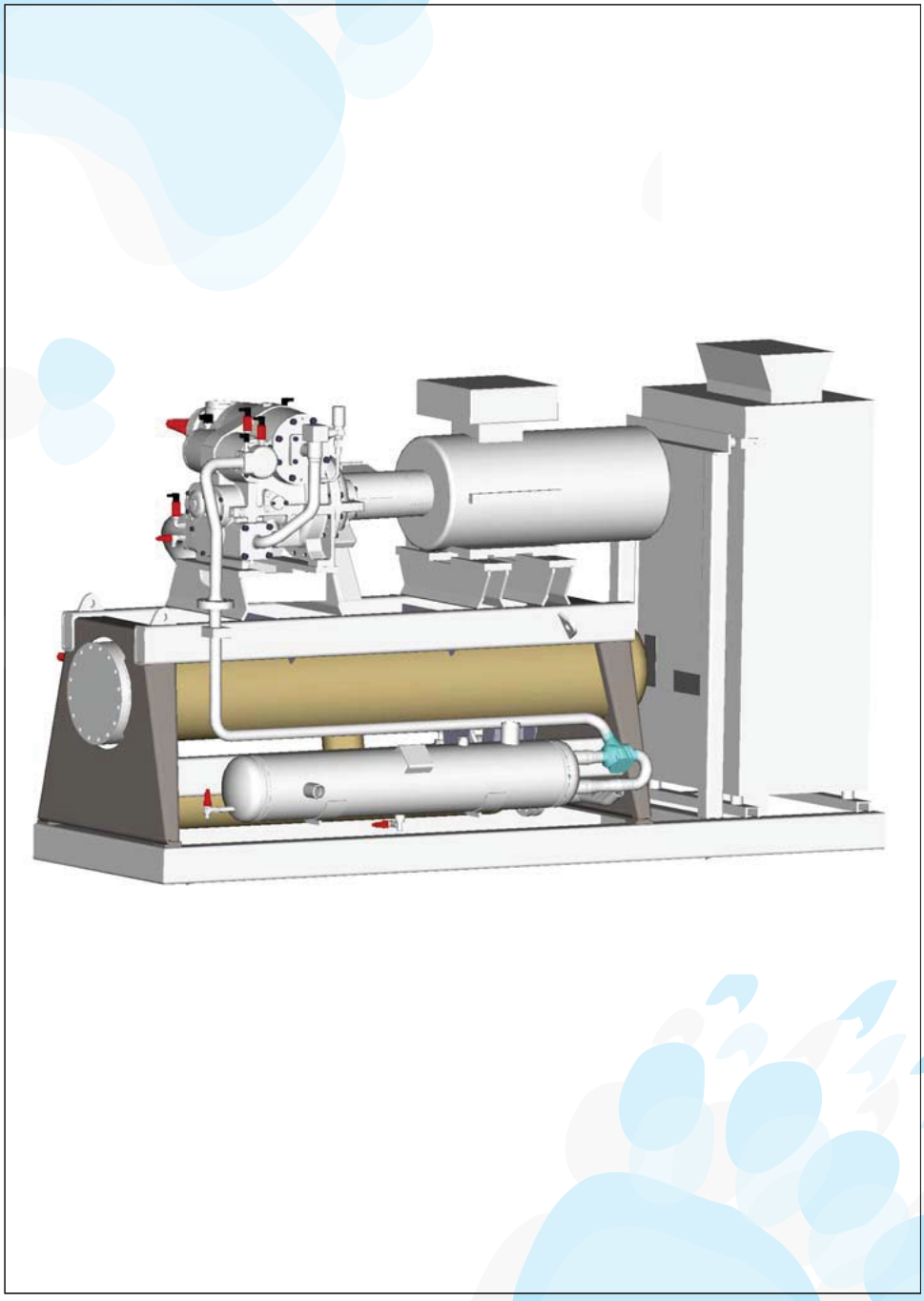
Johnson Controls

SAB 128R and SAB 163R Mk4

Screw compressor units



Service manual

en

SABROE
BY JOHNSON CONTROLS

Manual for
SAB 128R and SAB 163R Mk4

The screw compressor and unit can be fitted with different equipment, depending on their functions and requirements.

Some of these equipment is described in this instruction manual even though they are **not** fitted on your particular unit.

A cross (x) in the following table indicates which variants that are fitted on your unit – with the compressor no stated below.

Compressor	☐ SAB 128 ☐ SAB 163	
Type of drive	☐ (Male drive)	
Refrigerant	☐ R717 Other _____	
Compressor no		
Designation		
Instrumentation	UNISAB II and manual regulation of the V_i slide	
	UNISAB II and automatic regulation of the V_i slide	
Oil cooling	Water-cooled oil cooler OWRF/OWTF	
	Refrigerant-cooled oil cooler OOSI	
	Refrigerant injection into discharge pipe BLI	
Economizer system (ECO-system)	Vessel type HESS	
	Closed system and vessel type EOSE	
	Open system and vessel type SVER	
Ex-execution	Both compressor and unit are Ex safeguarded.	

04.02

Contents

This *Service Manual* contains the following Standard Documents:

Service Manual SAB 128R and SAB 163R Mk4
Contents

1. Introduction

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

- Dangers resulting from failure to comply with safety precautions when performing maintenance tasks.
- What standard service tasks there are for this equipment and how to safely carry them out.

This manual describes how to repair rotatune compressors. It also includes drawings indicating the location of the individual compressor parts.

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

It is essential that the service personnel familiarize themselves with the contents of this manual in order to ensure a proper and efficient operation. Sabroe Refrigeration is not liable for damage occurring during the warranty period where this is attributable to incorrect operation.

Sabroe Refrigeration's manual concept includes six standard manuals: Engineering, Operating, Spare Parts, Service, Installation and Commissioning and Transport.

This manual was produced by:

Sabroe Refrigeration
Chr. X's Vej 201
DK-8270 Hoejbjerg
Denmark

In the space below you may enter the name and address of your local Sabroe Representative

1. Introduction

2. Signs and Warnings

Table of Contents

Signs and Warnings

The purpose of this document 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 document is intended for all user categories.

This document 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 fitted with the warning signs belonging to the type of compressor/unit in accordance with the rules and regulations in force.

This document was produced by:

Sabroe Refrigeration
Chr. X's Vej 201
DK-8270 Hoejbjerg
Denmark

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 in the following drawings:

Fig. 2.1 Rotatune Screw compressor unit, location of name plates

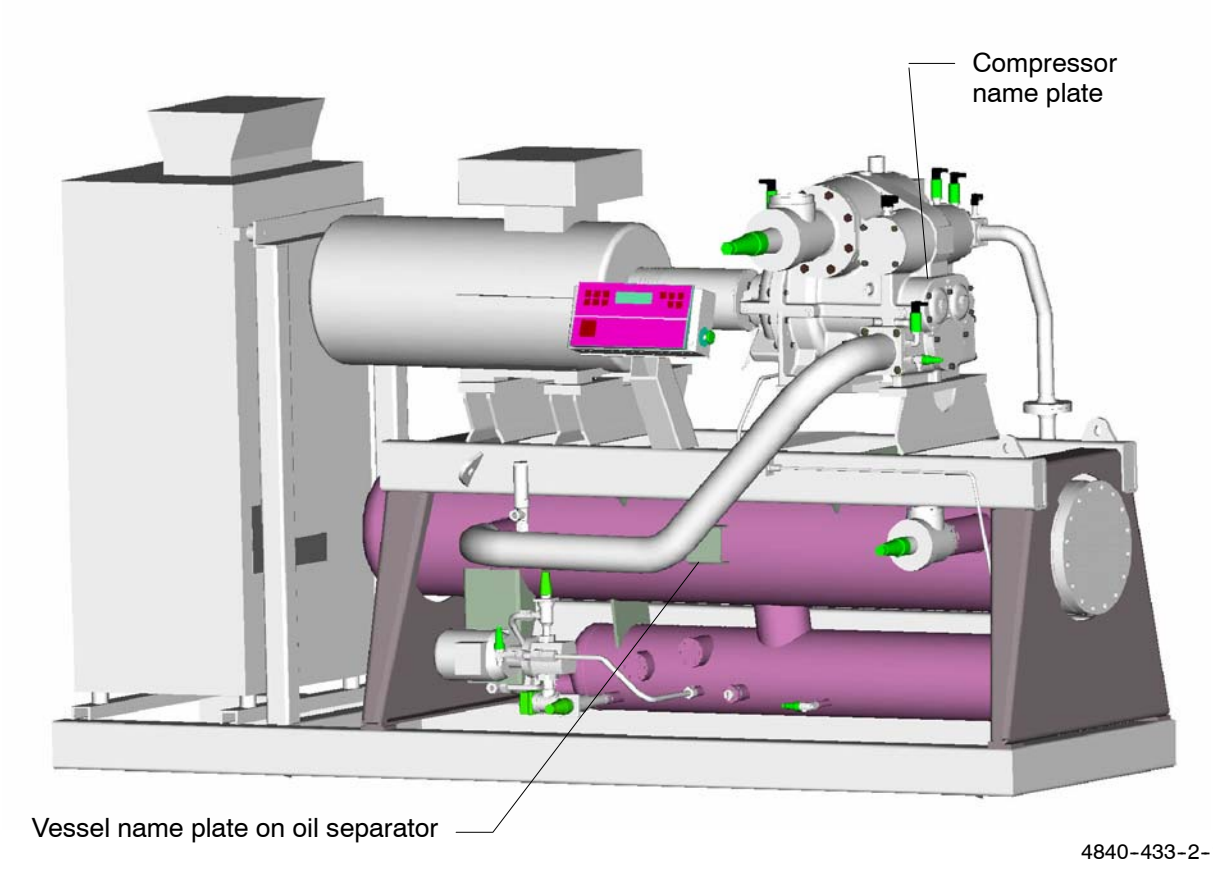


Fig. 2.2 Location of name plates, unit with OWSG oil cooler

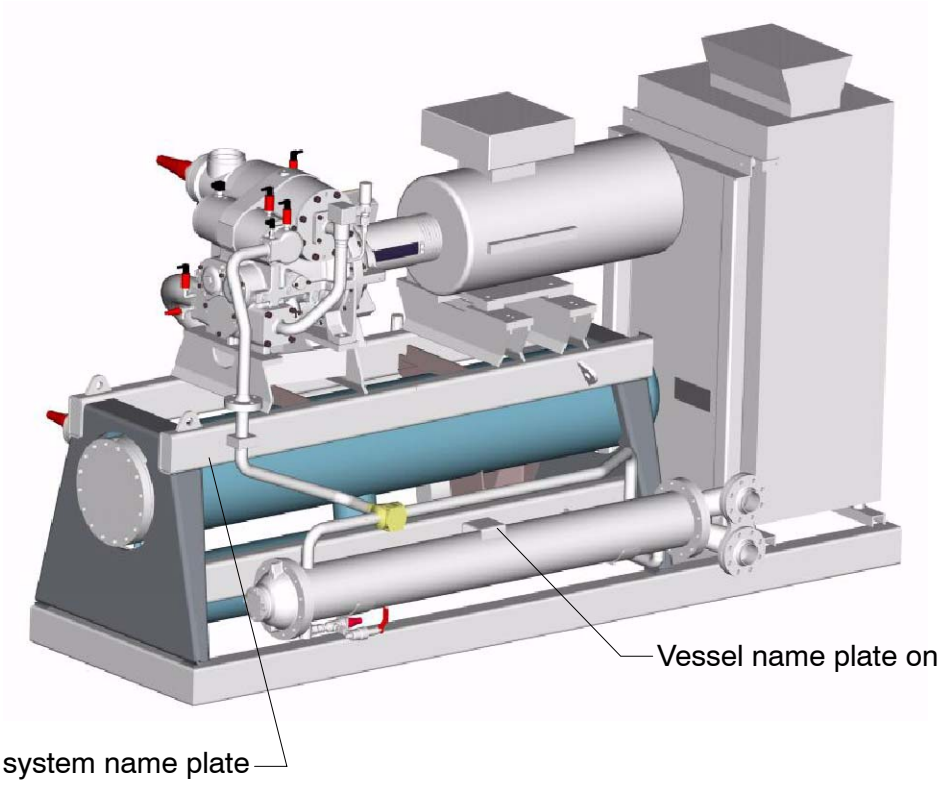
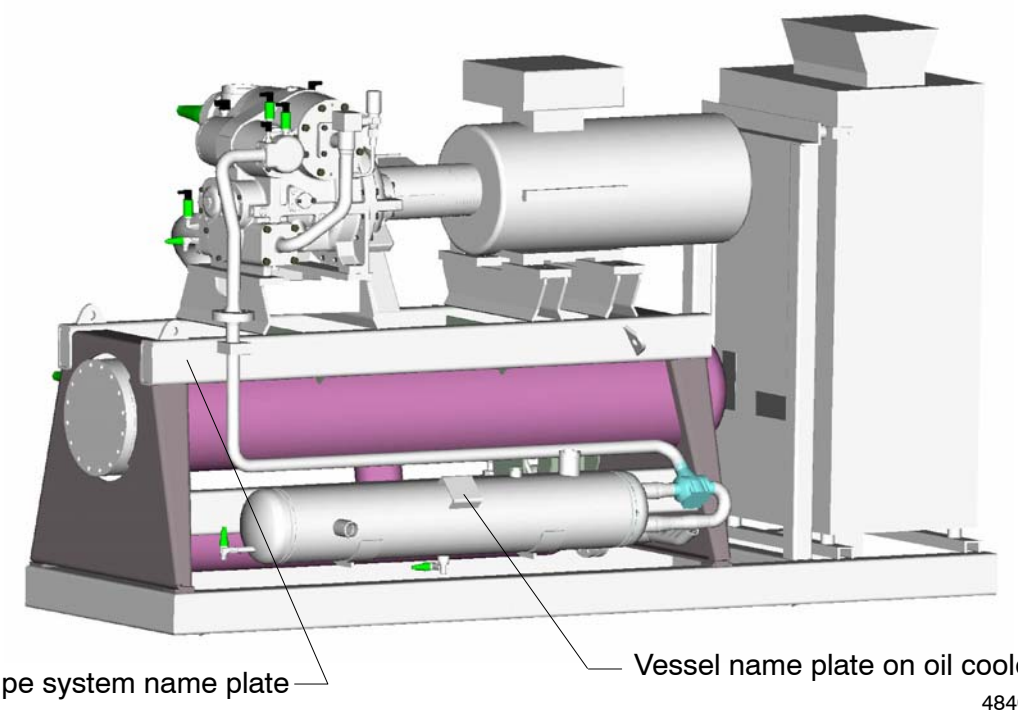
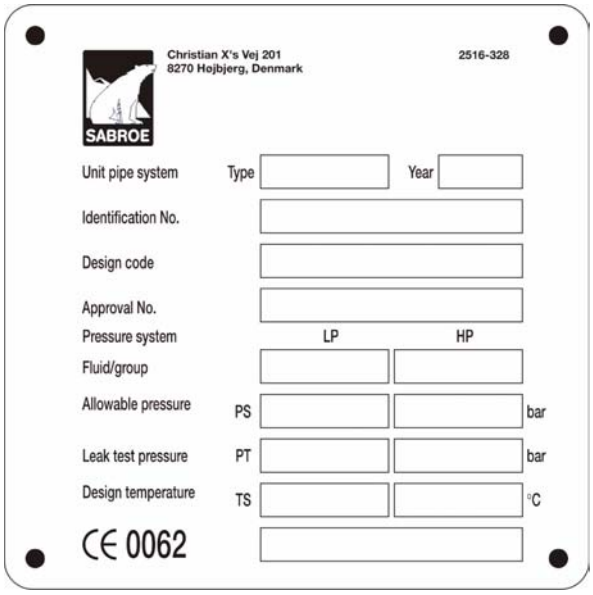


Fig. 2.3 Location of name plates, unit with OOSI oil cooler



Unit Pipe System Name Plate

Fig. 2.4 Unit Pipe System Name Plate

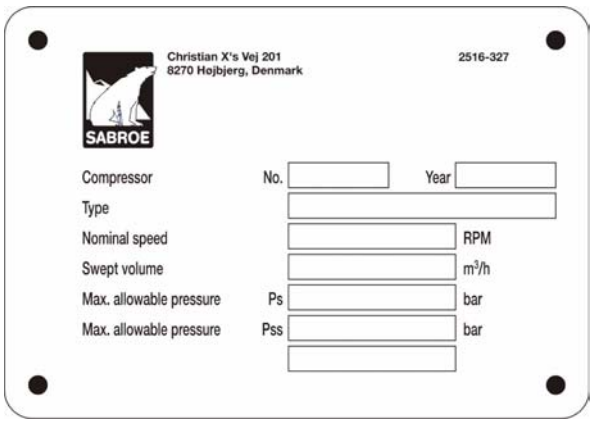


The unit pipe system name plate is positioned on the frame - see Fig. 2.2 . The name plate contains the following information:

- **Type**
  Manufacturer's type designation.
- **Year**
  Year of manufacture.
- **Identification no**
  Individual no for identification of supplied pipe system.
- **Design code**
  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**
  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 have been designed.
- **CE xxxx**
  The four digits compose the registration no of the notified body in charge of the assessment modules for the unit.

Compressor Name Plate

Fig. 2.5 Compressor Name Plate



The compressor name plate is positioned on the compressor - see Fig. 2.1. 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.
- **Allowable pressure**
  Shows max working pressure of compressor.
- **Test pressure**
  Shows pressure at which compressor enclosure has been strength tested.

Vessel Name Plate

Fig. 2.6 Vessel Name Plate

The vessel name plate is positioned on the shell of the vessel as indicated in Fig. 2.1, Fig. 2.2 and Fig. 2.3. The name plate contains the following information:

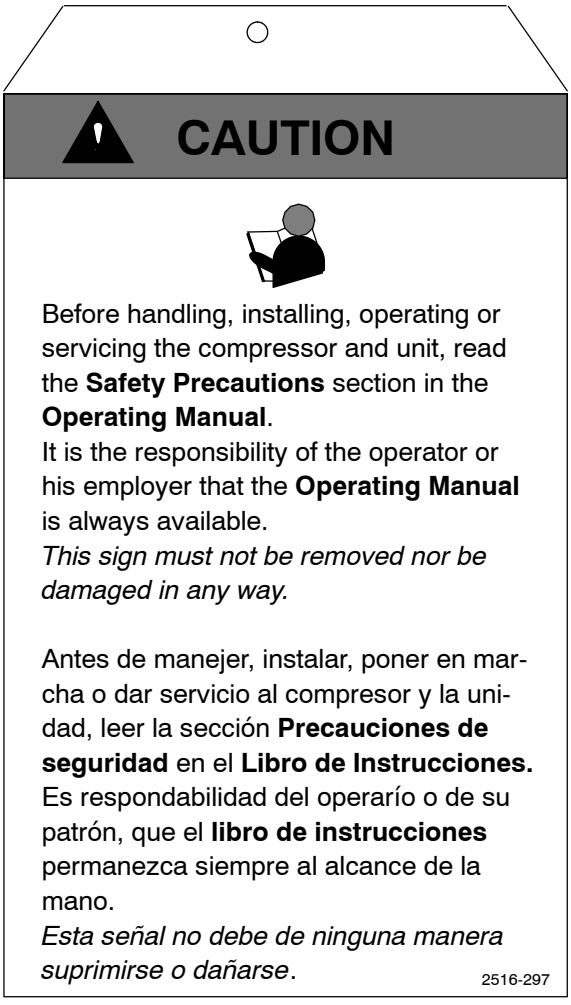
- **Vessel no**
  Vessel number stated by Sabroe Refrigeration.
- **Year**
  Year of manufacture.
- **Type**
  Manufacturer's type designation.
- **Design code**
  Shows the design code according to which the vessel was manufactured.
- **Approval no/CAT**
  Shows the approval no of the vessel issued 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".
- **Media**
  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. However, the number of signs 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* section in the manual before handling, operating or servicing the compressor and unit.



The Sign: High Voltage

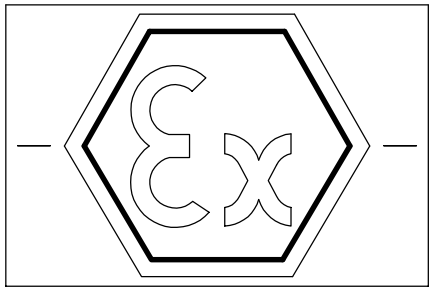
DANGER:
HIGH VOLTAGE

Before working on any electrical circuits, turn the machine Main Disconnect Device “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: Explosion-Proof Electrical Execution

If the compressor is delivered in an explosion-proof electrical execution, it will together with the Sabroe Refrigeration name plate be fitted with an Ex-name plate like the one illustrated below**.**



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The Label: Temperature of Tangible Surfaces

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

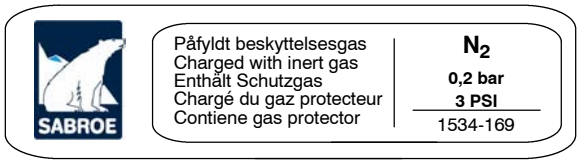
Consequently, the compressors are fitted with yellow warning labels signalling that pipes, vessels and machine parts will become so hot during operation that your skin will get burnt if you touch them for one second or more.

The Label: 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 label like the one shown below is affixed to a visible spot on the compressor.



Other Warning Labels

Hazardous substance!

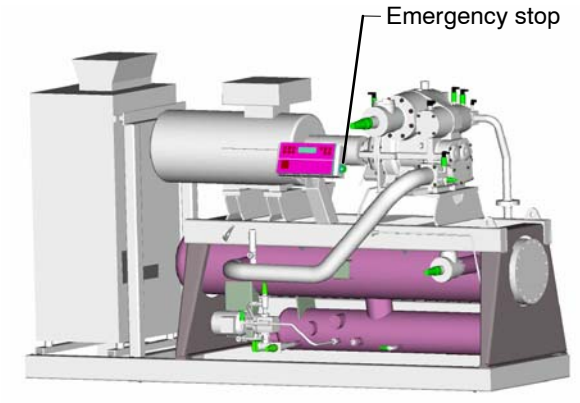
Dangerous noise level, use hearing protectors!

Internal overpressure!

Cold surfaces!

Emergency Stop

Fig. 2.7 Emergency stop on screw compressor unit



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Safety at Servicing

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

- Read the section Safety Precautions in this manual 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 starting the dismantling/servicing process.
- Make sure that there is neither overpressure nor any refrigerant in the part to be dismantled. Close all necessary stop valves.
- Use gloves and protective goggles and make sure to have a gas mask ready.
- Use the prescribed tools and check that they are properly maintained and in good working condition. In explosion-proof areas, use tools specially suited for this specific purpose.

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, the principle is the same at all three levels.

Note:

Sometimes information is presented in a Note. A Note is used to emphasize information. It is never used for information which is of vital importance to the safety of personnel and equipment.

Texts Marked with “Danger!”

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

Danger !

Risk of electric 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 which is of importance to the safety of the personnel involved or of major importance to the safety of the 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 which is of vital importance to the safety of the personnel involved 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 the equipment.

3. Safety Precautions

Table of Contents

Safety Precautions

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

The safety precautions are intended for all user categories.

This document was produced by:

Sabroe Refrigeration
Chr. X's Vej 201
DK-8270 Hoejbjerg
Denmark

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.

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 and regulations.

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 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. Safety shoes with slip-proof soles can help 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 you are able to escape should a dangerous situation 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.

Lifting and Carrying Safety

Contact Sabroe Refrigeration in case of questions or if in doubt 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 eg 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 instruction 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 may indicate problems requiring 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 replacement 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 dis-

connect 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 switch, 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 when maintenance work is being performed.

When removing electrical equipment, number or place labelled tags on the wires which are 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 must be taken as described in the following sections:

- First aid for accidents with ammonia
- First aid for accidents with HFC/HCFC.
- 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. This means that no person will remain voluntarily in concentrations which are hazardous. Since ammonia is lighter than air, adequate ventilation is the best means of preventing an accumulation.

Experience has shown that ammonia is extremely hard to ignite and under normal conditions 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

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

Inhalation

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

Eye injuries from liquid splashes or concentrated vapour

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

Skin burns from liquid splashes or concentrated vapour

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

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First Aid for Accidents with HFC/HCFC

Refrigerant no.: R134a - R505A - R507 - R22, etc.

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

Basic Rules for First Aid

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

Inhalation

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

Eye Injuries

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

Skin Injuries - Freeze Burns

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

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.

Be especially careful with 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 are 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, which have a very pungent odour, thus warning the personnel of their presence.

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

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

Usually the strong smell of ammonia will warn the personnel before the concentrations become dangerous.

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

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

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Furthermore, it can be said about refrigerants:

HFC/HCFC

- If released to the atmosphere, halogenated refrigerants of the type HFC/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 HFC/HCFC are greenhouse gases which contribute to an intensification of the greenhouse effect. They must, therefore, **never** be released to the atmosphere. Use a separate compressor to draw the refrigerant into the plant condenser/receiver or into separate refrigerant cylinders.
- Most halogenated refrigerants are miscible with oil. Oil drained from a refrigeration plant will often contain significant amounts of refrigerant. Therefore, reduce the pressure in the vessel or compressor as much as possible before draining the oil.

Ammonia

- Ammonia is easily absorbed by water: At 15°C 1 litre of water can absorb approx. 0.5 kg liquid ammonia (or approx. 700 litres ammonia vapour).
- Even small amounts of ammonia in water (2-5 mg per litre) are enough to wreak havoc with marine life if allowed to pollute waterways and lakes.
- As ammonia is alkaline, it will damage plant life if released to the atmosphere in large quantities.

CO_2

- CO_2 is a gas which can be discharged into the open without causing any harm to the environment. It must be ensured, however, that the eyes and skin of people working in the proximity of the plant are not exposed to the discharged CO_2 as it can be extremely cold.
- CO_2 is a harmless gas, but in closed rooms it can displace the oxygen and thus cause suffocation.
- CO_2 is odourless.

Refrigerant evacuated from a refrigerant 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 to the atmosphere.
- 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 using a leak detector.

Cooling Media

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

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

In general, all brines must be considered as being 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, avoid that your skin comes into direct contact with the oil. Direct contact with oils may in the long run develop allergy attacks. Use therefore always 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 conditions.

- Mineral oil
- Semi-synthetic oil
- Alkyl benzene-based synthetic oil
- Polyalphaolefine-based synthetic oil
- Glycol-based synthetic oil.
- Ester oil

When changing the oil in the compressor or draining oil from the vessels of the refrigeration plant, always collect the used oil in containers marked “waste oil” and send them to an approved incineration plant.

NOTE

This instruction only provides 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

Table of Contents

Technical Description

The purpose of this document is to describe the intended purpose, the physical characteristics and the functions of the screw compressor units.

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

This document was produced by:

Sabroe Refrigeration
Chr. X's Vej 201
DK-8270 Hoejbjerg
Denmark

Areas of Application of Screw Compressor Unit

Application

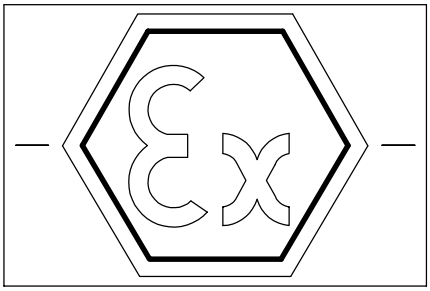
To prevent unintentional application of the compressor, which could injure the personnel or damage the equipment, the following must be observed:

- The compressor must only be used as a refrigeration compressor with the number of revolutions per minute specified by Sabroe Refrigeration and the operating limits stated in this manual or in a written agreement with Sabroe Refrigeration.

- The compressor must only be used with the following refrigerants: R717.
  Other refrigerants must only be used in accordance with Sabroe Refrigeration's instructions.
  All other types of gas must only be used with a written permission from Sabroe Refrigeration.

- Installation of the compressor in an explosion-prone environment must only take place if the compressor is fitted with approved explosion-proof equipment. The compressor will then be fitted with an EX-name plate, see Fig. 4.1.

Fig. 4.1



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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 is not liable for injuries to personnel or damage to equipment resulting from using the 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.

Description of the Screw Compressor

Fig. 4.2 SAB 128R
Screw Compressor Unit

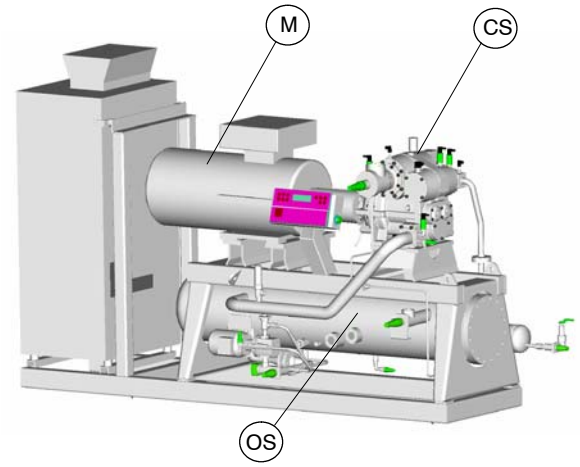
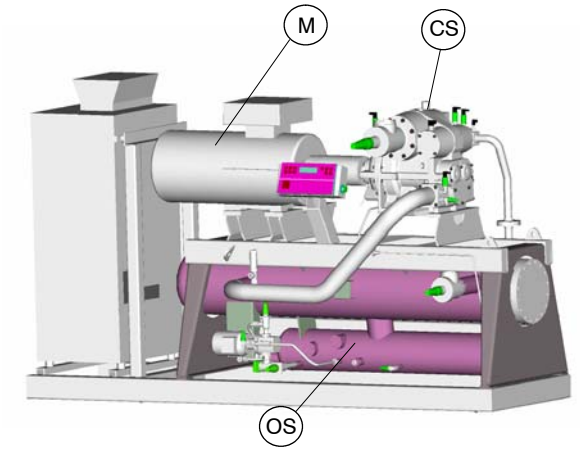


Fig. 4.3 SAB 163R
Screw Compressor Unit



Area of Application

The screw compressor unit is intended for high pressure operation and booster operation. Since it is designed and constructed as a ready-to-operate unit, all that is required is external connections to the plant - suction line, discharge line, etc.

Design/Construction

A description of the components which form part of the unit is given below. More detailed descriptions are included in separate documents for the individual components.

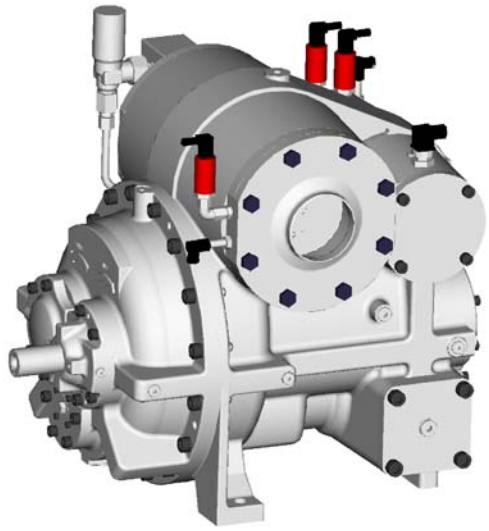
The compressor (CS), the electric motor (M) and the oil separator (OS) are mounted on a base frame. The base frame also serves as a foundation for the other components of the unit.

The electric motor torque is transmitted to the compressor via a flexible disc coupling.

When describing the individual components, the position numbers stated in the piping diagram later in this section will be used.

Compressor Description

Fig. 4.4 Compressor Block SAB 163R



The screw compressor series includes two compressors. The compressors are identical as regards their construction.

The drawing below illustrates how the compressor name is made up.

