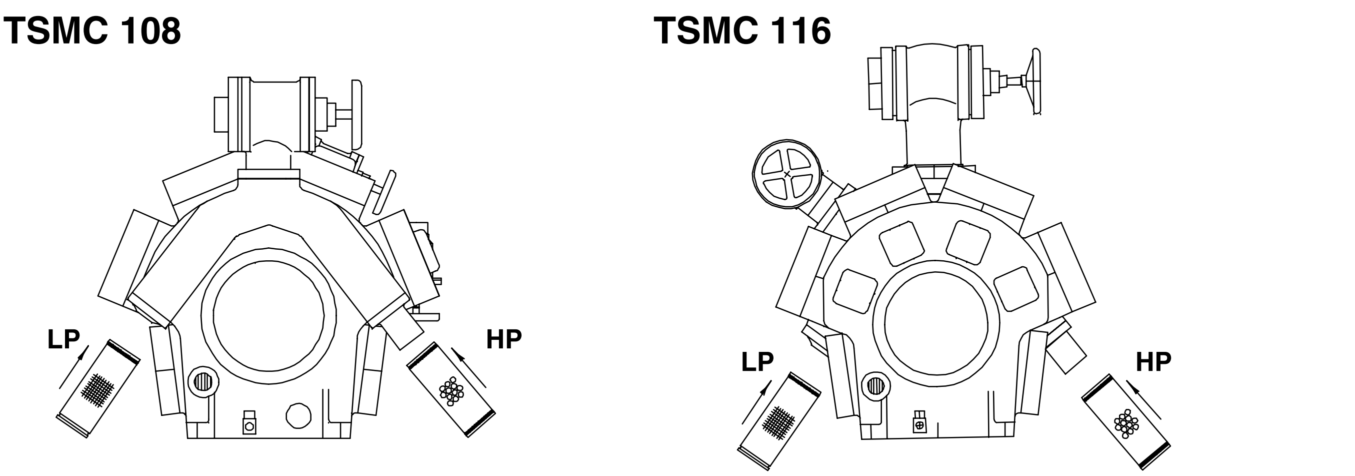
If the filter bag is badly soiled after the 50 operating hours mentioned, it is recommended that a new bag be fitted for an additional 50 operating hours. Similarly, a filter bag ought to be fitted for a period of 50 operating hours after any major repair work to the refrigeration plant.

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 described 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.

Fig. 13.24



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 with an O-ring in the end facing up towards the suction stop valve.

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.

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 **lifting reserve** must be checked in the order mentioned and as described in sections 1 and 2. During service, it is recommended that the cylinder linings are 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, as it directly influences the compressor performance.

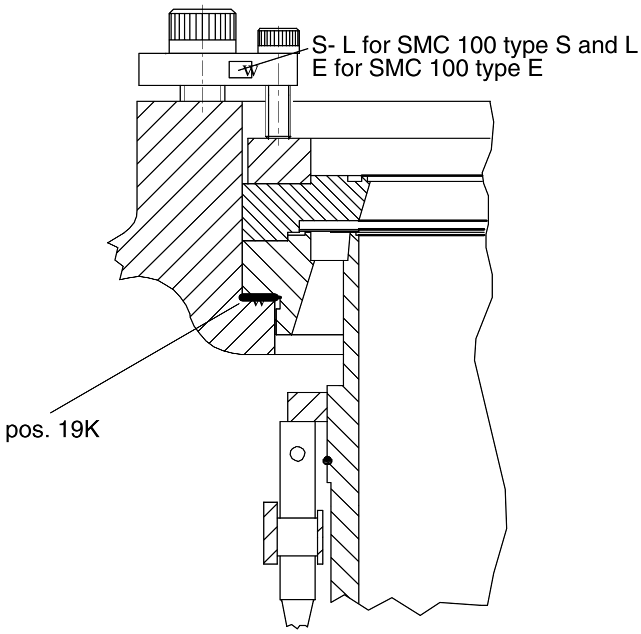
Adjustment of the clearance volume is done by means of gasket pos. 19K which, in addition to its sealing function, is also used as an adjusting element. Consequently, the gaskets come in two sizes and may sometimes be used at the same time under the same cylinder lining.

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

Adjustment is carried out as follows:

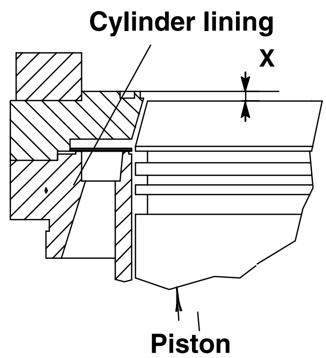
- The rocker arm system is **lowered** by fitting the long plug no. 4 from the tools kit in the unloading cylinder pos. 12 instead of screw pos. 12D.
- Insert an 0.5mm gasket pos. 19K and mount cylinder lining.
- Press cylinder lining against gasket pos. 19K by means of two locking devices - no. 1 from the tools kit. Fit the locking devices diagonally as shown in Fig. 13.25.

Fig. 13.25



- Turn crankshaft until piston is in top position.
- Using a depth or slide gauge, measure "X" as shown in Fig. 13.26.

Fig. 13.26



- "X" must be within the mentioned limits in the table and may, and as mentioned earlier, be adjusted by the use of gasket pos. 19K.

Clearance volume "X"	min. mm	max. mm
HPC SMC 100 Mk1,Mk2,Mk3, Mk4	0.6	1.0
SMC 180 Mk1,Mk2	0.9	1.5

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

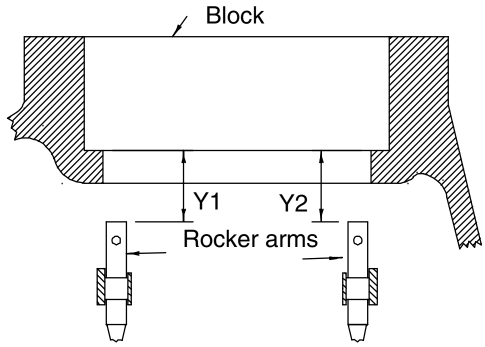
2. Checking lifting reserve

When fitting a **new** cylinder, or if changing refrigerant on the compressor from R717 to another one or vice versa, or in the event of any major overhaul of 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:

1. 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. 13.27.

Fig. 13.27



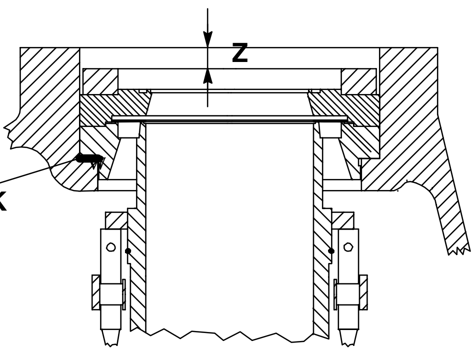
2. The rocker arms must be in their vertical position i.e. with the short screw pos. 12D and gasket 12E fitted. The measured distances "Y1 and Y2" may not vary more than max. 0.25mm.
3. If this difference is greater, a shim Pos. 15E must be placed under the lowest rocker arm bearing pos. 15B or a shim 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, which will make 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 gas-

ket pos. 12E have been mounted in the unloading cylinder.

Fig. 13.28



- Measure distance "Z" as shown in Fig. 13.28. Write 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. 13.25, 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 Mk1, Mk2, Mk3, Mk4	0.6	1.0
SMC 180 Mk 1, Mk 2	0.8	1.5

- If the difference between the two measurements is not 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 in the normal plug pos. 12D 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 *blowout* safety device which is fitted in the back plate of the pressure gauge housing.

Adjustment to other temperature ranges

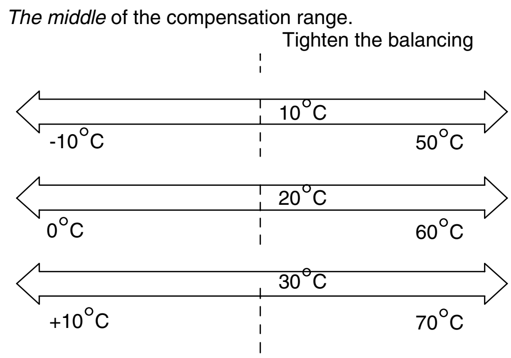
A balancing screw at the rear of the instrument is firmly tightened at a temperature of 20°C - the normal ambient temperature.

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.

Fig. 13.29



Cleaning and refilling glycerine-filled gauges

- Remove *blowout* 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.

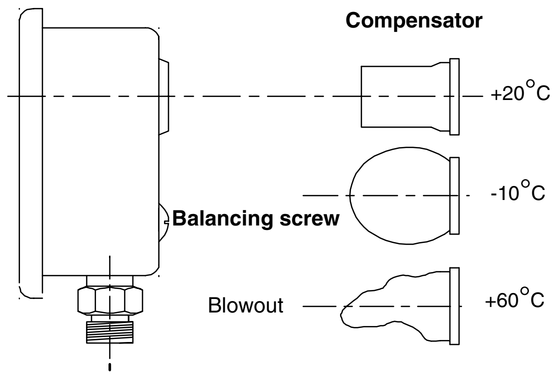
Note:
The glycerine must be absolutely waterfree.

- Refit compensator and *blowout* disk in gauge housing and cover centre hole in *blowout* 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 in top of the following drawing.

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

Fig. 13.30



Fitting and alignment of coupling type AMR

4. Installation and alignment

In principle, alignment involves manoeuvring the motor to make the shaft form an extension of the crankshaft.

Important!

Before performing any work on the coupling, make sure that the compressor motor cannot start inadvertently.

Fig. 13.31

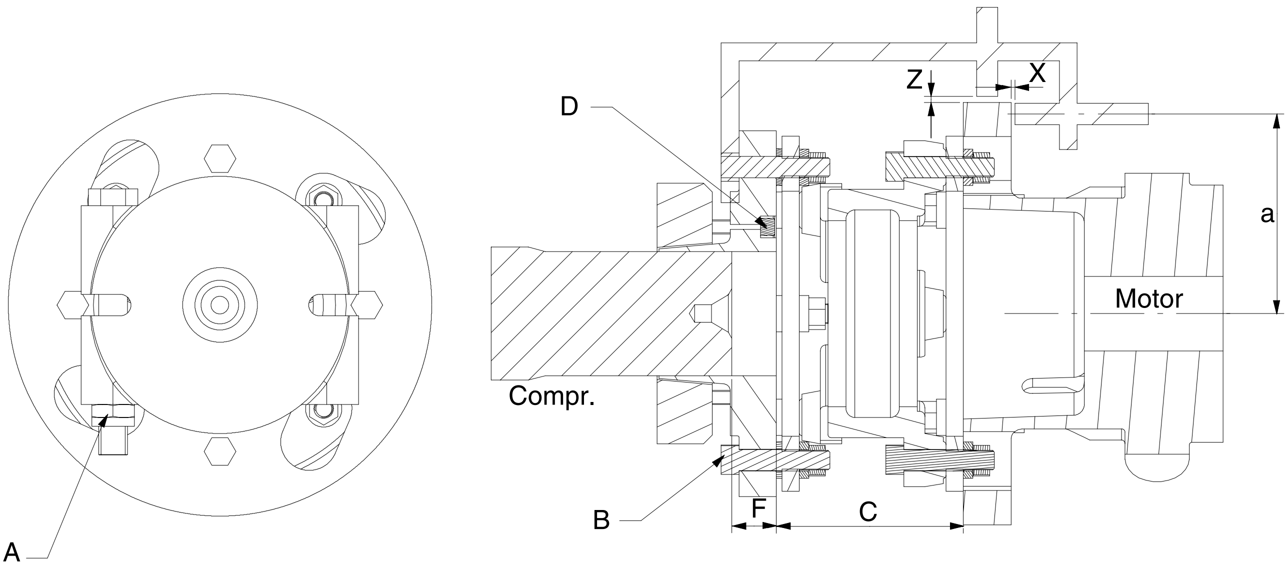


Table 13.1

Compressor	Coupling size	Distance mm		Torque Nm		
		C Nominal*	F	A	B	D
SMC 104-106-108	312 S	105	25	147	55	43
SMC 112-116	350 S	116	27	147	128	43

* See final installation

Preliminary installation

Note: Never tighten the cone screws "D" unless there is a shaft inside the bore. Otherwise it might damage the cone system.

- Degrease the compressor shaft and hub bore surfaces. Any lubricant here will reduce the transferred torque.
- Place the hub at the compressor side, observing the measurement "F".
- Tighten the screws "D" crosswise in two or three steps of torque. Assembly is completed when no screw can be tightened any further (one by one) with tightening torque “D”.
- Place the hub at the motor side. Tighten the bolts "A" and the pointed screw loosely.
- Mount the retaining plate from the coupling screen onto the compressor and insert a support ring for the coupling screen over the motor flange.
- Assemble the intermediate piece and the lamella segments with the 8 screws, applying the prescribed torque. Remember the shaped washers facing the lamellas.
- Insert the coupling intermediate piece. Create space between the flanges either by shifting the entire motor or just the 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 the motor so that the free holes in the motor feet are right above the threaded holes in the base frame.
- Shift the motor coupling flange to make up distance "C" in table. See Table 13.1.
- Tighten the two bolts and the pointed screw in the hub.
- Tighten the measuring pin on the coupling flange of the compressor, as shown in the drawing.

Alignment

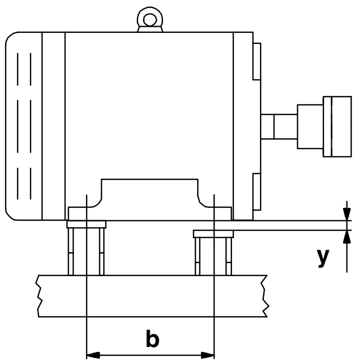
Check that the motor with loose bolts is positioned with all four feet on the base frame. Insert any liner plates needed where there is an air gap beneath the feet. Tighten the bolts loosely.

Achieving parallel shafts in horizontal plane

- Turn the coupling so that the alignment gauge is in upper position.
- Guide the measuring pin (pos. 2) towards the coupling flange, using a 1.0 mm feeler gauge, and fix the pin. Remove the feeler gauge.
- Rotate the coupling 180° and measure the change in distance from the measuring pin to the flange, using feeler gauges. This change is called "x".
- Measure the distance “b” between the motor feet as shown in Fig. 13.32. Measure the distance “a” from the centre of the pin pos. 2 to the centre of the motor as illustrated in Fig. 13.31
- Insert shims of thickness "y" either under both front feet or both rear feet, thereby tilting the motor in the direction required.
- Shim thickness "y" is calculated by using the following formula (see also Fig. 13.32):

$$\mathbf{y} = X \bullet \frac{b}{2 \times a}$$

Fig. 13.32



- After tightening the motor bolts, repeat the measurement and compare the result with the values in the table below:

Table 13.2

Compressor	Coupling size	Maximum variation (mm) measured with feeler gauge at a 180° turning of the coupling		
		Pos 1		Pos 2 max. mm
		Horizontal max. mm	Vertical min./max. mm	
SMC 104-106-108	312 S	0.2	0.1/0.3	0.2
SMC 112-116	350 S	0.2	0.1/0.3	0.2

Achieving correct centre height

- Turn the coupling so that the alignment gauge faces vertically down.
- Guide the measuring pin (pos. 1) towards the coupling flange, using a 1.0 mm feeler gauge, and fix the pin. Remove the feeler gauge.
- Rotate the coupling 180° and measure the increase in distance "z" from one millimetre using feeler gauges.
- Then lift the motor by placing shims of a thickness equal to half value of "z" **under all four feet**.
- After securing the motor, repeat the measurement and compare the result with the 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 remains is to push and turn the motor at the level on which it is already lined up.
- Turn the coupling so that the alignment gauge faces out to one side horizontally.
- Guide both measuring pins towards the coupling with a 1.0 mm feeler gauge in between.
- Turn the coupling 180° and by using feeler gauges measure deviations from one millimetre at both pins.
- Move and turn the motor and repeat this measurement, align the motor in accordance with pos. 1 horizontal and pos. 2 in the table. Remember that the motor must be firmly secured during any measurements.

Final installation

- Tighten the foundation bolts on the motor (see torque table).
- Fit four bolts into the motor coupling flange so that thin shims are placed between the flange and the lamellae, with the rounded side facing lamella.
- Tighten the bolts to torque specified in the table.
- Readjust the flange distance "C" so that the lamellae are aligned, by moving the motor flange on the shaft and fastening the motor flange.
- Check the alignment of the coupling in horizontal and vertical planes for pos. 1 and pos. 2.
- Dismantle the measuring pin and tighten the screw to the prescribed torque.
- Fit the coupling guard.
- Once normal operating temperature has been achieved, double-check the coupling alignment.

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. Antifreeze 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, 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 dismounting 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 pressure.
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.
5. 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%.

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

Dismantling plant

In order to prevent moisture penetrating into the refrigeration plant during 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.

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.

3. No two points in the system should be opened at the same time.

4. Plug, close or at least cover opening with oiled paper or suchlike.
5. Be aware that filters may be 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 reciprocating 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.

Torques etc.

All relevant data and tables regarding torques, coupling data etc. are specified in chapter 21, Appendices.

Ordering spare parts

When ordering spare parts, please state the following:

1. Compressor no.

All compressors are fitted with an identification plate, which states the type and compressor no. of the compressor and indicates which refrigerant to use.

2. Part no.

Spare part drawings and part lists inserted in an instruction manual identify spare parts with the following:

a. Spare part no. - a reference number which makes it easy to find a part in a drawing and cross-reference in the part list or vice versa.

b. Designation of the part.

c. Part no. - a 7-digit number which refers to Sabroe Refrigeration´s stocks.

When ordering spare parts, please always state at least the designation and part number. If in doubt, state the spare part no. as well.

3. Forwarding instructions

When ordering spare parts, please state the forwarding address and the address where the invoice should be sent. If appropriate, please state the name of your local bank, how you wish the goods to be transported and a delivery date.

4. Classification certificate

If requiring 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 you have received a quotation no. in earlier correspondence, please refer to this when placing your order - it will help us identify and execute your order quickly.

18. Part list

How to use the part list

The key to identify a spare part is the pos. no. of the spare part.

By means of the pos. no., the position of the spare part can be found on the spare parts drawings.

Usually the spare part no. is stated next to the pos. no. If no spare part no. is stated, it may because the part is not considered a spare part or because the part is not sold as a spare part.

Parts which are not sold individually are contained in spare parts kits.

The spare parts list contains single parts and components, complete main parts, e.g. cylinder liner with suction valve, kit assemblies which is a collection of spare parts, service kits and gasket kits.

Spare parts which are not available as single parts will be contained in complete main parts as sub parts, kit assemblies, service kits and gasket kits.

Example

Component:	Pos 19-1, part number 3112.085, designation: Cylinder liner with suction valve S&L.
Kit assembly:	Part number 3184.350, designation: Kit assembly oil pump housing
Service kit:	Part number 3188.027, designation: Service kit ring plates
Gasket kit:	Part number 3188.009, designation: Gasket kit unloading cylinder

The part list is divided into sections with the main components of the compressor as headlines.

For each main part, e.g. cylinder liner complete, the part no. of the main part is stated first and then the pos. nos. of all single parts contained in the main part.

Then all kits related to the main part - including the pos. nos. of all sub parts contained in these kits - are indicated.

In some cases a kit will be related to several main parts which is why the kit is not indicated until after the relevant main parts.