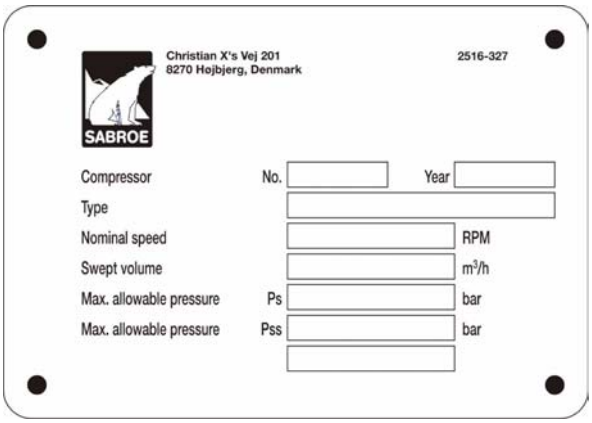
Screw Compressor: **SAB 163 R**

Rotor diameter

Rotatune

Section 6, Technical Data includes a list of tables indicating weight, dimensions, etc.

The compressor type and version can be read from the name plate shown below. Each compressor is fitted with a name plate.



Similarly, the serial number of each compressor has been stamped into the compressor block.

Whenever contacting Sabroe Refrigeration regarding a compressor, please state the compressor serial number.

Compressor

The unit is connected to the suction side via a stop valve pos. 20, see the piping diagram later in this section. The discharge gas is sent to the oil separator (25) via the discharge line.

The Screw compressors have a wide range of application in the field of refrigeration.

The capacity of the compressor can be regulated automatically from approx. 16% to 100% by changing the rotation speed of the rotors from 1000 to 6000 rpm by means of a frequency controlled electromotor.

Moreover, the compressor has a built-in volume regulating system V_i, by means of which it is possible to regulate manually the internal volume ratio of the compressor to the pressure ratio of the refrigeration plant. The V_i-regulating system is adjusted manually by means of an adjusting spindle on the compressor.

When the compressor has been adjusted correctly, it will obtain the highest efficiency.

The compressor has two rotors where the driving rotor, **the male rotor,** has four lobes and the driven rotor, **the female rotor,** has six lobes.

The rotors are constructed with an asymmetrical profile according to SRM licence. At the suction end the rotors are provided with roller bearings. The bearings at the discharge end consist of a combined set of roller bearings, assimilating the radial load, and ball-bearings, assimilating the axial load. The axial forces are partly equalized by rotating balance piston mounted on the rotors.

The rotor shaft to wich the motor is connected is fitted with a shaft seal of the metal below type. The purpose of this shaft seal is to seal between the interior volume of the compressor and the atmosphere.

The shaft seal is equipped with multi-point oil injection for more efficient cooling and lubrication of sealing surfaces.

The compressor is provided with a large built-in filter preventing dirt particles in the refrigeration plant from penetrating into the compressor together with the suction gas.

Furthermore, the compressor is fitted with a non-return valve preventing the rotors from rotating backwards when the power to the motor is cut off. The non-return valve is controlled by the compressor internal suction pressure. Thus the valve is kept open during operation without causing unnecessary loss of pressure in the suction gas.

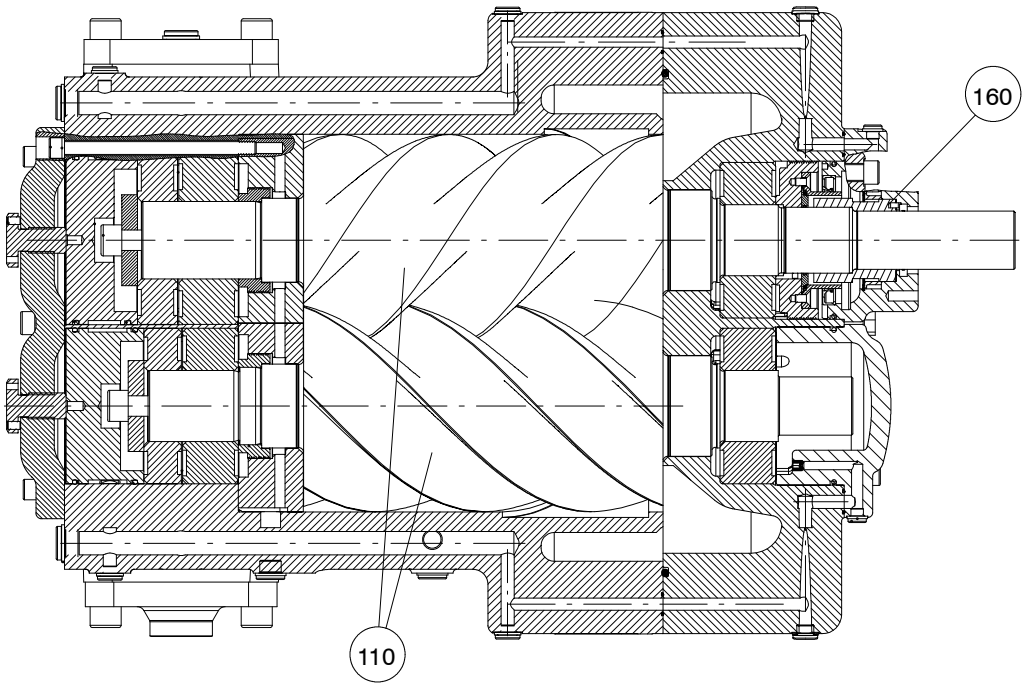
The compressor block is a very compact contruction with internal oil channels, built-in oil filter and electric flow switch. Thus the number of piping connections can be reduced considerably.

For the purpose of lubricating, cooling and sealing the movable parts in the compressor, large amounts of oil are sprayed into the compressor compression chamber. The oil is taken from the oil separator. It is separated from the discharge gas when passing through the oil separation filters in the oil separator as described in the following section.

As the pressure in the oil separator is the same as the pressure on the compressor discharge side, a stable lubricating pressure for the bearings, the rotor injection and the capacity regulating system is obtained.

When starting the compressor a prelubrication pump - mounted on the unit - ensures that the unit lubrication system is filled with oil so that the bearings are lubricated immediately when the compressor is started.

Fig. 4.5 Sectional View of Compressor Block



The rotors, Fig. 4.5, pos. 110, are constructed with an asymmetrical profile according to SRM licence. The male rotor has four lobes whereas the female rotor has six, see Fig. 4.6. The compressors are only available with male drive.

Fig. 4.6

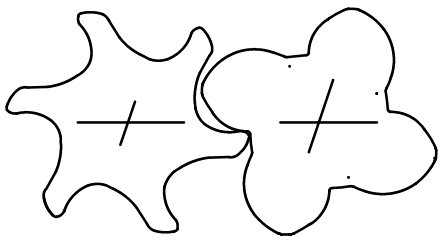
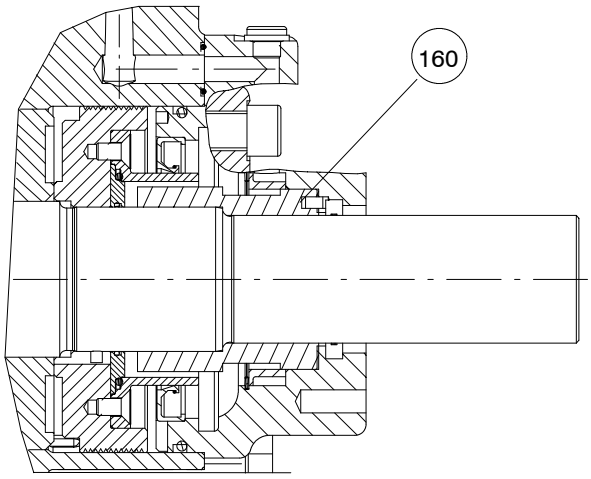


Fig. 4.5 shows a sectional view of the compressor block. A shaft seal of the slide type, Fig. 4.7, pos. 160, is mounted at the shaft end (driving shaft) of the male rotor.

The shaft seal has a rotating metal bellow and ensures complete tightness between the compressor housing and the compressor shaft, thus preventing atmospheric air from entering the compressor.

Fig. 4.7 Shaft seal with multi-point injection

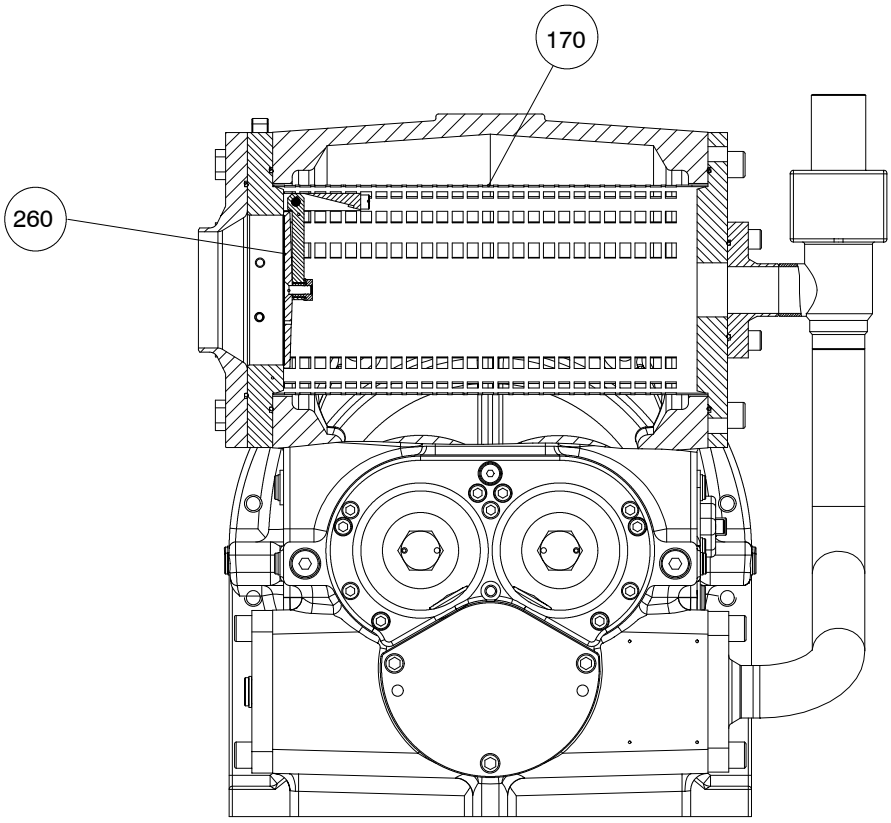


Suction Filter

The suction filter is built into the compressor housing above the rotors, Fig. 4.8, pos. 170.

The purpose of the filter is to collect the impurities which are led around the refrigeration system with the suction gas. Experience has shown that impurities will be collected in the filter especially after start-up of a new plant. The filter must therefore be cleaned after 200 operating hours at the latest, see Section 11, Maintenance.

Fig. 4.8



SECTION Y–Y

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Non-return Valve

In the suction filter housing a non-return valve is fitted. This valve prevents the return of the rotors when the compressor stops, Fig. 4.8, pos. 260.

Oil Filter

The oil filter pos. 470, Fig. 4.9, is a replaceable filter cartridge mounted in the compressor block. As the capacity of the filter cartridge is used, the pressure loss across the filter will increase, which will be registered by the two pressure transducers, pos. 752 and pos. 753.

It is therefore important to make sure that a new filter cartridge is available before removing the used filter as it is **not** possible to clean the used filter.

Fig. 4.9

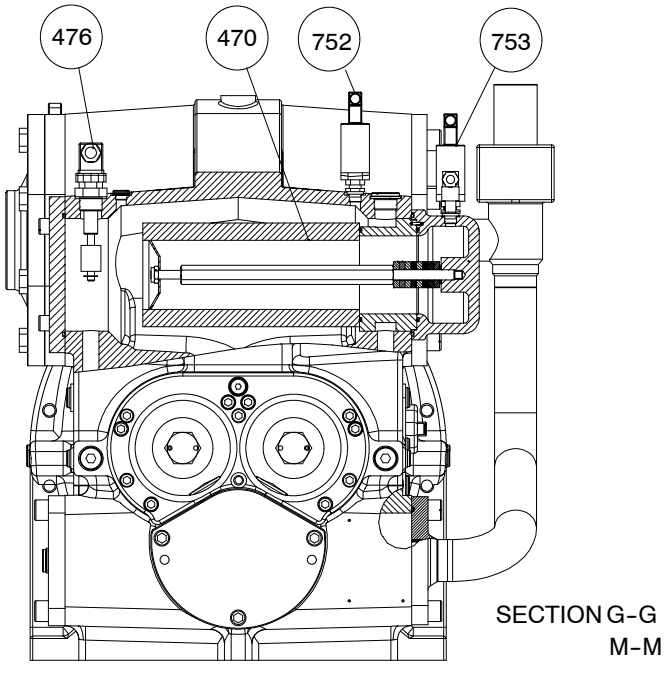
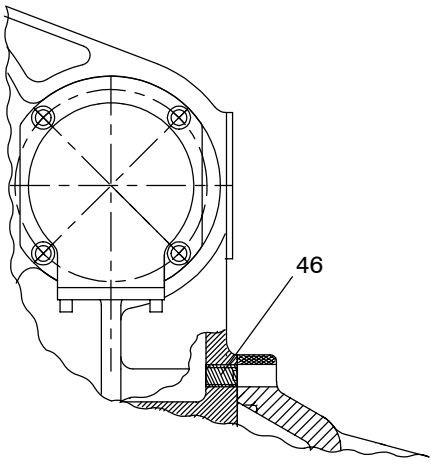


Fig. 4.10 Drain Valve

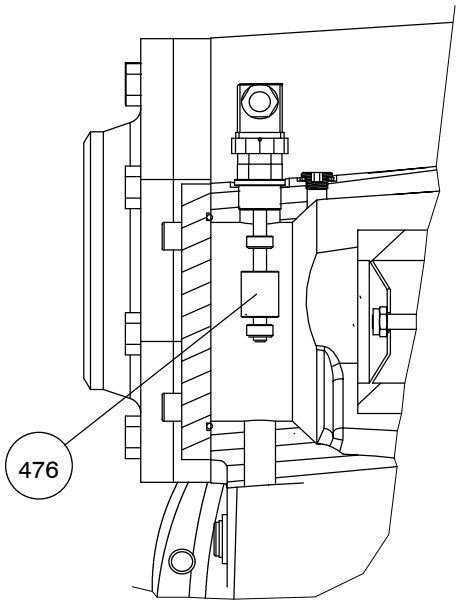


Before removing the filter cartridge from the compressor block, stop the compressor and equalize the pressure to atmospheric pressure. Furthermore, **drain the oil filter housing of oil.** This is done by unscrewing the threaded plug, pos. 46, see Fig. 4.10.

Draining of the oil is best done while there is still an excess of pressure in the compressor.

Flow Security

Fig. 4.11



To ensure a continuous lubrication of the compressor, the compressor block has a built-in flow security, Fig. 4.9, pos. 476. For detailed illustration see Fig. 4.11. The flow security works as described in the following.

The float contains a permanent magnet which activates a built-in **reed switch.** If there is no oil flow through the housing, the float will be in its lowest position, thus disconnecting the power supply through the **reed switch.** If oil flows through the housing, the float will lift ifself to its highest position, thus establishing a connection.

For **compressor units with instrument board:**
If the float drops, thus disconnecting the power supply, a time relay will stop the compressor after 10 seconds.

For **compressor units with UNISAB II:**
The signal is transmitted to UNISAB II, which will stop the compressor once the encoded time has expired and after the float has cut off the flow connection.

For details, see the UNISAB II instruction manual.

Systems for Regulating of Compressor Capacity and V_i-ratios SAB 128R and SAB 163R

This section describes the following two subjects:

1. Regulation of compressor capacity.
2. Manual regulation of the V_i-slide.

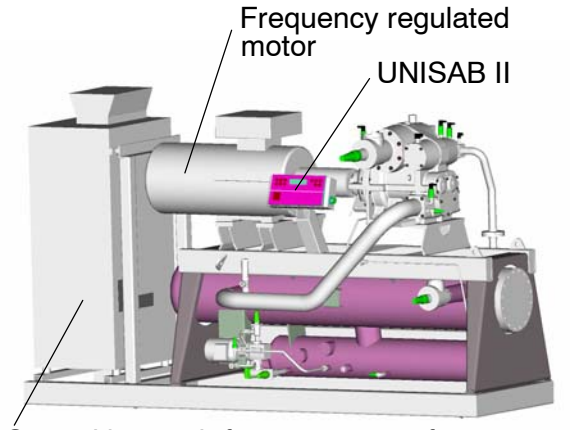
1. Regulation of Compressor capacity

The compressor capacity can be regulated from 16-100% by regulating the number of revolutions of the rotors from 1000-6000 rpm. This is done by means of a frequency transformer, which controls the number of revolutions of the electric motor driving the compressor.

The frequency transformer is located in the unit control box as shown in Fig. 4.12.

The operating data of the frequency transformer is factory set. Any regulation of the compressor capacity is carried out from the UNISAB II mounted on the unit.

Fig. 4.12



2. Manual Regulation of the V_i-slide

For the purpose of obtaining the highest efficiency on the screw compressor, the compressor is fitted with a slide system by means of which the built-in volume ratio V_i of the compressor can be adjusted manually to the pressure ratio of the refrigeration plant (evaporating pressure/condensing pressure).

Fig. 4.13

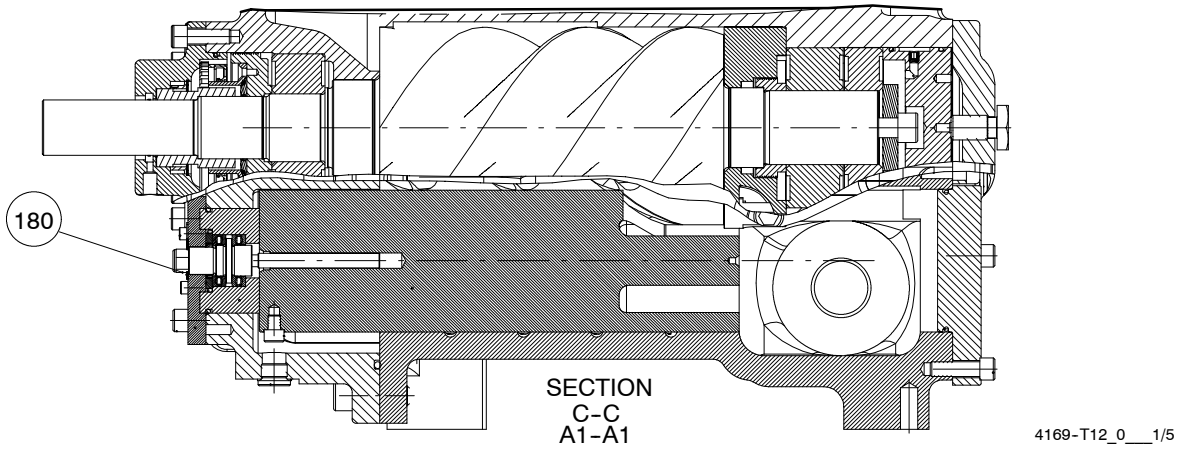


Fig. 4.13 shows a section of the construction of the manual system, which operates as described in the following.

Function

The regulating slide pos. 200 can be moved in the longitudinal direction of the rotors and can thus change the size of the radial discharge port. Thus the built-in volume ratio of the compressor can be changed.

The regulating slide is moved by giving the spindle pos. 180 a predetermined number of turns.

- If the spindle is turned **clockwise,** a lower V_i is obtained.
- If the spindle is turned **anti-clockwise** a higher V_i is obtained.

For correct adjustment of the V_i-slide position, use the following diagrams Fig. 4.14 and Fig. 4.15 as explained below.

For the actual **refrigerant and evaporation temperature TE**, follow the horizontal line to the intersection with the curve for the actual **condensing temperature TC.** From this point of intersection two readings can be made by following the line either vertically up or down:

- **vertically up**, reading the V_i-ratio. Notice whether the compressor is connected to an **economizer** or not.
- **vertically down,** reading the number of revolutions the spindle pos. 180 must be turned **anti-clockwise** - **from its extreme position** - in order to achieve optimum efficiency at the given temperatures TE and TC. Notice whether or not the compressor is connected to an **economizer.**

Note:

- *Due to the difference in pressure between the suction side and the discharge side, adjustment of V_i must be carried out only when the compressor is stopped.*
- *Do not secure the V_i-slide against the limit ends when adjusting the slide to its max. or min. position as this may impede the movement of the capacity slide.*
  Consequently, when adjusting the V_i-slide to max. or min. position, loosen the spindle by turning it 1/2 to 1 turn in the opposite direction from its extreme position.

Fig. 4.14

Adjusting the position of the V_i-slide, R717, SAB 128 Mk3/4 and SAB 128R Mk3/4

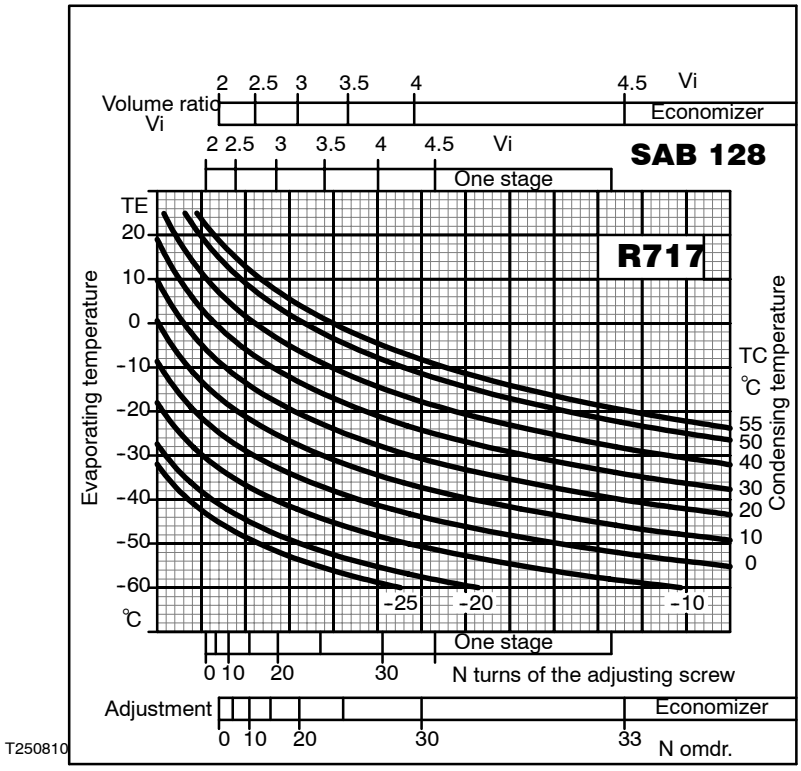
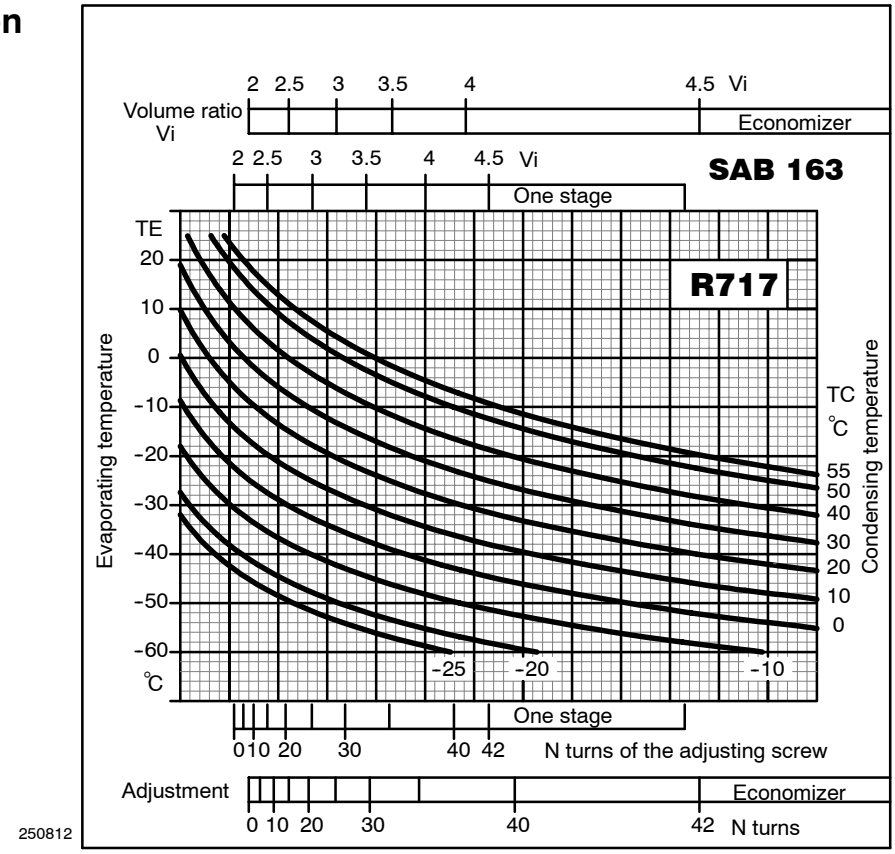


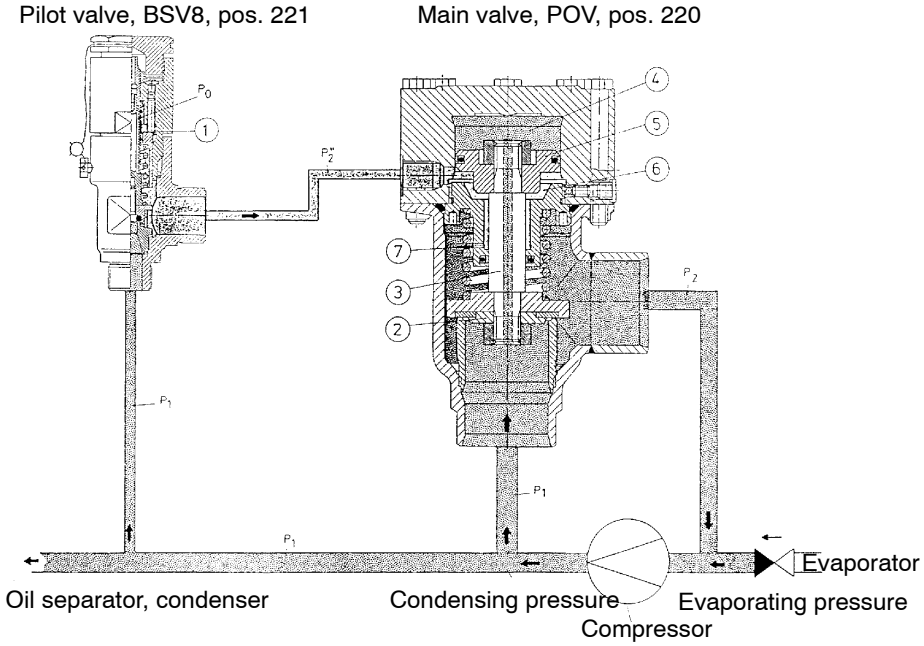
Fig. 4.15

Adjusting the position of the V_i-slide, R717, SAB 163 Mk3/4 and SAB 163R Mk3/4



Compressor Protecting System pos. 220 and 221

Fig. 4.16



In order to protect the compressor against an inadmissible high pressure (if the electric system has not already stopped the compressor), the compressor is fitted with a protecting system with a main valve pos. 220 and a pilot valve pos. 221, see piping diagrams Fig. 4.35 and Fig. 4.36.

Functional Description

The pilot valve pos. 221 is actuated by the compressor discharge pressure P_1 and is kept closed by a built-in spring whose closing force is adjusted to the pressure shown on the valve plate. The reference pressure of the pilot valve is the atmospheric pressure P_o, and the valve is dimensioned in such a way that the pressure P_2" does not affect the opening pressure of the valve.

If the pressure P_1 rises above the set opening value on the valve plate, the pilot valve pos. 221 opens modulatingly and raises the pressure P_2" below the piston pos. 5 in the main valve.

In the chamber **above** the piston pos. 5 there is the same pressure P_1 as under the valve cone pos. 2 since the piston rod pos. 3 is pierced. When the main valve is closed, the pressure P_2" in the chamber pos. 6 **below** the piston will be the same as the compressor discharge pressure P_2 since the pressure P_2" is equalized through the nozzle pos. 7.

If the pilot valve pos. 221 opens due to a too high pressure P_1, gas will flow from the pilot valve to the main valve through the P_2" line. If there is more gas that can flow through the nozzle pos. 7 the pressure will rise in the chamber pos. 6 and open the main valve modulatingly.

Thus the way is open for a gas flow through the main valve from the compressor discharge side to the suction side.

When the pressure P_1 again falls below the set pressure of the pilot valve, the pilot valve will close. The pressure P_2" in the chamber pos. 6 is equalized to the P_2 pressure

through the nozzle pos. 7 and the main valve closes in less than 50 seconds.
The activation of the compressor protecting system will usually not result in valve leaks or in a need for regulation.

Oil System

As shown in the general piping diagrams, Fig. 4.35 and Fig. 4.36, a mixture of oil and discharge gas is flowing from the compressor CS pos. 22 to the oil separator OS where the oil is separated from the discharge gas.

The main part of the oil is separated in the demisters pos. B whereas the small drops which continue with the discharge gas are separated in the fine separator element pos. 55.

If necessary, the fine separator element can be removed from the oil separator for inspection by dismounting the flange at the end of the oil separator.

The gas, which is almost free of oil, leaves the oil separator through the stop valve pos. 204. From the demisters pos. B the oil is drained to the bottom of the oil separator where the oil level can be seen through the sight glasses pos. 31. A heating element pos. 30 keeps the oil warm when the compressor is not in operation. The oil separator can be drained of oil through the valve pos. 47. From the oil separator the oil is led to the oil cooler pos. 32/33 via the non-return valve pos. 210. Different oil coolers can be used as standard where the secondary refrigerant is either water or the refrigerant used in the refrigeration plant.

For oil temperature regulation, a temperature regulating valve can be mounted at point A and B of the oil cooler.

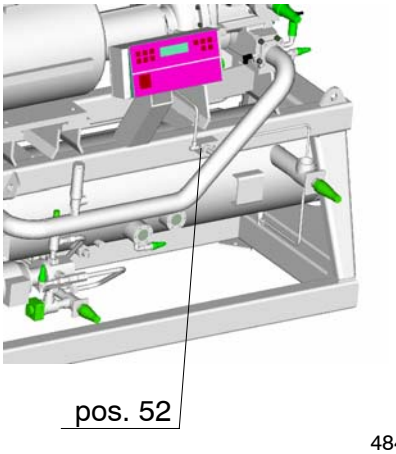
The illustrated oil coolers can be drained of oil through the valve pos. 34 and of refrigerant through the valve pos. 35.

From the oil separator the oil flows to the compressor where it is filtered in the oil filter pos. 39 before it is led to the lubricating places in the compressor.

As part of the starting procedure of the compressor, the secondary oil pump pos. 63 starts first and fills the oil system with oil until the float switch pos. FT18 floats up and signals that the compressor can be started.

The oil which is separated in the fine separator element in the oil separator is returned separately to the compressor via the oil return valve pos. 52. See Fig. 4.17. See also the section *Oil Return Valve* where the valve function is described in detail.

Fig. 4.17



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The piping diagrams, Fig. 4.35 and Fig. 4.36, for SAB 128R and SAB 163R respectively show i.a. alternative choices of oil coolers. Note that SAB 163R is equipped with separate oil vessel.