Example

A ring plate kit contains a discharge valve ring plate pos. 20C, a suction valve ring plate pos. 19F and valve springs. Therefore, the ring plate kit will be indicated after the discharge valve ring plate pos. 20.

Parts list - 0662-022

Relevant drawings

- SMC 104-106-108: 0662-020
- TSMC 108: 0662-030
- SMC 112-116: 0662-040
- TSMC 116: 0662-050
- Common drawings: 0662-060

Table 18.1

Pos	Part no.	Designation	Kit Qty	Compressor						
				SMC					TSMC	
				104	106	108	112	116	108	116
Compressor frame										
1A-1		Frame SMC 104		1						
1A-2		Frame SMC 106			1					
1A-3		Frame SMC 108				1				
1A-4		Frame TSMC 108							1	
1A-5		Frame SMC 112					1			
1A-6		Frame SMC 116						1		
1A-7		Frame TSMC 116								1
1B-1	1226-015	Oil level glass		1	1	1	1	1	1	1
1C-1		O-ring: Included Gasket kit in 3188-111 and 3188-141								
1D-1	1424-148	Hexagon head M6 x 18		4	4	4	4	4	4	4
Top cover - air cooled										
2A-1	3113-263	Top covers S–L-E, SMC 100 Mk 4		1	2	3	6	8	2	7
2A-2	3113-264	Top cover with flange S–L-E SMC 100 Mk 4		1	1	1			2	1
2E-1	1424-083	Hexagon head M14x90		30	46	62	96	128	60	128
2F-1	1424-090	Hexagon head M14x120		2	2	2			4	2
Top cover - water cooled										
2A-1	3113-263	Top covers S–L-E, SMC 100 Mk 4		1	2	3	6	8	2	7
2A-2	3113-264	Top cover with flange S–L-E, SMC 100 Mk 4		1	1	1			2	1
2B-1	3113-260	Water cover for cover with flange, SMC 100 Mk 4		1	1	1			2	1
2B-2	3113-259	Water cover left, SMC 100 Mk 4		1	1	2	3	4	2	4
2B-3	3113-258	Water cover right, SMC 100 Mk 4			1	1	3	4		3
2E-1	1424-083	Hexagon head M14x90		22	34	46	72	96	44	94
2F-1	1424-090	Hexagon head M14x120		2	2	2			4	2
2G-1	1432-066	Nut M14		16	24	32	48	64	32	64
2H-1	2112-161	Staybolt M14 x 138, SMC/HPC 100 Mk 4		8	12	16	24	32	16	32

Pos	Part no.	Designation	Kit Qty	Compressor						
				SMC					TSMC	
				104	106	108	112	116	108	116
	3184-380	**Kit assembly staybolts for top cover**		2	3	4	6	8	4	8
2G-1/2J-1		Nut M14	8							
2H-1		Staybolt M14x138, SMC/HPC 100 Mk4	4							
Side cover - air cooled										
3A-1	3113-148	Side cover - air cooled		2	2	2	4	4	2	4
3E-1	1424-246	Hexagon head screw M14 x 65		32	32	32	64	64	32	64
Side cover - water cooled										
3A-2	3113-265	Side cover with cooling fins, SMC 100 Mk 4		2	2	2	4	4	2	4
3B-1	3113-258	Water cover right, SMC 100 Mk 4		1	1	1	2	2	1	2
3B-2	3113-259	Water cover left, SMC 100 Mk 4		1	1	1	2	2	1	2
3F-1	1424-241	Screwe M14x40		24	24	24	48	48	24	48
3G-1/3J-1	1432-066	Nut M14		8	8	8	16	16	8	16
	3184-381	**Kit assembly staybolts for Side cover**		2	2	2	4	4	2	4
3G-1/3J-1		Nut M14	8							
3H-1		Staybolt M14 x 85, SMC 100/HPC 100 Mk 4	4							
	3188-119	**Gasket kit top/side cover SMC 104 Mk4**		1						
2C-1 3C-1		Gasket for top and side cover	4							
25AG		Gasket for valve/compr.	1							
	3188-120	**Gasket kit top/side cover SMC 106 Mk4**			1					
2C-1 3C-1		Gasket for top and side cover	5							
25AG		Gasket for valve/compr.	1							
	3188-121	**Gasket kit top/side cover T/SMC 108 Mk4**				1			1	
2C-1 3C-1		Gasket for top and side cover	6							
25AB-1		O-ring	1							
25AG		Gasket for valve/compr.	1							
	3188-122	**Gasket kit top/side cover SMC 112 Mk4**					1			
2C-1 3C-1		Gasket for top and side cover	10							

18. Part list

Pos	Part no.	Designation	Kit Qty	Compressor						
				SMC					TSMC	
				104	106	108	112	116	108	116
	3188-123	**Gasket kit top/side cover T/SMC 116 Mk4**						1		1
2C-1 3C-1		Gasket for top and side cover	12							
25AG		Gasket for valve/compr.	1							
	3188-124	**Gasket kit top/side water covers SMC 104 Mk4**		1						
2D-1		O-ring 253.59 x 3.53	1							
2D-2 3D-1		O-ring 266.29 x 3.53	3							
	3188-125	**Gasket kit top/side water covers SMC 106 Mk4**			1					
2D-1		O-ring 253.59 x 3.53	1							
2D-2 3D-1		O-ring 266.29 x 3.53	4							
	3188-126	**Gasket kit top/side water covers SMC 108 Mk4**				1				
2D-1		O-ring 253.59 x 3.53	1							
2D-2 3D-1		O-ring 266.29 x 3.53	5							
	3188-127	**Gasket kit top/side water covers TSMC 108 Mk4**							1	
2D-1		O-ring 253.59 x 3.53	2							
2D-2 3D-1		O-ring 266.29 x 3.53	4							
	3188-128	**Gasket kit top/side water covers SMC 112 Mk4**					1			
2D-1		O-ring 253.59 x 3.53	10							
	3188-129	**Gasket kit top/side water covers SMC 116 Mk4**						1		
2D-2 3D-1		O-ring 266.29 x 3.53	12							
	3188-130	**Gasket kit top/side water covers TSMC 116 Mk4**								1
2D-1		O-ring 253.59 x 3.53	1							
2D-2 3D-1		O-ring 266.29 x 3.53	11							
Oil pump housing										
4A-1	3141-178	House for oil pump T/SMC 100 Mk 4		1	1	1	1	1	1	1
	3184-350	**Kit assembly oil pump housing**		1	1	1	1	1	1	1
4		Allen screw M5x10	1							
4C-1		Screw M12 x 40	12							
4F-1		Male stud coupling	1							

Pos	Part no.	Designation	Kit Qty	Compressor						
				SMC					TSMC	
				104	106	108	112	116	108	116
4J-1		Screw M5 x 30	4							
	3184-351	**Kit assembly valves oil pump housing**		1	1	1	1	1	1	1
4D-1 4E-1 4K-1		Needle valve	3							
4L-1		Check valve 16 bar	1							
	3184-352	**Kit assembly**		1	1	1	1	1	1	1
4H-1		Intermidiate bracket	1							
4N-1		Differential pressure control	1							
4P-1		Connector with diode	1							
	3184-353	**Kit assembly oil pump counter clockwise rotation**		1	1	1	1	1	1	1
11A-1		Oil pump counter clockwise rotation	1							
11C-1		Screw M8 x 30	8							
	3188-131	Gasket kit oil pump	1							
	3184-354	**Kit assembly oil pump clockwise rotation**		1	1	1	1	1	1	1
11A-2		Oil pump clockwise rotation	1							
11C-1		Screw M8 x 30	8							
	3188-131	Gasket kit oil pump	1							
	3184-182	**Kit assembly plugs oil pump housing**		1	1	1	1	1	1	1
		Plug with gasket 1/4	4							
		Plug with gasket 1/8	2							
		Plug with gasket 3/8	1							
		Plug with gasket 1/2	1							
	3188-131	**Gasket kit oil pump**		1	1	1	1	1	1	1
4		Gasket 14.5/6 x 1.5	2							
4B-1		Gasket for oil pump housing	1							
4G-1		Gasket for differential pressure control	1							
4M-1		Gasket 27/21	1							
4Q-1		O-ring 82.22 x 2.62 for oil pump house	1							
11B-1		Gasket for oil pump	1							

Pos	Part no.	Designation	Kit Qty	Compressor						
				SMC					TSMC	
				104	106	108	112	116	108	116
End cover at pump end										
5A-1	3113-266	Bearing cover		1	1	1	1	1	1	1
5B-1	1424-241	Hexagon head screw M14x40		14	14	14	14	14	14	14
End cover at shaft seal end										
6A-1	3113-124	Bearing cover		1	1	1	1	1	1	1
6B-1	1424-245	Hexagon head screw M14x60		14	14	14	14	14	14	14
6E-1	1436-037	Washer		14	14	14	14	14	14	14
	3188-132	**Gasket kit end/bearing cover T/SMC 104-108 Mk4**		1	1	1			1	
5D-1		Gasket 0.3 mm	1							
5D-2		Gasket 0.5 mm	1							
5D-3		Gasket 0.75 mm	1							
5D-4		Gasket 1.00 mm	1							
6D-1		Gasket	1							
8B-1		Gasket for cover	1							
	3188-133	**Gasket kit end/bearing cover T/SMC 112-116 Mk4**		1	1	1			1	
5D-3		Gasket 0.75 mm	1							
5D-4		Gasket 1.00 mm	1							
5D-5		Gasket 1.30 mm	1							
5D-6		Gasket 1.50 mm	1							
5D-7		Gasket 1.75 mm	1							
5D-8		Gasket 2.00 mm	1							
6D-1		Gasket	1							
8B-1		Gasket for cover	1							
49J		Gasket 34/27 x 1.5	2							
	3188-134	**Service kit main bearings T/SMC 104-108 Mk4**		1	1	1			1	
5C-1 6C-1		Bushing	2							
	3188-132	Gasket kit end/bearing cover T/SMC 104-108 Mk4	1							
	3188-135	**Service kit main bearings T/SMC 112-116 Mk4**					1	1		1
5C-1 6C-1		Bushing	2							
49E-1		Half section bearing	8							

Pos	Part no.	Designation	Kit Qty	Compressor						
				SMC					TSMC	
				104	106	108	112	116	108	116
	3188-133	Gasket kit end/bearing cover T/SMC 112-116 Mk4	1							
	3188-136	**Service kit main bearings T/SMC 104-108 Mk4 under-size**		1	1	1			1	
5C-2 6C-2		Bushing for repair	2							
	3188-132	Gasket kit end/bearing cover T/SMC 104-108 Mk4	1							
	3188-137	**Service kit main bearings T/SMC 112-116 Mk4 under-size**					1	1		1
5C-2 6C-2		Bushing for repair	2							
49E-2		Half section bearing for repair	8							
	3188-133	Gasket kit end/bearing cover T/SMC 112-116 Mk4	1							
	3184-385	**Kit assembly driving hub for oil pump**		1	1	1	1	1	1	1
7A-1		Driving hub for oil pump	1							
7B-1		Spring washer	2							
7C-1		Hexagon head screw	2							
Shaft seal										
	3184-355	**Kit assembly shaft seal cover**		1	1	1	1	1	1	1
8A-1		Shaft seal cover	1							
8B-1		Gasket for cover	1							
8C-1		Hexagon head screw M10 x 40	6							
	3184-356	**Kit assembly hose connection**		1	1	1	1	1	1	1
8D-1		Hose connection	1							
8E-1		Hose	1							
	3184-357	**Kit assembly shaft seal**		1	1	1	1	1	1	1
8F-1		Spirolox ring dia. 76	1							
8G-1		Lock spring	1							
8H-1		Groover pin dia. 4 x 20	1							
10A-1		Retaining flange	1							
10B-1		Spring	10							
10H-1		Locking ring	1							

18. Part list

Pos	Part no.	Designation	Kit Qty	Compressor						
				SMC					TSMC	
				104	106	108	112	116	108	116
	3188-029	**Service kit shaft seal**		1	1	1	1	1	1	1
10D-1		O-ring	1							
10E-1		Slide ring, steel	1							
10F-1		Slide ring, carbon	1							
10G-1		O-ring	1							
10J-1		Hexagon head screw M5 x 16	4							
8B-1		Gasket for cover	1							
Oil filter										
9B-1	2311-075	Nipple		1	1	1	1	1	1	1
	3188-111	**Service kit oil change**		1	1	1	1	1	1	1
1C-1		O-ring	1							
2C-1		Gasket for top and side cover	1							
9A-1	1517-153	Oil filter	1							
Unloading cylinder										
	3135-149	**Unloading cylinder complete L=75 S=21.5**		1	1	1	2	2		1
12A-1		Unloading cylinder	1							
12B-1		Piston	1							
12C-1		Pistin rod 75 mm	1							
12D-1		Threaded plug	1							
12E-1		Gasket	1							
12F-1		Seeger ring	1							
12G-1		Spring guide	1							
12H-1		Spring retainer	1							
12J-1		Spring outer	1							
12J-2		Spring inner	1							
12K-1		Benzing ring dia. 9 mm	1							
12K-2		Benzing ring dia. 7 mm	1							
	3135-150	**Unloading cylinder complete L=100 S=46.5**		1	1	1	2	2	1	1
12A-1		Unloading cylinder	1							
12B-1		Piston	1							
12C-2		Pistin rod 100 mm	1							

Pos	Part no.	Designation	Kit Qty	Compressor						
				SMC					TSMC	
				104	106	108	112	116	108	116
12D-1		Threaded plug	1							
12E-1		Gasket	1							
12F-1		Seeger ring	1							
12G-1		Spring guide	1							
12H-1		Spring retainer	1							
12J-1		Spring outer	1							
12J-2		Spring inner	1							
12K-1		Benzing ring dia. 9 mm	1							
12K-2		Benzing ring dia. 7 mm	1							
	3135-151	**Unloading cylinder complete L=125 S=71.5**			1	1	2	2	1	2
12A-1		Unloading cylinder	1							
12B-1		Piston	1							
12C-3		Pistin rod 125 mm	1							
12D-1		Threaded plug	1							
12E-1		Gasket	1							
12F-1		Seeger ring	1							
12G-1		Spring guide	1							
12H-1		Spring retainer	1							
12J-1		Spring outer	1							
12J-2		Spring inner	1							
12K-1		Benzing ring dia. 9 mm	1							
12K-2		Benzing ring dia. 7 mm	1							
	3135-152	**Unloading cylinder complete L=150 S=96.5**				1		2	1	2
12A-1		Unloading cylinder	1							
12B-1		Piston	1							
12C-4		Pistin rod 150 mm	1							
12D-1		Threaded plug	1							
12E-1		Gasket	1							
12F-1		Seeger ring	1							
12G-1		Spring guide	1							
12H-1		Spring retainer	1							

Pos	Part no.	Designation	Kit Qty	Compressor						
				SMC					TSMC	
				104	106	108	112	116	108	116
12J-1		Spring outer	1							
12J-2		Spring inner	1							
12K-1		Benzing ring dia. 9 mm	1							
12K-2		Benzing ring dia. 7 mm	1							
	3135-161	**Unloading cylinder complete HP L=82 S=24.5**							1	1
12A-2		Unloading cylinder HP	1							
12B-1		Piston	1							
12C-5		Pistin rod 80 mm	1							
12D-1		Threaded plug	1							
12E-1		Gasket	1							
12G-1		Spring guide	1							
12J-1		Spring outer	1							
12J-2		Spring inner	1							
12K-1		Benzing ring dia. 9 mm	1							
12M-1		Cover	1							
12N-1		Gasket	1							
12P-1		Lock nut	1							
12Q-1		Socket cap screw	6							
12R-1		O-ring 12.37 x 2.62	1							
	3135-154	**Unloading cylinder complete HP L=107**								1
12A-2		Unloading cylinder HP	1							
12B-1		Piston	1							
12C-6		Pistin rod 107 mm	1							
12D-1		Threaded plug	1							
12E-1		Gasket	1							
12G-1		Spring guide	1							
12J-1		Spring outer	1							
12J-2		Spring inner	1							
12K-1		Benzing ring dia. 9 mm	1							
12M-1		Cover	1							
12N-1		Gasket	1							

Pos	Part no.	Designation	Kit Qty	Compressor						
				SMC					TSMC	
				104	106	108	112	116	108	116
12P-1		Lock nut	1							
12Q-1		Socket cap screw	6							
12R-1		O-ring 12.37 x 2.62	1							
	3188-009	**Gasket kit unloading cylinder**		2	3	4	6	8	4	8
12E-1		Gasket 25/17 x 1.5	1							
12N-1		Gasket for cover (TSMC HP only)	1							
12R-1		O-ring (TSMC HP only)	1							
12S-1		Gasket 100 x 100 x 2	1							
12L-1	1424-192	Hexagon head screw M10 x 30		8	12	16	24	32	16	32
Frame for unloading										
	3184-216	**Frame complete**		2	3	4	6	8	4	8
13A-1		Suspension rod	1							
13B-1		Suspension rod	1							
13C-1		Cross piece	1							
13D-1		Cross piece	1							
13E-1		Countersunk screw	4							
	3188-034	**Service kit unloading frame**		2	3	4	6	8	4	8
12K-1		Benzing ring dia. 9mm	1							
12K-2		Benzing ring dia. 7mm	1							
12P-1		Lock nut (TSMC HP only)	1							
15C-1		Spring retainer	4							
15D-1		Spring	4							
15E-1		Washer for bearing cup	8							
	3188-009	Gasket kit unloading cylinder	1							
Bracket for unloading mechanism										
	3184-358	**Kit assembly bracket for unloading mechanism**		2	3	4	6	8	4	8
14A-1		Bracket with pin	2							
14B-1		Spacing ring	4							
14C-1		Hexagon head screw M6 x 30	4							
14D-1		Spring washer	4							

Pos	Part no.	Designation	Kit Qty	Compressor						
				SMC					TSMC	
				104	106	108	112	116	108	116
Rocker for unloading mechanism										
	3184-359	**Kit assembly rocker for unloading mechanism LP**		2	3	4	6	8	3	6
15A-1		Rocker	4							
15B-1		Bearing for SMC and TSMC LP	4							
	3184-360	**Kit assembly rocker for unloading mechanism HP**							1	2
15A-1		Rocker	4							
15B-2		Bearing for TSMC HP	4							
Crankshaft - all without certificate										
16A-1	3121-258	Crankshaft SMC 104S Mk 4 complete		1						
16A-2	3121-262	Crankshaft SMC 106S Mk 4 complete			1					
16A-3	3121-266	Crankshaft SMC 108S Mk 4 complete				1			1	
16A-4	3121-277	Crankshaft SMC 104L Mk 4 complete		1						
16A-5	3121-280	Crankshaft SMC 106L Mk 4 complete			1					
16A-6	3121-283	Crankshaft SMC 108L Mk 4 complete				1			1	
16A-7	3121-270	Crankshaft SMC 112S Mk 4 complete					1			
16A-8	3121-274	Crankshaft SMC 116S Mk 4 complete						1		1
16A-9	3121-286	Crankshaft SMC 112L Mk 4 complete					1			
16A-10	3121-289	Crankshaft SMC 116L Mk 4 complete						1		1
16A-11	3121-243	Crankshaft SMC 104E Mk 4 complete		1						
16A-12	3121-246	Crankshaft SMC 106E Mk 4 complete			1					
16A-13	3121-249	Crankshaft SMC 108E Mk 4 complete				1			1	
16A-14	3121-252	Crankshaft SMC 112E Mk 4 complete					1			
16A-15	3121-255	Crankshaft SMC 116E Mk 4 complete						1		1
16F-1	1413-260	Plug M12 S–type		1	1	1	4	4	1	4
16F-2	1343-141	Plug 1/4” L–type		3	3	3	4	5	3	5
Connecting rod										
17	**3123-004**	**Connecting rod, complete**		4	6	8	12	16	6	12
17A-1		Half -section of bearing	2							
17B-1		Bushing for piston pin	1							
17C-1		Bolt for connecting rod	2							
17D-1		Lock nut	2							