Oil Separator for SAB 128R and SAB 163R

Fig. 4.18 Oil Separator SAB 128R

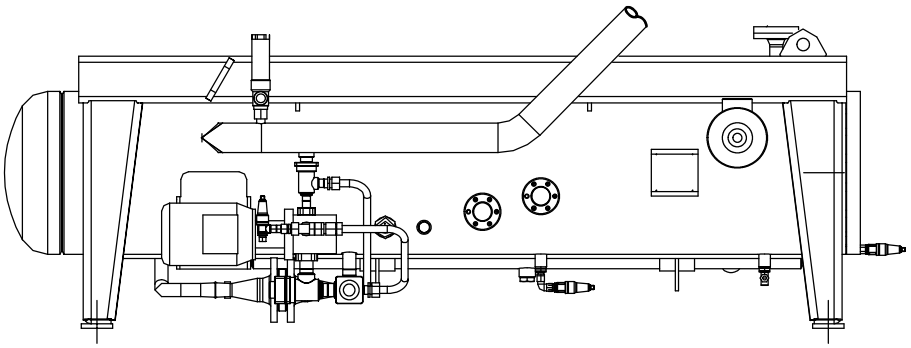
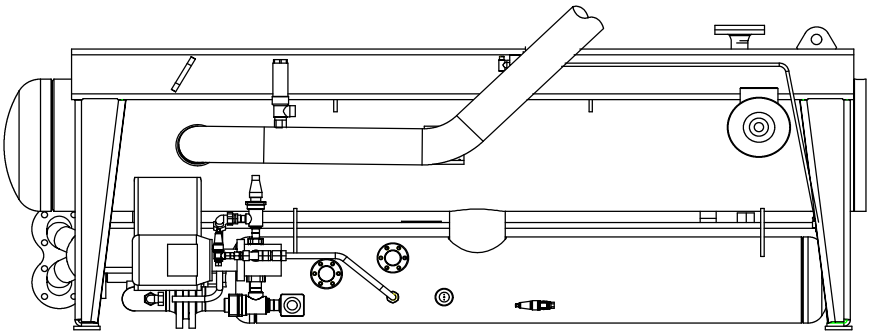


Fig. 4.19 Oil Separator SAB 163R



The oil charged to the compressor for lubrication, sealing and cooling of the compressor block is mixed with the refrigerant gas and led to the oil separator collectively.

In the oil separator oil and gas are separated whereupon the gas, which is almost free of oil, leaves the compressor unit through the discharge connecting piece pos. A.

Two filter elements separate the oil from the gas. The main part of the oil is separated in the demisters and drained to the bottom of the oil separators on SAB 128 and down into the separate oil vessel on SAB 163 as shown in Fig. 4.20 and Fig. 4.21.

Fig. 4.20

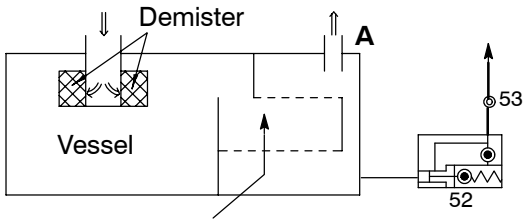


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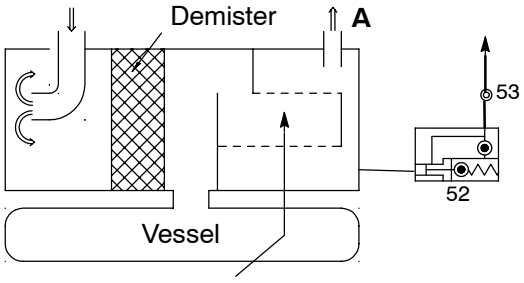
Fig. 4.21



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The remaining oil in the gas is separated in the fine separator element pos. 55 and returned to the compressor through the oil return valve pos. 52. See piping diagrams Fig. 4.35 and Fig. 4.36.

Fine Separator Element

Usually it is **superfluous** to remove or replace the fine separator element, but in case of increasing oil consumption, it is possible to inspect the filter or remove it through flange pos. B.

The element can be removed through the ends of the oil separator. This, however, must be done by Sabroe Refrigeration's Service organization.

Nominal Oil Carry-over to Plant

	Operating conditions (6000 rpm)	SAB 128R	SAB 163R
R717	-40/-10°C -10/35°C -40/35°C 0/35°C	0.2 - 0.6 0.7 - 2.1 0.2 - 0.6 0.9 - 2.7	0.4 - 1.2 1.4 - 4.2 0.3 - 0.9 2.0 - 6.0

Oil carry-over in kg/100h

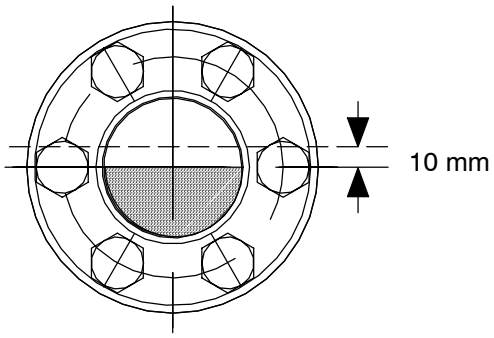
The above figures are based on a separator efficiency of 5-15 ppm

All figures are based on 100% compressor capacity and no economizer loading.

Oil Level Glass

It must always be possible to see an oil level in one of the two oil level glasses pos. 31, Fig. 4.35 and Fig. 4.36. The oil level will rise approx 10 mm if the indicated amount of oil is charged:

Compressor type	Amount of oil per 10 mm Litres
SAB 128	6
SAB 163	4



Section 6, Technical Data - *Oil Charge SAB128R/163R* includes a list of the total oil charge of the unit. However, the list does **not** include the amount of oil circulating in the refrigeration plant. In R22 systems with large quantities of refrigerant, special allowance must be made for the amount of oil dissolved in the refrigerant.

Consequently, it is important – during the operating period after initial start-up – to be aware that the oil level may sink rather quickly until the oil contents in the refrigeration system has stabilized.

Discharge Stop Valve and Non-return Valve

Discharge Stop Valve

Standard units are supplied with a **stop valve** welded on the oil separator discharge branch. The discharge branch of the stop valve is made for welding connection.

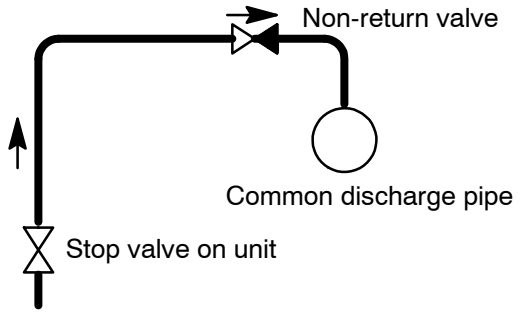
Non-return Valve

In addition to the discharge stop valve in the discharge pipe, a non-return valve must be fitted. This valve must close tightly whenever the pressure in the oil separator is reduced to suction pressure during idle periods.

The non-return valve **must** be positioned on the uppermost part of the discharge pipe as shown in Fig. 4.22. This prevents any condensation that may have been created in the discharge pipe during the standstill of the unit from running into the oil separator when the unit is restarted.

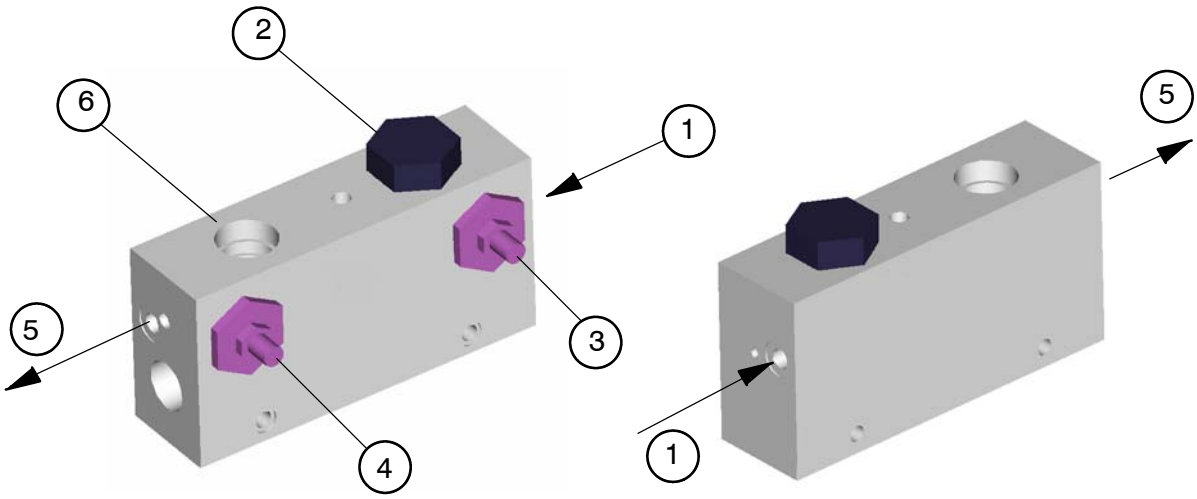
The size of the non-return valve must be calculated on the basis of the current operating conditions of the unit.

Fig. 4.22



Oil Return Valve

Fig. 4.23



1: Inlet G1/4”
2: Filter
3: Stop valve, inlet side
4: Stop valve, outlet side
5: Outlet G 1/4”
6: Sight glass

Note:

Valve inlet and outlet are marked on the valve housing with ”in” and “out”.

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Function

The function of the oil return valve is to return the separated oil in the fine separator to the compressor.

Oil and gas from the fine separator flow into the oil return valve at pos. 1, through the filter pos. 2 and via the nozzles pos. 7 and 8 (see Fig. 4.24) back to the compressor through the outlet pos. 5.

The gas and oil flow through the nozzles pos. 7 and 8 is adapted to the spring force of pos. 9 as well as the viscosity difference between oil and gas. Consequently, the pressure loss of the gas flow through the nozzle pos. 7 is unable to move the piston pos. 7.

However, the pressure loss of the oil flow through the nozzle pos. 7 is able to move the piston pos. 7.

Thus the spring force pos. 9 is equalized and a transverse bore pos. 10 with a considerably larger bore than pos. 7 will open.

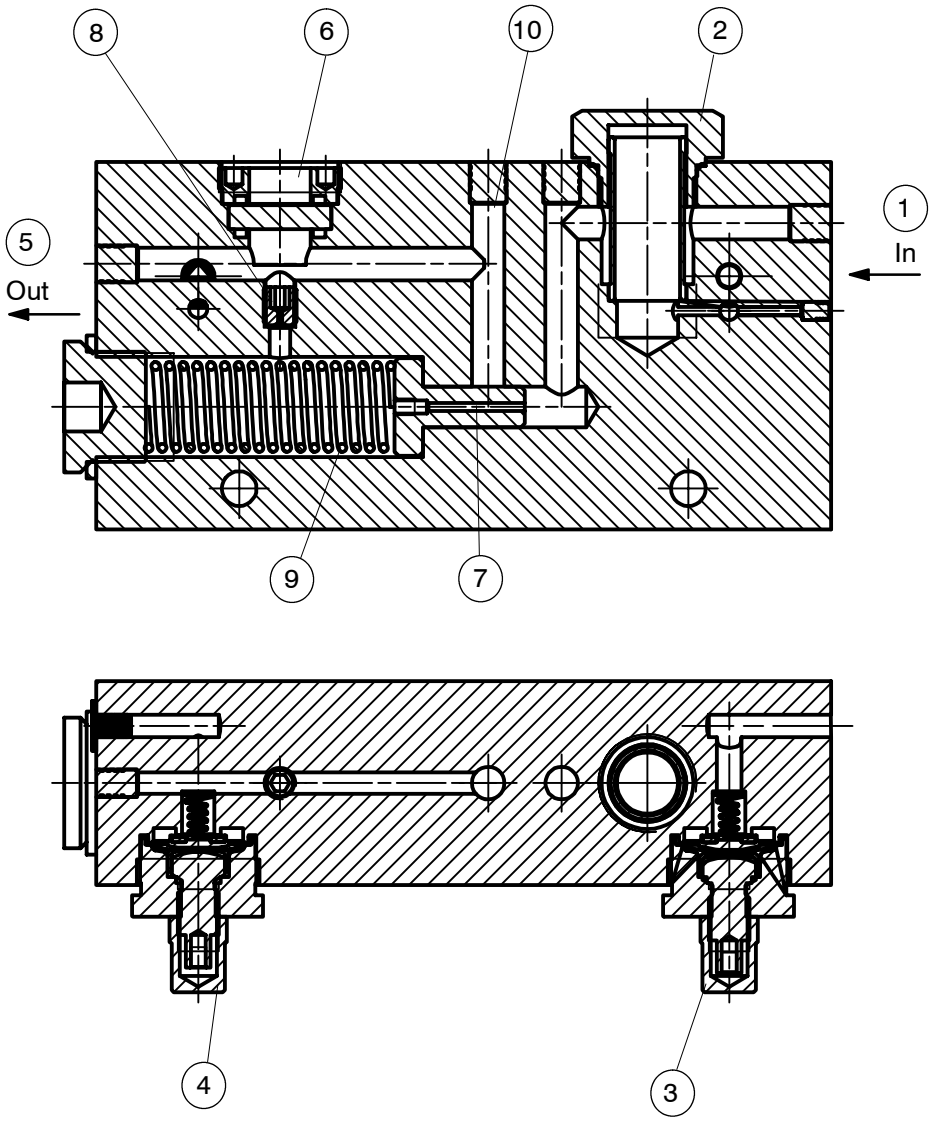
The fact that the bore is larger makes it possible quickly to remove oil collections at the oil return valve inlet.

When the oil has been removed, the gas flow will rise and the piston pos. 7 will close the transverse bore. The gas flow will be lowered to a minimum.

Through the sight glass pos. 6 it is possible to watch the oil return. As a small amount of gas will always pass through the nozzle pos. 7, gas bubbles will be visible.

The valve can be serviced by closing the stop valves pos. 3 and 4.

Fig. 4.24



Note:

The sectional view shows the valve structure. Not all internal oil channels are visible.

Heating Rods, Element for Oil Heating

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

For **screw compressors** starting with much refrigerant dissolved in the oil, there is a risk of the compressor being stopped by the Flow Switch. The reason for this is that the oil will foam owing to the fall in pressure through oil pipe and oil filter.

As illustrated in the drawing Fig. 4.25, the heating rod consists of an electric heating element incorporated in a pipe with a diameter of 30 mm. The entire heating cartridge is screwed on tight at the G 1 $^1/_4$" thread.

Note:

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

Fig. 4.25

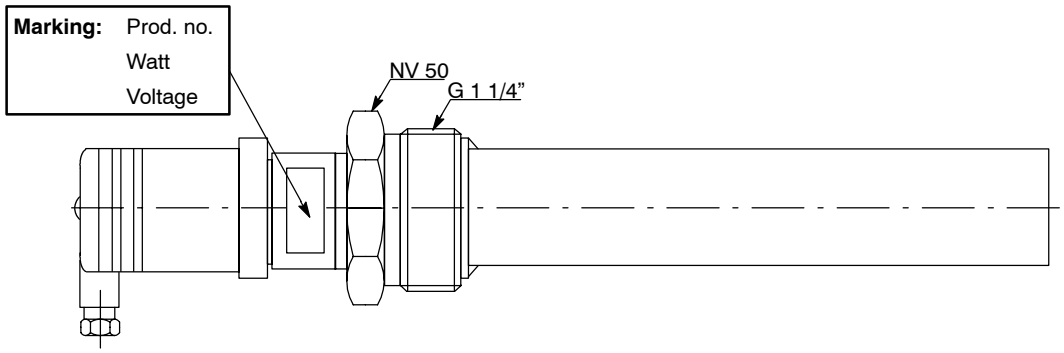


Fig. 4.26 Table of Power and Application

Heating Rods				Used for:
Power Watt	Voltage V	L1 mm	L2 mm	
270 270 270	250 230 115*	158	175	CMO-TCMO-SMC100-TSMC100
460 460 460	250 230 115*			HPO-HPC-SMC180-TSMC180-SAB81/83/85/87/89-SAB110-SAB128Mk3-SAB163Mk3-SAB128HR-SAB163HR-SAB202-SAB330-VMY536-SAB283L/E-SAB355L

* Can be delivered with a UL approval

All heating rods are executed in **Degree of Protection IP54.**

Oil Cooling System

Various types of oil cooling systems can be applied for cooling of the lubricating oil in the compressor.

- **Water-cooled oil cooler, type OWSG** is designed for connection to a fresh-water system incorporating anti-corrosion and anti-scaling measures.

  When the oil cooler is operating with a cooling tower, algicides, rust and fouling inhibitors must be added to the water according to normal practice in connection with cooling tower systems.
- **Water-cooled oil cooler, type OWRG** is used where the water quality cannot be guaranteed to be satisfactory and constant.
- **Refrigerant-cooled oil cooler, type OOSI**
  for cooling of the oil with refrigerant.
  A closed, welded tubular heat exchanger of the OOSI type can be used.
- **Other**

Closed System

OWSG

If the oil cooler is connected to a **closed system** such as a heat recovery system, the water flow can still be regulated.

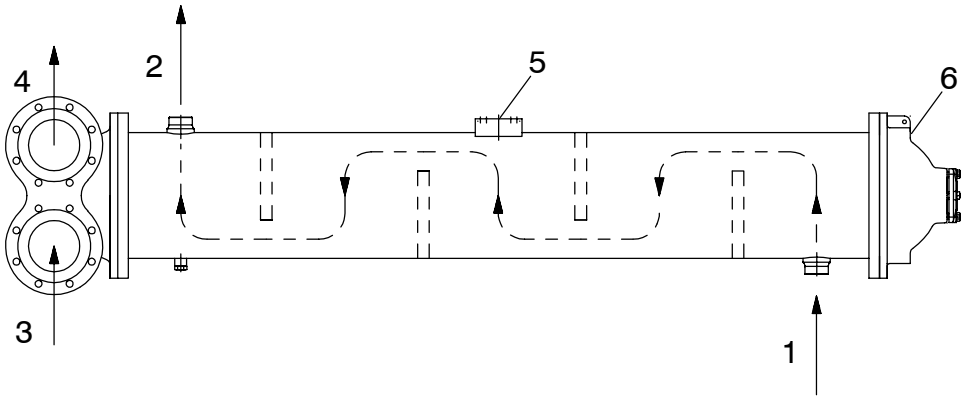
OWRG

Only use the mentioned oil coolers for the prescribed water flow to minimize the risk of corrosion as a result of the combination of **high temperature** and **chloride content (Cl^-)** in the cooling water.

Therefore, Sabroe Refrigeration recommends the use of the regulating system described under *Open System.*

Water-cooled Oil Cooler, Type OWSG/OWRG pos. 33

Fig. 4.27



No	Used for
1	Hot oil inlet
2	Cooled oil outlet
3	Water inlet
4	Water outlet
5	Name plate
6	Air purging from water side

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For oil cooling with water a welded shell and tube heat exchanger of the OWSG/OWRG type can be supplied.

Design

In principle the oil cooler consists of a cylindrical shell with a steel tube insert.

The cooler has oil inlet and outlet branches in the shell whereas the water inlet and outlet are positioned in one of the end covers.

The covers are made of cast iron. The tube insert consists of two tube plates into which a number of tubes are welded.

Baffle plates are positioned between the tubes to extend the oil passage through the cooler, thus causing the oil to flow across the tubes. This improves the heat transmission from oil to cooling water significantly.

The cooler end covers are designed to lead the water back and forth a number of times to ensure adequate water velocity.

Oil cooler, type **OWRG,** is made of stainless steel and available in two versions, one for freshwater and one for sea water. The type is indicated on the name plate.

Furthermore, the oil cooler can be fitted with end cover corrosion plugs. To ensure the corrosion resistance of the two oil cooler types, the pipes must never become overheated. Consequently, they must **not** be uncovered.

To avoid this, it is important that

- there are no air pockets on the water side. Therefore, the oil cooler must be fitted with a purge valve at the top of the cover without connections. This valve may be omitted if the water discharge

pipe points upwards so that air can escape with the water.

- the water velocity through the oil cooler is never below the velocity stated by Sabroe Refrigeration to prevent fouling and soiling.

For OWRG applies:

In the fresh water version the content of chloride ions (Cl^-) in the water must not exceed 400 ppm at max outgoing water temperature = 35°C.

In case of chlorine treatment (sea water version), the amount of chlorine must not exceed 0.5 mg Cl_2 per litre water for 30 minutes once every 24 hours. Max outgoing water temperature = 40°C.

Moreover, the oil cooler must be drained of water during idle periods of more than 1 or 2 weeks.

Application

Oil cooler type **OWSG** is designed to be connected to a freshwater system where measures have been taken to prevent corrosion and calcareous deposits.

When operating with an evaporating cooling tower, corrosion inhibitors and agents against algae growth and calcareous deposits must be added to the water according to common practice.

Oil cooler type **OWRG** is used where the water cannot be guaranteed to be of a good and constant quality.

Cleaning

Fouling or soiling of the water side will reduce the heat transfer and hence the cooler capacity.

The cooler must therefore be checked and cleaned at regular intervals, depending on how pure the cooling water is.

The **OWSG**/**OWRG** oil cooler can be cleaned by removing the end cover without branches and scrubbing the tubing clean with a bronze brush. The internal pipe diameter is 8 mm.

Finally, the tubing is rinsed with fresh water. Alternatively, ready-mixed inhibitive scouring acids can be used with subsequent neutralization. Such agents must be intended for untreated steel tube heat exchangers. The chemical manufacturer's instructions should be followed precisely.

Oil Temperature Regulation

Open System

If the oil cooler is connected in an **open system**, ie it cools by means of cooling tower water, other freshwater or sea water, the oil temperature must **not** be regulated by altering the water flow through the cooler.

Decreasing water flow will result in fouling and perhaps clogged-up tubes, which will lead to tube corrosion.

Instead, the following is prescribed:

- If necessary, use a temperature-regulated three-way valve to regulate the oil flow through the cooler.
- Or use a temperature-regulated three-way valve on the water side in connection with a water pump to maintain the prescribed water flow through the oil cooler.

Closed System

OWSG

If the oil cooler is connected in a **closed system** such as a heat recovery system, the water flow can still be regulated.

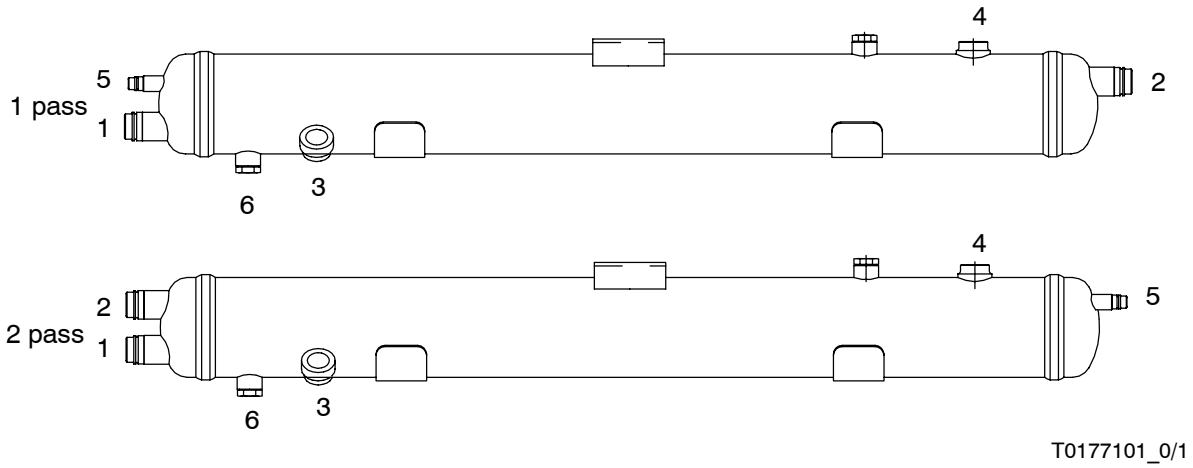
OWRG

Only use the mentioned oil coolers for the prescribed water flow to minimize the risk of corrosion as a result of the combination of **high temperature** and **chloride content (Cl^-)** in the cooling water.

Therefore, Sabroe Refrigeration recommends the use of the regulating system described under *Open System.*

Refrigerant-cooled Oil Cooler, Type OOSI

Fig. 4.28



1	Oil inlet	4	Refrigerant outlet
2	Oil outlet	5	Oil draining (oil side)
3	Refrigerant inlet	6	Oil draining (refrigerant side R717)

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Description

The OOSI oil cooler, Fig. 4.28, is an all-welded tubular heat exchanger made of steel. On the inside the pipes are fitted with a special insert to improve the heat transfer.

The oil flows through the pipes while the refrigerant evaporates outside the pipes. It is a flooded system, which means that the refrigerant leaves the oil cooler as a mixture of liquid and vapour. This ensures that, under normal conditions, no oil is accumulated on the refrigerant side.

Mounting

In order for the condenser to function correctly, it has to be mounted higher up than the oil cooler to ensure a natural circulation of the refrigerant. The draft on the following page is an example of a common pipe layout.

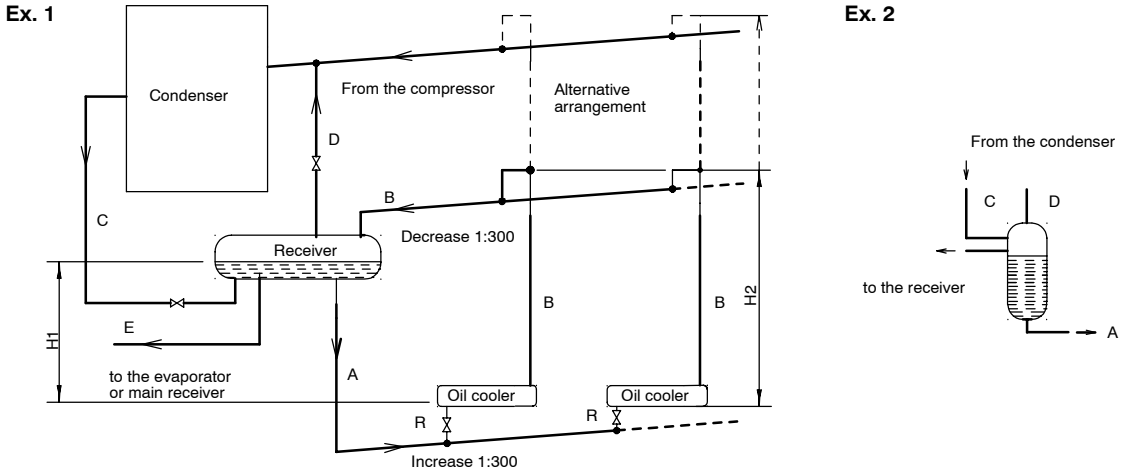
Ex. 1: The receiver is positioned above the oil cooler.

Ex. 2: In case the inlet height (H1) is insufficient, a small **priority vessel** can be positioned between condenser and receiver as shown in the example.

If it proves quite impossible to obtain a satisfying inlet height, a pump could be mounted for the refrigerant supply.

Normally, the inlet height (H1) will be sufficient when constituting min 75% of the return height (H2), provided that the horizontal length of the return pipe is less than 50% of the vertical pipe length or if executed, min 1 pipe dimension larger.

More detalied calculations and choice of velocity are made by Sabroe Refrigeration.



The oil temperature, typically within the range of 35-60°C, depends on the actual operating conditions and oil cooler size.

The choice of oil cooler size also depends on the chosen oil type. The calculated oil temperatures for the various oil types may be seen from Sabroe Refrigeration's Oil Recommendation, see Section 6, Technical Data. The set points of the safety equipment are adjusted according to the calculated oil temperatures. Normally, the alarm limit is 10K above the calculated oil temperature for the oil type in question. See Section 9, Settings.

Oil Temperature Regulation

Most units are fitted with **an oil temperature regulating system** as described in the following section. This system is of special importance if the condensing temperature, eg during cold periods, drops below 20°C during operation or below 10°C during standstill.

If this oil temperature regulating system is not fitted and the condensing temperature drops **below 10°C during standstill**, the liquid supply line to the oil cooler must be closed. For this purpose, a solenoid valve with a low pressure drop, closing whenever the compressor stops, can be mounted. The valve will reopen once the compressor is working again and the oil temperature has reached min 20°C.

Before the compressor is started, the temperature of the oil in the piping system must be at least 10°C. In machine rooms without any heating it may be necessary to mount a heating rod. Oil separators are usually mounted with heating rods as standard to ensure a sufficiently high oil temperature in the oil separator.

In case several oil coolers are mounted in parallel with a considerably different flow resistance due to the pipe lengths, etc, a throttle valve (R) (see Ex. 1) can be fitted in the liquid supply line (A) so that the flow can be equalized between the oil coolers, ensuring the full function of all oil coolers. Do not throttle so much that the oil cooler does not remain flooded.

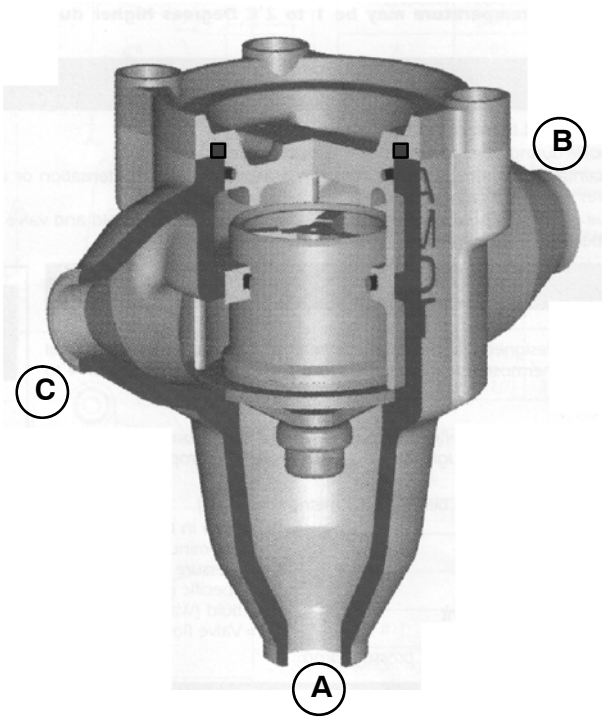
Do not regulate the oil temperature by throttling on the liquid supply line (A) or the return line (B). In that case the oil cooler does not remain flooded, and the return line will only contain refrigerant gas.

Thus oil will accumulate on the refrigerant side of the oil cooler, causing malfunction and a heavy thermal loading of the oil cooler. This will increase the risk of breakdown.

Oil Temperature Regulating System

In screw compressor units where the oil system is cooled by means of either a refrigerant-cooled oil cooler, type OOSI or a water-cooled oil cooler, type OWSG, the oil temperature is usually regulated by a **thermostatic three-way valve** as illustrated in Fig. 4.29.

Fig. 4.29



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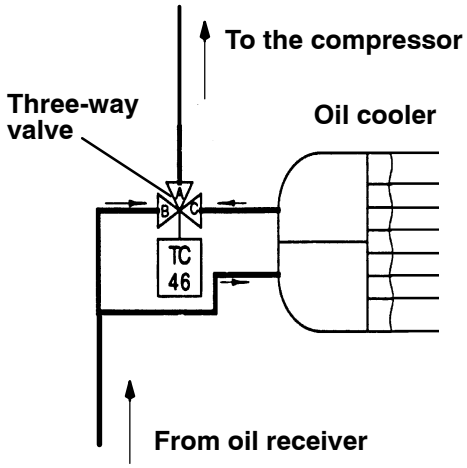
Function

The valve pos. 46, see general diagram Fig. 4.35 and Fig. 4.36, is fitted in a by-pass piping system as shown in Fig. 4.30.

Fig. 4.30



As shown in Fig. 4.31 and Fig. 4.32, the valve works by letting a built-in thermo element pos. 1 regulate a cone pos. 2 so that cold and warm oil is mixed to the factory set temperature.

Note Pos. 3

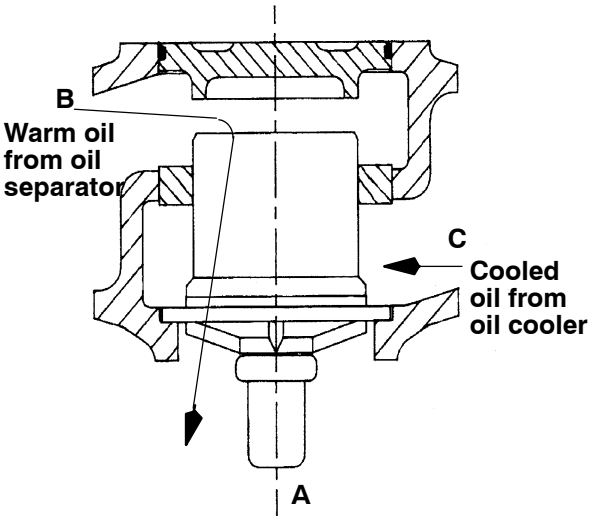
Check that the Teflon ring is mounted and intact. If this is not the case, the thermo element will wear when it rotates, resulting in malfunction.