Pos	Part no.	Designation	Kit Qty	Compressor						
				SMC					TSMC	
				104	106	108	112	116	108	116
17	**3123-006**	**Connecting rod, complete**							2	4
17A-1		Half -section of bearing	2							
17B-2		Needle rollar bearing	1							
17C-1		Bolt for connecting rod	2							
17D-1		Lock nut	2							
Piston										
18-1	**3124-002**	**Piston with pin and rings S**		4	6	8	12	16	8	16
18A-1		Piston pin	1							
18B-1		Piston ring	2							
18C-1		Oil scraper ring	1							
18D-1		Seeger ring dia. 40	2							
18-2	**3124-052**	**Piston with pin and rings L**		4	6	8	12	16	8	16
18A-1		Piston pin	1							
18B-1		Piston ring	2							
18C-1		Oil scraper ring	1							
18D-1		Seeger ring dia. 40	2							
18-3	**3124-065**	**Piston with pin and rings E**		4	6	8	12	16	8	16
18A-1		Piston pin	1							
18B-1		Piston ring	2							
18C-1		Oil scraper ring	1							
18D-1		Seeger ring dia. 40	2							
	3188-028	**Service kit pair of piston rings**		2	3	4	6	8	4	8
18B-1		Piston ring	4							
18C-1		Oil scraper ring	2							
	3188-090	**Service kit half section bearings**		2	3	4	6	8	4	8
17A-1		Half -section of bearing	4							
17D-1		Lock nut	4							
	3188-089	**Service kit Piston pins LP**		2	3	4	6	8	3	6
17B-1		Bushing for piston pin	2							
17C-1		Bolt for connecting rod	4							
18A-1		Piston pin	2							

Pos	Part no.	Designation	Kit Qty	Compressor						
				SMC					TSMC	
				104	106	108	112	116	108	116
18D-1		Seeger ring dia. 40	4							
	3188-030	**Service kit pair of connecting rod bearings LP**		2	3	4	6	8	3	6
	3188-090	Service kit half section bearings	1							
	3188-089	Service kit Piston pins LP	1							
	3188-097	**Service kit piston pin HP**							2	2
17B-2		Needle rollar bearing	1							
17C-1		Bolt for connecting rod	2							
18A-1		Piston pin	1							
18D-1		Seeger ring dia. 40	2							
	3188-031	**Service kit pair of connecting rod bearings HP**							2	4
17A-1		Half -section of bearing	2							
17D-1		Lock nut	2							
	3188-097	Service kit piston pin HP	1							
Cylinder liner										
19-1	**3112-085**	**Cylinder liner with suction valve S&L, LP, R717**		4	6	8	12	16	6	12
19A-1		Cylinder liner S & L	1							
19B-1		Unloading ring with pins S & L	1							
19C-1		Washer dia. 8/4.3 x 0.5	6							
19D-1		Spring for unloading ring	6							
19E-1		Tension spring	1							
19F-1		Ring plate	1							
19G-1		Valve spring	6							
19H-1	3132-083	Suction valve retaining plate R717	1							
19J-1	3134-008	Guide ring for discharge valve	1							
19N-1	1413-343	Socket cap screw M6 x 30	6							
19T-1		Gasket	1							
19-2	**3112-086**	**Cylinder liner with suction valve S&L, LP, HFC**		4	6	8	12	16	6	12
19A-1		Cylinder liner S & L	1							
19B-1		Unloading ring with pins S & L	1							
19C-1		Washer dia. 8/4.3 x 0.5	6							
19D-1		Spring for unloading ring	6							

Pos	Part no.	Designation	Kit Qty	Compressor						
				SMC					TSMC	
				104	106	108	112	116	108	116
19E-1		Tension spring	1							
19F-1		Ring plate	1							
19G-1		Valve spring	6							
19H-2	3132-095	Suction valve retaining plate HFC	1							
19J-1	3134-008	Guide ring for discharge valve	1							
19N-1	1413-343	Socket cap screw M6 x 30	6							
19T-1		Gasket	1							
19-3	**3112-087**	**Cylinder liner with suction valve S&L, HP, R717**							2	4
19A-1		Cylinder liner S & L	1							
19B-1		Unloading ring with pins S & L	1							
19C-1		Washer dia. 8/4.3 x 0.5	6							
19D-1		Spring for unloading ring	6							
19E-1		Tension spring	1							
19F-1		Ring plate	1							
19G-1		Valve spring	6							
19H-1	3132-083	Suction valve retaining plate R717	1							
19J-1	3134-008	Guide ring for discharge valve	1							
19M-1		O-ring 107.55 x 3.53	1							
19N-1	1413-343	Socket cap screw M6 x 30	6							
19T-1		Gasket	1							
19-4	**3112-088**	**Cylinder liner with suction valve S&L, HP HFC**							2	4
19A-1		Cylinder liner S & L	1							
19B-1		Unloading ring with pins S & L	1							
19C-1		Washer dia. 8/4.3 x 0.5	6							
19D-1		Spring for unloading ring	6							
19E-1		Tension spring	1							
19F-1		Ring plate	1							
19G-1		Valve spring	6							
19H-2	3132-095	Suction valve retaining plate HFC	1							
19J-1	3134-008	Guide ring for discharge valve	1							
19M-1		O-ring 107.55 x 3.53	1							

Pos	Part no.	Designation	Kit Qty	Compressor						
				SMC					TSMC	
				104	106	108	112	116	108	116
19N-1	1413-343	Socket cap screw M6 x 30	6							
19T-1		Gasket	1							
19-5	**3112-081**	**Cylinder liner with suction valve E, LP, R717**							2	4
19A-2		Cylinder liner E	1							
19B-2		Unloading ring with pins E	1							
19C-1		Washer dia. 8/4.3 x 0.5	6							
19D-1		Spring for unloading ring	6							
19E-1		Tension spring	1							
19F-1		Ring plate	1							
19G-1		Valve spring	6							
19H-1	3132-083	Suction valve retaining plate R717	1							
19J-1	3134-008	Guide ring for discharge valve	1							
19N-1	1413-343	Socket cap screw M6 x 30	6							
19T-1		Gasket	1							
19-6	**3112-097**	**Cylinder liner with suction valve E, HP, R717**							2	4
19A-2		Cylinder liner E	1							
19B-2		Unloading ring with pins E	1							
19C-1		Washer dia. 8/4.3 x 0.5	6							
19D-1		Spring for unloading ring	6							
19E-1		Tension spring	1							
19F-1		Ring plate	1							
19G-1		Valve spring	6							
19H-1	3132-083	Suction valve retaining plate R717	1							
19J-1	3134-008	Guide ring for discharge valve	1							
19M-1		O-ring 107.55 x 3.53	1							
19N-1	1413-343	Socket cap screw M6 x 30	6							
19T-1		Gasket	1							
	3184-361	**Kit assembly springs for unloading ring**		2	3	4	6	8	4	8
19C-1		Washer dia. 8/4.3 x 0.5	12							
19D-1		Spring for unloading ring	12							
19E-1		Tesion spring	2							

Pos	Part no.	Designation	Kit Qty	Compressor						
				SMC					TSMC	
				104	106	108	112	116	108	116
	3188-039	**Service kit pair of unloading rings SMC 100 S/L**		2	3	4	6	8	4	8
19B-1		Unloading ring with pins S & L	2							
	3188-010	Gasket kit pair of cylinder liners SMC 100	1							
	3184-361	Kit assembly springs for unloading ring	1							
	3188-040	**Service kit pair of unloading rings SMC 100 E**		2	3	4	6	8	4	8
19B-2		Unloading ring with pins E	2							
	3188-010	Gasket kit pair of cylinder liners SMC 100	1							
	3184-361	Kit assembly springs for unloading ring	1							
Discharge valve										
20-1	**3136-090**	**Discharge valve HP, R717**		4	6	8	12	16	2	4
20A-1	3133-028	Discharge valve seat	1							
20B-1		Retatining plate	1							
20C-1		Ring plate	1							
20E-1	1432-033	Nut	1							
20H-1	1437-066	Lock washer	1							
20G-1		Valve spring	8							
20-2	**3136-091**	**Discharge valve LP, R717**		4	8	8	12	16	6	12
20A-1	3133-028	Discharge valve seat	1							
20B-2		plate	1							
20C-1		Ring plate	1							
20E-1	1432-033	Nut	1							
20H-1	1437-066	Lock washer	1							
20G-2		Valve spring	6							
20-3	**3136-092**	**Discharge valve HP, HFC**		4	6	8	12	16	2	4
20A-1	3133-028	Discharge valve seat	1							
20B-3		Retatiningplate	1							
20C-1		Ring plate	1							
20E-1	1432-033	Nut	1							
20H-1	1437-066	Lock washer	1							
20G-3		Valve spring	12							

Pos	Part no.	Designation	Kit Qty	Compressor						
				SMC					TSMC	
				104	106	108	112	116	108	116
20-4	**3136-093**	**Discharge valve LP, HFC**		4	6	8	12	16	6	12
20A-1	3133-028	Discharge valve seat	1							
20B-4		Retatining plate	1							
20C-1		Ring plate	1							
20E-1	1432-033	Nut	1							
20H-1	1437-066	Lock washer	1							
20G-4		Valve spring	6							
20-5	**3136-094**	**Discharge valve VHP, HFC**		4	6	8	12	16		
20A-1	3133-028	Discharge valve seat	1							
20B-5		Retatining plate	1							
20C-1		Ring plate	1							
20E-1	1432-033	Nut	1							
20H-1	1437-066	Lock washer	1							
20G-5		Valve spring	16							
	3188-010	**Gasket kit pair of cylinder liners SMC 100**		2	3	4	6	8	4	8
19K-1		Gasket for cylinder liner - 0.5mm	2							
19K-2		Gasket for cylinder liner - 0.8mm	2							
19M-1		O-ring 107.55x3.53 (TSMC HP only)	2							
19T-1		Gasket dia. 163/141 x 0.2mm	2							
	3188-027	**Service kit ring plates**		2	3	4	6	8	4	8
19F-1		Ring plate	2							
19G-1		Valve spring	12							
20C-1		Ring plate	2							
20G-1		Valve spring	24							
	3188-010	Gasket kit pair of cylinder liners SMC 100	1							
	3188-098	**Kit assembly valve springs**								
19G-1 20G-1		Valve spring	20							
Note: for service of compressors equipped with discharge vales of type 3136.094 extra set of 3188-098 must be ordered				2	3	4	5	7	4	
21A-1	2142-063	Spring for safety head S & L		4	6	8	12	16	8	16
21A-2	2142-064	Spring for safety head E		4	6	8	12	16	8	16

Pos	Part no.	Designation	Kit Qty	Compressor						
				SMC					TSMC	
				104	106	108	112	116	108	116
Oil pressure valve										
	3184-362	**Kit assembly oil pressure valve**		1	1	1	1	1	1	1
22A-1		Oil pressure valve	1							
22B-1		Gasket	1							
22C-1		Hexagon head screw M12 x 35	2							
22B-1		Gasket included in Gasket kit 3188-141								
Oil charging valve										
	3184-363	**Kit assenbly oil charging valve**		1	1	1	1	1	1	1
23A-1	2412-585	Oil charging valve	1							
23B-1		Threaded reduction nipple	1							
23C-1		Socket	1							
23D-1		Gasket	1							
23E-1		Nut	1							
23F-1		Gasket	1							
23G-1		Male stud coupling	1							
23H-1		Gasket	1							
23J-1		Bend	1							
	3188-138	**Gasket kit oil charging valve**		1	1	1	1	1	1	1
23D-1		Gasket 19/14	1							
23F-1		Gasket 18/10	1							
23H-1		Gasket 34/27	1							
23		Packing gland	1							
By-pass valve										
24-1	3137-033	By–pass valve dia. 20 - 22 bar							1	
24-2	3137-010	By–pass valve dia. 20 - 24 bar							1	
24-3	3137-046	By–pass valve dia. 28 - 14 bar							1	2
24-4	3137-007	By–pass valve dia. 28 - 22 bar		1	1	1	1	1		1
24-5	3137-009	By–pass valve dia. 28 - 24 bar		1	1	1	1	1		1

Pos	Part no.	Designation	Kit Qty	Compressor						
				SMC					TSMC	
				104	106	108	112	116	108	116
	3188-020	**Gasket kit by pass valve ø 20**							1	
24B–1		O–ring 44.0 X 3.53	1							
24C–1		O-ring 56.74 X 3.53	1							
	3188-019	**Gasket kit by pass valve ø 28**		1	1	1	1	1	1	3
24B–2		O–ring for cylinder *)	1							
24C–2		O-ring 66.27 X 3.53	2							
24D–1	1424-168	Skrue M8x25 Kv.8.8								
24E–1	1437-023	Washer DIN 127-								
24F-2	2469-002	Intermediate piece								
Stop valves										
25–1	2414-073	Complete stop valve DN 50							1	
25–2	2414-069	Complete stop valve DN 65		1	1	1			1	1
25-3	2414-070	Complete stop valve DN 100		1	1	1	1	1	1	1
25-4	2414-048	Complete stop valve DN 125					1	1		1
25AV-1	2333-053	Intermidiate flange					1	1		1
	3184-364	**Kit assembly welding nipple 65/65**		1	1	1			1	1
25AC–1		Counter flange 65	1							
25AD–1		Welding nipple dia. 65	1							
25AK–1		Screw for counter flange M10x40	6							
	3184-365	**Kit assembly welding nipple 100/65**		1						
25AC–2		Counter flange 100	1							
25AD–2		Welding nipple dia. 65	1							
25AK–2		Screw for counter flange M12x50	6							
	3184-366	**Kit assembly welding nipple 100/80**		1	1	1			1	
25AC–2		Counter flange 100	1							
25AD–3		Welding nipple dia. 65	1							
25AK–2		Screw for counter flange M12x50	6							
	3184-367	**Kit assembly welding nipple 100/100**			1	1	1	1	1	1
25AC–2		Counter flange 100	1							
25AD–4		Welding nipple dia. 100	1							
25AK–2		Screw for counter flange M12x50	6							

Pos	Part no.	Designation	Kit Qty	Compressor						
				SMC					TSMC	
				104	106	108	112	116	108	116
	3184-368	**Kit assembly welding nipple 125/125**					1	1		1
25AC-3		Counter flange 125	1							
25AD-5		Welding nipple dia 125	1							
25AK-3		Screw for counter flange M16x65	6							
25AF–1	2314-065	Threaded plug 3/4		1	1	1	1	1	1	1
	3184-369	**Kit assenbly stop valve 50/65**		1	1	1			1	1
25AJ–1		Screw bonnet/valve M10 x 25	8							
25C–1		Front part for cone	1							
25D–1		Rear part for cone	1							
25E–1		Screw for valve cone	1							
25G–1		Threaded connection	1							
25K–1		Spindle	1							
25L–1		Lock washer for spindle	1							
25N-1		Guide pin	1							
	3184-370	**Kit assenbly stop valve 100**		1	1	1	1	1	1	1
25AJ–2		Screw bonnet/valve M 12 x 30	8							
25C-3		Front part for cone	1							
25D–3		Rear part for cone	1							
25E–2		Screw for valve cone	1							
25G–2		Threaded connection	1							
25K–2		Spindle	1							
25L–2		Lock washer for spindle	1							
25N-1		Guide pin	1							
	3184-371	**Kit assembly stop valve 125**					1	1		1
25AJ-3		Screw bonnet/valve M16 x 60	6							
25C-3		Front part for cone	1							
25D-3		Rear part for cone	1							
25E–2		Screw for valve cone	1							
25G–3		Threaded connection	1							
25K–3		Spindle	1							
25L–2		Lock washer for spindle	1							

Pos	Part no.	Designation	Kit Qty	Compressor						
				SMC					TSMC	
				104	106	108	112	116	108	116
25N–2		Guide screw	1							
	3184-372	**Kit assembly hand wheel 120**		1	1	1			2	1
25S–1		Hand wheel dia. 120	1							
25T–1		Skrue M5x10 Kv.8.8	1							
25U–1		Washer for hand wheel	1							
	3184-373	**Kit assembly hand wheel 180**		1	1	1	2	2	1	2
25S–4		Hand wheel dia. 180	1							
25T–4		Screw for hand wheel M8 x 16	1							
25U–4		Washer for hand wheel	1							
	3188-015	**Gasket kit stop valve 50-65**		1	1	1			2	1
25F–1		Gasket for screw dia. 31/24 x 1.5	1							
25H–1		Sealing ring dia. 62/45 x 3	1							
25J–1		Gasket for bonnet dia. 72.39 x 5.33	1							
25M–1		Packing gland	1							
25P-1		O-ring 21.82 x 3.53	1							
25Q–1		Nylon washer dia. 39.5/28 x 1.5	1							
25Y–1		Gasket for welding nipple	1							
25AG–1		Gasket for valve/compr.	1							
25AH-1		Gasket for plug	1							
	3188-016	**Gasket kit stop valve 100**		1	1	1	1	1	1	1
25F–2		Gasket for screw dia. 36/28 x 1.5	1							
25H–2		Sealing ring dia. 110/90 x 3	1							
25J–2		Gasket for bonnet dia. 116.84 x 7	1							
25M–2		Packing gland	1							
25P–2		O-ring 28.17 X 3.53	1							
25Q–2		Nylon washer dia. 48/34 x 1.5	1							
25Y–2		Gasket for welding nipple	1							
25AG–2		Gasket for valve/compr.	1							
25AH–1		Gasket for plug	1							

Pos	Part no.	Designation	Kit Qty	Compressor						
				SMC					TSMC	
				104	106	108	112	116	108	116
	3188-018	**Gasket kit stop valve 125**					1	1		1
25F–2		Gasket for screw dia. 36/28 x 1.5	1							
25H–3		Sealing ring dia. 133/110x3.0	1							
25J–3		Gasket for bonnet dia. 167.5 x 148.5 x 2.0	1							
25M–2		Packing gland	1							
25P–2		O-ring 28.17 X 3.53	1							
25Q–2		Nylon washer dia. 48/34 x 1.5	1							
25Y–3		Gasket for welding nipple	1							
25AG–3		Gasket for valve/compr.	1							
25AH–1		Gasket for plug	1							
25V–1	1437-023	Spring washer								1
25Z–1	1424-241	Screw valve/compr. M14 x 40		4	4	4			4	
25Z–2	1424-242	Screw valve/compr M 14 x 45		4	4	4			4	4
25Z–3	1424-102	Screw valve/compr M16 x 45		4	4	4	4	4	4	4
25Z–4	1424-268	Screw valve/compr. M16 x 100					6	6		6
Pressure gauges										
30A–1	1541-108	R717		1	1	1	1	1	1	1
30A-2	1541-068	R407C and R507		1	1	1	1	1	1	1
30A–3	1541-074	R22, R134a and R404A		1	1	1	1	1	1	1
30A-4	1541-136	R410A and R744		1	1	1	1	1	1	1
Dicsharge pressure gauge										
31A–1	1541-029	R717		1	1	1	1	1	1	1
31A–2	1541-069	R407C and R507		1	1	1	1	1	1	1
31A–3	1541-075	R22, R134a and R404A		1	1	1	1	1	1	1
31A–4	1541-137	R410A and R744		1	1	1	1	1	1	1
31A–5	1541-101	R717							1	1
31A-6	1541-077	R407C and R507							1	1
31A-7	1541-076	R22, R134a and R404A							1	1
31C–1	1412-350	Screws for gauges M4 x 20		6	6	6	6	6	6	6

18. Part list

Pos	Part no.	Designation	Kit Qty	Compressor						
				SMC					TSMC	
				104	106	108	112	116	108	116
	3188-021	**Gasket kit pressure gauges**		1	1	1	1	1	1	1
30B-1		Nozzle and gasket dia. 14/0.8 x 1.5	1							
30C–1		Gasket dia. 11/4 x 1.5	1							
31B–1		Nozzle and gasket dia. 14/0.8 x 1.5	2							
Oil suction filter										
	3184-374	**Kit assembly oil suction filter**		1	1	1	1	1	1	1
33A-1		Oil suction filter	1							
33B-1		Male stud coupling	1							
33C-1		Oil pipe suction	1							
33D-1		Flange connector, el-bow, 22 mm pipe (CR-mat)	1							
Suction filter										
	3188-035	**Service kit suction filter**		2	2	2			1	
34A-1		Suction filter open, complete	1							
	3188-011	Gasket kit suction filter	1							
	3188-036	**Service kit suction filter**							1	
34A-2		Suction filter closed, complete	1							
	3188-012	Gasket kit suction filter	1							
	3188-037	**Service kit suction filter**					2	2		1
34A-1		Suction filter open, complete	1							
	3188-013	Gasket kit suction filter	1							
	3188-038	**Service kit suction filter**								1
34A-2		Suction filter closed, complete	1							
	3188-014	Gasket kit suction filter	1							
	3188-011	**Gasket kit suction filter**		1	1	1				
34D-1		O-ring 75.57 X 5.33	2							
34F-1		O-ring 91.67 X 3.53	2							
	3188-012	**Gasket kit suction filter**							1	
34D-1		O-ring 75.57 X 5.33	3							
34F-1		O-ring 91.67 X 3.53	1							
	3188-013	**Gasket kit suction filter**					1	1		
34D-1		O-ring 104.1 x5,33	2							

Pos	Part no.	Designation	Kit Qty	Compressor						
				SMC					TSMC	
				104	106	108	112	116	108	116
34F-1		O-ring 120.24 X 3.53	2							
	3188-014	**Gasket kit suction filter**								1
34D-1		O-ring 104.1 x5,33	3							
34F-1		O-ring 120.24 X 3.53	1							
34B-1	3425-083	Filter bag		2	2	2			2	
34B-2	3425-096	Filter bag					2	2		2
34C-1	3424-058	Insert for filter bag		2	2	2			2	
34C-2	3424-061	Insert for filter bag					2	2		2
34E-1	3422-103	Cover for suction filter		2	2	2			1	
34E-2	3422-114	Cover for suction filter					2	2		1
34G-1	1424-217	Hexagon head screw M12x40		8	8	8			4	
34G-2	1424-102	Hexagon head screw M16x45					8	8		4
34H-1	1437-027	Spring washer		8	8	8			4	
34H-2	1437-026	Spring washer					8	8		4
Discharge pipe oil system										
38A-1	3141-176	Discharge pipe oil system		1	1	1	1	1	1	1
38C-1	2333-024	Connection for discharge pipe		1			1			
38C-2	2333-025	Connection for discharge pipe			1					
38C-3	2333-026	Connection for discharge pipe				1		1	1	1
38H-1	3141-114	Discharge for oil pipe					1	1		1
38J-1	2213-150	Support for oil pipe					1	1		1
38K-1	1424-189	Hexagon head screw M10 x 16					2	2		2
38L-1	1437-027	Spring washer					2	2		2
	3188-139	**Gasket kit discharge pipe oil system**		1	1	1	1	1	1	1
38M-1		O-ring 21.82 x 3.53	1							
38D-1		O-ring 21.82 x 3.53	1							
38E-1		O-ring 29.51 x 5.33	1							
38F-1		O-ring 21.82 x 3.53	1							
38G-1		O-ring 26.58 x 3.53	1							

18. Part list

Pos	Part no.	Designation	Kit Qty	Compressor						
				SMC					TSMC	
				104	106	108	112	116	108	116
Analogous control and safety equipment										
39A–1	3146-042	Gauge panel		1	1	1	1	1	1	1
39B–1	1413-382	Socket cap screw M10 x 60		2	2	2	2	2	2	2
39C–1	2213-142	Console		1	1	1	1	1	1	1
39D–1	2213-143	Bar for controls (4 controls)		1	1	1	1	1		1
39D–2	2213-144	Bar for controls (5 controls)		1	1	1	1	1	1	1
39D–3	2213-145	Bar for controls (6 controls)		1	1	1	1	1	1	1
39D–4	2213-154	Bar for controls (7 controls)		1	1	1	1	1	1	1
39D–5	2213-368	Bar for controls (US, SMC)		1	1	1	1	1		1
39D–6	2213-369	Bar for controls (US, TSMC)							1	
39J-1	1413-330	Socket cap screw M5x10		4	4	4	4	4	4	4
39K-1	1437-021	Spring washer dia. 9/5		4	4	4	4	4	4	4
Cooling water										
40A–1	3185-230	Set of hoses for cooling water SMC104		1						
40A–2	3185-231	Set of hoses for cooling water SMC106			1					
40A–3	3185-232	Set of hoses for cooling water SMC/TSMC108				1			1	
40A–4	3185-235	Set of hoses for cooling water SMC/TSMC108 side cover only				1			1	
40A-9	3185-233	Set of hoses for cooling water SMC112					1			
40A-11	3185-246	Set of hoses for cooling water SMC112 side cover only					1			
40A-10	3185-234	Set of hoses for cooling water SMC/TSMC116						1		1
40A-8	3185-236	Set of hoses for cooling water SMC/TSMC116 side cover only						1		1
Purge valve										
42A–1	2412-585	Purge valve		1	1	1	1	1	2	2
42B–1	1349-078	Threaded nipple		1	1	1	1	1	1	1
42C–1	1349-062	Male stud coulping		1	1	1	1	1	1	2
42E–1	2313-045	Nut		1	1	1	1	1	2	2
42F–1	2334-027	Connecting pipe with collar		1	1	1	1	1	2	2
42G-1		Gasket: Included in Gasket kit 3188.141		2	2	2	2	2	4	4
42H-1	2313-027	Nut		1	1	1	1	1	2	2

Pos	Part no.	Designation	Kit Qty	Compressor SMC 104	SMC 106	SMC 108	SMC 112	SMC 116	TSMC 108	TSMC 116
Pressure and temperature controls										
		Pressure controls for R717								
45A-1	1373-125	KP 5A		1	1	1	1	1	1	1
45B-1	1373-142	KP15A		1	1	1	1	1	1	1
45C-1	1373-162	MP 55A		1	1	1	1	1	1	1
45	1373-113	KP 1A		1	1	1	1	1	1	1
45	1373-132	KP7ABS		1	1	1	1	1	2	2
		Pressure controls HFC								
45D-1	1373-123	KP 5		1	1	1	1	1	1	1
45E-1	1373-135	KP 15		1	1	1	1	1	1	1
45F-1	1373-159	MP 55		1	1	1	1	1	1	1
45	1373-103	KP 1		1	1	1	1	1	1	1
45	1373-132	KP7ABS		1	1	1	1	1	2	2
		Temperature controls								
45	1373-043	KP 98		1	1	1	1	1	1	1
45	1373-044	KP 77		1	1	1	1	1	1	1
45J-1	1377-171	Phail pocket for temperature controls		1	1	1	1	1	1	1
45K-1		Gasket: Included in Gasket kit 3188.141		1	1	1	1	1	1	1
Coupling AMR 312S										
48F-1	1524-159	Compressor hub for coupling AMR 312		1	1	1			1	
	1524-152	**Spare part set AMR 312S**		1	1	1			1	
48A-1		Disc pack	2							
48B-1		Bolt	16							
48C-1		Bevel washer	8							
48D-1		Lock nut	16							
48E-1		Washer	16							
Coupling AMR 350S										
48F-2	1524-160	Compressor hub for coupling AMR 350					1	1		1
	1524-153	**Spare part set AMR 350S**					1	1		1
48A-2		Disc pack	2							
48B-2		Bolt	16							

18. Part list

Pos	Part no.	Designation	Kit Qty	Compressor						
				SMC					TSMC	
				104	106	108	112	116	108	116
48C-2		Bevel washer	8							
48D-2		Lock nut	16							
48E-2		Washer	16							
Intermediate bearing										
49-1	3113-146	Intermediate bearing complete					1	1		1
49A-1		Housing					1	1		1
49B-1	1413-389	Socket cap screw M12x45					4	4		4
49C-1	1437-081	Spring washer					4	4		4
49D-1	1446-022	Guide pin 5x26					2	2		2
49F-1	1424-199	Hexagan head screw M10x65					2	2		2
49G-1	1437-033	Spring washer					2	2		2
49H-1	2314-027	Threaded plug 3/4" BSP					2	2		2
Capacity regulation										
50A–1	3143-383	Valve body with 1 solenoid valve		1						
50A–2	3143-384	Valve body with 2 solenoid valves			1		2			
50A–3	3143-385	Valve body with 3 solenoid valves				1		2	1	1
50A–4	3143-386	Valve body with 4 solenoid valves								1
50B–1	1372-537	Coil 10W 220/230V - 50/60Hz		1	2	3	4	6	3	7
50B–2	1372-538	Coil 10W 110V - 50/60Hz		1	2	3	4	6	3	7
50B–3	1372-539	Coil 10W 240V - 50Hz		1	2	3	4	6	3	7
50C-1	1372-424	Service Kit for one solonoid valve								
Crankcase heater 1 1/4 BSP										
	3184-375	**Kit assembly crankcase heater - 270W, 115V**		1	1	1	2	2	1	2
57A-1		Heater	1							
57B–1		Sealing ring	1							
	3184-376	**Kit assembly crankcase heater - 270W, 230V**		1	1	1	2	2	1	2
57A-1		Heater	1							
57B–1		Sealing ring	1							
	3184-377	**Kit assembly crankcase heater - 270W, 250V**		1	1	1	2	2	1	2
57A-1		Heater	1							
57B–1		Sealing ring	1							

Pos	Part no.	Designation	Kit Qty	Compressor						
				SMC					TSMC	
				104	106	108	112	116	108	116
57B-1		Sealing ring: Included in Gasket kit 3188.141								
Oil return										
80A-1	1372-179	Valve block EVRB								
80B-1	1371-037	3.3 mm orifice for mounting in valve block								
80C-1	1375-094	TLT valve		1	1	1	1	1	1	1
80J-1	1372-537	Coil 10W 220/230V - 50/60Hz								
80J-2	1372-538	Coil 10W 110V - 50/60Hz								
80J-3	1372-539	Coil 10W 240V - 50Hz								
80J-4	1372-541	Coil 10W 24V - 50Hz								
	1372-089	**Strainer kit EVRB block**		1	1	1	1	1	1	1
80E		Strainer								
80G		Gasket								
	1372-086	**Service kit EVRB block**		1	1	1	1	1	1	1
80P		Armature tube								
80H		Armature								
80K		O-ring								
80M		O-ring								
80L		Gasket								
	1372-091	**Seal kit EVRB block**		1	1	1	1	1	1	1
80G		Gasket								
80K		O-ring								
80M		O-ring								
80L		Gasket								
80Q		Gasket								
	1371-037	**Orifice kit 3.3 mm**		1	1	1	1	1	1	1
80L		Gasket								
80Q		Gasket								
80I		Orifice 3.3 mm								

18. Part list

Pos	Part no.	Designation	Kit Qty	Compressor						
				SMC					TSMC	
				104	106	108	112	116	108	116
Intermidiate pressure connections TSMC 108										
90A–1	3114-095	Mixing chamber with flange TSMC108							1	
90B–1	3115-102	Counter flange for mixing chamber TSMC108							1	
90C–1	3422-100	Intermediate ring 107/88							1	
90F–1	1424-222	Hexagon head screw M12 x 65							4	
90G–1	1424-246	Hexagon head screw M14 x 65							4	
90H–1	1437-026	Spring washer dia.13.2/21.2 x 2.5							4	
90J–1	1437-030	Spring washer dia. 14							4	
90K–1	1432-066	Nut M14							4	
Intermidiate pressure connections TSMC 116										
90A-1	3114-070	Mixing chamber with flange TSMC116								1
90B-1	2331-051	Counter flange for mixing chamber TSMC116								1
90C-1	3422-111	Intermediate ring 148/116								1
90F-1	1424-108	Hexagon head screw M16 x 75								4
90G-1	1424-104	Hexagon head screw M16 x 55								4
90H-1 90J-1	1437-027	Spring washer								8
	3188-023	**Gasket kit intermidiate connection TSMC 108**							1	
90D–1		O-ring 82.14 X 3.53	1							
90E–1		O-ring 98.02 X 3.53	1							
90L–1		O-ring 91.67 X 3.53	1							
90N-1		Gasket 18/10x1.5	1							
90M-1		O-ring 91.67 X 3.53	1							
	3188-024	**Gasket kit intermidiate connection TSMC 108**								1
90D-1		O-ring 113.89 x 3.53	1							
90E-1		O-ring 120.24 X 3.53	1							
90L-1		O-ring 132.94 x 3.53	1							
90N-1		Gasket 18/10x1.5	1							
Oil cooling										
		Oil cooler HFC								
92-1	4242-038	Oil cooler OOKH HFC		1	1	1	1	1	1	1
		Oil cooler R717								

Pos	Part no.	Designation	Kit Qty	Compressor						
				SMC					TSMC	
				104	106	108	112	116	108	116
92-2	4242-029	Oil cooler OOSI R717		1	1	1	1	1	1	1
	3184-378	**Kit assembly oil cooling type HFC/R717**		1	1	1	1	1	1	1
92A-1		Adapter for oil cooler	1							
92C-1		Cyl skrue M6x40 kv.12.9 DIN912	4							
92F-1		Gevind nippel	1							
92H-1		Prop med rand 1/4"RG	1							
92L-1		Plug 3/8	1							
	3188-140	**Gasket kit oil cooling**		1	1	1	1	1	1	1
92B-1		O-ring 25.07 x 2.62	1							
92D-1		Gasket ø25/17	1							
92E-1		Gasket ø32/27	1							
92G-1		Gasket ø27/21	1							
92J-1		Gasket ø20/13	1							
92K-1		O-ring 21.82 x 3.53	1							
92	1371-301	Expansion valve TX 2		1	1	1	1	1	1	1
92	1371-339	Nozzle no.01 for T2/TE2 valve		1	1	1	1	1	1	1
92	1371-026	Expansion valve TN 2		1	1	1	1	1	1	1
92	1371-340	Nozzle no.02 for T2/TE2 valve		1	1	1	1	1	1	1
92	1371-027	Expansion valve TS 2		1	1	1	1	1	1	1
92	1371-340	Nozzle no.02 for T2/TE2 valve		1	1	1	1	1	1	1
92	1371-085	Expansion valve TU-A		1	1	1	1	1	1	1
92	1371-366	Nozzle no.04 for TUA valve		1	1	1	1	1	1	1
92	1371-027	Expansion valve TS 2		1	1	1	1	1	1	1
92	1371-366	Nozzle no.04 for TUA valve		1	1	1	1	1	1	1
92	1371-230	Expansion valve TEA20-2 w. nozzle		1	1	1	1	1	1	1
Thermo pump										
98A-1	3113-145	Side cover for thermo pump		1	1	1	2	2	1	1
98B-1	1553-215	Control box for thermo pump		1	1	1	2	2	1	1
98D-1	1372-179	Valve block EVRB		1	1	1	2	2	1	1
98	1371-037	3.3 mm orifice for mounting in valve block								
98C-1	3185-038	Level feeler - complete for SMC		2	2	2	4	4	2	2

18. Part list

Pos	Part no.	Designation	Kit Qty	Compressor						
				SMC					TSMC	
				104	106	108	112	116	108	116
98G-1	1372-422	Solenoid valve 2/2 EVRA 1.5		1	1	1	2	2	1	1
98H-1	1372-423	Solenoid valve 2/2 EVRA 3.5		1	1	1	2	2	1	1
98J-1	1372-537	Coil 10W 220/230V - 50/60Hz								
98J-2	1372-538	Coil 10W 110V - 50/60Hz								
98J-3	1372-539	Coil 10W 240V - 50Hz								
98K-1	1364-008	Check valve		2	2	2	4	4	2	2
98M-1	2314-103	VA-joint		3	4	5	7	9	1	3
98Q-1	3113-143	Cooling cover		1	1	1	2	2	1	1
98R-1		Gasket for top- and side cover		2	2	2	4	4	2	2
98S-1	1424-081	Hexagon head screw M14 x 80		16	16	16	32	32	16	16
98T-1	4242-029	Oil cooler type OOSI for R717		1	1	1	1	1	0	1
98U-1	1372-422	Solenoid valve 2/2 EVRA 1.5		1	1	1	0	0	0	1
98V-1	1372-422	Solenoid valve 2/2 EVRA 1.5		1	1	1	2	2	1	1
98X-1	1373-253	PT 100 sensor		1	1	1	1	1	1	1
98Y-1	2412-277	Stop valve		1	1	1	2	2	1	1
98Z-1	1364-022	Non return valve		1	1	1	2	2	1	1
Pulley										
999	1526-073	Clamping unit		1	1	1	1	1	1	1
999	2152-151	Pulley DP 400, 4 Grooves, SPB		1	1	1	1	1	1	1
999	2152-152	Pulley DP 400, 6 Grooves, SPB		1	1	1	1	1	1	1
999	2152-153	Pulley DP 400, 8 Grooves, SPB		1	1	1	1	1	1	1
UNISAB										
	3184-379	**Kit assembly support for UNISAB**		1	1	1	1	1	1	1
99A–1		Support for UNISAB	1							
99B-1		Distance washers	4							
99C–1		Hexagon head M10 x 20	2							
99D-1		Hexagon head M6 x 20	4							
99F–1		Washer	4							
	3084-394	**Normal spare parts set**								
		Set of accessories - UNISAB II								
		EPROM tongs								