In Fig. 4.31 the thermo element is shown in its cold position. It will try to raise the mixed temperature of the oil at the outlet A. The thermo element has thus shut off the flow of cold oil, inlet C. However, the flow of warm oil is completely unobstructed.

Fig. 4.32 illustrates the opposite situation where the thermo element is in its warm position, thus shutting off the flow of warm oil, inlet B, and opening for the flow of cold oil, inlet C.

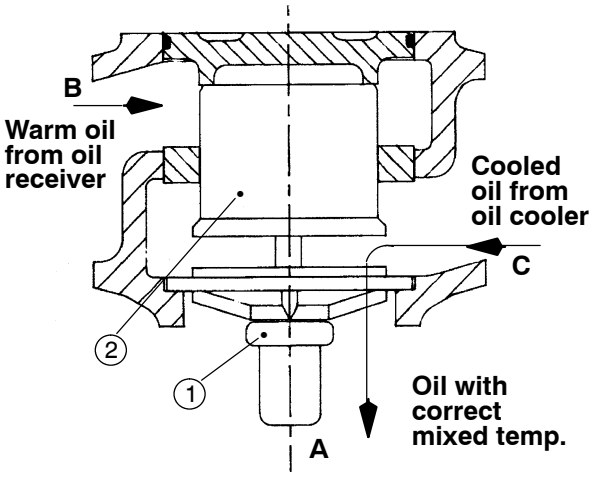
During operation the thermo element will adjust the regulating cone in a modulating way so that the two oil flows are mixed to the set oil temperature and leave the valve through connecting branch A.

Fig. 4.31



Thermo element in cold position

Fig. 4.32



Thermo element in warm position

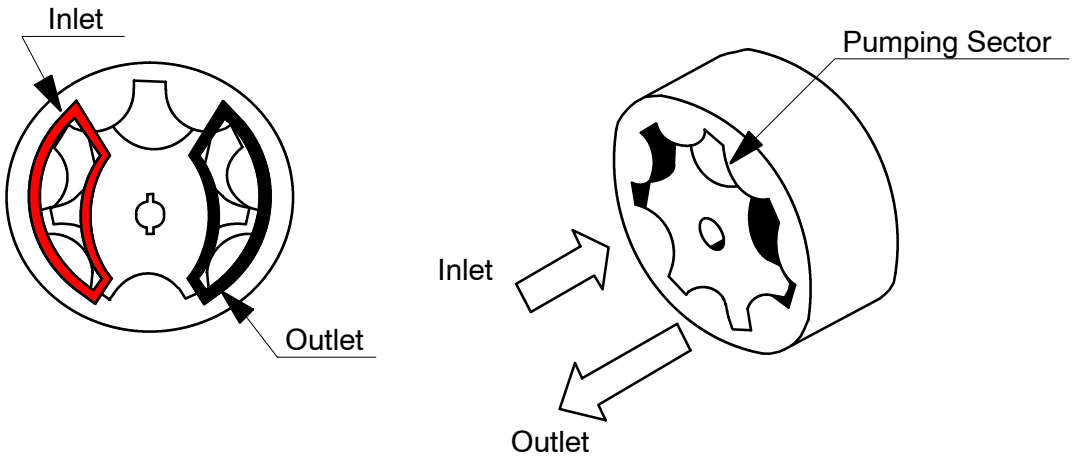
Service

As a rule it is not necessary to dismantle a well-functioning three-way valve as it does **not** contain any gaskets or wearing parts that must be replaced at fixed intervals.

Oil pump pos. 63

The gerotor is a positive displacement pumping unit consisting of just two elements. The inner rotor has one less tooth than the outer and has its centerline positioned at a fixed eccentricity from the centerline of the outer element.

Fig. 4.33



Start-up

The pump must only run without oil flow for brief periods.

Checking Rotating Direction of Motor

Before initial start-up of the oil pump, remember to check the rotating direction of the motor. The rotating direction is indicated on the electric motor with an arrow. Seen through the motor shield of the motor, the motor must rotate **anti-clockwise**.

Economizer

The compressor block is prepared for the mounting of an economizer system.

By connecting the economizer port to an intermediate cooler (economizer), gas of intermediate pressure can be fed to the compressor, thus superfeeding the grooves. The function of the economizer is to cool the liquid refrigerant (subcooling) from the condenser before it is led to the evaporator.

The economizer can be of the open flash type as shown in Fig. 4.34.

Due to the lower liquid temperature created by the economizer, there will be more enthalpy available in the evaporator, and the refrigerating capacity will thus increase.

The power input will also increase due to the superfeed through the economizer inlet, but less than the refrigerating capacity in most economizer arrangements.

The Coefficient Of Performance, i.e.

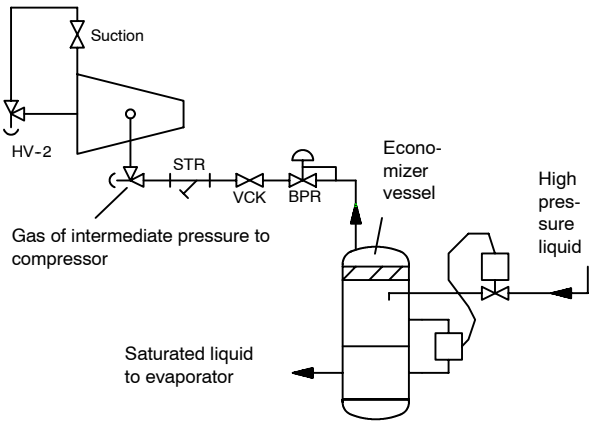
COP = Capacity/power (kW/kW)

will therefore usually increase by economizer operation.

Selecting Economizer

The economizer is calculated by means of the COMP1 calculation program.

Fig. 4.34 Flash Economizer System



Refrigerant Injection into Discharge Pipe, type BLI (Booster Liquid Injection), Screw Compressors

For oil cooling a system may be used with refrigerant injection into the compressor discharge pipe.

Function

During compression of refrigerant vapours from evaporating pressure to intermediate pressure in the LP compressor of a two-stage system, a considerable amount of heat is generated. This heat must be dissipated to keep the gas and oil temperatures at a suitable level. This is done by injecting liquid refrigerant from the receiver into the discharge pipe immediately after the LP compressor. This process is controlled by a modulating injection valve of the TEAT type, pos. 83.

The liquid refrigerant evaporates in the hot mixture of oil and discharge gas, and the mixture is thus cooled. The injection valve size is chosen on the basis of the refrigerant, intermediate pressure temperature, condensing temperature and the cooling requirements specified in the order. The thermo element of the valve has a working range of 35-65°C.

The liquid supply to the BLI system must be taken from a point in the plant where there is **always** refrigerant.

Adjustment

The **opening temperature** of the injection valve is at the mid-temperature range of the thermo element.

Before starting the compressor, adjust the injection valve **opening temperature**:

20K lower than the desired discharge gas temperature.

See Danfoss instructions regarding setting of the injection valve.

Fine adjust the valve once the installation is stable.

The solenoid valve, pos. 82, in front of the injection valve must have an opening temperature of 15K below the desired discharge gas temperature.

In case of operation with BLI, a relatively large amount of foam may occur on the oil in the oil separator.

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Safety and monitoring devices

Compressor units with relay control or terminal strip for remote control are usually fitted with the following instruments for safety and operating control, depending on the specific order.

Safety devices

Pos. 28 Safety valve on oil separator with exhaust to the atmosphere. The exhaust line must be routed from the engine room out into the open air.

Pos. 43 Float switch pos. FT18 is fitted in an oil distributor chamber in the compressor.
The float switch consists of a float with a built-in permanent magnet activating a reed switch mounted in the float guide.
When starting the compressor, oil will be pumped to the compressor lubricating system. The float will then be lifted up, signalling that the oil system has been filled. A time relay must be set so that it will stop the starting signal if the float has not been lifted within 50 seconds.
When the float switch sends out its signal within the 50 seconds, the system will wait for another 10 seconds before the start signal is accepted and the compressor starts.

Note: For Rotatune compressors SAB 128R and SAB 163R the following start-up procedure applies:
After the 50 second prelubricating time the compressor must be started. A further 10 second delay must not take place as the compressor lobes will then be filled with oil.

If the oil flow fails during operation so that the float flows down and interrupts its control signal, the compressor will stop after 10 seconds.

Pos. LIT1 The oil level transmitter is mounted in the oil discharge pipe.
The transmitter is a capacitive level switch for measuring of oil flow. The switch consists of a sensor pocket in which a sensor is mounted. The switch will register when the oil passes, and it will send a signal to the control.
When the compressor is started, the oil pump will start and fill the lubricating system with oil. If the oil flow is not satisfactory after 50 seconds, a built-in timer will cancel the start-up. However, if the oil flow is satisfactory within 50 seconds, another 10 seconds will pass before the compressor starts. If the level switch registers a failing oil flow for a period of 10 seconds during operation, the compressor will stop.

Pos. PAZ1 Pressure cut-out **KP1**, which stops the compressor in the event of the suction pressure falling below the set value. The pressure cut-out is not equipped with a reset, so the compressor starts again when the pressure has risen above the difference

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between the setpoints of the pressure cut-out.

Pos. PAZ2 High pressure cut-out KP5. The pressure cut-out is intended to safeguard the compressor against excessive discharge pressure.

Note: On units to be approved by TÜV (*Germany*), the **KP5** is replaced by a pressure cut-out **KP 7ABS** which has been approved by TÜV. This high pressure cut-out will stop the compressor in the event of damage to the cut-out bellow or excessively high discharge pressure.

Pos. PDAZ 11
Differential oil pressure cut-out **MP55.** This pressure cut-out is designed to ensure sufficient lubricating pressure and oil pressure for capacity regulation. The pressure cut-out is equipped with a time lag of 45 secs. If the preset differential pressure has not been obtained by that time, the compressor will stop. The **MP55** is equipped with manual reset.

Pos. 0376-A12
Differential pressure cut-out for control of pressure drop across oil filter. If pressure drop across oil filter becomes excenssive due to impurities, the pressure cut-out will stop the compressor and a pilot lamp will light. Futher, the differential pressure cut-out contains a visual indication of presure drop represented by a green field for permissible pressure drop and a red field indicating excenssive a pressure drop across oil filter in which case the pressure cut-out will stop the compressor.

Pos. TAZ12 Thermostat **KP79** with sensor in oil flow control. Designed to safeguard against excessive oil temperature.

Pos. TAZ13 Thermostat **KP79** or **KP81** with sensor in oil separator. Designed to safeguard against excessive discharge gas temperature.

Pos. TC14 Thermostat K**P77** with sensor in oil separator. Designed to safeguard against too low discharge pipe temperature and hence too low oil temperature in connection with **HLI** oil cooling.

Please see section on setting of safety devices for various values.

Monitoring devices

Pos. PI15 Suction pressure gauge (evaporator pressure)

Pos. PI16 Discharge pressure gauge (condenser/intermediate pressure)

Pos. TI5 Thermometer in oil separator (discharge gas temperature)

Pos. TI6 Thermometer in oil flow control (oil temperature)

Pos. TI7 Thermometer with sensor in suction pipe. Supplied as extra. Used to calculate superheat of the suction gas. Superheat is the temperature difference found by deducting the temperature read off the suction pressure gauge from the temperature read off the thermometer.

Key to Piping Diagrams/Component List

CS	Screw compressor
OS	Oil separator
M	Electric motor
EC	Electronic control system
240	Coupling

———————— • ————————

PT1	Pressure transducer (suction pressure)
PT2	Pressure transducer (discharge pressure)
PT3	Pressure transducer (oil pressure after oil filter)
PT4	Pressure transducer (oil pressure before oil filter)
PT5	Pressure transducer (oil pressure after oil pump)
TT5	Temperature transducer (discharge gas temperature)
TT6	Temperature transducer (oil temperature in flow control)
TT7	Temperature transducer (suction gas temperature)
GT8	Position transmitter (capacity slide)
GT9	Position transmitter (V_i slide)
PAZ10	Safety pressure cut-out (for TÜV, SDM and SA only)
PAZ1	Low-pressure cut-out (only for classified systems)
PAZ2	High-pressure cut-out
PDAZ3	Differential pressure cut-out (pressure drop across oil filter)
TI5	Thermometer (discharge gas temperature)
TI6	Thermometer (oil temperature)
TI7	Thermometer (suction gas temperature) - only if specially ordered
PDAZ10	Oil pressure difference cut-out (oil pressure - discharge pressure)
PDAZ11	Oil pressure difference cut-out (oil pressure - suction pressure) - for classified systems only
TAZ12	Thermostat (oil temperature in manifold)
TAZ13	Thermostat (discharge gas temperature)
TC14	Thermostat (pilots solenoid valve pos. 82)
PI15	Suction pressure manometer
PI16	High-pressure manometer
PDI17	Oil difference manometer
FT18	Level switch
YY1	Double acting, four-way solenoid valve – unload capacity
YY2	Double acting, four-way solenoid valve – load capacity
YY3	Double acting, four-way solenoid valve – volume ratio/increase
YY4	Double acting, four-way solenoid valve – volume ratio/decrease

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SC1	Throttle valve
SC2	Throttle valve
SC3	Throttle valve
SC4	Throttle valve
BP	Throttle valve – by-pass
LIT1	Oil level transmitter
19	Compressor safety valve
20	Suction stop valve
21	Non-return valve
22	Flanged joint discharge pipe - compressor
23	Suction filter built into compressor
23a	External suction filter
24	Service valve - air purge valve
25	Oil separator
26	Non-return valve in outlet pipe from oil separator
27	Stop and non-return valve in outlet pipe from oil separator
28	Safety valve - the unit
29	Change-over valve for double safety valve
30	Immersion heater in oil separator
31	Oil level indicators (2 pieces)
32	Oil cooler OOSI (refrigerant-cooled)
33	Oil cooler (water-cooled)
34	Stop valve for oil purging (oil side)
35	Stop valve for oil purging (refrigerant side)
36	Oil outlet branch to oil cooler/filter
37	Oil branch to pump suction end
38	Stop valve before oil filter
39	Oil filter
40	Oil inlet from pump
41	Non-return valve built into oil filter
42	Stop valve after oil filter
43	Combined flow control and oil distributing manifold
44	Check valve, rotor lubrication
45	Nozzle in injection pipe for rotors
46	Thermostatically-controlled 3-way valve for oil temperature regulation
47	Service valve for oil drainage
48	Oil purge valve on oil filter
49	Thermostatic water valve for water-cooled oil cooler
50	Stop valve
51	Oil filter
52	Nozzle/throttle valve
53	Oil level indicator
54	Stop valve
55	Oil separation element (fine separation)
56	Non-return valve
57	Hand-regulated valve
58	Temperature regulated main valve
59	Oil receiver
60	Stop valve
61	Oil filter
62	Oil charging valve
63	Oil pump
64	Stop valve for air purging of pump

65	Stop valve
66	Non-return valve for oil charging
67	Solenoid valve (NC) - open during prelubrication
68	Stop valve
69	Non-return valve
70	Solenoid valve (NC) - capacity regulation min. –> 100%
71	Solenoid valve (NO) - capacity regulation 100 -> min.%
72	Throttle valve for regulation of slide velocity
73	Solenoid valve (NC) - capacity regulation min. –> 100%
74	Solenoid valve (NO)
75	Non-return valve
76	Three-way non-return valve
77	Solenoid valve for suction side throttling system
78	Regulating valve for throttling system
80	Stop valve
81	Liquid refrigerant filter
82	Solenoid valve (NC)
TC83	Liquid injection valve TEAT
84	Stop valve
90	Oil supply to bearings at discharge end
91	Oil supply to shaft seal and bearings at suction end
92	Oil injection in compressor
93	Oil return from capacity regulation
94	Oil to and from regulating cylinder
95	Liquid supply for HLI cooling V_i 4.0
96	Liquid supply for HLI cooling V_i 2.6
97	Economizer connection
98	Oil connection from flow switch
99	Oil to and from V_i regulation (only by auto-V_i)
100	Oil return from fine oil separator
101	Bypass throttle valve at suction stop valve
102	Non-return valve
103	Stop valve
104	Nozzle
105	Flow switch
106	External oil filter
107	Oil filter for units with full flow oil pump
108	Oil regulating valve
110	Stop valve
TC111	Thermostatic valve
112	Solenoid valve (NC)
113	Liquid filter
114	Stop valve
115	Stop valve for oil purge
116	Economizer vessel
120	Stop valve
122	Main valve
123	Solenoid valve (NC)
124	Stop valve for oil drainage
125	Safety valve
126	Float valve

127	Stop valve
128	Stop valve
129	Solenoid valve (NC)
130	Stop valve
131	Stop valve
132	Liquid filter
PI139	Oil pressure manometer
140	Stop- and non-return valve
141	Main valve
142	Pilot valve
143	Solenoid valve
144	Stop valve
145	Float valve
147	Liquid filter
148	Stop valve for oil purge
149	Non-return valve
150	Stop valve
151	Safety valve
152	Solenoid valve
153	Stop valve
154	Stop valve
160	Stop valve
200	Gas-powered stop valve
201	Solenoid valve (NC)
202	Stop/non-return valve
203	Non-return valve in discharge pipe
204	Stop valve after oil separator
205	Filter
206	Nozzle
207	Solenoid valve (NO)
208	Solenoid valve (NC)
FT209	Oil level switch in oil separator
210	Non-return valve
211	Stop valve
212	Service valve - air purge valve
213	Non-return valve
214	Filter
215	Non-return valve (5 bar)
220	Compressor protecting valve (main valve)
221	Compressor protecting valve (pilot valve for pos. 220)
222	Filter in economizer pipe connection
223	Brake motor for capacity slide
224	Three-way solenoid valve
225	Oil return pump
226	Solenoid valve for baby slide (NC)
227	Quick closing oil drain valve

Note:

On units supplied without valves the bracketed figures near the branches refer to the component numbers in this list. These components are to be fitted by the customer.

Fig. 4.35 General Piping Diagram for SAB 128R Mk4

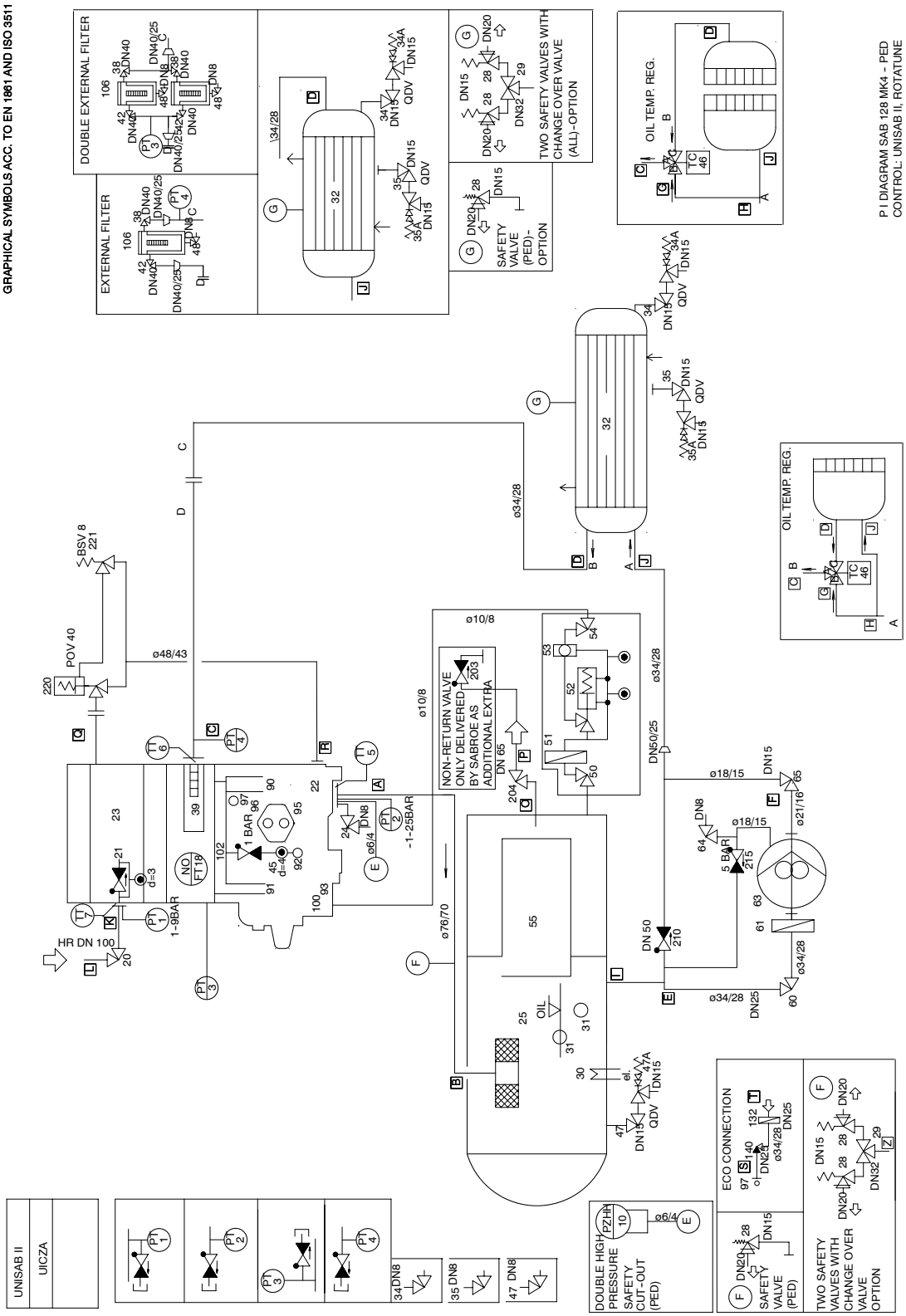
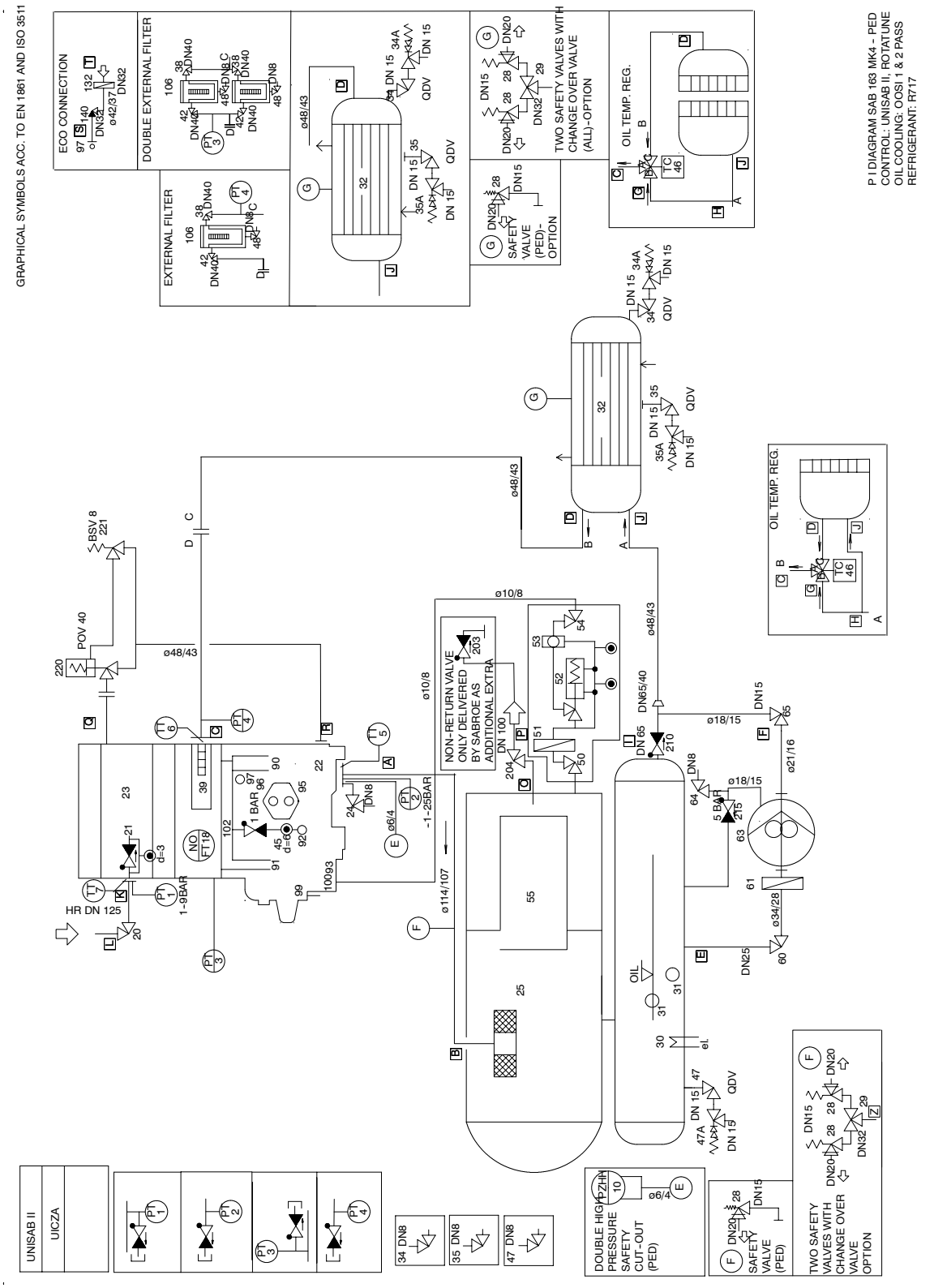


Fig. 4.36 General Piping Diagram for SAB 163R Mk4



Instrumentation

The screw compressor unit can be controlled by a UNISAB II regulation and control system, which is mounted on the unit and connected to a number of temperature and pressure sensors on the unit.

The UNISAB II control system is described in Section 10, Operating Instructions.

Fig. 4.37, Fig. 4.38, Fig. 4.39 and Fig. 4.40 show the location of sensors, valves, etc.

See, moreover, the piping diagram in this section.

The numbers refer to the *Key to Piping Diagrams* in this section.

Fig. 4.37 Location of Components SAB 128R

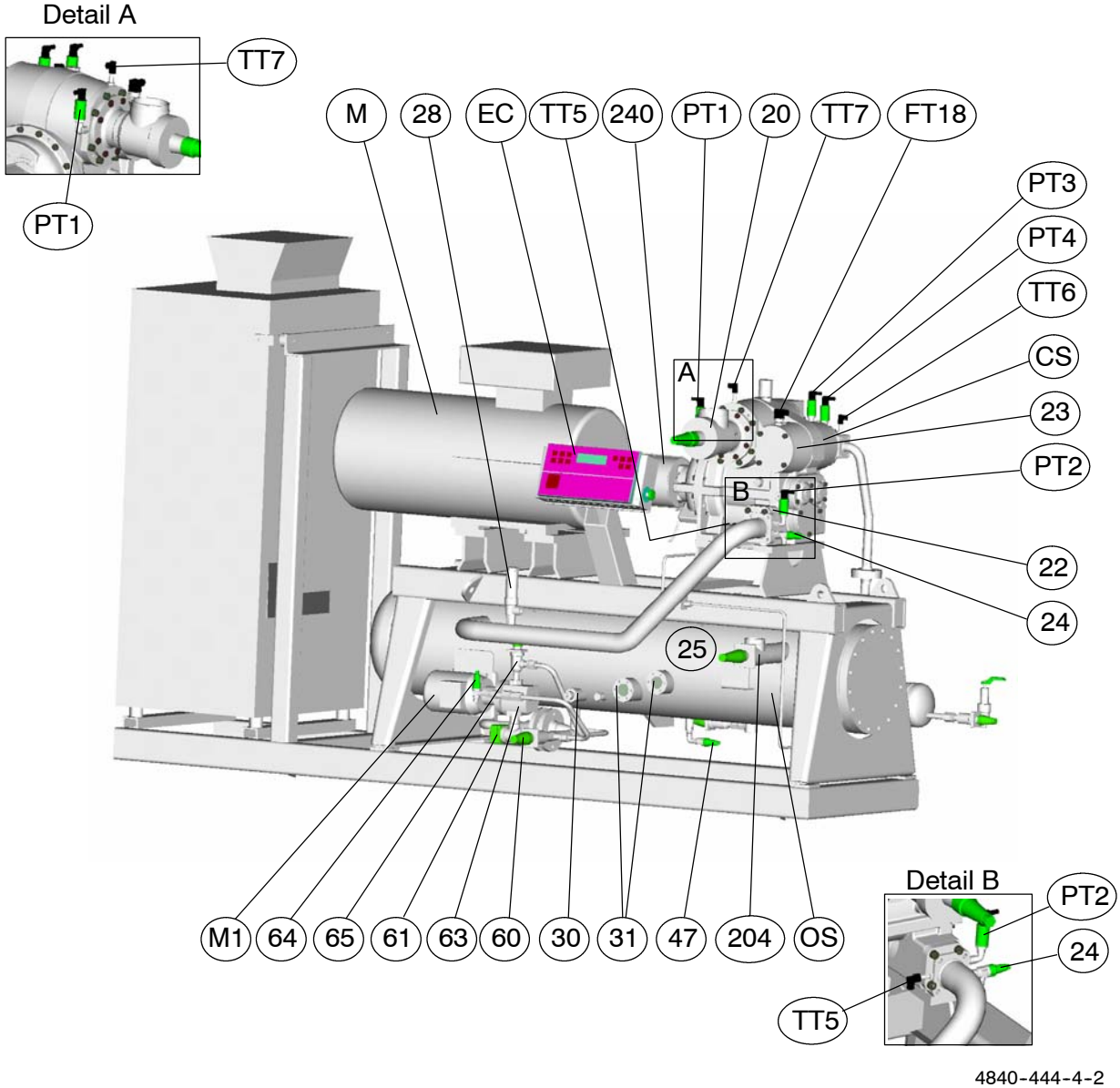


Fig. 4.38 Location of Components SAB 163R

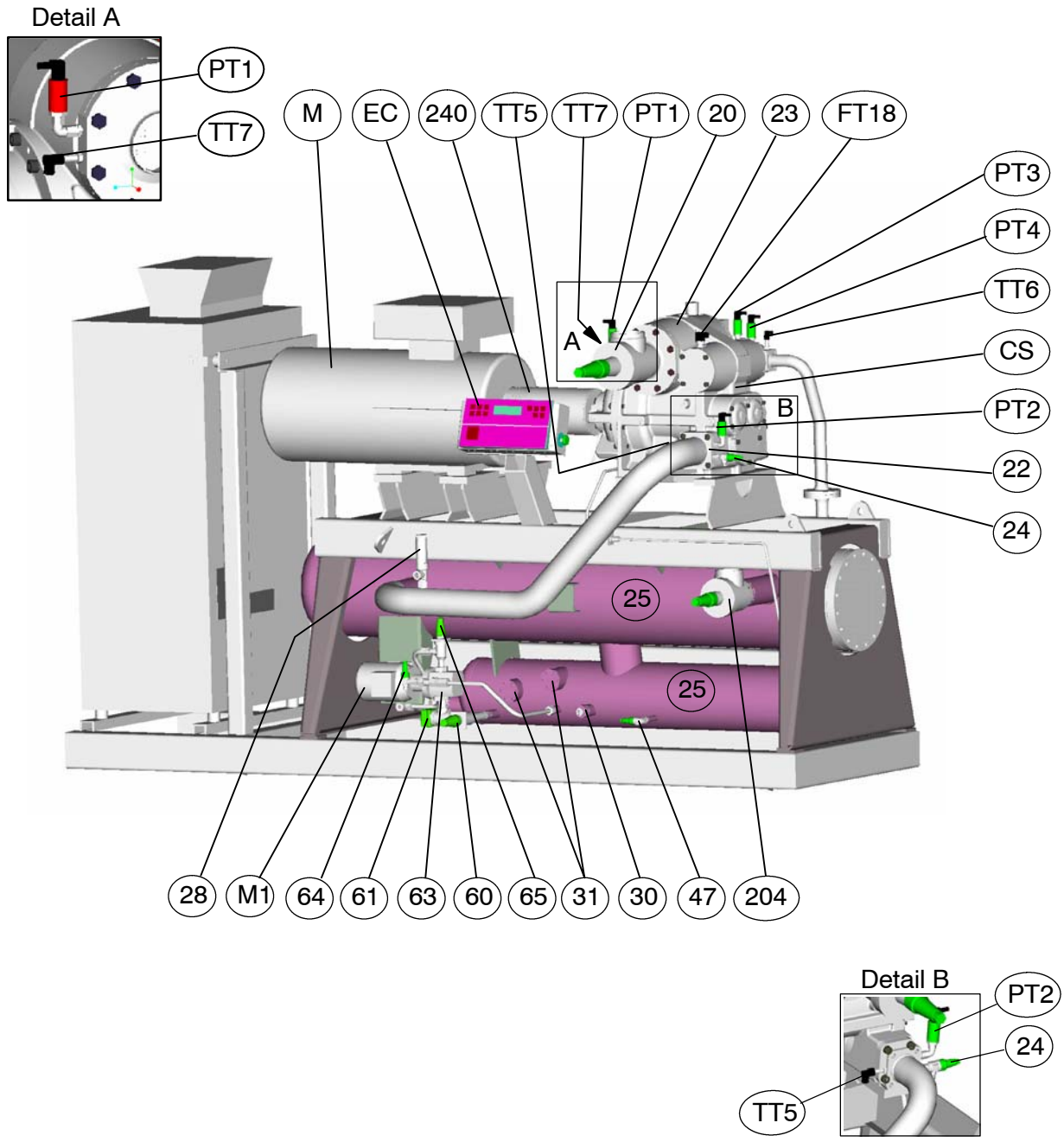


Fig. 4.39 Location of Components - Unit with OWSG Oil Cooler SAB 128R and SAB 163R