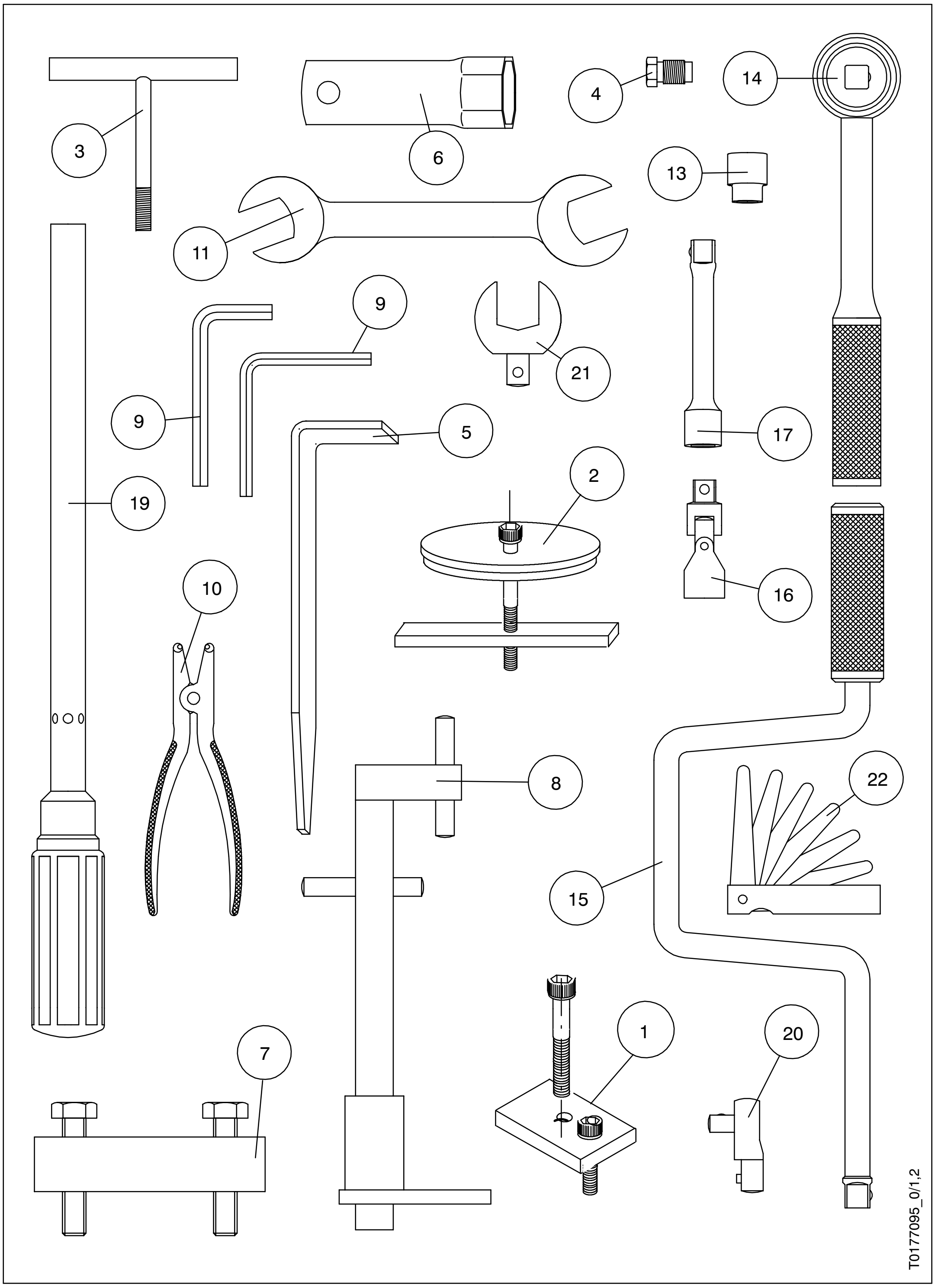
Pos	Part no.	Designation	Kit Qty	Compressor						
				SMC					TSMC	
				104	106	108	112	116	108	116
		EEPROM tongs								
		EEPROM (2kB-serial) - To be used in version Eprom 1.10 and earlier versions.								
		EEPROM (4kB-serial) - To be used in version Eprom 1.12 and later versions.								
	3084-383	**Certificate set**								
	3084-394	Normal spare parts set								
	1573-007	Front cover with sheet and display, Sabroe logo								
	1572-026	CPU print (rev. C)								
	1574-016	Relay print (rev. G)								
	1373-249	Pressure transducer dia.10 AKS32R-1-9 bar 1)								
	1373-271	Pressure transducer dia.10 AKS2050-1-25 bar								
	1373-251	Pressure transducer dia.10 AKS32R-1-59 bar 2)								
	3449-542	Pt100 sensor kit, 4-conductor (1/2" thread) 3)								
Notes:	1) **Not** used for HPO/HPC compressors 2) **Only** used forHPO/HPC compressors 3) With 1/2” / 1/4” nipple, cutting ring and instruction									

18 spare parts list _ tool list.fm

Tools for compressor

The SMC Mk4 compressor tool set comprises the tool set for Mk3 and a supplementary set for Mk4.

The tool set for Mk3



Tools for compressor

SMC 104-116 Mk3 & TSMC 108-116 Mk3 - Type S-L-E

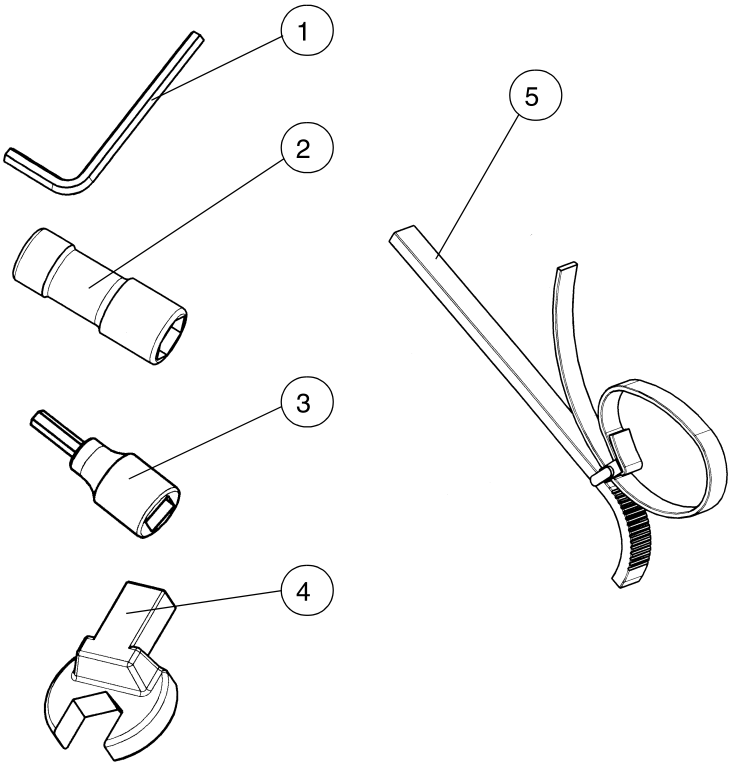
Line no. A600 = Normal set, tools set no 3183-109
Line no. A601 = Extended set, tools set no 3183-110
Line no. A602A = Tools for coupling (SMC 104-108)
Line no. A602B = Tools for coupling (SMC 112-116)
Line no. A603 = Tools for alignment of coupling

Pos. No.	Designation	Dimen-sion	Part No.	Line No.				
				A600	A601	A602		A603
						A	B	
1-1	Clamp with screw, compr. type S and L		3183-144	4	4			
1-2	Clamp with screw, compr. type E		3183-145	4	4			
2	Tools for shaft seal		3183-139	1	1			
3	Tommy screw for cylinder liner		3183-041	2	2			
4	Theaded plug for unloading cylinder	3/8" BSP	2314-017	2	2			
5	Supporting plate for pistons		3183-115	8	8			
6	Spanner for heating cartridge	NV 55	3183-060	1	1			
7	Trigger for coupling or belt pulley		3183-059	1	1			
8	Adjusting jig for coupling		3183-105					1
9-1	Wrench for cylinder screw	NV 4			1			
9-2	Wrench for cylinder screw	NV 5			1			
9-3	Wrench for cylinder screw	NV 8			1			
9-4	Wrench for cylinder screw	NV 10			1			
9-5	Special wrench for shaft seal	NV 4	1612-392	1	1			
10-1	Retaining-ring plier	J 21/G			1			
10-2	Retaining-ring plier	A 11/G			1			
11-1	Open end and ring spanner	NV 10			1			
11-2	Open end and ring spanner	NV 17			1			
11-3	Open end and ring spanner	NV 19			1			
11-4	Open end and ring spanner	NV 22			1			

18. Part list

Pos. No.	Designation	Dimen-sion	Part No.	Line No.				
				A600	A601	A602		A603
						A	B	
11-5	Open end and ring spanner	NV 24			1			
11-6	Open end and ring spanner	NV 27			1			
13-1	Socket wrench	NV 10			1			
13-2	Socket wrench	NV 13			1			
13-3	Socket wrench	NV 17			1			
13-4	Socket wrench	NV 19			1			
13-5	Socket wrench	NV 22			1			
13-6	Socket wrench	NV 24			1	1	1	
13-7	Socket wrench	NV 27			1			
13-8	Socket wrench	NV 30			1			
13-9	Socket wrench	NV 32			1			
13-10	Socket wrench	NV 9/16”			1			
13-11	Socket wrench	NV 3/4”			1		1	
13-12	Socket wrench	NV 11/16”			1	1		
14	Ratchet handle				1			
15	Speed handle				1			
16	Universal joint for socket wrench				1			
17-1	Extension rod for socket wrench				1			
17-2	Extension rod for socket wrench				1			
19-1	Torque wrench 15-90 Nm				1			
19-2	Torque wrench 40-200 Nm				1	1	1	
20	Coupler for torque wrench 1/2				2	1	1	
21-1	Open spanner for torque wrench	NV 11/16”			1	1		
21-2	Open spanner for torque wrench	NV 3/4”			1		1	
22	Feeler gauge							1

Supplementary tool set for SMC 100 Mk4



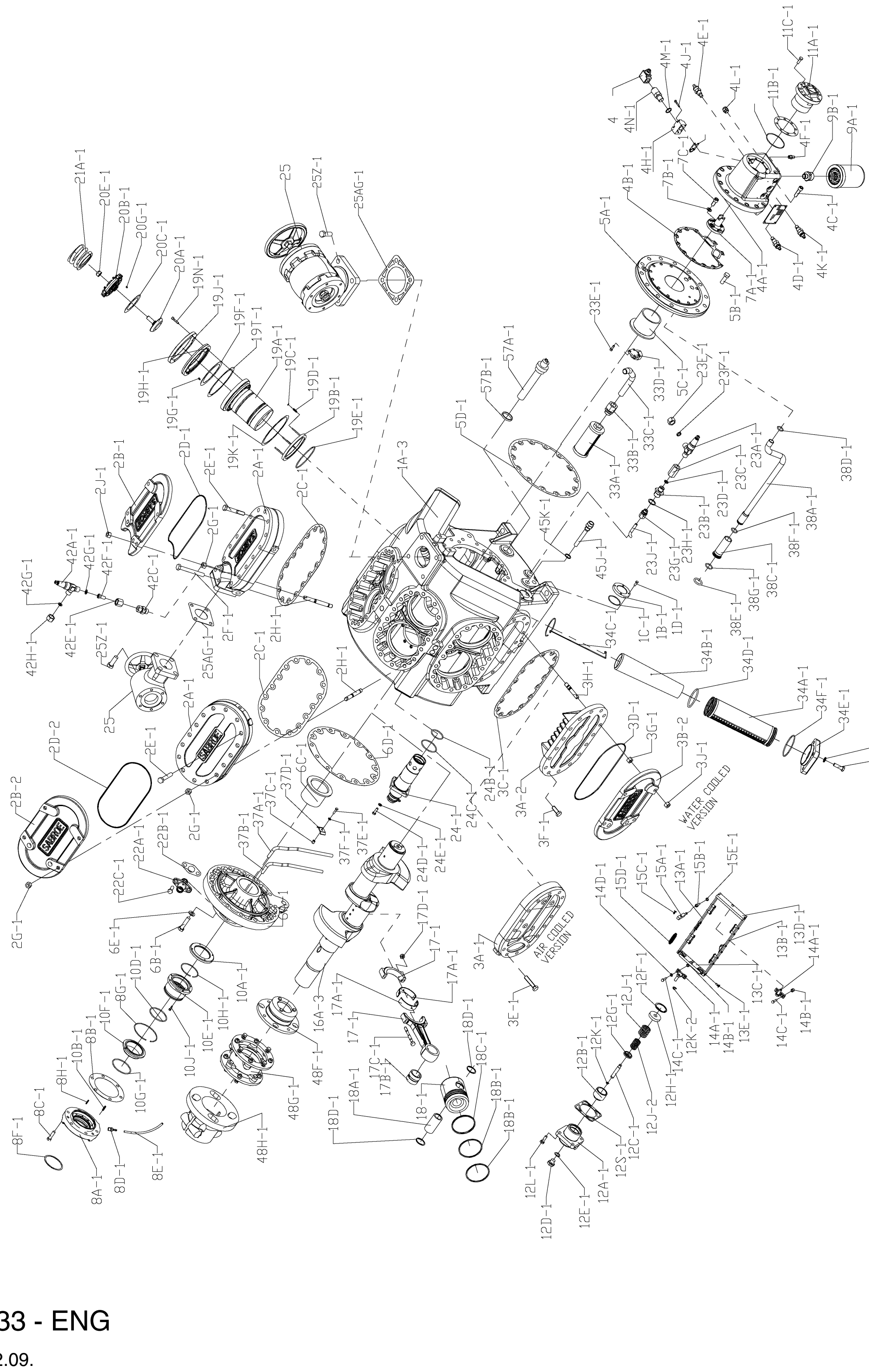
Line no. A605 = Supplementary tool set for Mk4 no 3183-148

Pos. No.	Designation	Dimension	Part No.	Line No.		
				A605		
1	Allen key for needle valves in pump housing	1/4”	1612-417	1		
2	Box spanner insert for water-cooled covers	22 mm 1/2” square	1612-323	1		
3	Bit adapter for Mk4 coupling	6 mm Allen key 1/2” square	1612-342	1		
4	Open end spanner for torque wrench (temporarily for Mk4 coupling)	NV 13	1612-262	1		
5	Oil filter wrench for Spin-on oil filter	dia.100	1612-166	1		