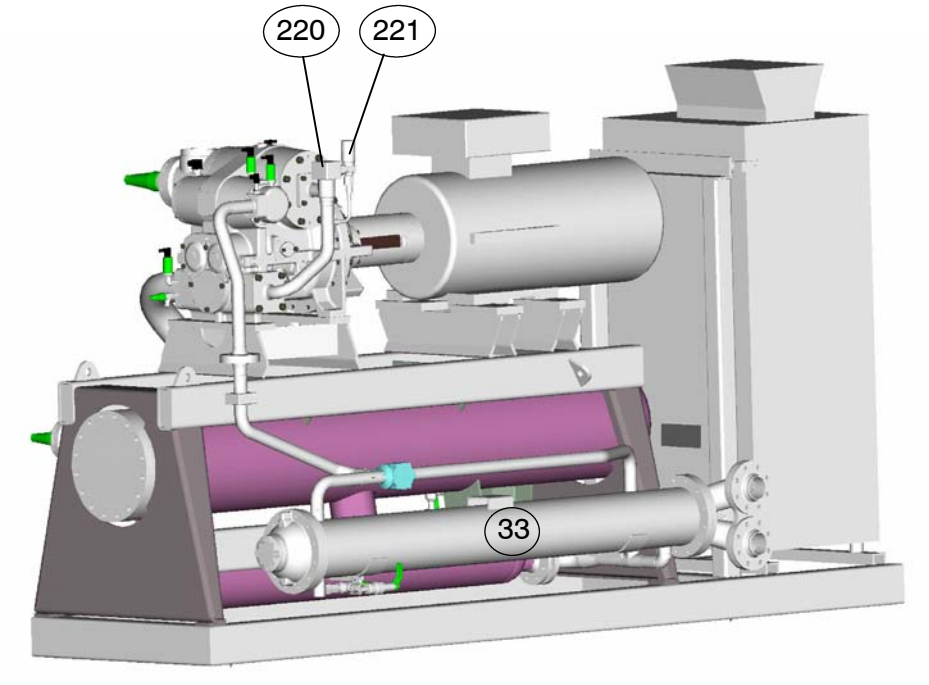
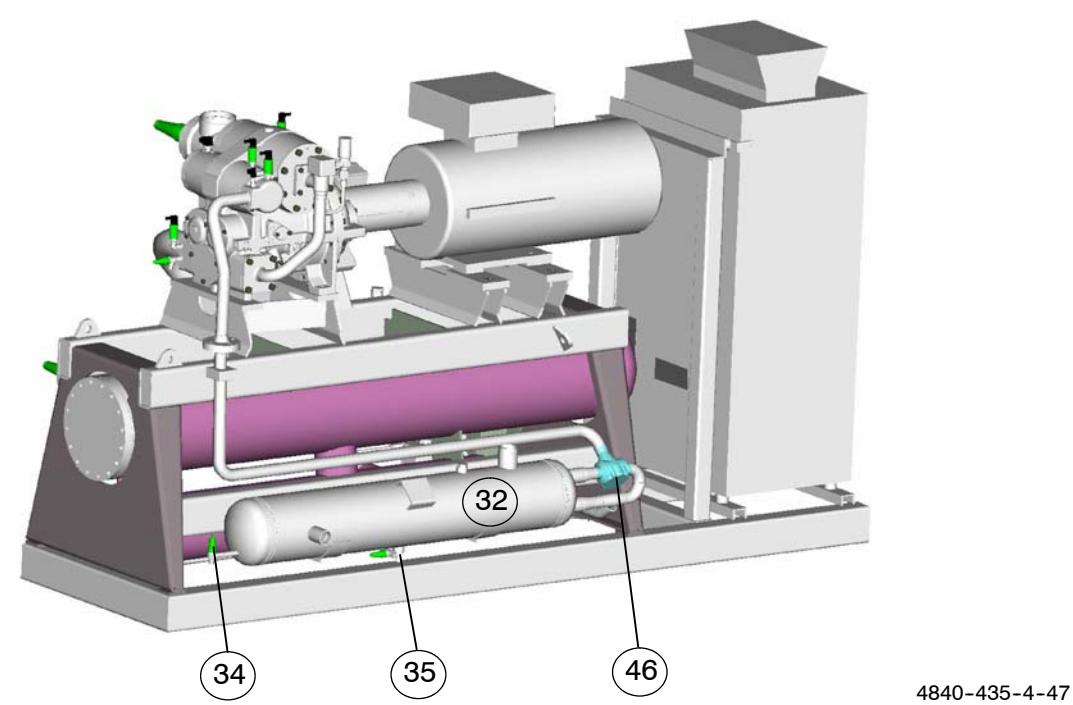


Fig. 4.40 Location of Components - Unit with OOSI Oil Cooler SAB 128R and SAB 163R



6. Technical Data

Table of Contents

Technical Data

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

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

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

This document was produced by:

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Denmark

Data for SAB 128R Compressor and Unit

Fig. 6.1 Unit with OWSG Oil Cooler

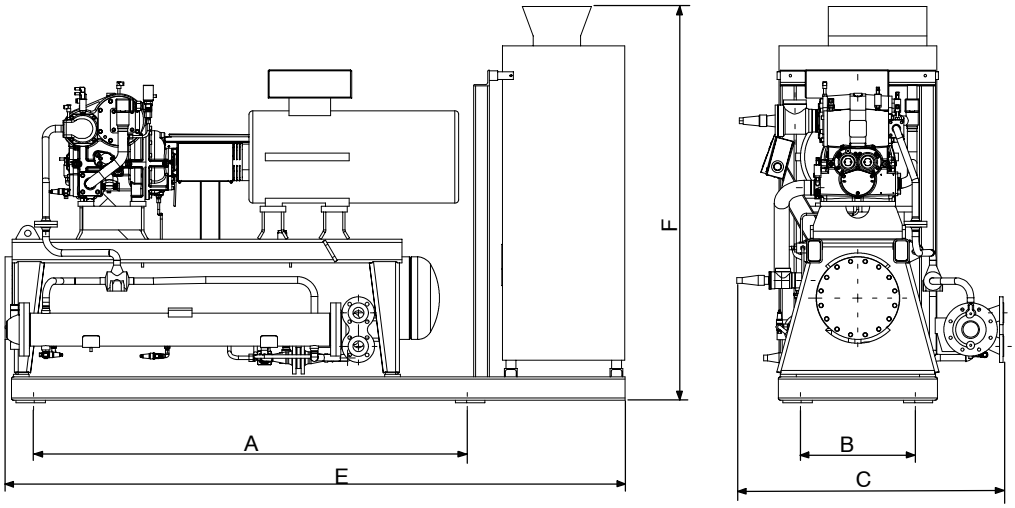

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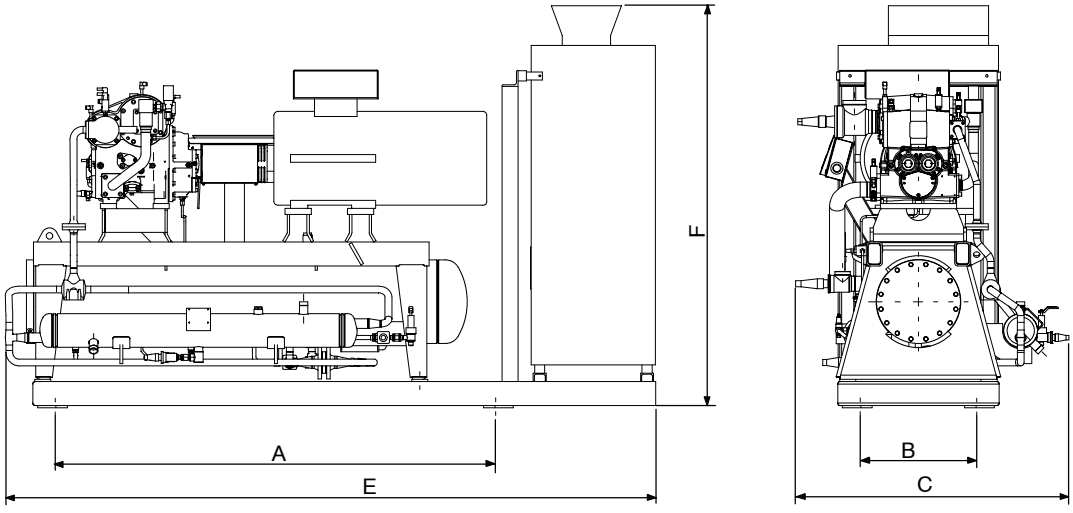
Fig. 6.2 Unit with OOSI Oil Cooler



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Data for SAB 163R Compressor and Unit

Fig. 6.3 Unit with OWSG Oil Cooler

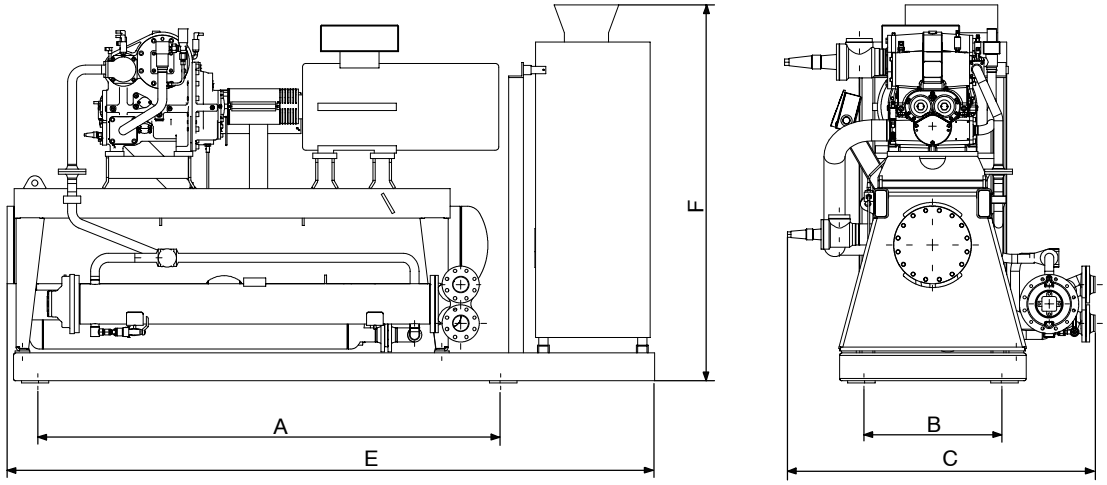

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Fig. 6.4 Unit with OOSI Oil Cooler

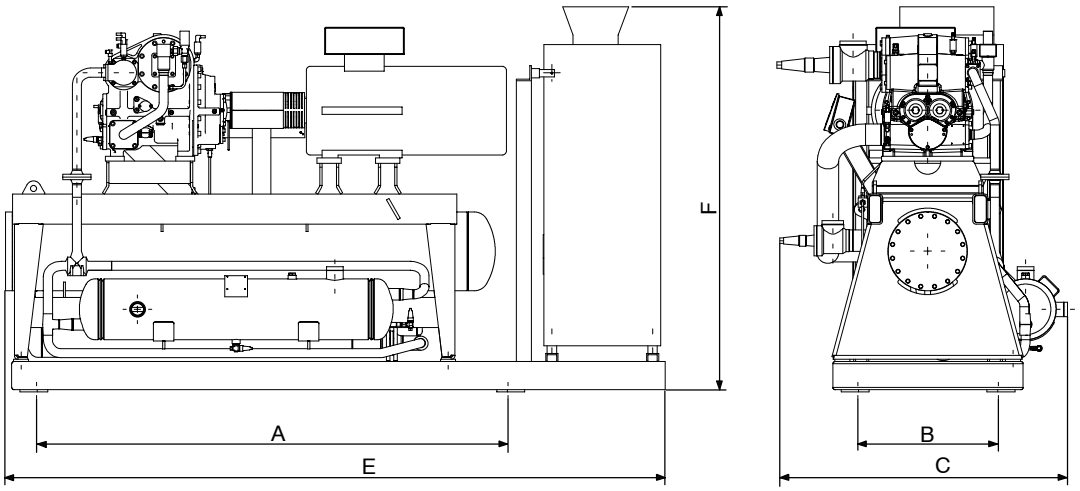

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Fig. 6.5 Table SAB 128R / SAB 163R

Compressor Type	Refrige-rant	Oil Cooling Sytem [1]	Dimensions					Max. Netto Weight kg [2]
			Width mm		Length mm		Height mm	
			B	C	A	E	F	
SAB 128R	R717	OWSG	575	1222	2140	3042	2062	2295
	R717	OOSI	575	1232	2140	3186	2062	2265
SAB 163R	R717	OWSG	640	1680	2507	3554	2527	2950
	R717	OOSI	640	1515	2507	3554	2527	2950

Fig. 6.6 Table SAB 128R / SAB 163R (US system)

Compressor Type	Refrige-rant	Oil Cooling Sytem [1]	Dimensions					Max. Netto Weight lbs [2]
			Width inch		Length inch		Height inch	
			B	C	A	E	F	
SAB 128R	R717	OWSG	23	48	84	120	81	5060
	R717	OOSI	23	49	84	125	81	4995
SAB 163R	R717	OWSG	25	66	99	140	99	6505
	R717	OOSI	25	60	99	140	99	6505

1) OWSG = Heat exchanger with shell (water)
OOSI = Heat exchanger with shell (refrigerant)
BLI = Refrigerant injection in discharge pipe

2) Excluding motor, oil and water

Fig. 6.7 Table SAB 128R / SAB 163R

Compressor Type	Rotor Drive	Internal Vol. Ratio V_i	Rotor Dia. mm	L/D 1)	P max. bar 2)	Motor at 1000 rpm Swept Volume m^3/h	Motor at 6000 rpm Swept Volume m^3/h
SAB 128R	MALE	2,0–4,5	127,5	1,7	20	103	615
SAB 163R	MALE	2,0–4,5	163,2	1,7	20	215	1292

Table SAB 128R / SAB 163R (US system)

Compressor Type	Rotor Drive	Internal Vol. Ratio V_i	Rotor Dia. mm	L/D 1)	P max. psi 2)	Motor at 1000 rpm Swept Volume cfm	Motor at 6000 rpm Swept Volume cfm
SAB 128R	MALE	2.0–4.5	127.5	1.7	290	61	362
SAB 163R	MALE	2.0–4.5	163.2	1.7	290	127	760

1) Rotor length L divided by rotor diameter D

2) Discharge pressure less suction pressure

See, however, permissible operating limits in the following diagrams.

Fig. 6.8 Block Weight and Center Height

	Block Weight		Center Height
	Kg	lb	mm
SAB 128R	290	639	200
SAB 163R	460	1014	245

Fig. 6.9 Weight (excluding motor, refrigerant, oil and water)

Oil Cooler Type	Kg		Basic Unit Kg		Compressor Block Kg		Total, Unit Kg	
	SAB 128	SAB 163	SAB 128	SAB 163	SAB 128	SAB 163	SAB 128	SAB 163
OOSI 1614	78	78					1008	1528
OOSI 2114	130	130					1060	1580
OOSI 2714	180	180					1110	1630
OOSI 3214		215						1665
OWSG 1615	120						1050	
OWSG 1619		130						1580
OWSG 2115	185		700	950	230	500	1115	
OWSG 2119	210	210					1140	1660
OWSG 2719		310						1760
OWSG 3219								

Fig. 6.10 Weight (excluding motor, refrigerant, oil and water) (US system)

Oil Cooler Type			Basic Unit lb		Compressor Block lb		Total, Unit lb	
	SAB 128	SAB 163	SAB 128	SAB 163	SAB 128	SAB 163	SAB 128	SAB 163
OOSI 1614	170	170					2225	3670
OOSI 2114	290	290					2335	3485
OOSI 2714	400	400					2450	3595
OOSI 3214		475						3450
OWSG 1615	265						2315	
OWSG 1619		290						3485
OWSG 2115	410		1545	4300	510	1105	2460	
OWSG 2119	465	465					2515	3660
OWSG 2719		685						3880
OWSG 3219								

Weight of Motor and Control Box with Frequency Converter

Fig. 6.11

Power kW	Motor Size	Weight of Motor and Control Box with Frequency Converter Kg	
	IEC	SAB 128	SAB 163
90	225	565	
110	225	570	
132	225	580	580
160	225	695	695
200	280	950	950
250	280	1155	1155
315	315		1650
400	315		1700

Fig. 6.12 (US system)

Power kW	Motor Size	Weight of Motor and Control Box with Frequency Converter lb	
	IEC	SAB 128	SAB 163
90	225	1245	
110	225	1255	
132	225	1280	1280
160	225	1530	1530
200	280	2095	2095
250	280	2545	2545
315	315		3640
400	315		3750

Shipping Volume (Excluding Motor)

Fig. 6.13

Oil Cooler Type		Compressor Type m^3	
		SAB 128	SAB 163
OOSI	2114	8	
OOSI	3214		11
OWSG	2115	9	
OWSG	2719		12

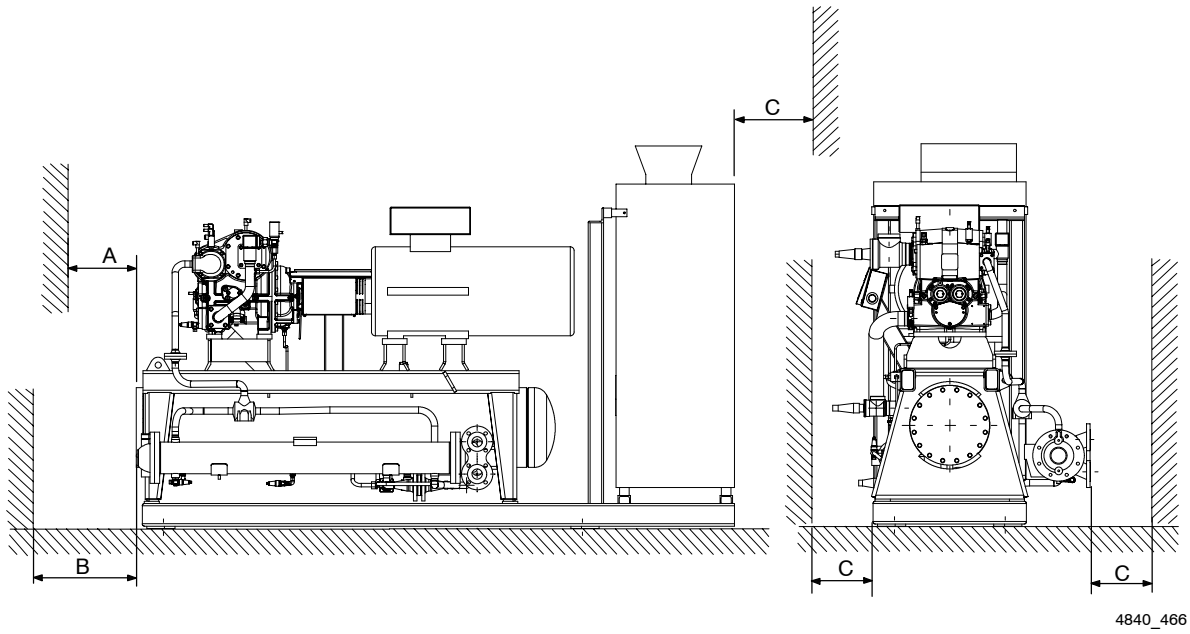
Fig. 6.14 (US system)

Oil Cooler Type		Compressor Type ft^3	
		SAB 128	SAB 163
OOSI	2114	285	
OOSI	3214		390
OWSG	2115	320	
OWSG	2719		425

Planning the Machine Room

When planning the machine room, it is important to make sure that there is enough space around the plant so that repairs and maintenance tasks can be carried out without problems. Fig. 6.15 shows the minimum spacing in millimetre.

Fig. 6.15



	SAB 128R	SAB 163R
A) Removal of fine oil separator element	600	800
B) Cleaning of oil cooler OWSG	1500	1900
C) Access to control box and pipe arrangement	1000	1000

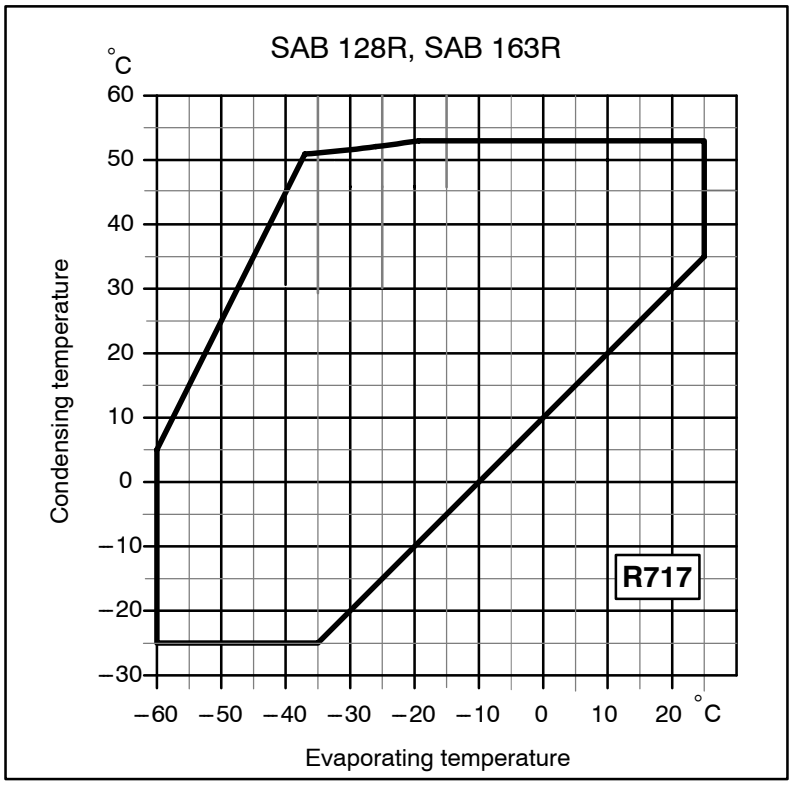
Operating Limits

The following diagram for R717 shows the operating limits within which the compressor is permitted to operate.

Please note the following:

- Use of economizer is permitted within the entire working range of the compressor.

Fig. 6.16 Operating Limits R717



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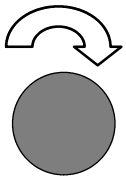
Direction of Rotation

The direction of rotation of the compressor is indicated by an arrow cast into the compressor cover as shown in the following sketch.

Fig. 6.17 Direction of rotation of compressor seen from A

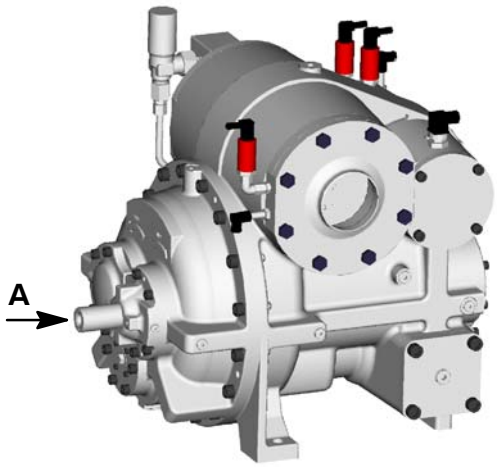


Seen towards shaft ends

Note:

The electromotor must only be connected to the compressor male rotor.

Fig. 6.18 Screw Compressor



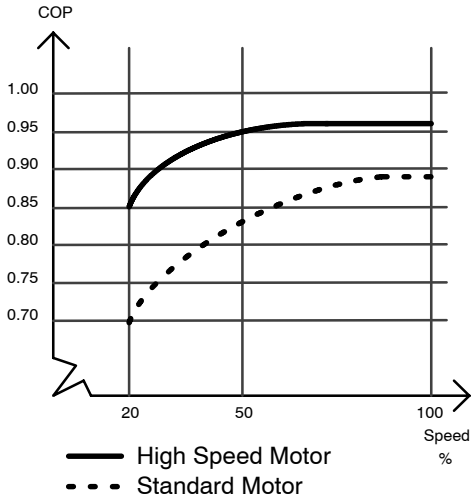
Electric Motor

The electric motor is a purpose-made high-speed motor with protection class IP23 (IP = Index of Protection).
By means of a frequency converter it is possible to adjust the number of revolutions from 1000 to 6000 rpm (17-100 Hz).

The motor is mounted on a fan.
The separately mounted fan lowers at the same time the noise level of the motor.

The design of the motor ensures a far better efficiency characteristic than that of a standard motor both at full load and part load, see Fig. 6.19.

Fig. 6.19



Efficiency of the new high-speed motors versus the relative speed n. compared with standard motors.

Finally, the motor has a power factor which is practically the same within the whole speed range Fig. 6.20. This combined with the high efficiency of the converter ensure low losses for the drive system. The reactive power is practically zero, resulting in a substantial cost reduction as expensive power factor compensation is not required.

Fig. 6.20

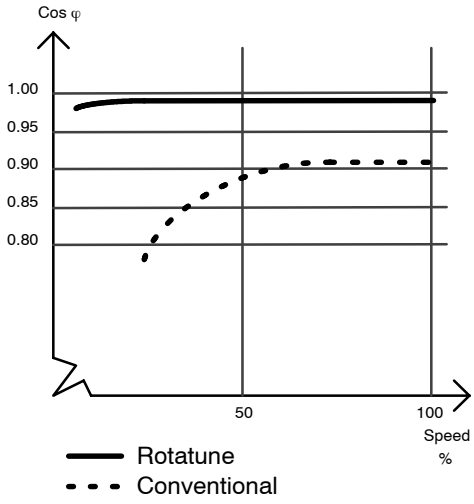


Fig. 6.20 shows the power factor as a function of the relative capacity of a conventional screw compressor and a compressor with the new frequency controlled drive. The power factor of the latter is almost 1, which shows that practically no reactive power is taken from the network.

Motor Dimension

The size of the motor is determined on the basis of the power requirements of the compressor under the current operating conditions calculated by means of the Sabroe COMP1 PC program. The motor effect can also be determined by using the tables Fig. 6.21 and Fig. 6.22 for SAB 128R and SAB 163R respectively.

The min. nominal effect of the motor is calculated as the power consumption at 6000 rpm multiplied with 1.05, thus ensuring that the motor is able to neutralise any variations in the refrigeration plant.

Fig. 6.21 Power Consumption SAB 128R N(CT,ET)

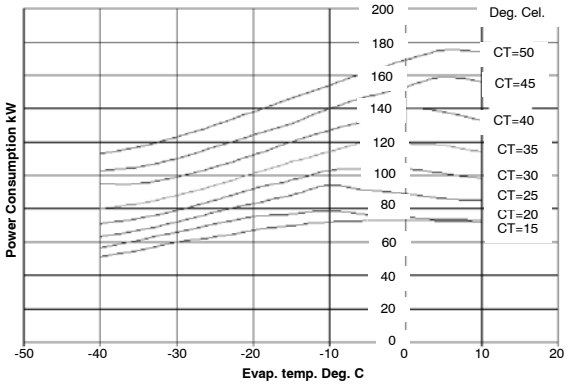
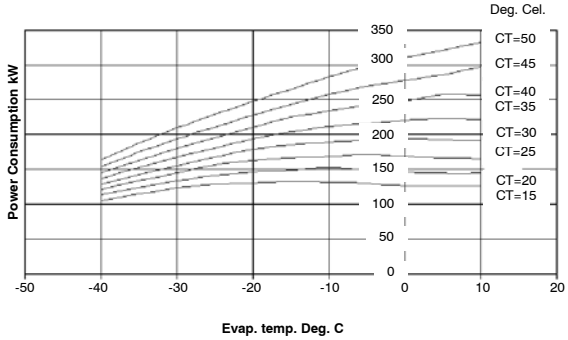


Fig. 6.22 Power Consumption SAB 163R N(CT,ET)



Note:

It is essential that the drive system is dimensioned for the worst possible situation.

As previously mentioned, it is possible to adjust the speed of the motor to max. 6000 rpm. For this purpose a frequency converter is used.

The converter allows soft starting and stopping with controlled acceleration and decelaration of the compressor

Fig. 6.23

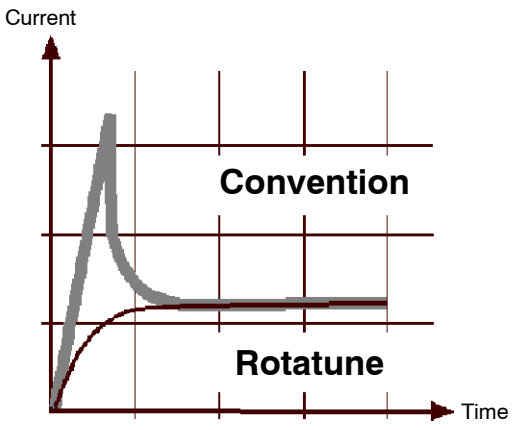


Fig. 6.23 shows motor current compared to time for a conventional screw compressor and a compressor with the new frequency controlled drive. As regards the rotatune compressor, soft start is obtained and no current peaks occur.

Handling of Compressor and Unit

The compressor is equipped with a threaded hole into which the lifting eye is fitted. As to the weight of the compressor, see table on *Compressor Data*.

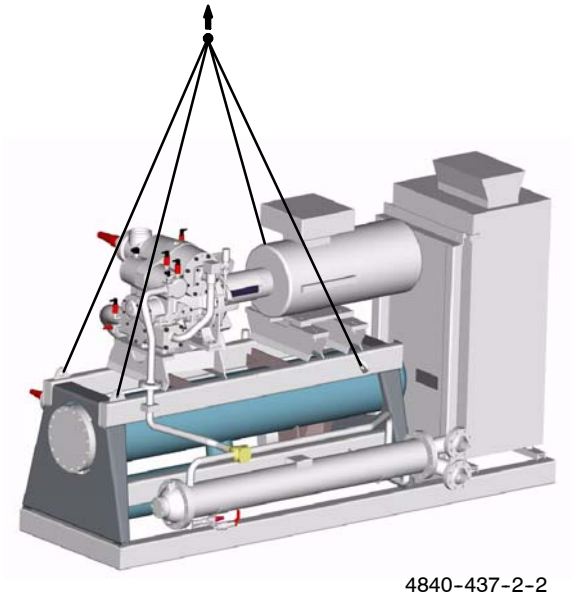
Note:

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

The **weight** of the unit is shown on the unit name plate.

When transporting and handling the compressor, care should be taken not to damage any of the components, piping or wiring connections.

Fig. 6.24



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Mounting of Series of 52 Coupling

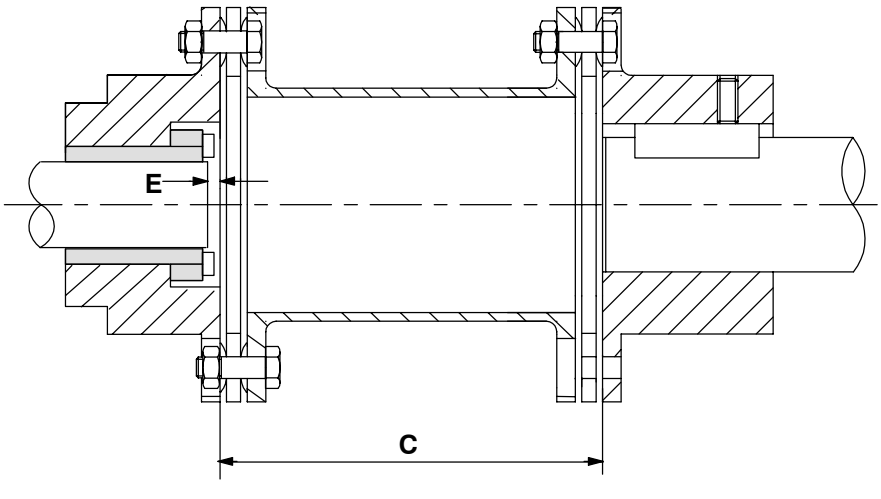
Series 52, Fig. 6.25, is a coupling of the flexible disc type which is torsionally stable, and as such does not cause any torsional fluctuations between motor and compressor.

The flexible discs and the intermediate section provide the coupling with the necessary radial and axial flexibility to absorb the minor radial and axial displacements between motor and compressor.

These displacements occur as a consequence of the heat and power impacts during operation.

Procedure for alignment of the coupling is described in detail in Section 7, Installation Instructions.

Fig. 6.25



Compressor Type	Coupling Type	Bolt Dimension Spanner	C mm	E mm
SAB 128R	225	1/2”	127±0.5	14±0.5
SAB 163R	262	9/16”		$10\ ^{+1.0}_{0}$

Laying of Unit Foundation

Standard units for stationary purposes have their foundations laid in one of the following two ways:

a: The unit is fixed directly on the concrete foundation.

b: The unit is mounted on vibration dampers.

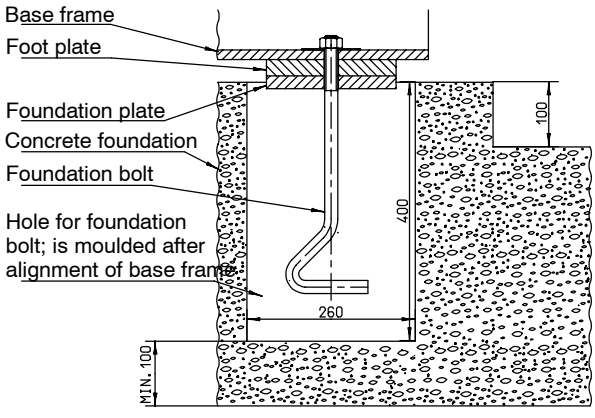
Both ways are described in the following.

a: Mounting directly on foundation

When installing a unit directly on a concrete foundation, the foundation should be cast in accordance with the foundation drawings dispatched.

In principle the foundation is designed as shown in Fig. 6.26.

Fig. 6.26 Foundation Sketch



All dimensions are in mm 245308

When the foundation has been cast with the holes set out (see foundation drawing) and has hardened, the unit is placed on wooden beams in a flush position. Adjust the height of the beams so that the foundation plate is slightly recessed into the foundation, see Fig. 6.26.

To make sure that the foundation plates are kept close to the base frame during the casting process, secure the foundation plates to the base frame by means of steel wire.

The concrete which is used for the foundation bolts must be dry, i.e. it must have a low water content. Stamp down the concrete around the bolts and the foundation plate.

It is important that the concrete has a low water content as this prevents the hardening concrete to shrink.

10-14 days should pass before tightening the foundation bolts. Remove the steel wire and the wooden beams beforehand and check that there is no air space between the foot plate of the base frame and the foundation plate. Otherwise, shims must be inserted between the plates before tightening them down.

As shown in Fig. 6.26 the foundation has been cast as part of the machine floor and – as indicated – it is 100 mm above the floor surface.

With this type of foundation vibrations can be transferred from the unit to the building.

However, the vibrations can be reduced by isolating the concrete foundation from the building as described in **section b** or by placing the unit on vibration dampers as described in **section c**.

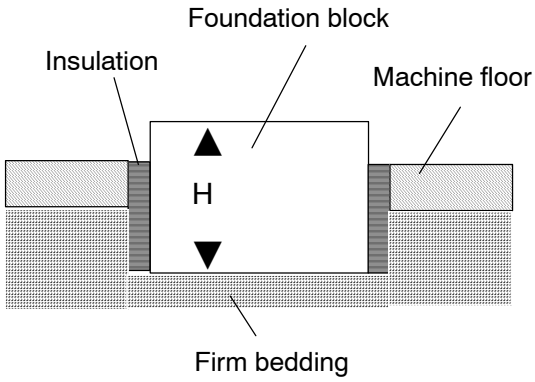
b: Isolating the unit foundation from the building

In order to avoid that vibrations from the unit are transferred to the building, the compres-

sor unit can be mounted directly on a foundation block that is isolated from the building

The foundation block is cast as an independent unit as shown in Fig. 6.27.

Fig. 6.27



This foundation block is cast directly on a **firm** and **supporting bedding** and is isolated from the machine floor by means of **approx. 20 mm thick plates made of either high density polystyrene or cork.**

If the bedding is part of the cast building construction, the foundation block can be cast on a vibration mat with a suitable bearing capacity. This should be taken into account by the supplier.

The dead weight **of the foundation block** must be in accordance with the weight of the unit. Consequently, the block is cast with an outer length and width as indicated in the foundation drawing accompanying the order.

The height **H** of the block must be **450 mm** for all units provided that concrete with a density of approx. 2.2 tonnes per m^3 is being used.

When mounting the compressor unit on top of the block, follow the description in **section a**. The general values for vibrations emitted from the unit are stated in the section *Sound Data*.

c: Mounting on vibration dampers

In view of reducing the transmission of vibrations from the compressor unit to the building, the unit is **often placed on vibration dampers**. In this way reductions can be obtained as indicated in the section *Sound Data.*

On delivery of a unit from Sabroe Refrigeration, the vibration dampers have not been mounted. They are included in the delivery and marked with a code.

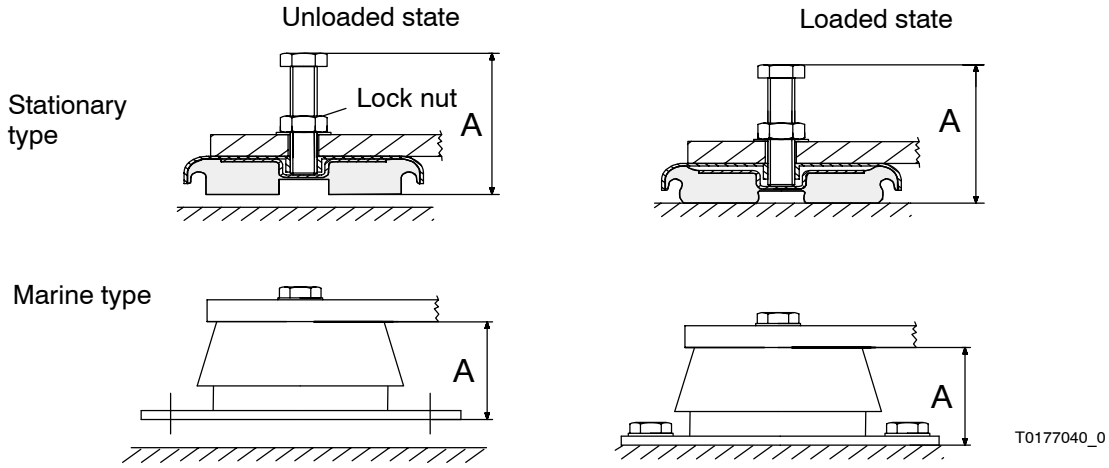
Similar codes are written in the drawing indicating the position of the vibration dampers, which will be forwarded for each specific order and which must only be used for that order.

It is very important that the vibration dampers are fitted correctly as shown in the drawing as the load on the foot plates varies.
Fig. 6.28 illustrates the different types of vibration dampers for stationary and marine units.

The vibration dampers for stationary units are made with a rubber surface underneath so that they can be positioned directly on the concrete foundation without having to be fixed, which means that pockets in the foundation are not required.

Further, vibration dampers for stationary use can be adjusted in height and thus equalize minor deviations that may occur in the level of the foundation. Vibration dampers for marine use, however, **cannot** be adjusted, which makes a level foundation even more important. **Read more about this in the following.**

Fig. 6.28



Stationary Plant

The machine room floor or foundation on which the unit is to be placed must have the necessary bearing strength. The floor must be plane within a **maximum of 5 mm** from the horizontal level so that the difference in height between the foundation plates does not exceed the scope for adjustment on the vibration dampers.

The vibration dampers are installed on the unit in their unloaded state while it is suspended from the crane; the unit is then placed in its final position. The unit is aligned with the aid of wedges placed close to the vibration dampers.

When the unit is horizontal, both longitudinally and laterally, the screws in the vibration dampers are tightened exactly enough to release the wedges.

The vibration dampers have been selected to compress between **1.0 and 2.0 mm** under the expected load calculated at the point of support in question.

To check that the vibration dampers are adjusted for the correct load, make a note of measurement “A” in the unloaded state for each individual damper. After loading of the vibration dampers, “A” should be reduced by 1 to 2 mm. When the adjustment is correct, tighten down the lock nut. The alignment of the unit against the foundation is now completed.

Marine Plant

As mentioned earlier the vibration dampers for marine use cannot be adjusted in height. This means that the foundation must be plane and horizontal within a **max. deviation of 2 mm**.

As the loads on the supporting surfaces of the unit vary, different vibrations dampers are used on the same unit. Consequently, it is important to position them in the right places in compliance with **the drawing forwarded for the unit in question**.

In order to check the deflection of the vibration dampers while loaded, measure ”A” (see Fig. 6.28) while the unit is still suspended in the crane. After the unit has been installed, measure ”A” once more. The difference (deflection) **must** be between 3 and 5 mm for all vibration dampers.

If this is not the case, liner plates must be inserted under the vibration dampers until the above deflection has been obtained.

As the vibration dampers for marine use also have to dampen the vibrations coming from the foundation caused by the main and auxiliary engine, vibration dampers are selected on the basis of the **information table** and the mentioned descriptions, etc. This table including appendices are sent to the person in charge at Sabroe Refrigeration, who will then select the appropriate dampers.

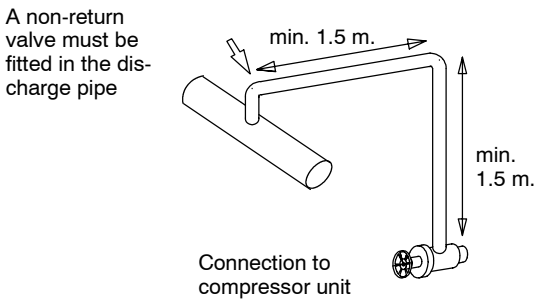
The Influence of Piping Connections on the Unit

To prevent transmission of stress in the piping connections between unit and plant, care must be taken that the pipes are positioned so as not to cause tensile or compressive stress during expansion or contraction due to temperature changes. Steel pipes will expand approx. 1 mm per metre per 100°C.

Thus, we recommend the pipe layout shown in Fig. 6.29 with a free length of min. 1.5 m in two directions which are at right angles to each other.

On some elevated point on the compressor unit discharge pipe, mount a non-return valve to prevent condensed refrigerant from returning to the oil separator.

Fig. 6.29



Test 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. The test pressure requirements can, however, be summarized into a number of standard pressure levels, which in practice meet the requirements set up, and which can therefore be approved by all the authorities involved.

The table, Fig. 6.30, 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.

When pressure testing compressors and vessels, components must first prove their strength by resisting the **test pressure** of the **strength test.** This test is carried out with air. Afterwards the **leak test** is carried out also with air at the prescribed pressure and with the component soaked in a water basin for 30 minutes.

Units consist of components which have been pressure tested as described in the table. This means that it is only necessary to leak test the unit. Dwelling time is 20 minutes. 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.

Fig. 6.30

Standard Test Pressure Levels					
Compressor Type	**Compressor Side**	**Strength Testing**		**Leak Testing with Pressurized Air**	
		bar	**[psi]**	**bar**	**[psi]**
CMO SMC 100 SMC 180	High pressure side	42	[609]	25	[363]
	Low pressure side	27	[392]	14	[203]
TCMO TSMC	High pressure side	42	[609]	25	[363]
	Low pressure side	27	[392]	14	[203]
	Intermediate pressure side	42	[609]	25	[363]
HPO HPC	High pressure side	80	[1160]	40	[580]
	Low pressure side	45	[653]	22	[319]
SAB 110 SAB 128 SAB 163 SAB 202	The entire compressor block	42	[609]	21	[305]
SAB 283L/E SAB 355 L		39	[566]	26	[377]
Compressor Unit	All types The entire unit			7	[102]
Vessels in general	Individual pressure testing in accordance with local rules and regulations. Consequently, no table can be set up.				

Oil Charging

Oil charging is carried out by means of a portable oil charging pump, see Fig. 6.31.

Oil charging is carried out in the following way: The high-pressure hose pos. 7, see Fig. 6.31, is connected to the charge valve pos. 24 on the unit via the non-return valve pos. 12 and the correct reduction nipple. See also Fig. 6.32. The free end of the suction hose from the pump pos. 1 is positioned together with the by-pass hose pos. 2 in the oil barrel. The ball valve pos. 9 and the charge valve pos. 24 will open whereupon the pump pos. 5 will start. The oil will now circulate until the system is free from air bubbles whereupon the ball valve pos. 9 will close. The oil will now be charged to the unit.

When the desired amount of oil has been charged, the pump will stop and the charge valve pos. 24 close. Open the ball valve pos. 9 carefully so that the pressure is equalized. The hoses can now be dismounted. Loosen the non-return valve carefully so that the remaining pressure is equalized. Remember to mount the cap nut on the charge valve and to seal the oil barrel if there is any oil left.

Fig. 6.31

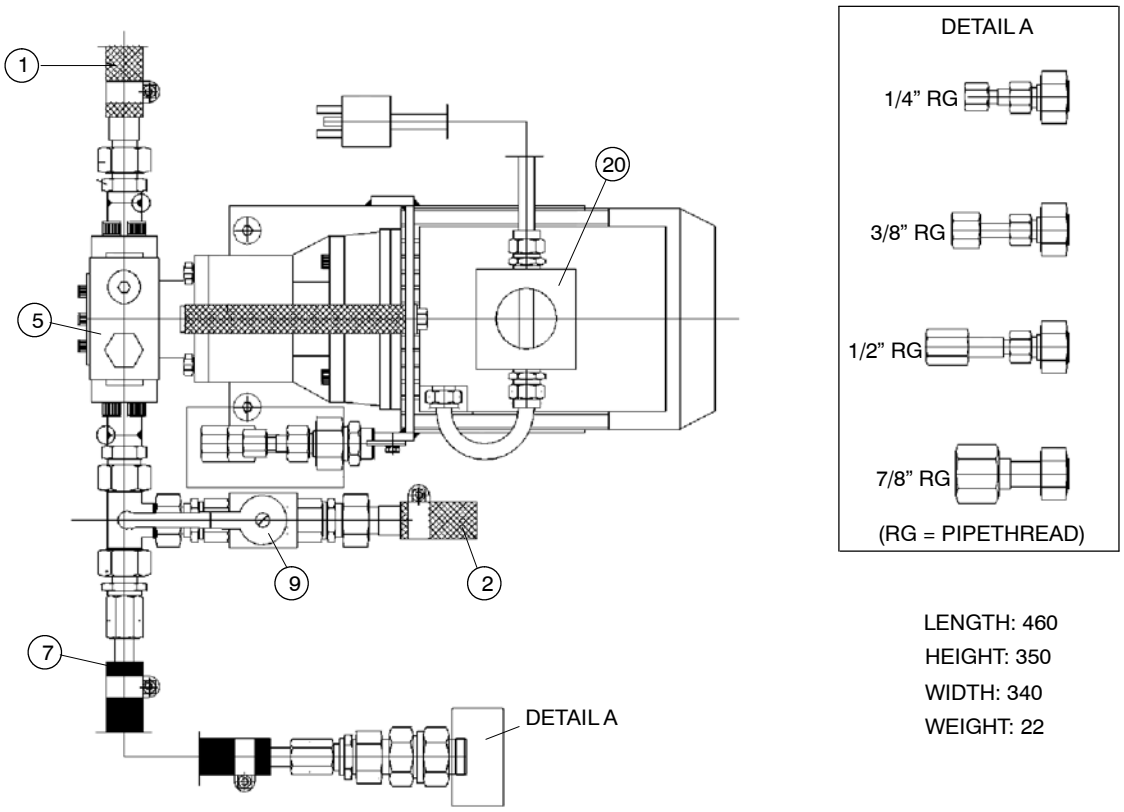
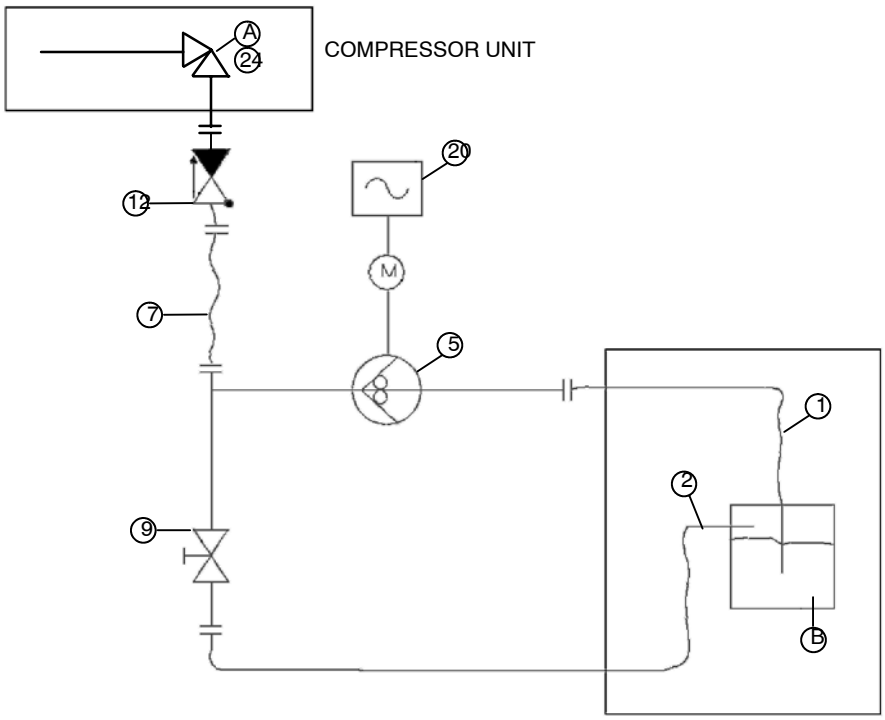


Fig. 6.32 Piping Diagram for Oil Charging



Oil Charge SAB 128R and 163R

Charging the unit with oil is carried out by means of a portable oil charging pump. See description in this section – *Oil Charging*. Fig. 6.33 shows all oil charges.

Fig. 6.33 Oil Charge (Oil level at the middle of upper sight glass during operation)

Oil Cooler Type	Litres		Oil Separator Litres		Compr. Pipes Litres		Total, Unit Litres	
	SAB 128	SAB 163	SAB 128	SAB 163	SAB 128	SAB 163	SAB 128	SAB 163
OOSI 1614	11	11	60	80	9	12	80	103
OOSI 2114	20	20					89	112
OOSI 2714		31						123
OOSI 3214		48						140
OWSG 1615	20		60	80	9	12	89	
OWSG 1619		25						117
OWSG 2115	31						100	
OWSG 2119		39						131
OWSG 2719		63						155

Oil Charge (US gal)

Oil Cooler Type	US gal		Oil Separator US gal		Compr. Pipes US gal		Total, Unit US gal	
	SAB 128	SAB 163	SAB 128	SAB 163	SAB 128	SAB 163	SAB 128	SAB 163
OOSI 1614	2.9	2.9					21.1	27.2
OOSI 2114	5.3	5.3					23.5	29.6
OOSI 2714		6.2						32.5
OOSI 3214		12.7						37.0
OWSG 1615	6.6		15.8	21.1	2.4	3.2	23.0	
OWSG 1619		6.6						30.7
OWSG 2115	10.3						25.6	
OWSG 2119		10.3						34.6
OWSG 2719		16.6						40.9

Comment: Be sure always to have approx 25% extra oil available to refill at first start-up.

Noise from Compressors and Units

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

Over the years Sabroe Refrigeration has been aware of this problem. Consequently, we have designed the compressors and units with a view to meeting market demands as regards maximum noise levels.

Of course, modern compressor units are loud and must be expected to issue noise. This makes it extremely important that the sound data stated for a compressor or unit is evaluated correctly.

The above issue will be discussed in the following. In this connection we would like to point out that at a failrly 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.

Sound data for compressor units

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

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

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

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

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

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

Dimension tolerances are :

1 ±3 dB for SAB, SV and FV screw compressors
±5 dB for SAB 283 L/E and SAB 355 L screw compressors

As to the **reciprocating compressors** the values are stated for the compressor block only. The dimensional values are stated for 100% capacity.

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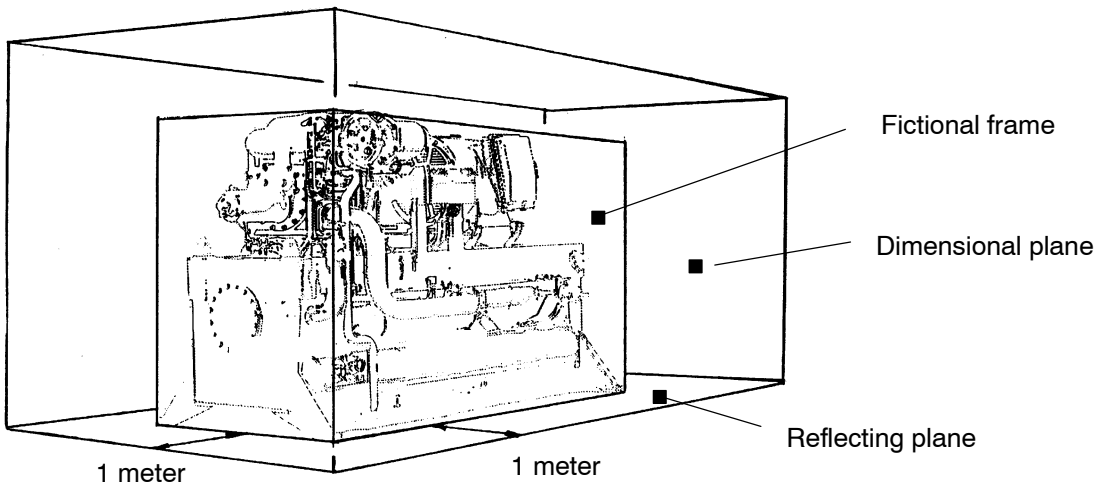
Fig. 6.34



Note the following, however:

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

Tables for Noise Data

The following tables show the operating conditions of the compressor during the noise measurements as well as the applied refrigerant.

Screw compressors

Evaporating temperature = -15°C
Condensing temperature = +35°C
Refrigerant = R22/R717
Number of revolutions = **2950 rpm.**
***Number of revolutions = **6000 rpm.**

	Compressor block	LW	LP
Mk1	SAB 110 SM	98	81
	SAB 110 SF	98	81
	SAB 110 LM	98	81
	SAB 110 LF	98	81
Mk 2	SAB 110 SM		
	SAB 110 SF		
	SAB 110 LM		
	SAB 110 LF		
	SAB 110 LR		
	SAB 110 SR		
Mk 3	SAB 128 M	100	82
	SAB 128 F	104	86
	SAB 128 R*	104	86
Mk 4	SAB 128 M		
	SAB 128 F		
	SAB 128 R*		
Mk3	SAB 163 M	103	85
	SAB 163 F	105	87
	SAB 163 R*	105	87
Mk 4	SAB 163 M		
	SAB 163 F		
	SAB 163 R*		

Compressor block	LW	LP
SAB 202 SM	105	86
SAB 202 SF	106	87
SAB 202 LM	105	86
SAB 202 LF	107	88
SAB 283 L	107	87
SAB 283 E	108	88
SAB 355 L	109	89
SAB 81	103	84
SAB 83	104	85
SAB 85	105	86
SV 87	106	86
SV 89	108	87

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

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

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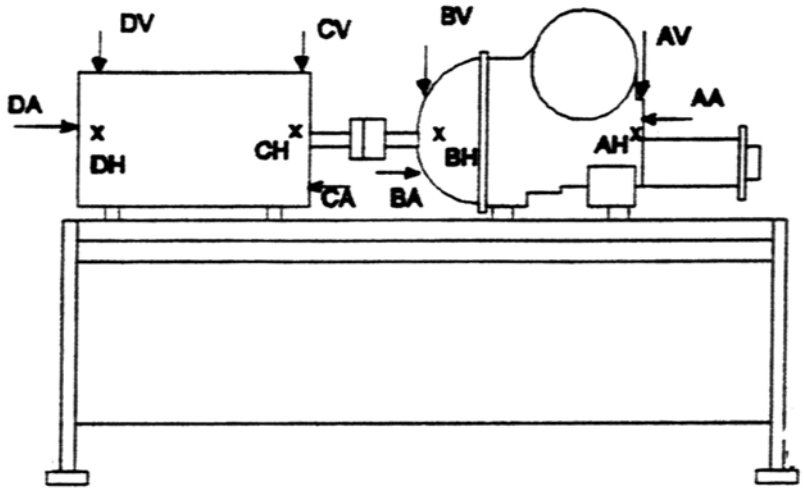
Vibration Data for Compressors - All Compressor Types

Vibration data for Sabroe Refrigeration's Sabroe **reciprocating** compressors complies 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 complies 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).



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Pay attention to the following, however:

- Motors comply with EN 60034-14 (CEI/ IEC 34-14) Class N.
- When placing the unit on vibration dampers supplied by Sabroe Refrigeration (additional), the vibrations against the foundation are reduced by:
  - 85-95% for screw compressor units
  - 80% for recip. compressor units
- However, a higher vibration level may occur if:
  - motor and compressor have not been aligned as described in the Instruction Manual**.**
  - the compressor runs at a wrong 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 with the order.

Assessing the Oil

Oil in refrigeration plants is a vital part of the compressor, as it not only lubricates and cools the movable parts of the compressor, it also prevents abrasive particles from entering the bearings.

An analysis of the oil can give important information on how the compressor is running. We would, therefore, advise that the **oil analyses** be carried out at the intervals prescribed.

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

Visual Assessment

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

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

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

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

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

Analytical Evaluation

Naturally, the oil sample can be analysed by the oil company which supplies the oil.
As a **special offer to our customers** Sabroe Refrigeration has developed an analytical concept, 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 you will be able to follow up on the state of both the oil and the compressor from one analysis to the next.

Procedure

- A form set with a plastic sampling bottle and a dispatching envelope can be requested from the local Sabroe Refrigeration 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.
  Do not fill the bottle completely.

- Please follow the *Sampling and Shipping Instructions* enclosed in the form set in which the address 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, you should be on the alert whenever the results of the analyses approach these values. In some cases the water content of 100 ppm in HCFC plants may be too much and thus lead to Cu-plating in the shaft seal.

Limiting Values

Parameter	Unit	Method	Sabroe Oil PAO 68			Sabroe Oil AP 68			Sabroe Oil A 100		
			Target Spec.	Max	Min	Target Spec.	Max	Min	Target 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	-
Appearance	-	-		report			report			report	
Colour	-	ASTM D 1500		report			report			report	
Pentane Insolubles (Sum)	W%	MM 490	-	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 concludes:

- Whether the oil can still be used – without taking any further action.
- Whether the oil can be used after it has been filtered through a very fine filter. If this is necessary, the oil must be pumped directly from the compressor unit through a 3 micron filter and back to the unit. The system must be completely closed, to prevent the oil being affected by moisture in the air.
- Whether the oil is no longer fit for use.

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

Selecting Lubricating Oil for SABROE Screw 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:

a: The oil changes viscosity within a few operating hours.
b: 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.

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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.

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
  - Oil temperature before injection into compressor, but after oil cooler
  - Max. permitted oil temperature = set point for alarm.
  - Min. permitted oil temperature = set point for alarm.
  - Condensing pressure
  - Evaporating pressure
- The viscosity of the oil in the compressor during operation:
  - Solubility of refrigerant in the oil
  - Operating temperatures
  - Vapour pressure in the oil reservoir
  - Discharge pressure and gas temperature
  - 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:

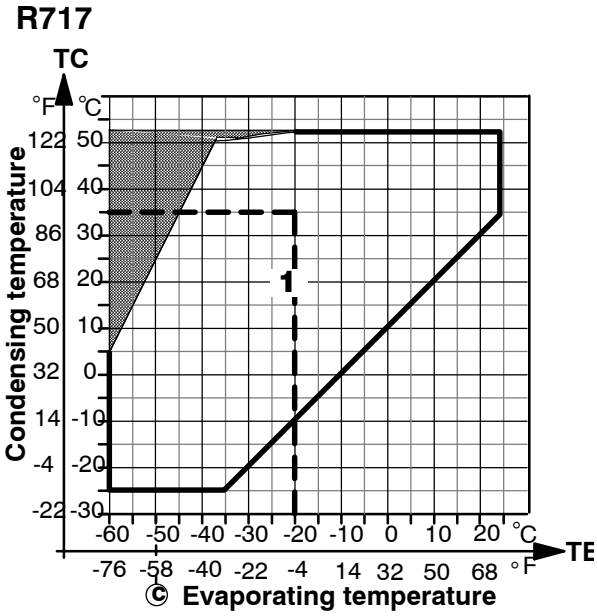
To find the correct **code number,** select refrigerant and compressor type in the *oil recommendation diagram.* Then insert the estimated operating conditions in the diagram.

Example (screw compressors):

Refrigerant:	**R717**
Condensing temperature:	**TC +35 °C**
Evaporating temperature:	**TE -20 °C**

Please observe !

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.



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.