19. Drawings

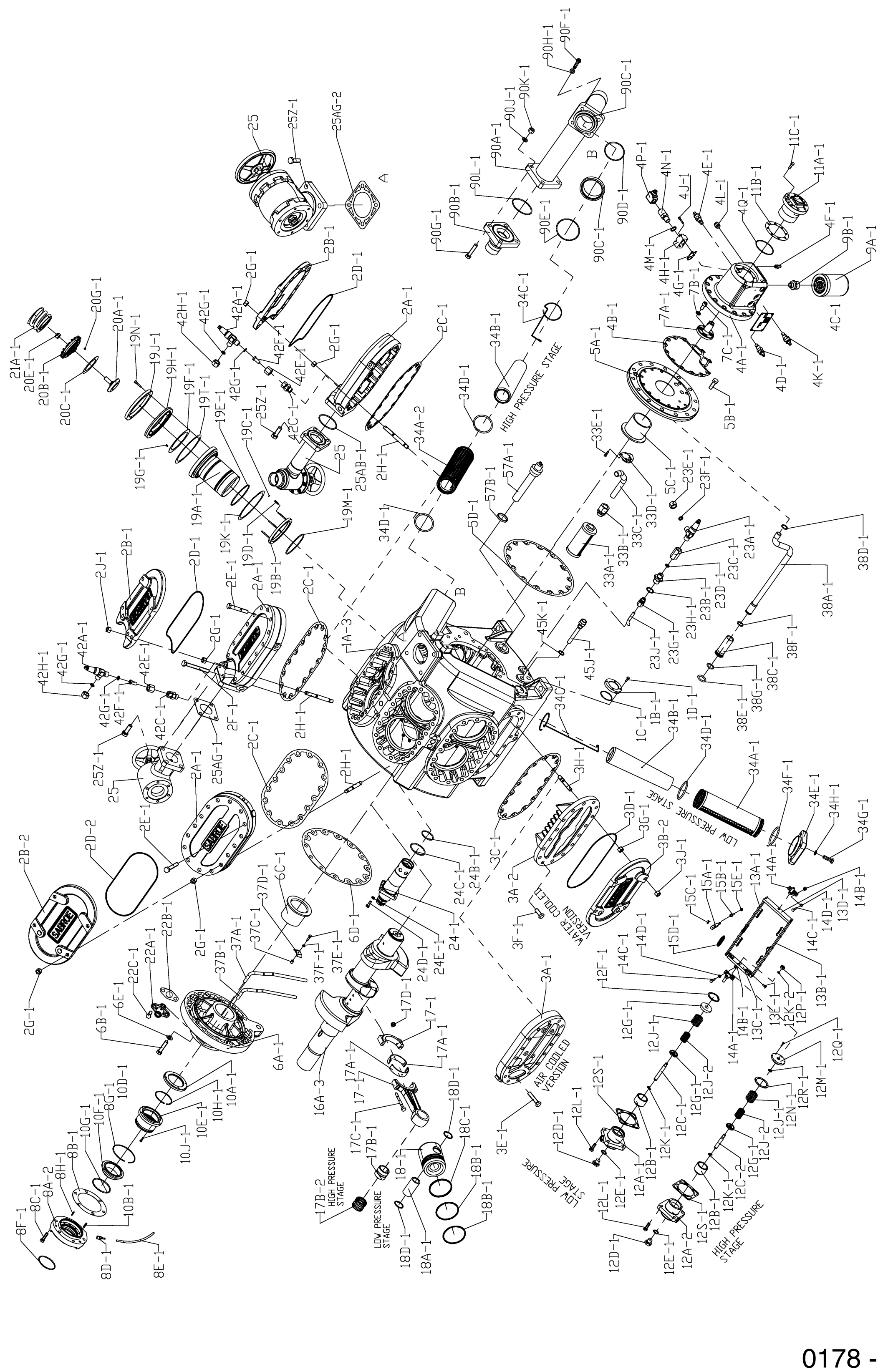
SMC 104-106-108

Drawing no. 0662-020



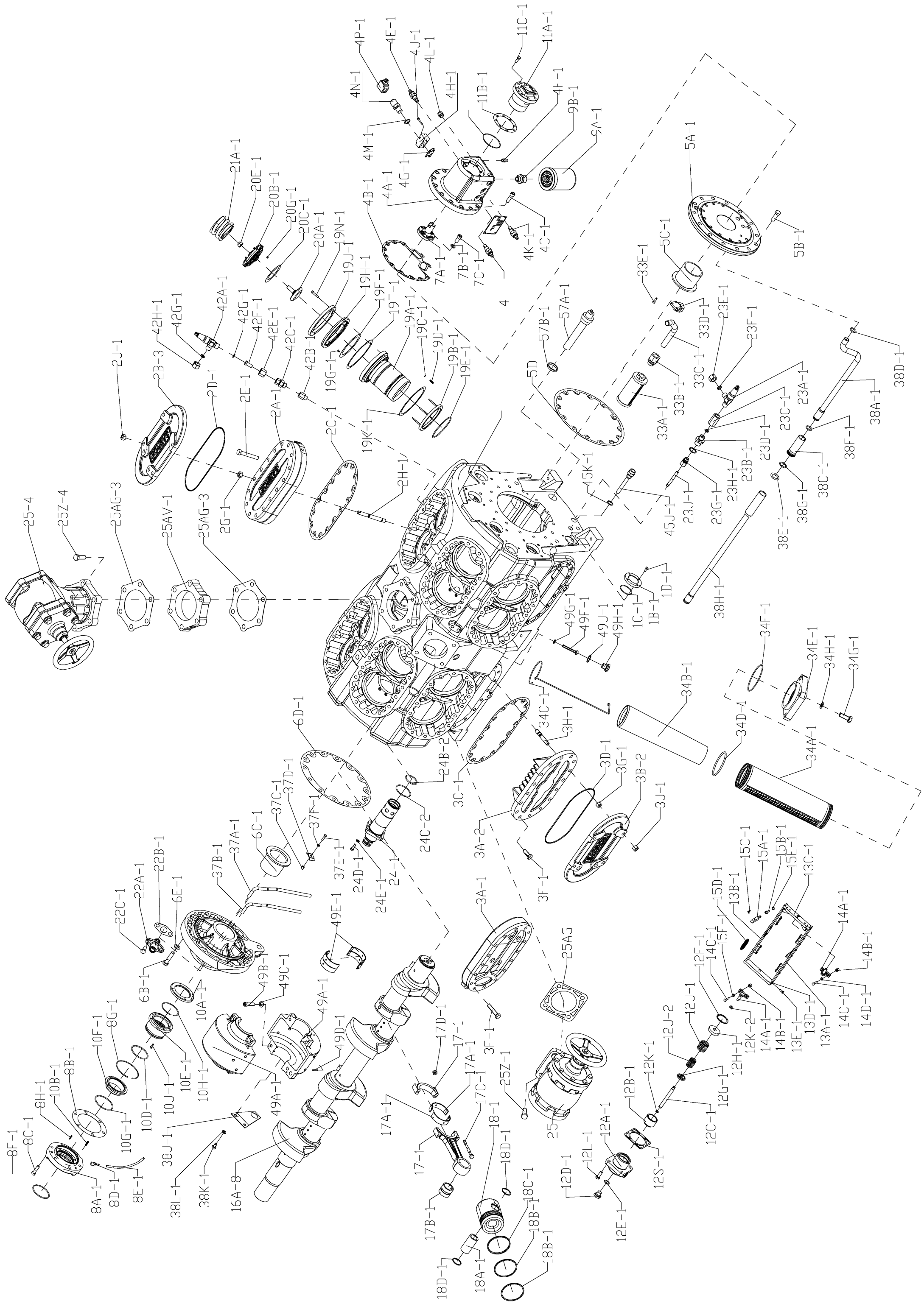
TSMC 108

Drawing no. 0662-030



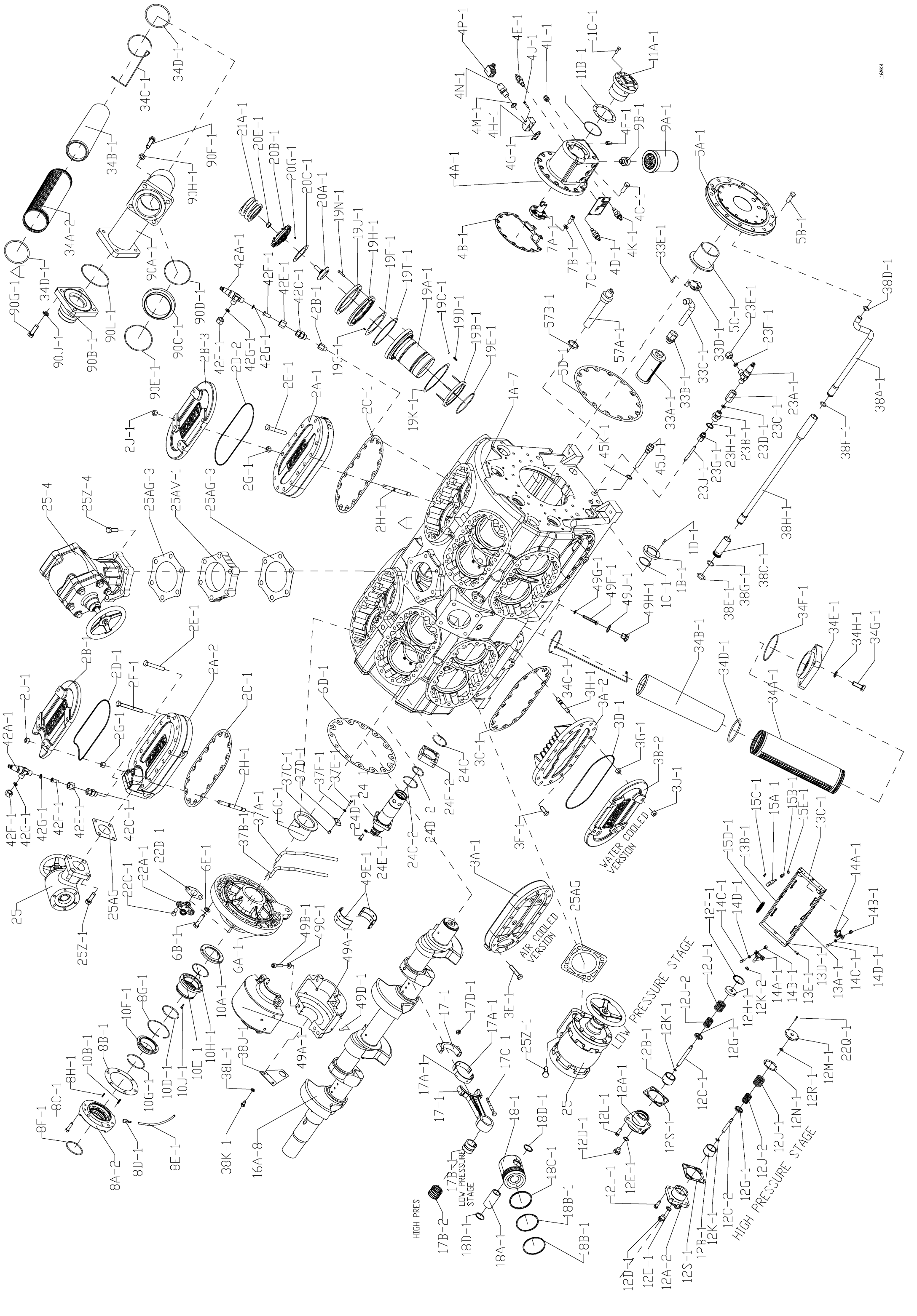
SMC 112-116

Drawing no. 0662-040



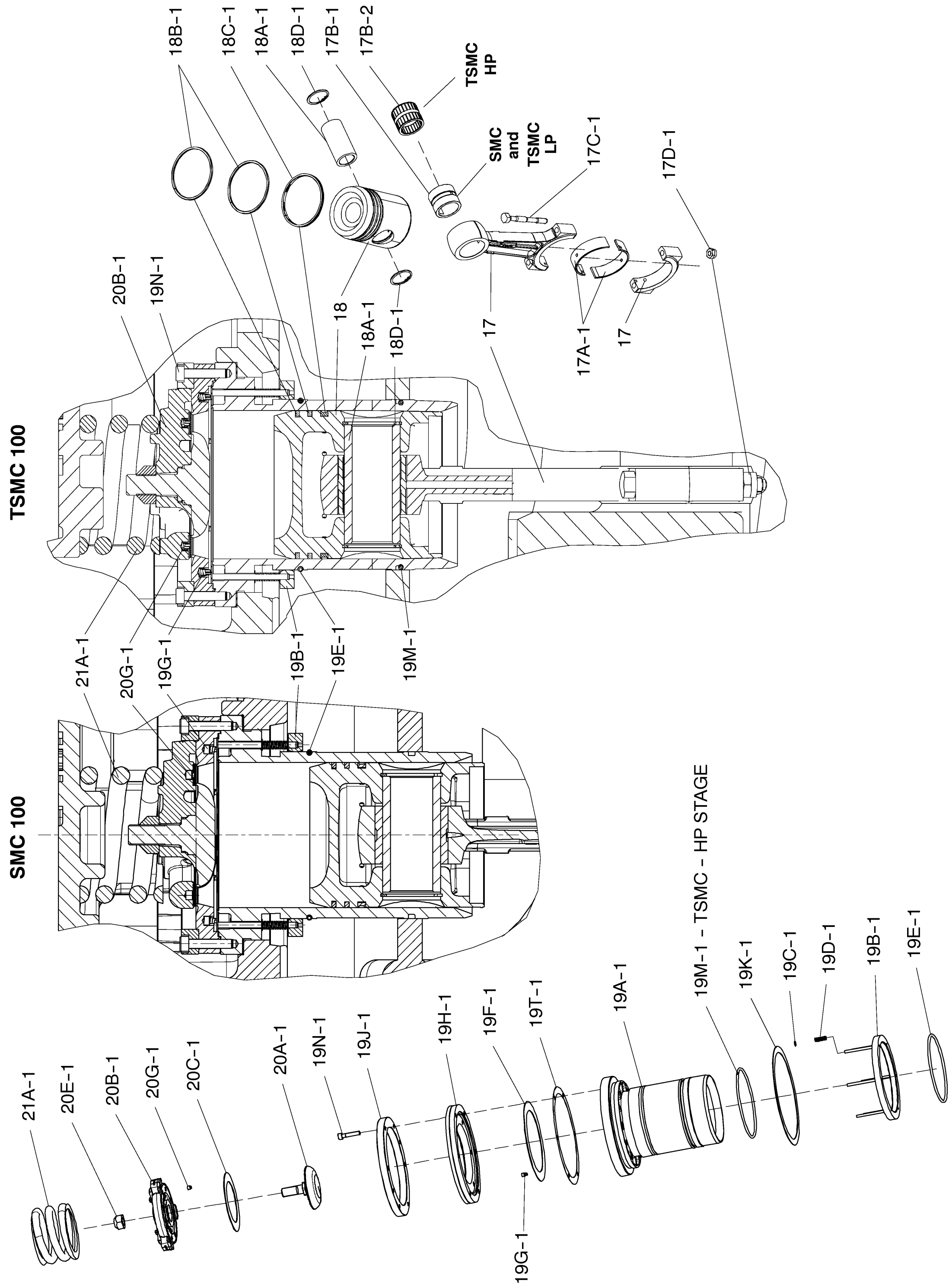
TSMC 116

Drawing no. 0662-050



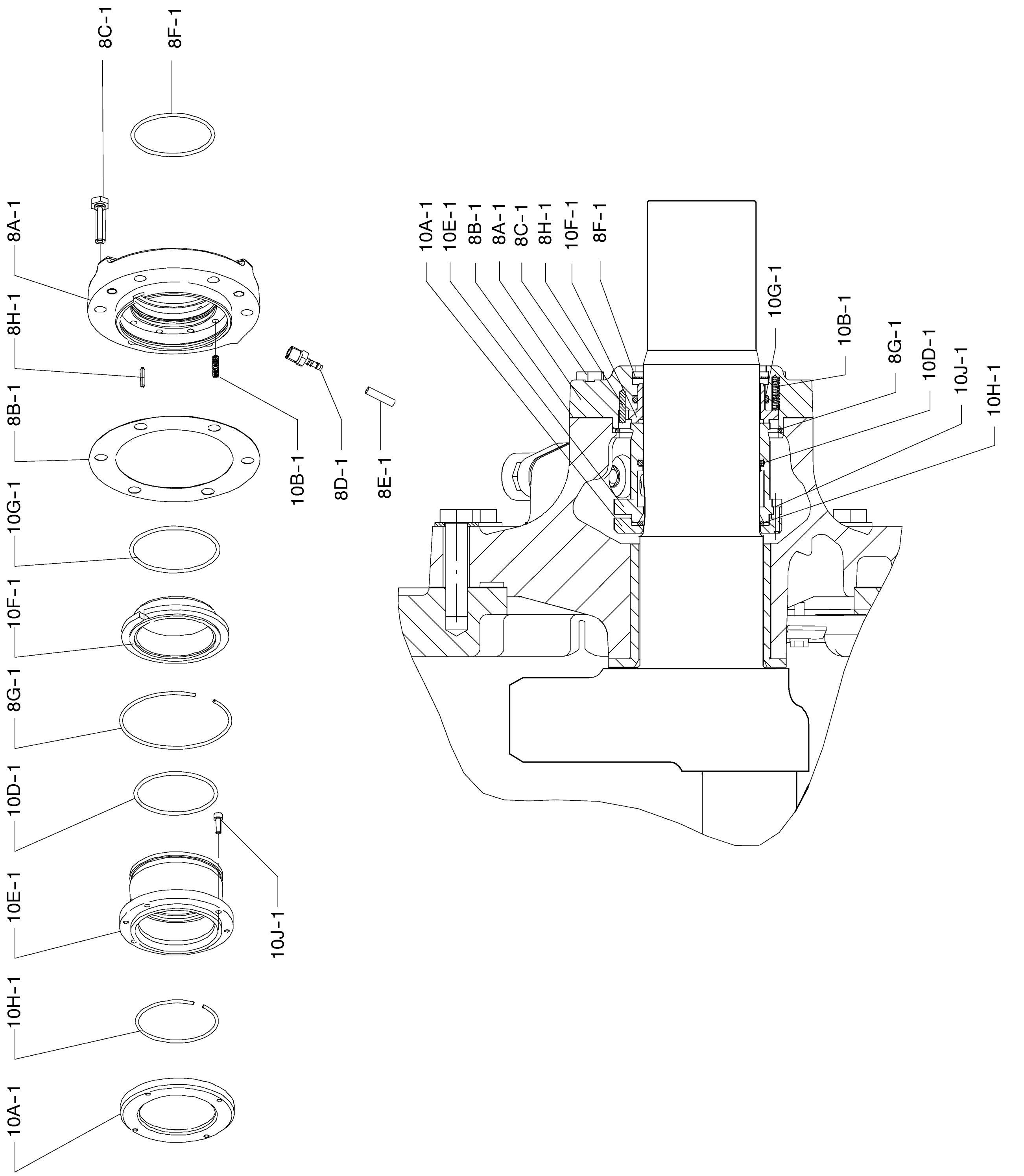
Piston, cylinder liner and connecting rod