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 other oil brands than the ones recommended by Sabroe Refrigeration, please contact the oil supplier to select the correct oil type.							
E5								
E9								
E11								

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	M 1 (M68)	1231-264	1231-296
Sabroe Oil A100	A 3 (A100)	1231-263	1231-262
Sabroe Oil AP68	AP 1 (AP68)	1231-257	1231-260
Sabroe Oil PAO68	PAO 3 (P68)	1231-256	1231-259
Mobil Gargoyle Arctic SHC 228	PAO 5 (P100)	1231-282	1231-283
Mobil Gargoyle Arctic SHC 230	PAO 9 (P220)	1231-284	1231-285
Mobil EAL Arctic 68	E 3 (E68)	1231-272	1231-273
Mobil EAL Arctic 100	E 5 (E100)	1231-274	1231-275
Mobil EAL Arctic 220	E 9 (E220)		1231-279
Sabroe H oil	E11 (E370)	3914 1512 954 [1)]	9415 0008 000

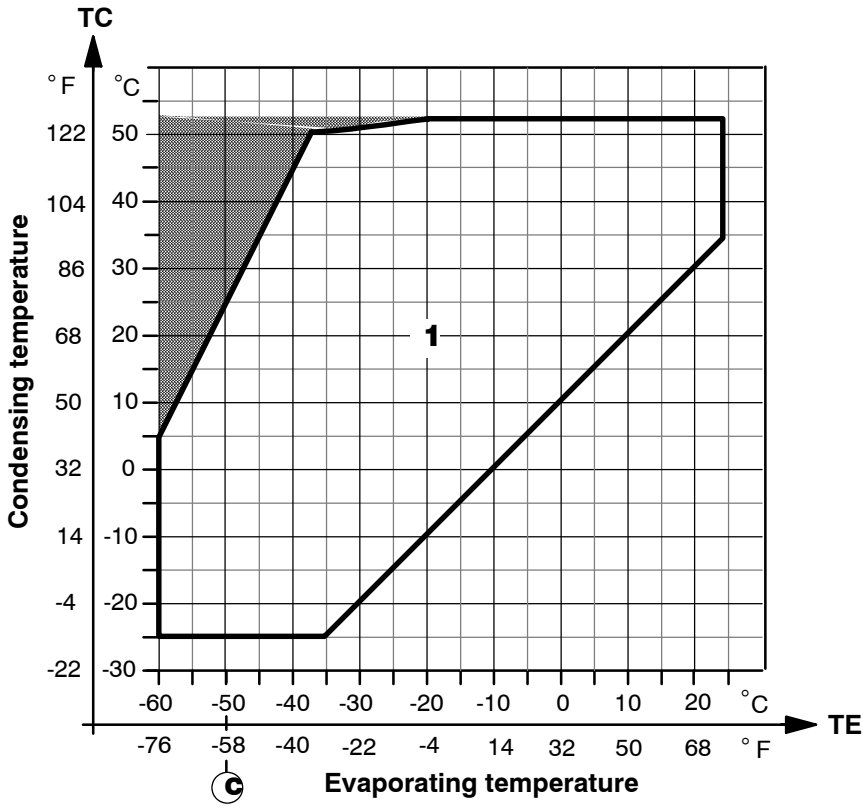
[1)] 18.9 litre pail (5 US gallons)

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

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

R717

screw compressors



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

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

HLI: Calculation must be performed using COMP1.

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

☆ : In case you wish to change from mineral oil.

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

▒ : Calculation must be performed using COMP1.

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

Selecting Lubricating Oil for SABROE Screw Compressors
Refrigerant: HFC/HCFC

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:

a: The oil changes viscosity within a few operating hours.
b: 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.

01.06
0170-156-EN

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.

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 order-

ing, 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
  - Oil temperature before injection into compressor, but after oil cooler
  - Max. permitted oil temperature = set point for alarm.
  - Min. permitted oil temperature = set point for alarm.
  - Condensing pressure
  - Evaporating pressure
- The viscosity of the oil in the compressor during operation and under the influence of:
  - Solubility of refrigerant in the oil
  - Operating temperatures
  - Vapour pressure in the oil reservoir
  - Discharge pressure and gas temperature
  - 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.

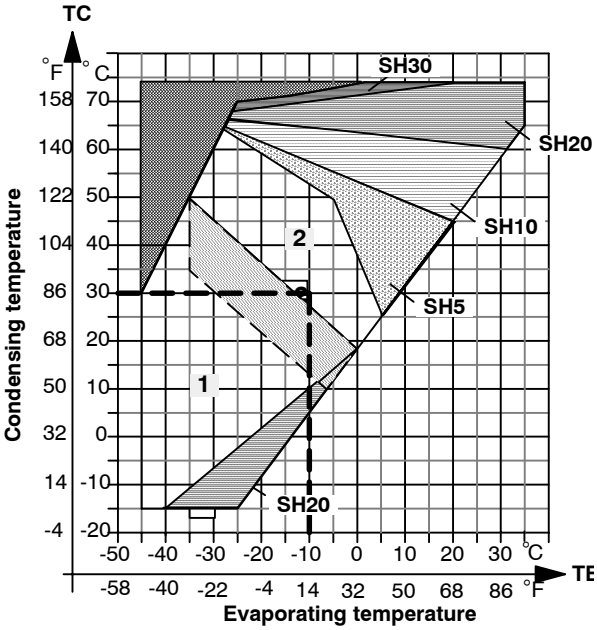
Example (screw compressors):

Refrigerant:	**R134a**
Condensing temperature:	**TC +35°C**
Evaporating temperature:	**TE -3°C**

Please observe !

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 2. If TE should change, e.g. from -10°C to -30°C, oil area 1 should be used. Since -30°C is within the marked area, oil area 2 can, however, also be used at this TE.

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 the **code number** E9 can be used.

Code no.	Area no. (See note)	
	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 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 other oil brands than the ones recommended by Sabroe Refrigeration, please contact the oil supplier to select the correct oil type.							
E5								
E9								
E11								

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	M 1 (M68)	1231-264	1231-296
Sabroe Oil A100	A 3 (A100)	1231-263	1231-262
Sabroe Oil AP68	AP 1 (AP68)	1231-257	1231-260
Sabroe Oil PAO68	PAO 3 (P68)	1231-256	1231-259
Mobil Gargoyle Arctic SHC 228	PAO 5 (P100)	1231-282	1231-283
Mobil Gargoyle Arctic SHC 230	PAO 9 (P220)	1231-284	1231-285
Mobil EAL Arctic 68	E 3 (E68)	1231-272	1231-273
Mobil EAL Arctic 100	E 5 (E100)	1231-274	1231-275
Mobil EAL Arctic 220	E 9 (E220)		1231-279
Sabroe H oil	E11 (E370)	3914 1512 954 [1)]	9415 0008 000

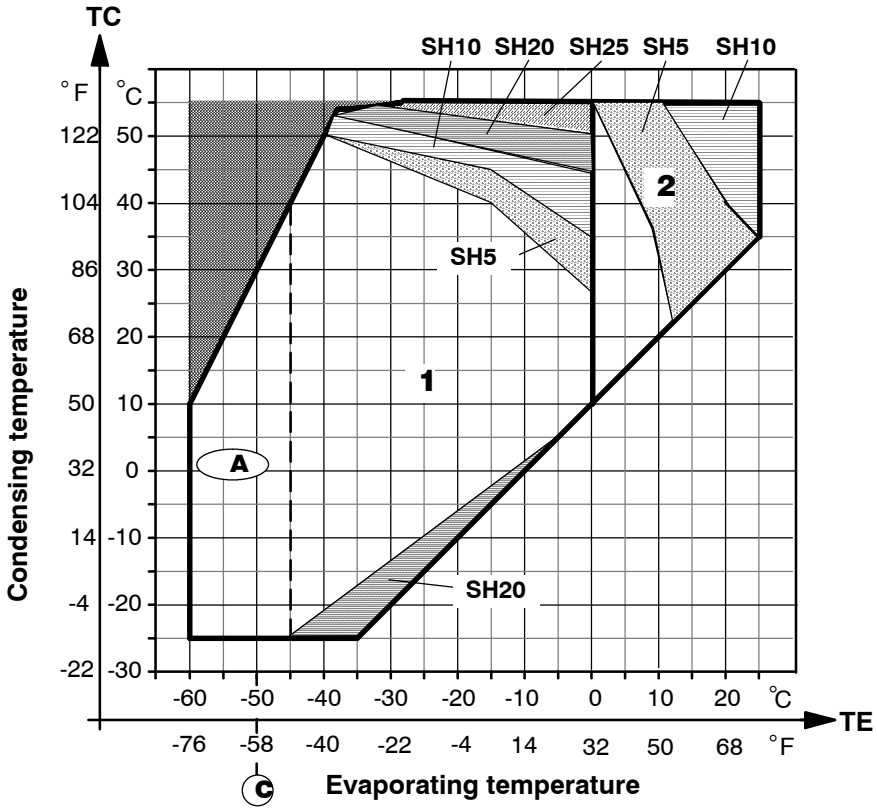
[1)] 18.9 litre pail (5 US gallons)

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

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

R22

screw compressors with journal bearings or roller bearings



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

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

HLI: Calculation must be performed using COMP1.

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

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

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

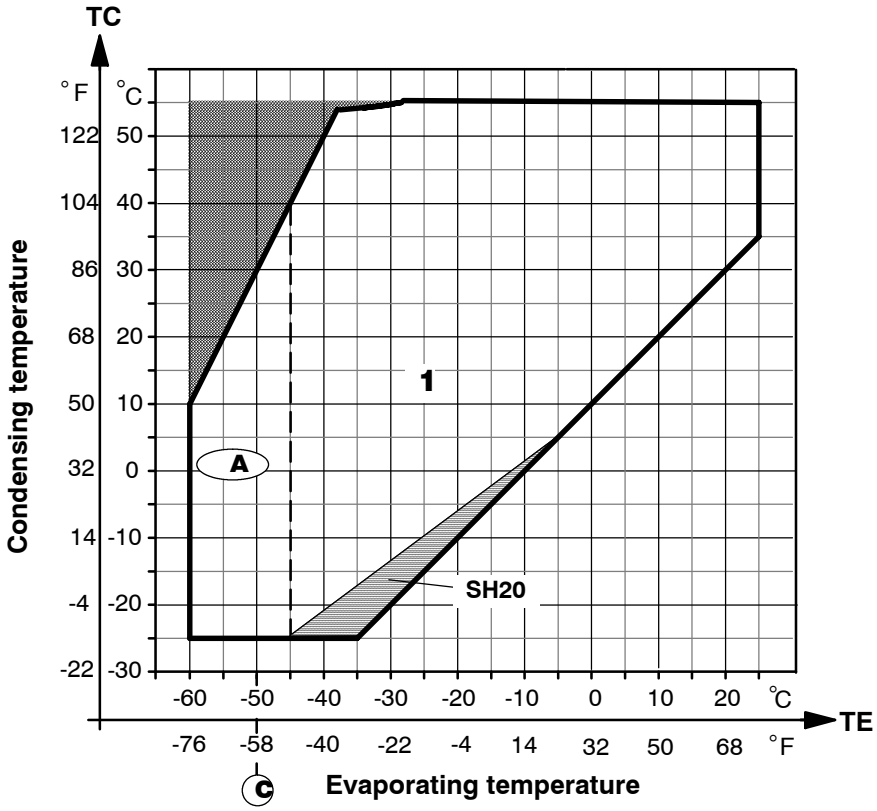
* : Dry expansion systems only. Flooded systems to be considered individually: contact Sabroe Refrigeration

SH : Suction gas superheat, K (Kelvin)

▒ : Calculation must be performed using COMP1

R22

screw compressors with roller bearings only



Code no.	Area no. 1
A 3	▲

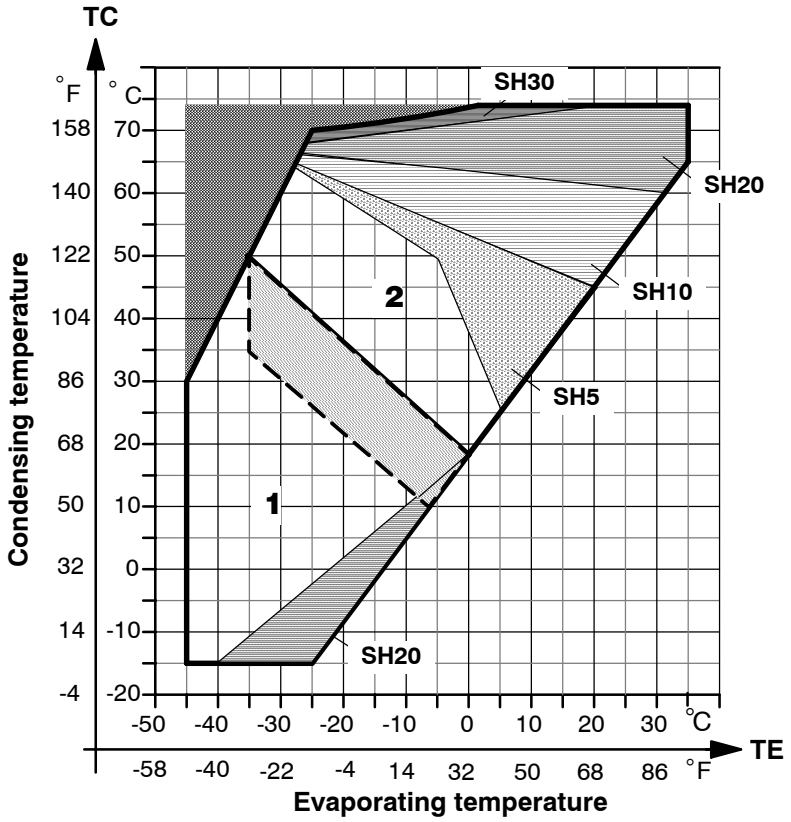
Using the calculating programme COMP1 it is possible to optimize the requirement for suction superheat values (SH) as stated in the diagram. See *Oil types and oil companies* in this section. Due to the ongoing development of lubrication oils, please contact Sabroe Refrigeration for an update on the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

HLI: Calculation must be performed using COMP1.

▲ : In case of a new plant. Very suitable.
Ⓐ : Max oil concentration in liquid phase at: T_E: 2% W
Ⓒ : Min suction temperature -50°C: at 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)
▒ : Calculation must be performed using COMP1

R134a

screw compressors



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

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

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

HLI: Calculation must be performed using COMP1.

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

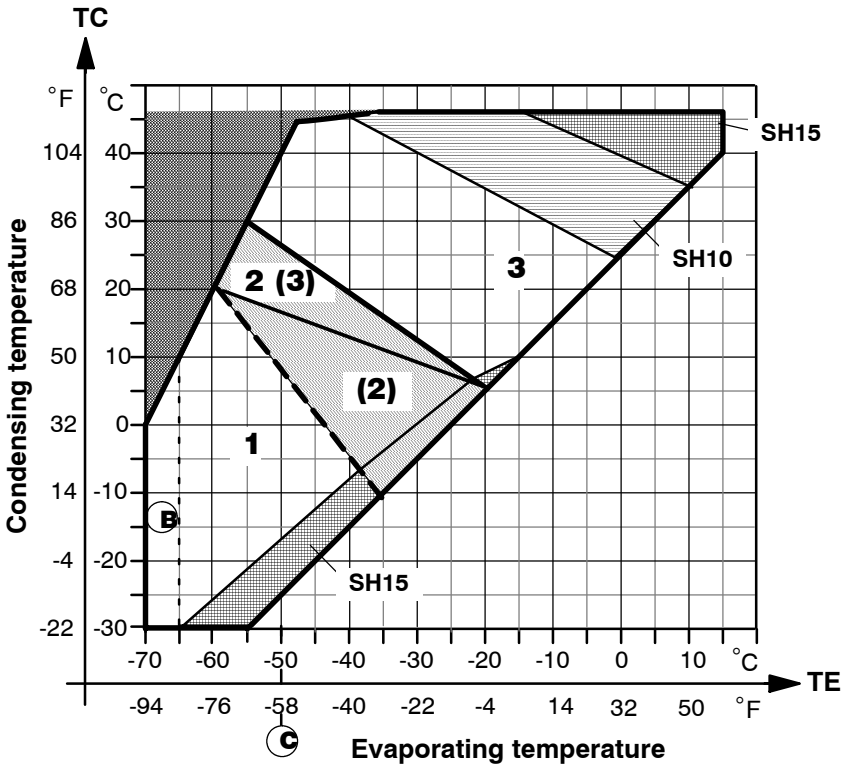
SH : Suction gas superheat, K (Kelvin)

: Zone in which both oils are useable

: Calculation must be performed using COMP1

R404A

screw compressors



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

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

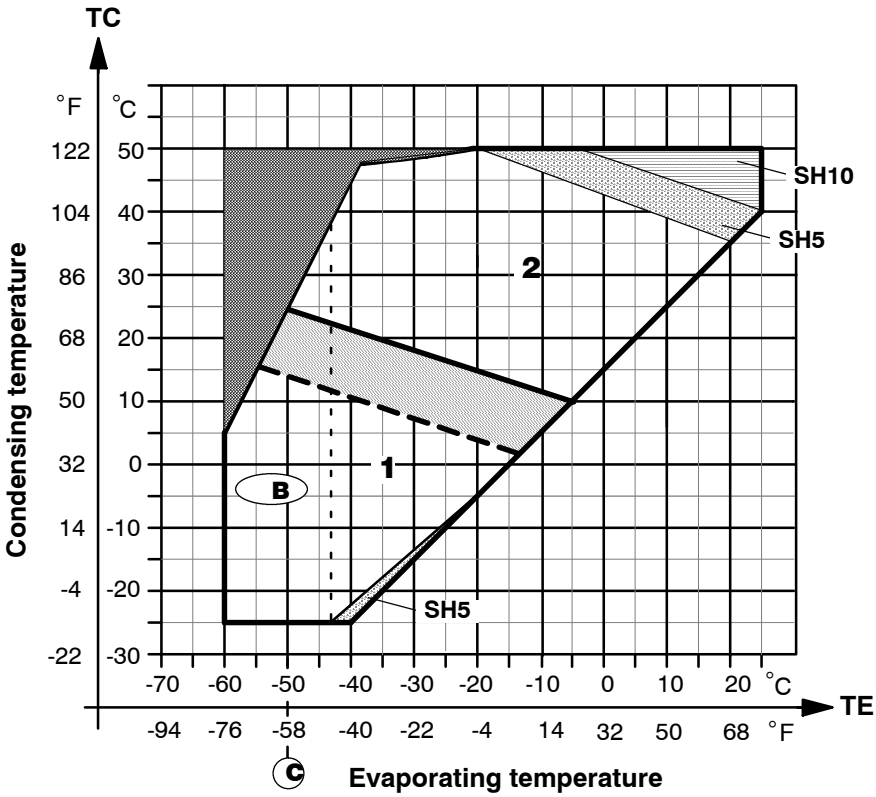
Using the calculating programme COMP1 it is possible to optimize the requirement for suction superheat values (SH) as stated in the diagram. See *Oil types and oil companies* in this section. Due to the ongoing development of lubrication oils, please contact Sabroe Refrigeration for an update on the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

HLI: Calculation must be performed using COMP1.

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

R407C

screw compressors



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

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

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

HLI: Calculation must be performed using COMP1.

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

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

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

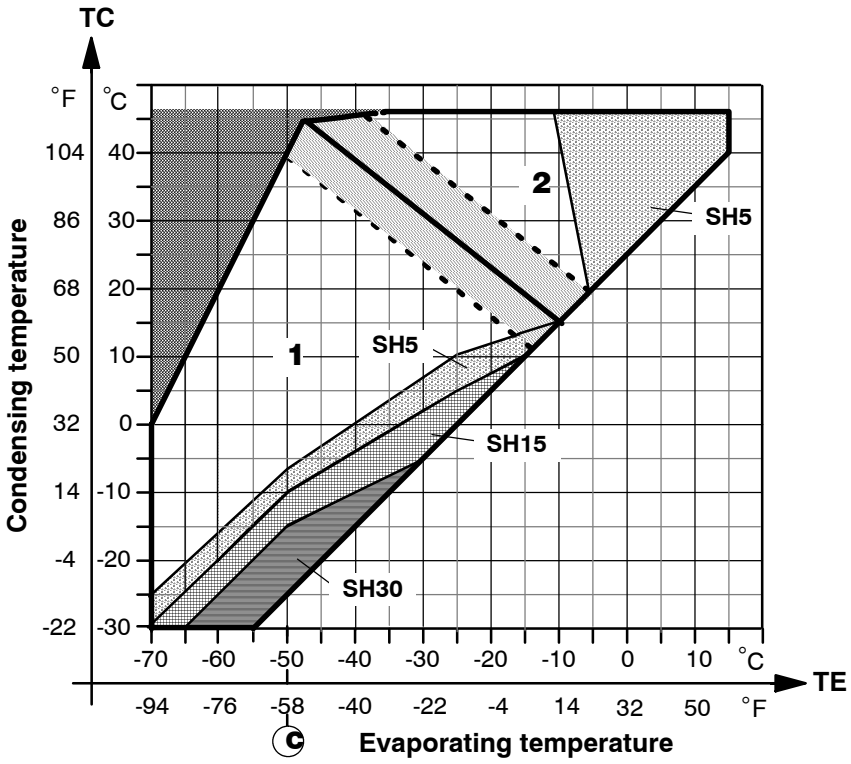
SH : Suction gas superheat, K (Kelvin)

: Zone in which both oils are useable

: Calculation must be performed using COMP1

R507

screw compressors



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

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

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

HLI: Calculation must be performed using COMP1.

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

List of Major Oil Companies

The oil from the companies listed below are **not** tested by 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	Oil Types				
Company	**M**	**A**	**PAO**	**AP**	**E**
Aral	●				●
Avia	●				
BP	●	●	●		●
Castrol	●	●	●		●
Chevron (UK: Gulf Oil)	●		●		●
CPI Engineering Services	●		●		●
DEA	●	●	●		●
Elf / Lub Marine 1	●	●			●
Esso/Exxon	●	●	●		
Fina	●	●			●
Fuchs	●	●	●		●
Hydro-Texaco	●	●	●		●
ICI					●
Kuwait Petroleum (Q8)	●			●	
Mobil	●	●	●	●	●
Petro-Canada	●				
Shell	●	●	●		●
Statoil	●	●			
Sun Oil	●				●

9. Settings

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Settings

The purpose of this document 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 document is primarily intended for installation and service engineers.

This document was produced by:

Sabroe Refrigeration
Chr. X's Vej 201
DK-8270 Hoejbjerg
Denmark

Safety Precautions

Danger !

Risk of injury to personnel and damage to equipment! In addition to the safety precautions in this document, 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.

The setting of pressure and temperatures must be made in accordance with the tables Fig. 9.1 and Fig. 9.2 supplemented by the numbered **notes.**

Fig. 9.1 Screw compressors - Measured and Calculated Pressure Levels

Measuring		Min	Max	Factory	Note
Suction pressure	High alarm	-	-	-	
(bar)	High warning	1.5	9.0	5.0	3+4+5
	Low warning	-1.0	6.0	1.5	3+4+5
	Low alarm	-1.0	6.0	1.0	3+4+5
Discharge pressure	High alarm	4.0	24.0	16.0	1+6
(bar)	High warning	3.0	22.0	15.0	1+6
	Low warning	-	-	-	
	Low alarm	-1.0	-1.0	-1.0	1+5
Oil pressure (bar)	Low warning	1.5	6.0	4.0	2+7
Calculated value	Low alarm	1.0	5.0	2.5	2+7
SAB Mk 1 compressors					
Oil pressure (bar)	Low warning	0.0	6.0	0.0	2+9
Calculated value	Low alarm	0.0	5.0	0.0	2+9
SAB Mk 2 compressors					
Oil pressure (bar)	Low warning	1.0	6.0	1.5	2+9
Calculated value	Low alarm	0.5	5.0	1.2	2+9
SAB Mk 3 compressors					
SAB 202, SAB 250, SAB 330	Set point 1	0.0	10.0	2.5	21
FV 19, SV 24/26, FV 24/26	Set point 2	0.0	10.0	4.0	21
Oil pressure (bar)	Low warning	1.5	6.0	2.0	2+9+17
Calculated value	Low alarm	1.0	5.0	1.5	2+9+17
VMY Mk 2-2.5 compressor					
Oil pressure(bar)	Low warning	1.5	6.0	4.0	2+9
Calculated value	Low alarm	1.0	5.0	3.0	2+9
VMY Mk 3 compressors	Set point 1	0.0	10.0	5.5	22
	Set point 2	0.0	10.0	7.0	22
Oil pressure (bar)	Low warning	1.5	6.0	2.0	2+9
Calculated value	Low alarm	1.0	5.0	1.5	2+9
SAB 80	Set point 1	0.0	10.0	0.5	20
	Set point 2	0.0	20.0	16.0	20
Diff. pressure	High alarm	0.0	1.5	1.0	2+11
across oil filter (bar)	Low warning	0.0	1.3	0.7	2+11
Calculated value					
All types but SAB 80					
Diff. pressure	High alarm	0.0	2.5	1.6	2+11+19
across oil filter (bar)	High warning	0.0	2.2	1.4	2+11+19
Calculated value					
SAB 80					

Fig. 9.2 Screw Compressors - Measured and calculated temperatures

Measuring		Min	Max	Factory	Note
Discharge temp.	High alarm	60.0	130.0	100.0	1+6
(°C)	High warning	50.0	120.0	90.0	1+6
	Low warning.	-65.0	-65.0	-65.0	
	Low alarm.	-	-	-	
Oil temperature	High alarm	40.0	80.0	60.0	2+7
(°C)	High warning	30.0	70.0	55.0	2+7
	Low warning.	10.0	50.0	25.0	2+7
	Low alarm.	0.0	40.0	20.0	2+7
Brine temperature	High alarm	-60.0	100.0	60.0	1+6
(°C)	High warning	-60.0	100.0	50.0	1+6
	Low warning.	-100.0	100.0	4.0	1+6
	Low alarm.	-100.0	100.0	2.0	1+6
Suction gas superheat	High alarm	6.0	120.0	110.0	2+7+12
(°C)	High warning	5.0	120.0	100.0	2+7+12
	Low warning.	0.0	40.0	2.0	2+7+10
Calculated value	Low alarm.	0.0	40.0	0.0	2+7+10
Disch. gas superheat	Low warning.	5.0	40.0	10.0	2+7+10
(°C)	Low alarm.	0.0	40.0	0.0	2+7+10
Calculated value					

4-20 m Auxiliary input signal

Measuring		Min	Max	Factory	Note
Auxiliary input	High alarm	-999.9	999.9	0.0	3+18
(4-20 mA)	High warning	-999.9	999.9	0.0	3+18
	Low warning.	-999.9	999.9	0.0	3+18
	Low alarm.	-999.9	999.9	0.0	3+18

Notes

Note 1 The alarm cannot be switched off until the problem has been solved.

Note 2 The alarm can be switched off immediately (RESET key).

Note 3 The alarm is switched off automatically.

Note 4 The safety limits can be entered in bar or °C/R.

Note 5 Alarm monitoring active when digital output ”compressor starting signal” has been chosen.

Note 6 Alarm monitoring always active – except when ”BLOCKED” has been selected in the picture COMPRESSOR CTRL MODE.

Note 7 Alarm monitoring 300 sec delayed after compressor start.

Note 8 Alarm monitoring 180 sec delayed after compressor start.

Note 9 Alarm monitoring 45 sec delayed after compressor start.

Note 10 A setting of 0.0 hinders monitoring.

Note 11 Delay of 300 sec, regardless of when the limits are exceeded.

Note 12 The compressor must have been above 5% capacity. Below 5% capacity monitoring is hindered.

Note 13 Alarm monitoring 15 sec delayed after compressor start.

Note 14 Delay of 60 sec, regardless of when the limits are exceeded.

Note 15 Only applies to HPO and HPC compressors.

Note 16 Alarm monitoring 20 sec delayed after compressor start.

Note 17 For VMY Mk 2-2.5, calculate the following (see Fig. 6 below):
Oil pressure = Oil pressure [3] (after oil filter) – Discharge pressure [2] .
For all other compressor types (except for SAB 80, see Note 20), calculate the following: Oil pressure = Oil pressure [3] (after oil filter) – Suction pressure [1] .

Note 18 The limits are not active until AUX. INPUT SIGNAL has been selected in the CALIBRATION 4-20 mA menu.

Note 19 For SAB 80 the differential pressure across the oil filter is calculated as follows (see Fig. 6 below): Oil filter diff. pressure = Discharge pressure [2] - Oil pressure [4] (after oil filter).

The shown oil filter pressure will thus be 0.1 to 0.7 bar higher than the actual pressure loss across the filter due to the pressure loss across the oil separator and the oil cooler.

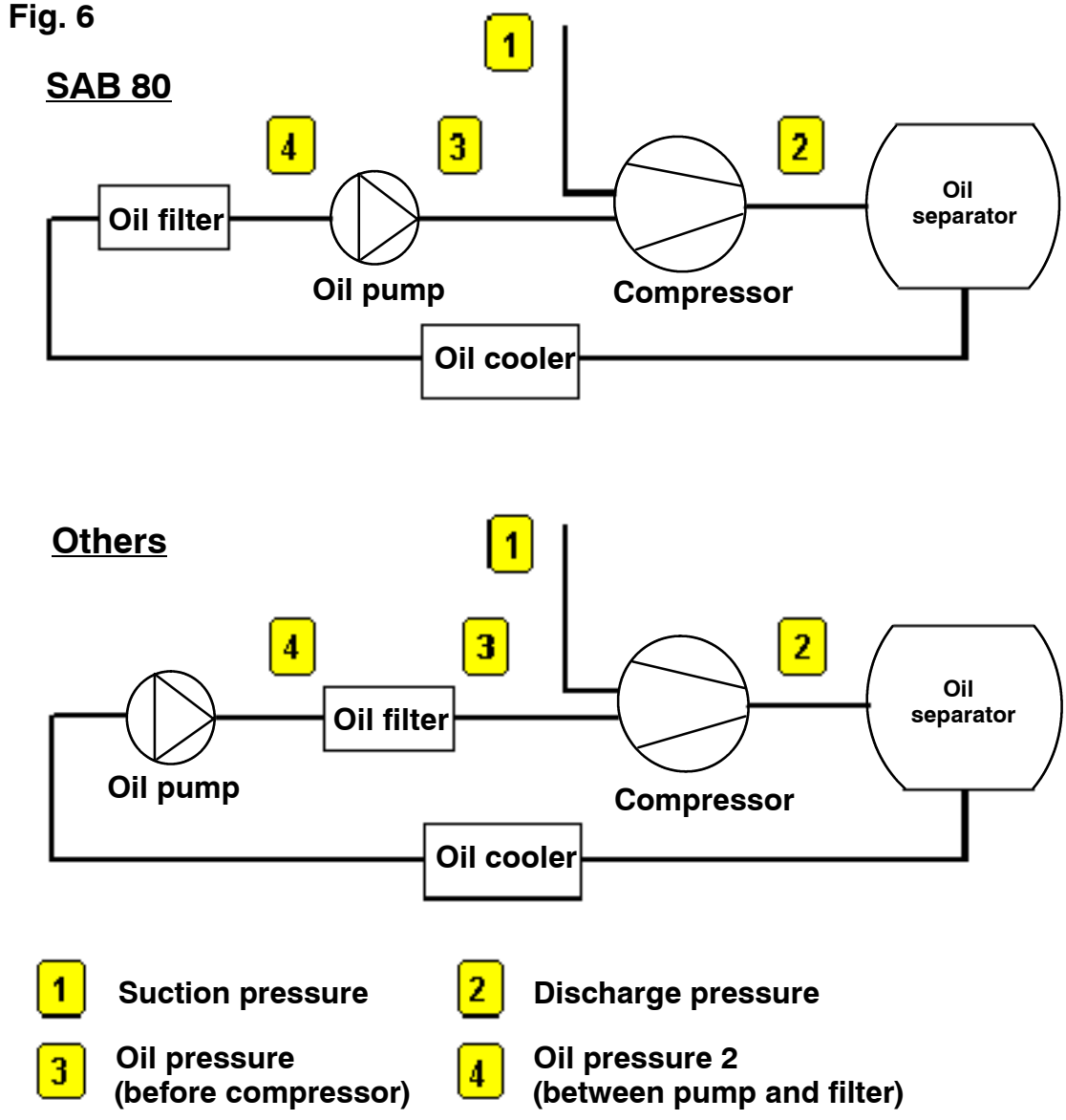
The maximum allowed pressure drop across the oil filter is 1.2 bar. Consequently, the warning limit should be set between 0.8 and 1.4 bar or lower. The alarm limit should be set between 1.1 and 1.7 bar or lower.

Note 20: Set points 1 and 2 are used for alarm monitoring of the mechanical oil pump. Cf. the description of the alarm under ”Oil pump error” in the section *Other Alarms.* For SAB 80, the oil pressure is calculated as follows (see Fig. 6 below):
Oil pressure = Oil pressure [3] (after pump) - Suction pressure [1] .

Note 21: The set points are used to control the oil pump. When the pressure falls below set point 1, the oil pump will start. When the pressure exceeds set point 2 for 60 seconds, the oil pump will stop.