Drawing no. 0662-060



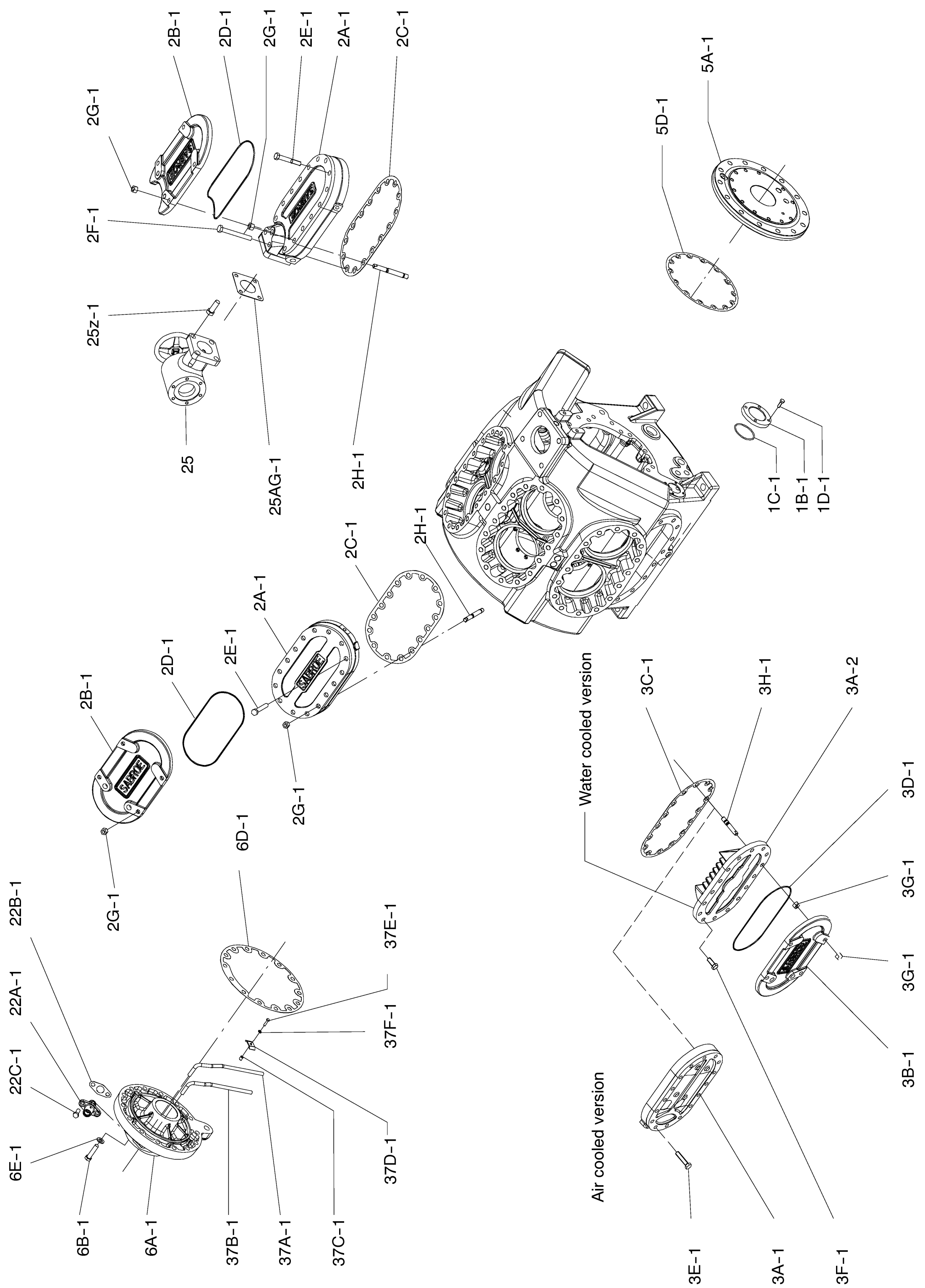
Shaft seal

Drawing no. 0662-060



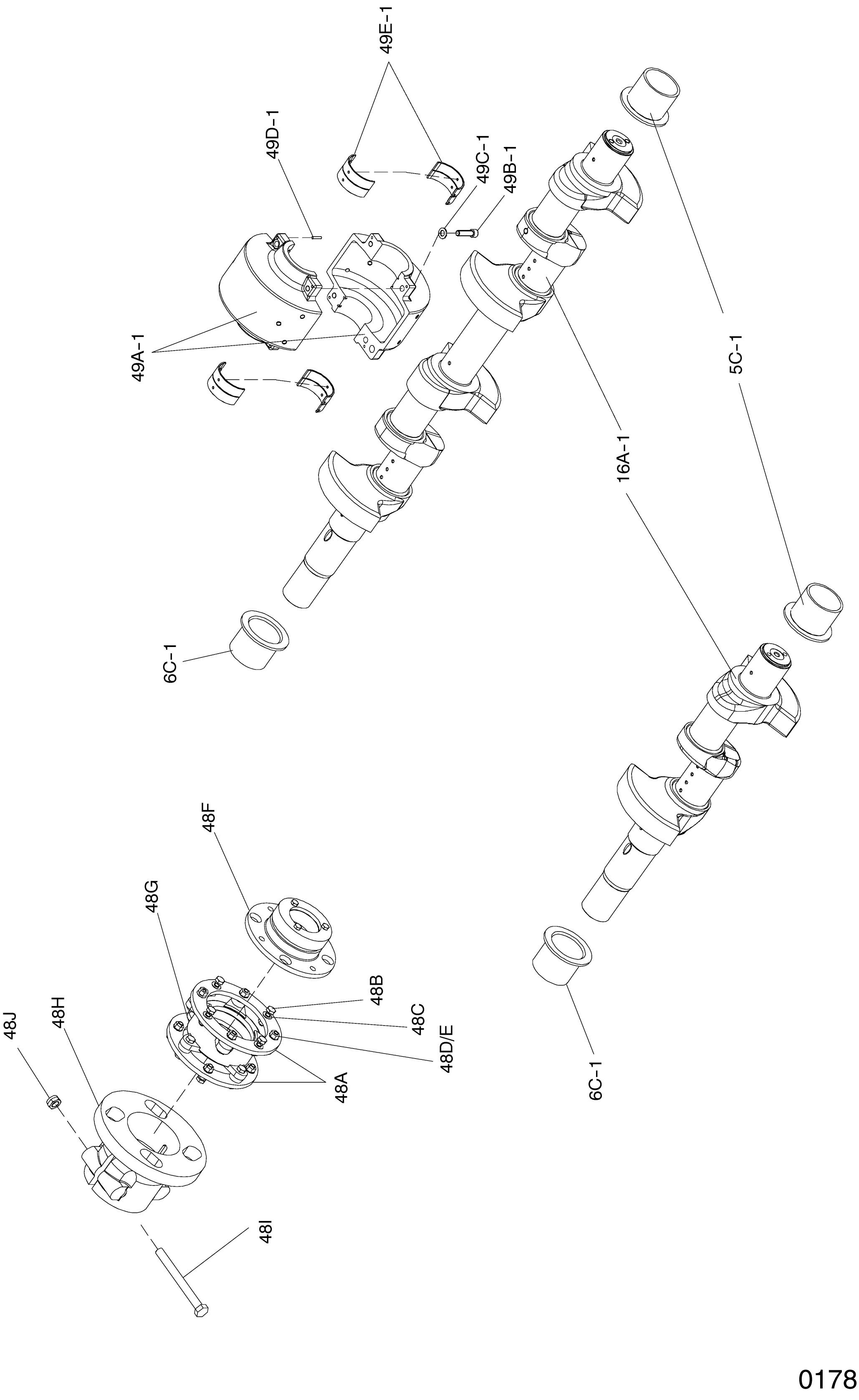
Covers

Drawing no. 0662-060



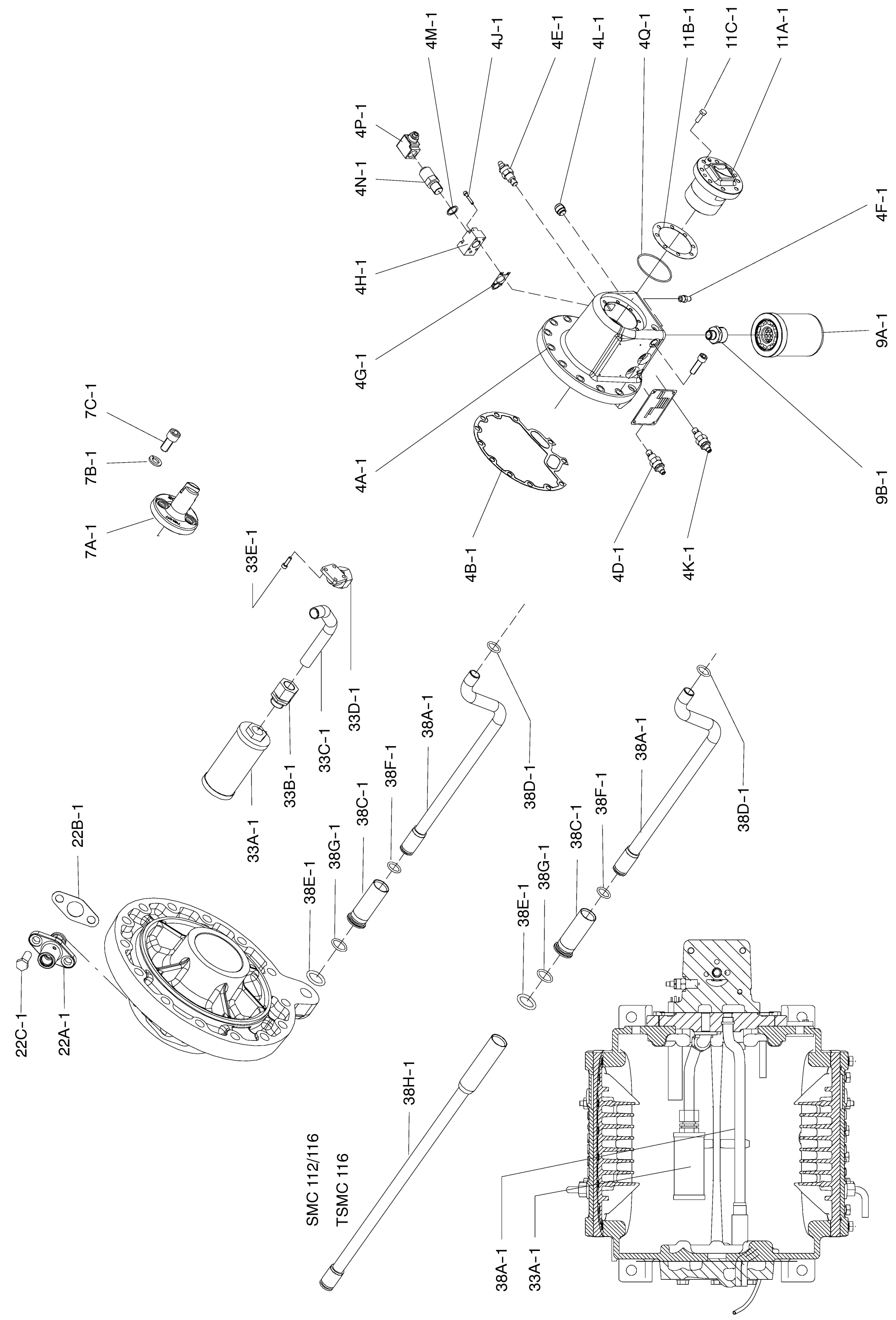
Crankshaft, bearings and coupling

Drawing no. 0662-060



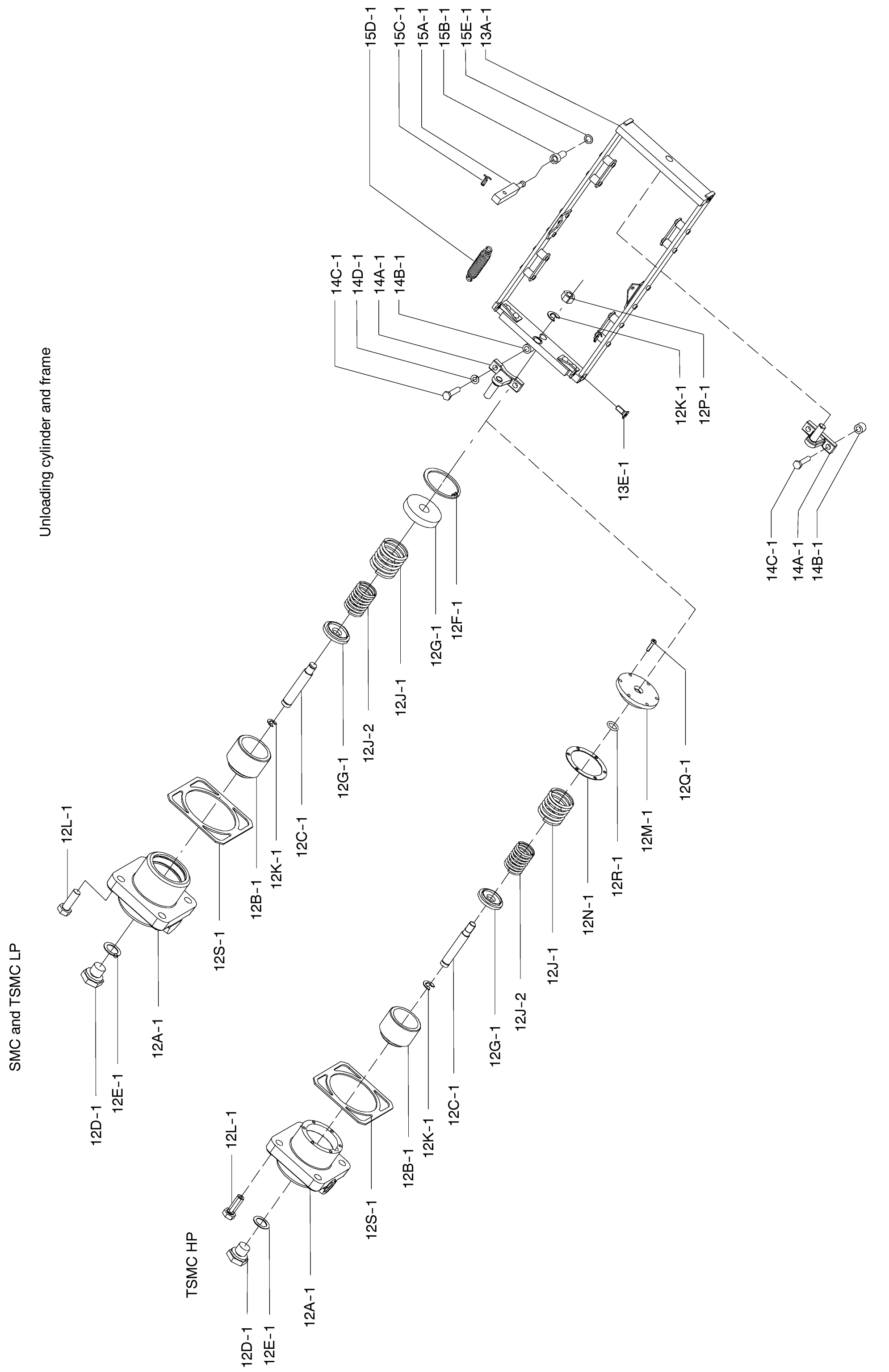
Oil system

Drawing no. 0662-060



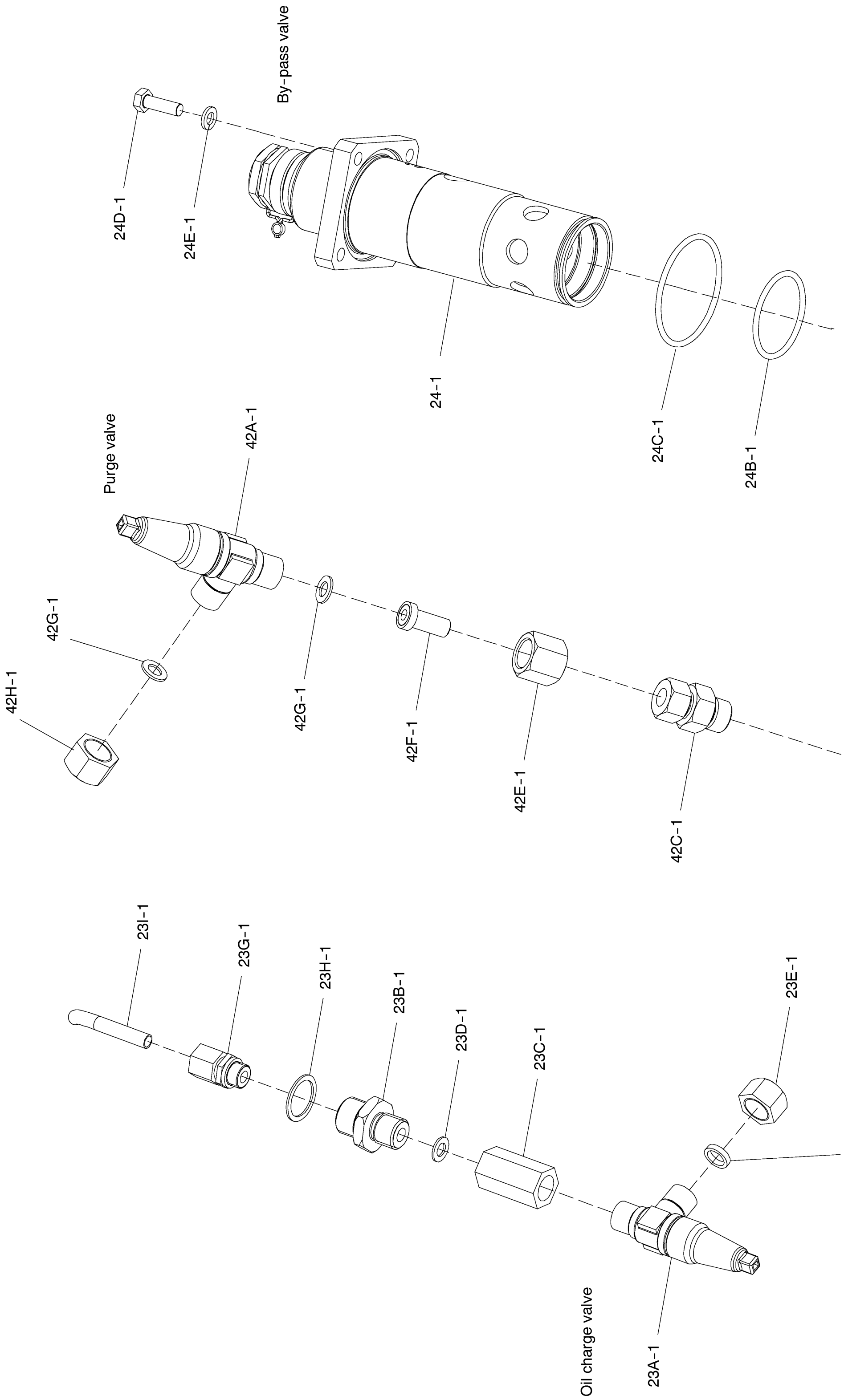
Unloading frame/cylinder

Drawing no. 0662-060



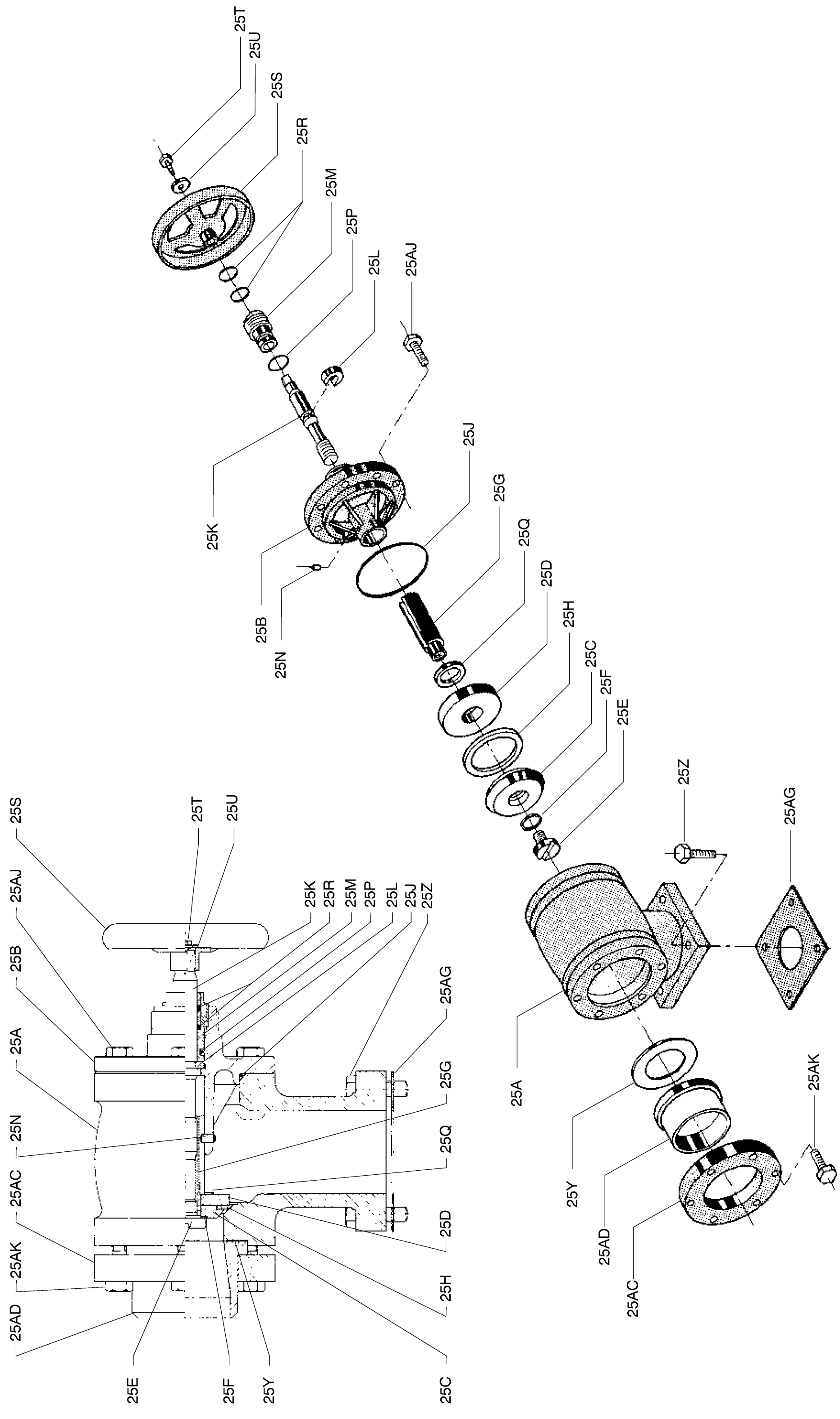
By-pass and service valves

Drawing no. 0662-060



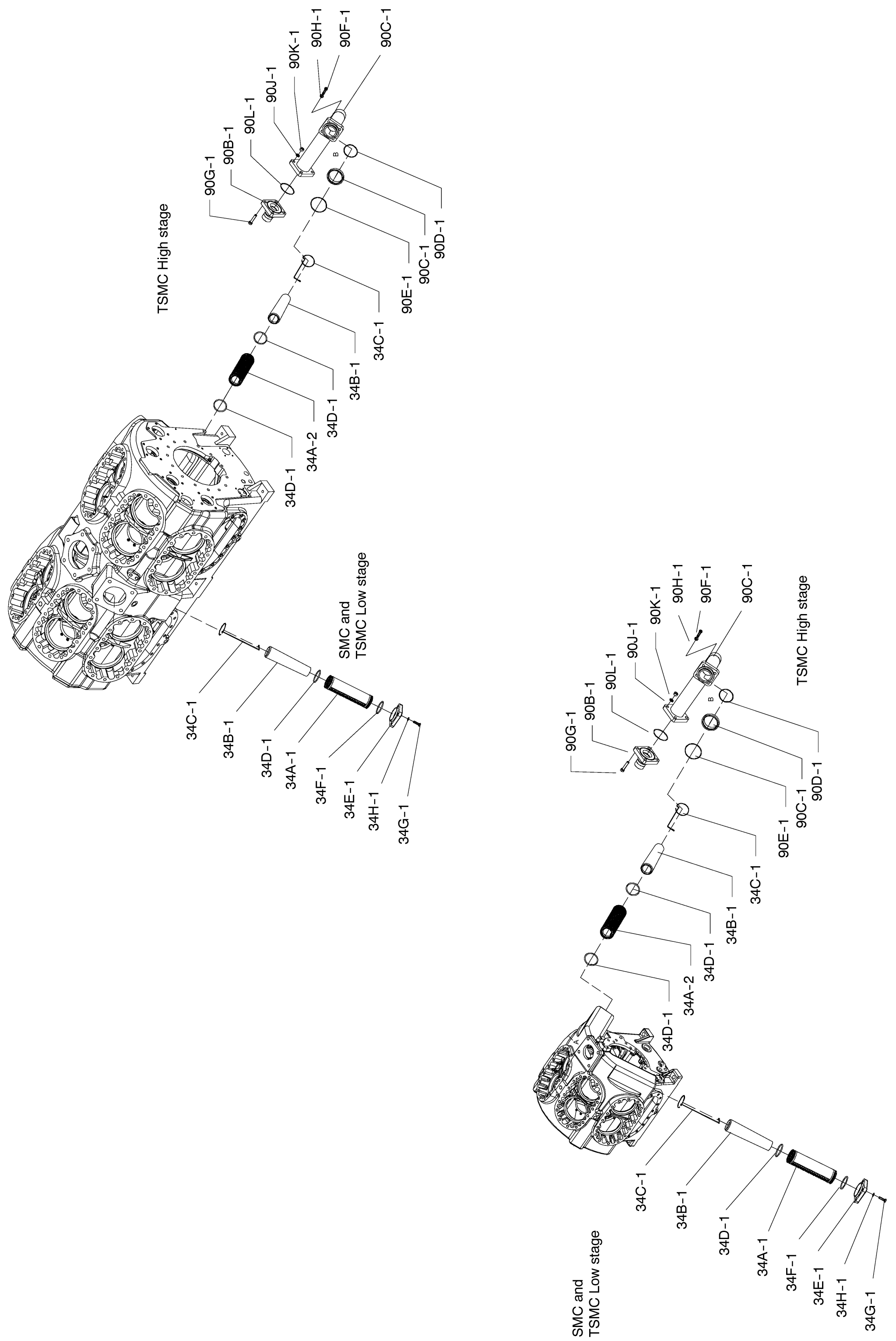
Stop valves

Drawing no. 0662-060



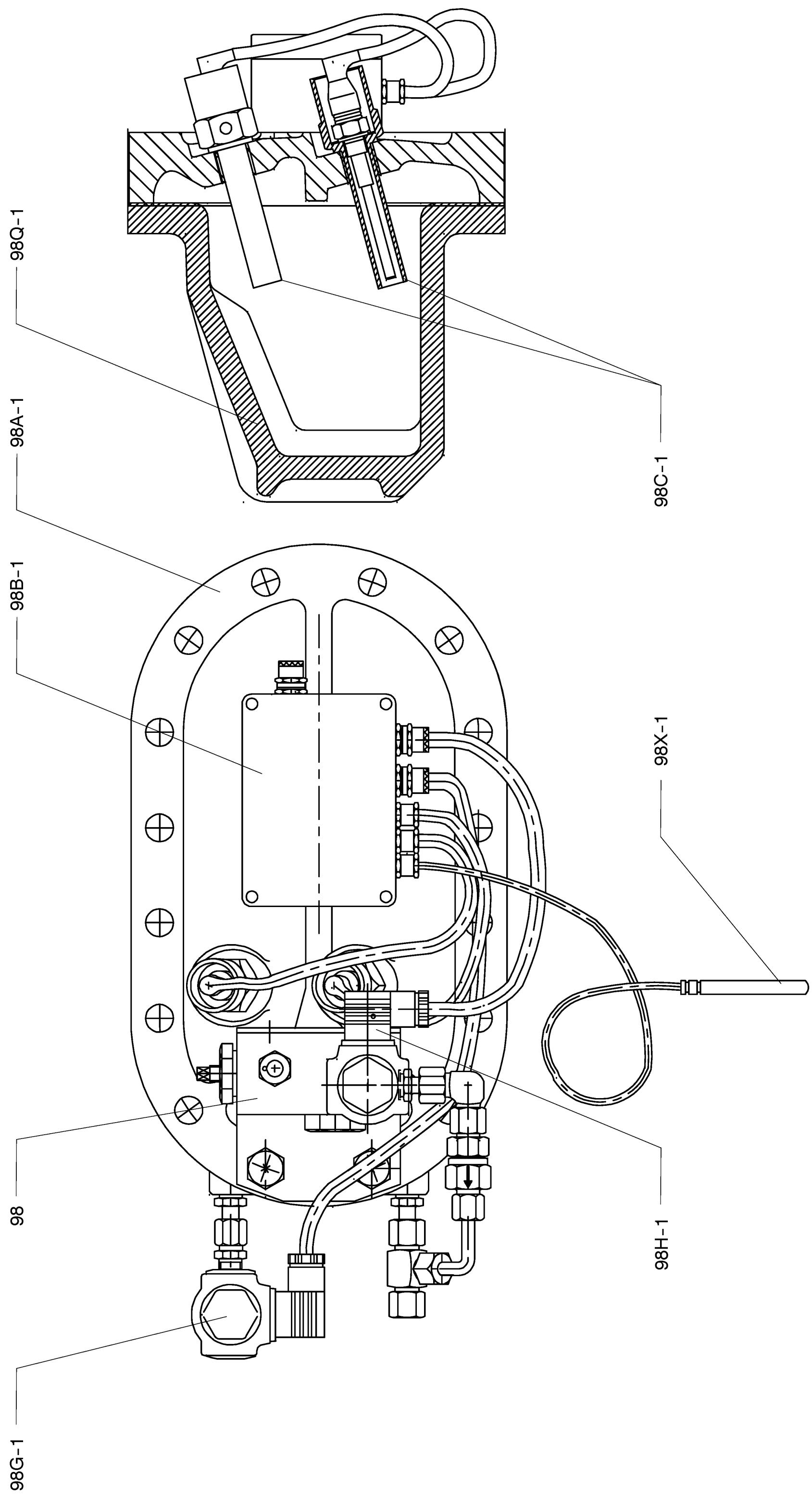
Suction filters

Drawing no. 0662-060



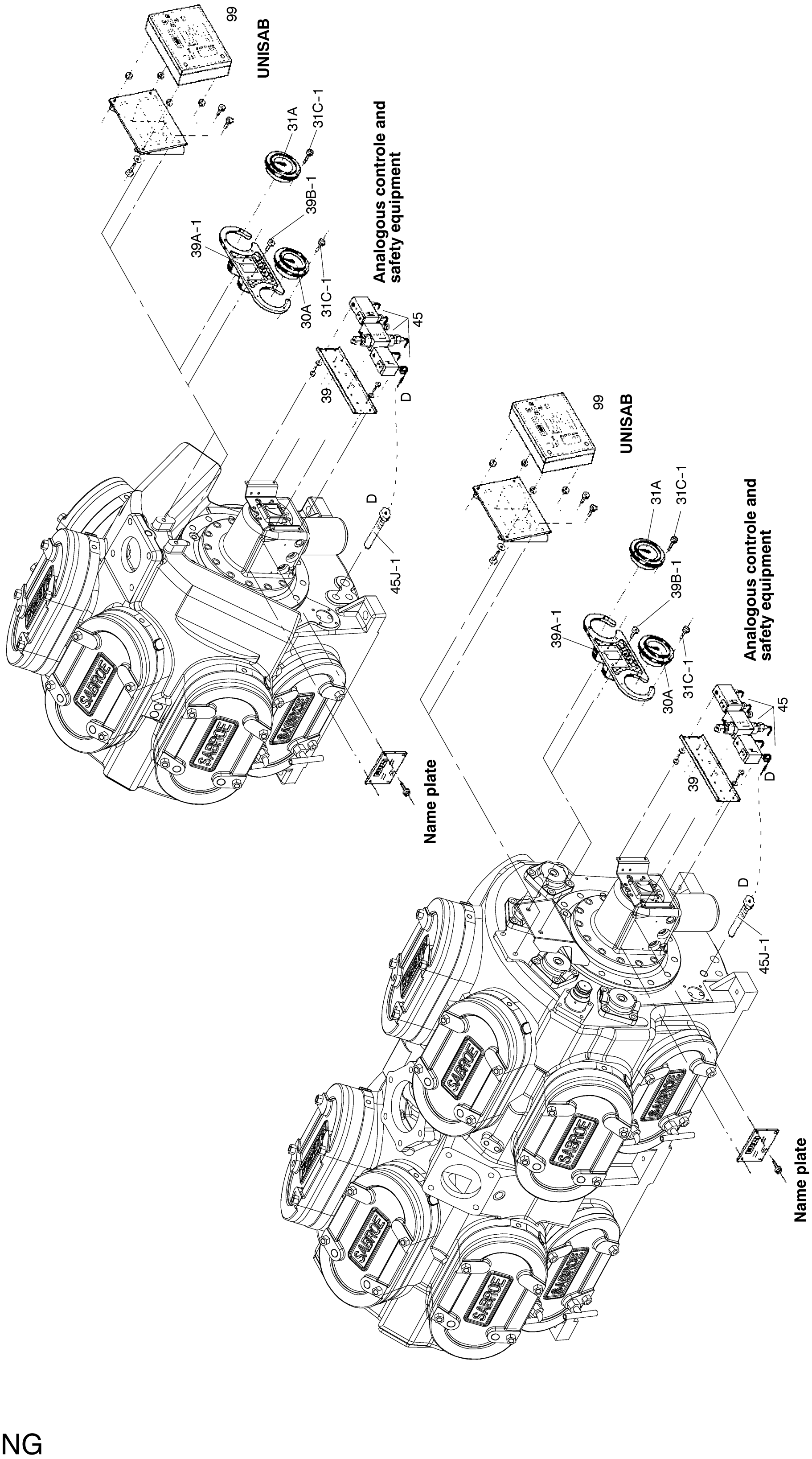
Thermo pump cover

Drawing no. 0662-060



Analogue control and safety equipment

Drawing no. 0662-060



20. Final Disposal

The purpose of this chapter is to describe how to safely dispose of this equipment or part of it.

This chapter is primarily intended for the de-commissioning engineers and authorities.

General

Safety Precautions

⚠ ***Danger!***

Before dismantling the plant, read chapter 3, Safety Precautions carefully. Failure to do so may result in personal injury or even death.

Dismantling of a cooling unit which is to be scrapped must be carried out in a safe way.

Authorized refrigeration personnel must participate in the first part of the dismantling process as fundamental knowledge of refrigerating systems and the risks involved is required.

Before dismantling the plant, refrigerant and oil must be drained into containers intended for the purpose. Disconnect all electrical connections to the unit. Remove fuses in the main switchboard.

During the dismantling process, the individual machine parts and components must be sorted so that disposal can take place in an efficient way.

⚠ ***Danger!***

Take great care if using cutting tools, e.g. angle grinder or flame cutter, during the dismantling process as pipes or the like will contain oil residue which may ignite. Refrigerant residue does also involve a great risk as HFC and HCFC refrigerants will develop toxic gasses when heated. Make sure that there are no air traps as heating will result in a pressure rise.

Disposal of Machine Parts

When dismantling the plant, it is important to sort the parts to be disposed of. Compressor, frame, containers, etc. belonging to the category of iron and metal scrap must be delivered to an approved scrap dealer complying with the prevailing rules and regulations of the individual country.

Disposal of Oil and Refrigerant

Oil and refrigerant must be delivered for destruction or regeneration at a receiving station for hazardous waste, including used oil filters. The receiving station must comply with the prevailing rules and regulations of the individual country.

Disposal of Electrical Components

Electrical and electronic products, e.g. wiring, panels, hardware, etc., must be delivered to a receiving station approved to handle electronic waste. The receiving station must comply with the prevailing rules and regulations of the individual country.

Disposal of Batteries

Used batteries from e.g. the backup of the computer control must be delivered for destruction at a receiving station. The receiving station must comply with the prevailing rules and regulations of the individual country.

21. Appendices

The purpose of this chapter is:

- to collect all relevant data and tables regarding torques, coupling data etc.
- to collect all relevant instructions of products supplied by sub-suppliers and used in the Sabroe product in question.

References to Instructions

The instructions from the sub-suppliers must as far as possible be copied from the original instructions, firstly, to avoid any errors and secondly, to avoid losing the right to claim damages.

Appendix

This chapter includes data sheets and instructions concerning the components and the tables of torques.

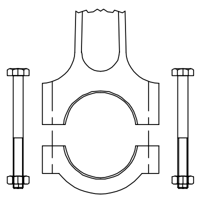
1. List of torques
2. Coupling data
3. Sundry Clearences and Check Dimensions
4. Instructions from sub-suppliers, valves, sensors, automatic etc.

Torque Moments for Screws and Bolts

Bolts for top, side and end covers

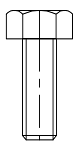
Compressor Location	T/CMO		HPO		T/SMC 100	HPC	T/SMC 180
	Top/side covers	End covers	Top/side covers	End covers	Top/side and end covers		
M	M12	M14	M12	M14	M14	M14	M20
Kpm	8.6	13.7	13.2	20.3	13.7	20.3	42.7
ft. lbf.	63	100	95	147	100	147	310
Nm	85	135	130	200	135	200	420

Connecting rods

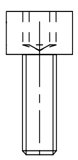


	HPO/CMO	HPC/SMC 100	SMC 180
UNF	5/16”	3/8”	5/8”
Kpm	2.1	4.4	17
ft.lbf.	15	32	130
Nm	20	43	167

General torque moments
(for bolts not specified in any table)



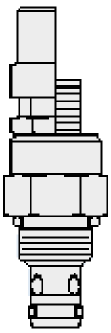
Metric thread (ISO 8.8)													
M	4	5	6	8	10	12	14	16	18	20	22	24	27
Kpm	0.28	0.53	0.94	2.2	4.1	7.0	11	15	23	30	38	52	68
ft.lbf.	2.1	3.9	6.8	16	30	50	80	110	170	220	270	370	490
Nm	2.7	5.2	9.2	22	40	69	108	147	225	295	375	510	670



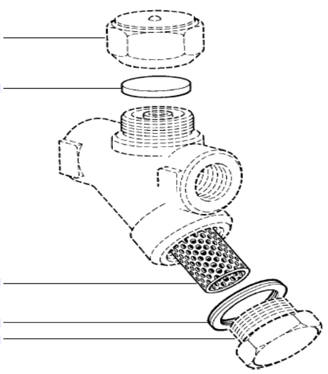
Metric thread (ISO 12.9)													
M	4	5	6	8	10	12	14	16	18	20	22	24	27
Kpm	0.42	0.78	1.4	3.2	6.1	10	16	23	34	44	55	76	100
ft.lbf.	3.0	5.7	10	23	44	75	120	160	240	320	400	550	720
Nm	4.1	7.6	14	31	60	98	157	225	335	430	540	745	980

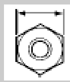
Fig. 21.1

Bolt on discharge valve			
	HPO/HPC	HPC/SMC 100	SMC 180
Kpm	3.2	7.1	35
ft. lbf.	23	52	255
Nm	32	70	344



Oil valves (pos 4K-1, 4D-1, 4E-1)	
	T/SMC/HPC 100
Kpm	2.5
ft. lbf.	18.4
Nm	25



Oil return valve - TLT			
			Recommended tightening torques
Item	 or mm		Nm
2	36		150
5	32	M28	170-190

Clamping element	
	T/SMC/HPC 100
Kpm	8.5
ft. lbf.	61.2
Nm	83

Coupling data

Fig. 21.2

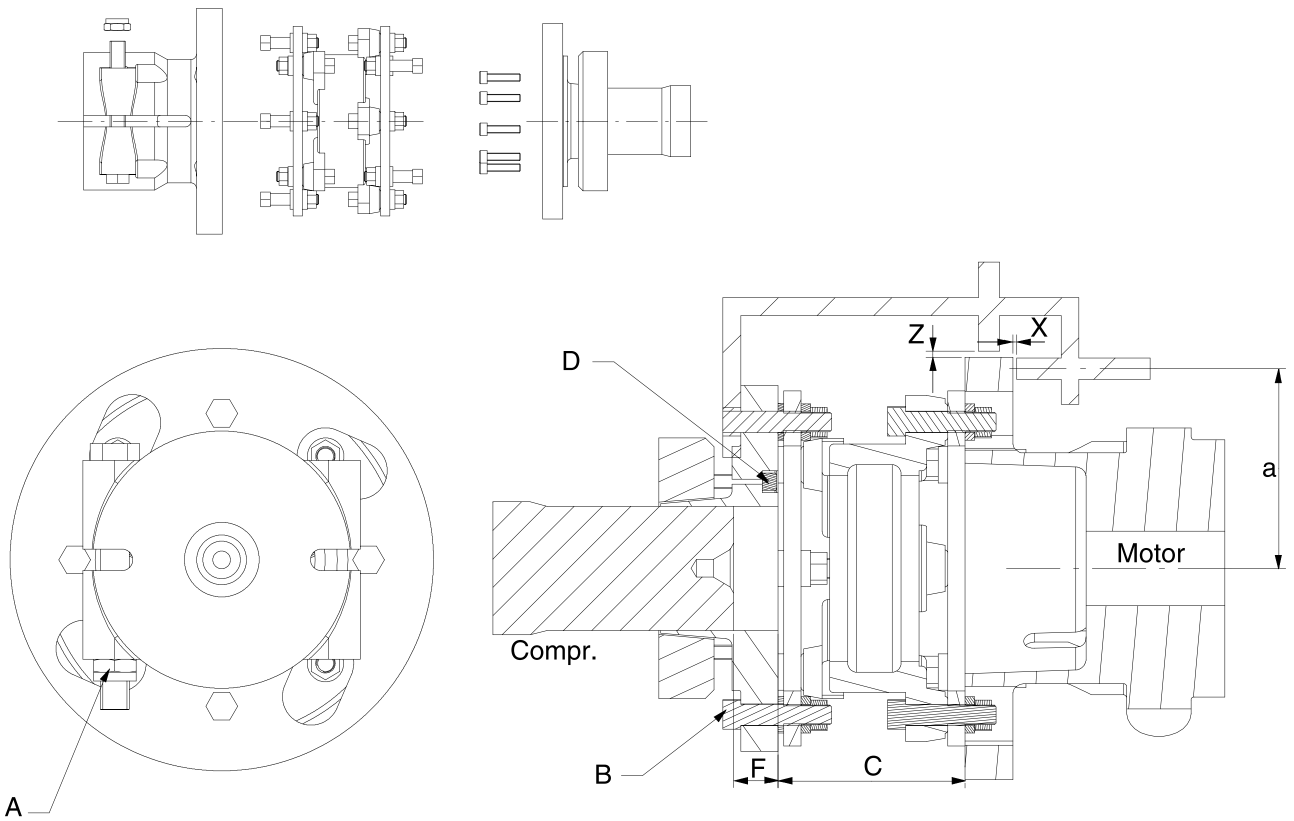


Table 21.1

Compressor	AMR type of coupling	Nominal Distance		Torque moment			Max. variation measured with a feeler gauge at a 180° turning of the coupling		
		C	F	A	B	D	Pos. 1		Pos. 2
		mm	mm	Nm	Nm	Nm	Horizon-tal max. mm	Vertical min./max. mm	max. mm
HPC/SMC 104-108	312 S	105	25	147	55	43	0,2	0,1/0,3	0,2
SMC 112-116	350 S	116	27	147	128	43	0,2	0,1/0,3	0,2

Sundry Clearances and Check Dimensions

Bearing clearance

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

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

Crankshaft end-play

	min.	0.30	0.30	0.40	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, 1.0, 1.3, 1.5, 1.75 and 2.0 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	1.50

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	-0.040 -0.059	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	-0.035 -0.050	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 valves can be supplied for all above journals.

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