Note 22: The set points are used to control the full flow pump. When the pressure falls below set point 1, the full flow pump will start. When the pressure exceeds set point 2 for 60 seconds, the full flow pump will stop.

Fig. 6



10. Operating Instructions

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Operating Instructions

The purpose of this document is to describe:

- Dangers resulting from failure to comply with safety precautions when operating the equipment.
- How to start, operate, and stop this equipment in a safe way.
- How to act when problems occur during operation.

This document is primarily intended for operators and service engineers.

This document was produced by:

Sabroe Refrigeration
Chr. X's Vej 201
DK-8270 Hoejbjerg
Denmark

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 !

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

Ventilation

Before operating the unit, always check to see that the ventilation system used in the area where the screw 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 screw 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 parts of the system.

Hot and Cold Surfaces

A screw compressor unit contains both hot and cold system parts. Always wear and use the recommended safety items.

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

Qualification Requirements

Before carrying out the measures set forth in this document, all personnel must have carefully studied the instructions issued for the screw compressor unit.

The personnel must also fulfil all national requirements for authorization.

Compressor Control and Alarm Functions

Operator's Panel, UNISAB II Control

All control operations for the screw compressor unit are carried out from the operator's panel and its keys. The following page gives a brief explanation of what the keys on the operator's panel are used for.

A detailed description of the control system, its functions and its use is presented in the Instruction Manual for UNISAB II Control.

The following points deal with daily operation of the screw compressor unit.

1. The emergency stop button on the side of the control cabinet can always be used to stop the compressor unit quickly.
2. When voltage is applied to UNISAB II, the following **main picture** will appear on the display, and UNISAB II is ready for operation.

SUCT. PRESS.	0.0 BAR
DISCH. PRESS.	0.0 BAR
MOTOR CURR.	0 A
STOPPED	0%

Values for warning limits, alarm limits and set points, etc are programmed into UNISAB II. This makes it possible to start the compressor immediately.

However, some of the values must always be adapted to the actual operating situation. For this purpose use the table *Quick Reference*, see Fig. 10.6 and Fig. 10.7.

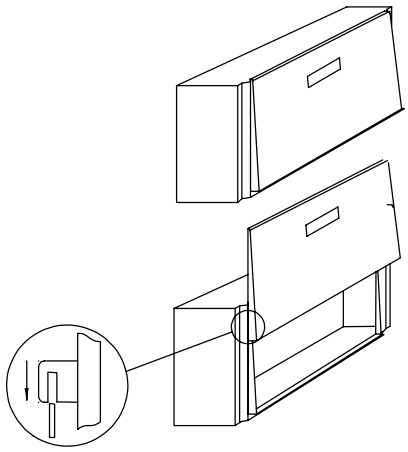
It is also recommended to read the Instruction Manual UNISAB II Control carefully to acquire a thorough knowledge of how to operate the control system.

UNISAB II is operated exclusively by means of the keys shown in Fig. 10.2. Reading of operating conditions as well as changing limit values and set points are carried out via the display.

The control panel is normally closed and locked with a screw at each end of the panel.

By turning the screws **half a turn** the control panel is loosened and can be lifted to open position whereupon it is secured to the cabinet as shown in Fig. 10.1.

Fig. 10.1 Opening the Cabinet



In this way it is still easy to operate the control panel. At the same time easy access to the cabinet interior is obtained.

When UNISAB II is open, it is still fully operational.

Display

Pos. 1 Has a constant background illumination and displays 4 lines, each with 20 characters. The contrast has been factory set, but can be adjusted if required. See subsection *Contrast (display)* in the section *Languages* in the UNISAB instruction manual.

In the display pressure levels, temperatures as well as all set points and warning and alarm limits can be read.

Front Panel

The UNISAB II front panel is divided into two sections:

- ***the control section,*** pos. 2-10, by means of which the compressor is controlled.
- ***the recording section,*** pos. 11-15, by means of which menu pictures are selected and values changed.

Control Section

Pos. 2 **Green lamp** indicating whether the compressor is running. At start-up this lamp will flash until UNISAB II has received feedback from the motor starter. At the same time the text ”STARTING” (lamp flashes) and ”OPERATING” (lamp light steady) can be seen in the bottom line of an operating picture.

Pos. 3 **Yellow lamp** indicating whether the state of operation is automatic or manual. **Yellow light = manual operation.**

Pos. 4 **Red lamp** indicating **warning** or **alarm**.
Slow flashes = warning
Quick flashes = alarm

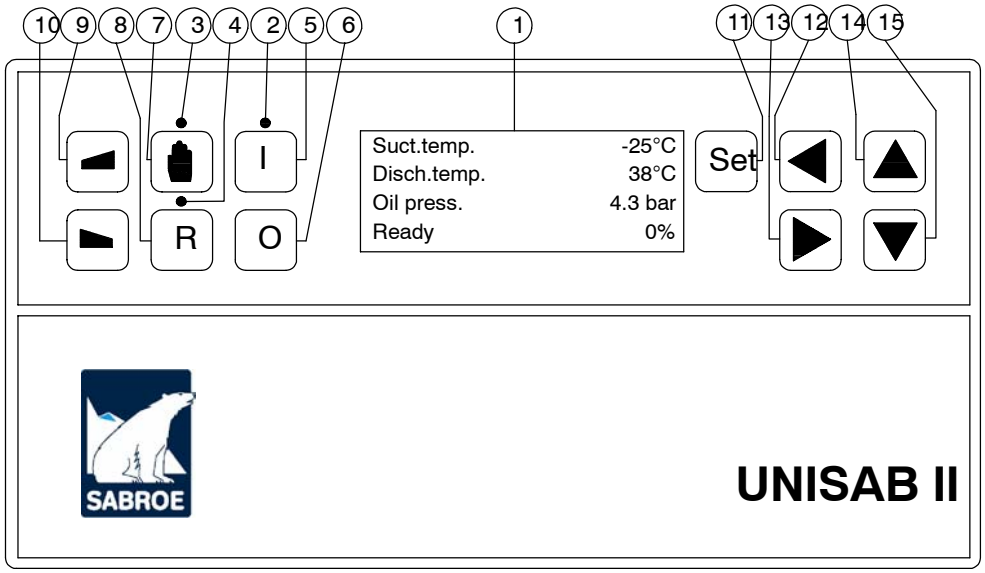
Pos. 5 [I] Compressor start at manual operation by pressing the key once. Works only if yellow lamp pos. 3 is lit.

Pos. 6 [0] Compressor stop at manual operation by pressing the key once. Works only if yellow lamp pos. 3 is lit.

Pos. 7 [hand] A change between manual (yellow lamp on) and automatic (yellow lamp off) takes place by pressing the key once.
Please note that if **manual** was selected from the CONTROL menu, it is not possible to change to automatic. See section *Control Mode* in the UNISAB instruction manual.

Pos. 8 [R] Key used to acknowledge alarms.

Fig. 10.2 UNISAB II Front Panel



Pos. 9 Loading of capacity during manual operation. On screw compressors the slide moves towards higher capacity as long as the key is held down.

Pos. 10 Unloading of capacity during manual operation. On screw compressors the slide moves towards lower capacity as long as the key is held down.

Recording Section

Pos. 11 The Set key has several functions.

- When pressing the Set key, a change will take place between Bar (PSI) and °C/R (°F/R) for saturated vapours when the display shows a suction or discharge pressure.
- Changing the set values can only be carried out by using the **password** shown on page 1 in the UNISAB instruction manual. As to the encoding of a password, see section *Changing of Set Values* in the UNISAB instruction manual.

Pos. 12 Used for moving left in the menu system. Used for selecting pictures or a digit when changing a value.

Pos. 13 Used for moving right in the menu system. Used for selecting pictures or a digit when changing a value.

Pos. 14 Used for moving upwards in a picture in order to point at a certain value, or when changing to a higher value.

Pos. 15 Used for moving downwards in a picture in order to point at a certain value, or when changing to a lower value.

Menu Structure

UNISAB II features a number of different pictures on **compressor operation, set values**, **configuration,** etc and these pictures are built up in a menu system in which a certain picture can be selected by means of the arrow keys. See Fig. 10.6 and Fig. 10.7.

Compressor Unit

Functions

The compressor unit functions are descibed in Section 4, Technical Description.

Preparations for Starting

1. Turn on the control voltage. The emergency stop button on the side of the control equipment cabinet must be in the ON position (pulled out). See Fig. 10.3. If the system fails to start, check the fuses. See Fig. 10.4.

Fig. 10.3 Operator's Panel

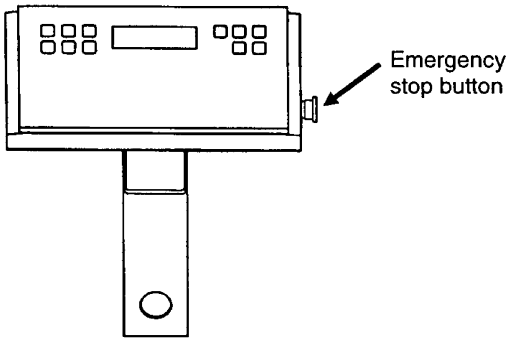
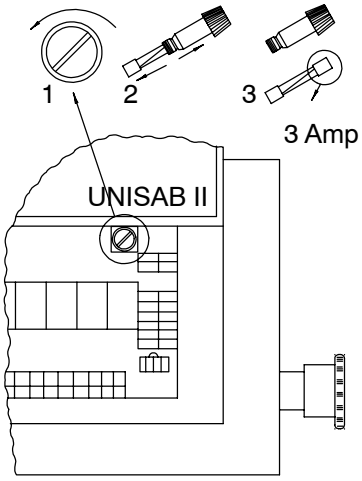


Fig. 10.4 Drawing of Fuses and their Position



2. Check the oil level in the oil separator. It must not be higher than the upper sight glass. Oil must be added when the level reaches the lower sight glass.

   The correct level appears only when the unit is in operation.

   If the oil level is too low, the reason must be found.

   The oil level switch FT209 will stop the compressor if the level drops too low.

3. Check that all valves are positioned in accordance with the following table Fig. 10.5 - *Position during Operation.*

Fig. 10.5 Position during Operation

Pos.no.	Qty	Designation	Position during operation
20	1	Stop valve suction line	Open
21	1	Non-return valve suction line	Is opened by the suction gas flow
24	1	Air purge valve/oil charging	Closed
34	1	Drain valve (oil side)	Closed
35	1	Drain valve (refrigerant side)	Closed
47	1	Service valve for oil drainage	Closed
52	2	Oil return valve	Partly open (See Section 4, *Technical Description*
60	1	Stop valve	Usually open Is also used for oil charging See Section 11, Maintenance
64	1	Stop valve for air purging of pump	Usually closed See Section 11, Maintenance
65	1	Stop valve	Usually open See pos. 60
203	2	Non-return valve in discharge pipe	Is opened by the suction gas flow
204	2	Stop valve after oil separator	Open
210	1	Non-return valve	Is opened by the oil flow
220	1	Compressor protection valve	Closed
221	1	Pilot valve for pos. 220	Closed

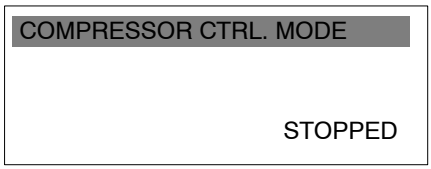
Starting

Before starting the screw compressor unit, always read the section *Preparations for Starting* in this document.

Reset any alarms in accordance with the instructions for the control system.

Modes of Operation, UNISAB II

The compressor can be adjusted to different modes of operation. These are found in SETUP ▶ CONTROL ▶.



When selecting this picture, the cursor will be in the top line. Press Set and the cursor moves to the second line.

Select the desired mode of operation with the keys ▲ ▼.

There are the following possibilities:

- STOPPED
- MANUAL
- AUTO
- REMOTE

STOPPED means that the compressor is blocked and thus **cannot start**.

MANUAL means that the compressor **only** operates manually, ie it is not possible to change to another mode of operation by means of the key ✋.

However, the compressor can be started with I and stopped with 0 and capacity increased/decreased with ◢ ◣.

AUTO means that the compressor runs in **local automatic** operation according to the form of regulation chosen (suction pressure, brine, etc). It is possible to change to MANUAL with the key ✋.

REMOTE means that the compressor runs in **remote regulation.** Choose REMOTE when **a number of compressors** are working together in a **common MULTISAB regulating system.**

Regulators

In UNISAB II it is possible to regulate the compressor according to different **pressure levels** and **temperatures**. These forms of regulation are found in CONFIG CONTROL ON.

If placing the cursor on CONTROL ON and pressing Set until the cursor moves to the right side of the picture, it is now possible to select different types of regulation with the keys ▲ ▼.

Choose between the following regulators:

- SUCTION SIDE
- BRINE
- DISCH. SIDE
- HOT WATER
- EXT. COOL
- EXT. HEAT

Each regulator has its own set of parameters. This means that when changing the CONTROL ON setting from one regulator to another and back again, the original parameters are kept.

The common regulator parameter set includes: Set point (Sp), Neutral zone (Nz) and Proportional band (Pb or P Band). On screw compressors PID parameters are also used, see the section *PID Controller* below.

Set point Sp is the pressure or the temperature desired in the plant.

Neutral zone Nz indicates how much the pressure or the temperature is allowed to fluctuate in relation to the Sp without the compressor changing its capacity. The set value of Nz is positioned symmetrically around the set point (Sp +/– 1/2 Nz).

Proportional band Pb indicates how powerful the regulating signal to the compressor capacity regulation is going to be, depending on the difference between the desired value (Sp) and the actual value.

In case the measured value is just outside the Nz, the regulating impulses will be very brief, whereas they will be very long if the measured value is outside the P band. The P band is positioned symmetrically around Sp outside the Nz.

PID Controller

On screw compressors a PID controller is used for capacity and V_i control. The theory of PID controllers is described in numerous books on automatic control. Methods of optimizing the parameters are also included in these books.

Fig. 10.6

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"QUICK REFERENCE" LEAFLET FOR UNISAB II - Ver. 2.01 Screw Compressor

1. MAIN PICTURE

Press ◀ until the picture remains unchanged and this is your **MAIN PICTURE**.

Factory-setting

SUCT.PRESS	XXXX
DISCH.PRES	XXXX
MOTOR CURR	XX
READY	X

2. SELECT THE "CONFIGURATION" MENU

Main picture - ▶ **suction** - ▼ **setup** - ▶ **config.** - ▶ **control** - - - - - - - - - - - - - - - ▶

Check whether UNISAB II is set correctly for the compressor.
Press ◀ until the **Main picture** appears.

CONTROL ON		XXXX
AUTO START	YES	XXX
AUTO STOP		XX
COLD STORE		XX

▼

3. SELECT THE "TIMER SETUP" MENU

Main picture - ▶ **suction** - ▼ **setup** - ▶ **control**
- ▼ **timers** - ▶ **timers** - ▼ **timer setup** - ▶

Check the set times in **Timer setup**
Press ◀ until the **Main picture** appears in the display.

START START	XXX
STOP START	XXX
START DELAY	XXX
STOP DELAY	XXX

▼

4. READ SUCTION PRESSURE OR DISCHARGE PRESSURE IN BAR OR °C/R.
Place cursor on suct. press or disch. pres and press "SET" (once).

5. SELECT THE MENU FOR SUCTION PRESSURE REGULATION

Main picture - ▶ **suction** - ▶ **suct. press** -
press **"SET"** for changing to °**C/R** - - - - - - - - - - - - - - - - ▶

Press ◀ until the **Main picture** appears.

HIGH ALARM	XXX	- ▼	SETPOINT 1	XXX
HIGH WARNING	XXX		SETPOINT 2	XXX
LOW WARNING	XXX		NEUTRAL ZONE	XXX
LOW ALARM	XXX		PROP. BAND	XXX

▼

6. CHANGING THE SET VALUES

In order to be able to change a set value, a **password** must be encoded as described:
Press **"SET"** for 2 seconds [Standard code number 1234].
Find the right password in the instruction manual
With ◀ ▶ **and** ▲ ▼ the correct password is encoded
Press **"SET"** and the password is kept open for 60 mins.

7. SETTING OF VALUES, f. inst. SUCTION PRESSURE (LOW ALARM)

Main picture - ▶ **suction** - ▶ **suct. press** - ▶ **high alarm** - ▼ **low alarm**
Encode password (see pt. 6) - ▲▼ and ◀ ▶ changing of set values - **"SET"** for confirmation.

8. SELECT FUNCTION, f.inst. REGULATOR MODE

Main picture - ▶ **suction** - ▼ **setup** - ▶ **control** - ▼ **config.** - ▶ **type** - ▼ **control on**
Encode password (see pt. 6) - ▲ ▼ for selection of regulator - **"SET"** for confirmation.

9. SELECT COMPRESSOR CONTROL MODE

Main picture - ▶ **suction** - ▼ **setup** - ▶ **control** - ▶ **compressor control mode** - **"SET"** (the cursor is now in line 2)
- ▲ ▼ for selection of control type **(manual** / **auto** / **remote** / **stopped)** - **"SET"** for confirmation.

10. CHANGING BETWEEN MANUAL- AND AUTOMATIC / REMOTE CONTROL MODE

Press - ☞ to swith between **manual - auto/remote**

The light diode above ☞ **lights up at manual control mode.**
It is always possible to change between manual and auto/remote - also during operation.

11. MANUAL START (THE I-KEY):

By **READY** in the main picture or in any other monitoring picture: Press **"I"** to start the compressor**.**
The ready-line changes to **Prelubrication** or **Starting** or **Operating**. (Text depending on compressor type)
During the **Starting** period **the green light diode flashes above the I-key**.
After feedback from the motor starter, **the light diode changes to a steady light**.

12. MANUAL STOP (THE 0-KEY)

By pressing the **"0"**-key during operation, **the compressor is stopped immediately.**

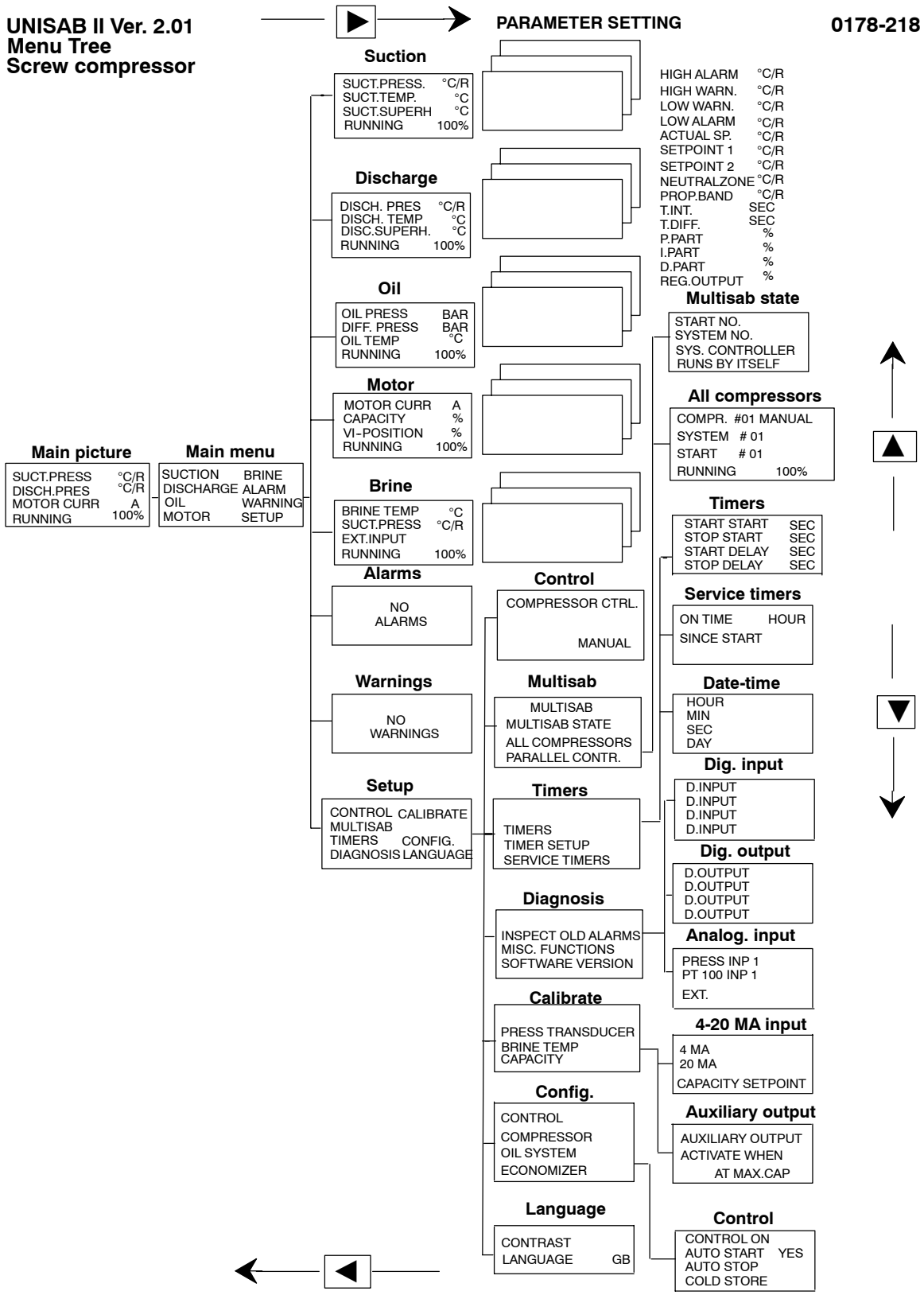
13. MANUAL LOADING/UNLOADING OF CAPACITY (the keys)

regulates the compressor capacity **upwards** - regulates the compressor capacity **downwards**.
The immediate compressor capacity can be seen in the main picture or in any of the other monitoring pictures.

14. CONFIRMATION OF ALARMS (THE R-KEY)

Slow flashes from the red light diode = The warning limit has been exceeded.
Quick flashes from the red light diode = Alarm and compressor will stop.
The alarm may be **confirmed by means of the R-key**, and the quick flashes will stop once the situation is back to normal.

Fig. 10.7


UNISAB II Ver. 2.01
Menu Tree
Screw compressor
PARAMETER SETTING
0178-218
Main picture
SUCT.PRESS °C/R
DISCH.PRES °C/R
MOTOR CURR A
RUNNING 100%
Main menu
SUCTION BRINE
DISCHARGE ALARM
OIL WARNING
MOTOR SETUP
Suction
SUCT.PRESS. °C/R
SUCT.TEMP. °C
SUCT.SUPERH °C
RUNNING 100%
Discharge
DISCH. PRES °C/R
DISCH. TEMP °C
DISC.SUPERH. °C
RUNNING 100%
Oil
OIL PRESS BAR
DIFF. PRESS BAR
OIL TEMP °C
RUNNING 100%
Motor
MOTOR CURR A
CAPACITY %
VI-POSITION %
RUNNING 100%
Brine
BRINE TEMP °C
SUCT.PRESS °C/R
EXT.INPUT
RUNNING 100%
Alarms
NO
ALARMS
Warnings
NO
WARNINGS
Setup
CONTROL CALIBRATE
MULTISAB
TIMERS CONFIG.
DIAGNOSIS LANGUAGE
HIGH ALARM °C/R
HIGH WARN. °C/R
LOW WARN. °C/R
LOW ALARM °C/R
ACTUAL SP. °C/R
SETPOINT 1 °C/R
SETPOINT 2 °C/R
NEUTRALZONE °C/R
PROP.BAND °C/R
T.INT. SEC
T.DIFF. SEC
P.PART %
I.PART %
D.PART %
REG.OUTPUT %
Multisab state
START NO.
SYSTEM NO.
SYS. CONTROLLER
RUNS BY ITSELF
All compressors
COMPR. #01 MANUAL
SYSTEM # 01
START # 01
RUNNING 100%
Timers
START START SEC
STOP START SEC
START DELAY SEC
STOP DELAY SEC
Service timers
ON TIME HOUR
SINCE START
Date-time
HOUR
MIN
SEC
DAY
Dig. input
D.INPUT
D.INPUT
D.INPUT
D.INPUT
Dig. output
D.OUTPUT
D.OUTPUT
D.OUTPUT
D.OUTPUT
Analog. input
PRESS INP 1
PT 100 INP 1
EXT.
4-20 MA input
4 MA
20 MA
CAPACITY SETPOINT
Auxiliary output
AUXILIARY OUTPUT
ACTIVATE WHEN
AT MAX.CAP
Control
CONTROL ON
AUTO START YES
AUTO STOP
COLD STORE
Control
COMPRESSOR CTRL.
MANUAL
Multisab
MULTISAB
MULTISAB STATE
ALL COMPRESSORS
PARALLEL CONTR.
Timers
TIMERS
TIMER SETUP
SERVICE TIMERS
Diagnosis
INSPECT OLD ALARMS
MISC. FUNCTIONS
SOFTWARE VERSION
Calibrate
PRESS TRANSDUCER
BRINE TEMP
CAPACITY
Config.
CONTROL
COMPRESSOR
OIL SYSTEM
ECONOMIZER
Language
CONTRAST
LANGUAGE GB

Checks to be Performed during Operation

1. Choose a suitable picture from the display to follow the data which are to be checked. After setup, check that oil pressure is obtained and that the evaporating and condensing pressure lie within the permissible ranges shown in the *Operating Limits* diagrams as described in Section 6, Technical Data.

2. Check the other operating data.

3. Listen for knocking valves or other abnormal noises indicating that pipes are poorly clamped or vibrating for some other reason. If necessary, submit a report so that remedial measures can be taken.

4. Check the pressure drop across the oil filter. If it exceeds 0.7 bar, replace the filter as soon as possible to prevent the compressor unit from being stopped.

5. Check the oil level in the oil separator.

6. Perform what is described in Section 11, Maintenance - *Daily Maintenance.*

Monitoring of Operation

To ensure an unproblematic operation, it is recommended to enter the following routines in a logbook. The service engineer will need this information in connection with eg an error report.

Daily reading of:

- Suction pressure
- Condensing pressure
- Oil differential pressure
- Oil level
- Suction gas superheating
- Discharge pipe temperature
- Condition of the oil (check colour, whether the oil foams, whether the temperature is normal)
- kW consumption
- Oil collection from shaft seal

It is also recommended that a logbook be made for the entire refrigeration plant, see example in Fig. 10.8.

Operations Log

Compr. type _____
Compressor no _____
Refrigerant _____
Compr. local no _____
Oil type _____

Fig. 10.8 Monitoring of Operation

Machine room or system designation						**Date:**		
Checklist	Normal level		Data registered at					
	From	To	04.00 am	08.00 am	12.00 am	04.00 pm	08.00 pm	12.00 pm
Suction pressure								
Suction temperature								
Superheating, suction gas								
Discharge pressure								
Discharge temperature								
Oil pressure, compressor								
Oil pressure, filter								
Oil temperature								
Oil temperature, separator								
Oil level								
Charged oil, ltr.								
Operation time (hours)								
Capacity piston position (%)								
Motor 1/1-load amp.								
Volume ratio								
Capacity load (%)								

Stopping Routine

Brief stop

The compressor can be stopped at any capacity setting. However, under normal conditions it is recommended to reduce the capacity to a minimum before stopping the compressor.

Leave all valves in their in-operation positions as stated in the table in Fig. 10.5 – *Position during Operation,* unless servicing or repair work is to be performed.

Do not turn off power to the screw compressor unit since the oil heater must be connected to keep the correct oil temperature.

Shutting Down for Long Idle Period

The compressor can be stopped at any capacity setting. However, under normal conditions it is recommended to reduce the capacity to a minimum before stopping the compressor.

The valves can be left in their in-operation positions. However, to permit servicing and repair work, the necessary valves must be closed.

If necessary, the refrigerant can be moved to parts of the system where no intervention will take place. Note that the parts of the system which are shut down must not be filled to the top with liquid refrigerant.

If the screw compressor unit is exposed to vibrations during a long idle period, the compressor and motor bearings may be damaged. To prevent this, the motor and the compressor should be started for a short period once a week, ie in operation for approx 30-60 min.

Problems

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

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

Fault-finding

Compressor does not start.

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

If an alarm caused by a tripped monitor occurs, call in experienced personnel who have access to the document entitled Fault-finding Instructions.

11. Maintenance Instructions

Table of Contents

Maintenance Instructions

The purpose of this document 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 document is primarily intended for operators and service engineers.

This document was produced by:

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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 document, 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 screw compressor unit. Before starting maintenance work, study carefully the general safety instructions/regulations that apply to this series of screw 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 Screw Compressor Unit

General

To make certain that the screw 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 point consists of visual inspections. When familiar with the normal noise and vibration of the unit, compare the performance of each day with previous observations. Make comparisons with the available diagrams, etc. to make certain that the operating data lie within permissible ranges.

   - Inspect the screw compressor unit and check that both noise and vibration are normal.
   - Enter the observed operating data into the operations log, see the table *Monitoring of Operation* in Section 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.
   - 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 screw 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 section.

Warning!

Daily maintenance is normally conducted by the 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 screw compressor unit that require regular periodical maintenance are shown under *Activities during Service Inspection* in this document.

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 e.g. poorly clamped pipes or defective valves.

Evaporating Pressure and Condensing Pressure

No special requirements are imposed regarding equipment and materials. Check on the operator's panel that the different kinds of pressure comply with what the specifications issued for the screw compressor unit in question prescribes and that they are within the permissible operating ranges.

Evaporating Pressure

The terms "evaporating pressure" and "suction pressure" refer to the pressure that prevails 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 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 outlet side of the compressor. 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 condenser inlet. The oil separator, the stop valve and the non-return 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 vapours 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 screw compressor unit to make sure that there are no refrigerant or oil leaks.

Oil Level

The oil separator in the screw compressor unit has an oil receiver. The oil pump takes the oil used for lubrication, cooling, sealing and regulation of the compressor from this receiver. It is thus very important to have sufficient oil available in the oil receiver.

Check the oil level in the oil reservoir. It must not be higher than the upper sight glass. Oil must be added when the level reaches the lower sight glass. The correct level appears only when the unit is in operation.

The section *Oil Level Glass,* in Section 4, Technical Description states how much oil must be charged to raise the oil level 10 mm.

If the oil level is too low, the reason must be found. For this purpose use Section 12, Fault-finding Instructions. The oil level switch 209 (additional equipment) will stop the compressor if the level drops too low.

If the oil level is too low, check for leaks. If there is no leakage, the oil can still be collected in the system.

Call in a service company to investigate the problem.

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, remember to change the oil in both the compressor and the plant.

- 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 at the same time, the container should be tightly sealed and stored in a warm place to prevent the absorption of moisture.

Note:

It is not recommended 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.

Section 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.

Oil Charging

See section 6, Technical Data.

Oil Change

As stated in the tables placed at the end of this document the oil in the unit must be changed after a specific number of operating hours or when an oil analysis shows that the oil needs to be changed.

Let Sabroe Refrigeration's service organization change the oil as it is recommended to replace all the filters in the unit at the same time.

Warning!

Corrosive oil is a hazardous substance, which can cause irritation and other injuries.

If the oil in the oil separator appears abnormal or if its condition is in any way questionable, take an oil sample via valve pos. 47 for analysis.

Valve pos. 47 is placed at the bottom of the oil receiver. See the piping diagram in Section 4, Technical Description.

Take the sample while the unit is running. Do not use the first 100 ml. Empty the sample

into a clean and dry sample bottle and follow the description in Section 6, Technical Data, *Assessing the Oil.*

Note:

The postion numbers above refer to General Piping Diagram in Section 4, Technical Description.

Caution!

Leave the sample bottle open for an hour after filling it so that the refrigerant dissolved in the oil will have time to evaporate and disappear. Otherwise the sample bottle may explode.

Searching for Leaks

Leak searching can be performed in many ways. The most frequently used method is to use a leak detector. When finding a leak, a good way to find its exact location is to apply soapy water.

When searching for large leaks, divide the system into sections to prevent needless amounts of refrigerant from leaking out.

Proceed as follows:

- Ascertain whether there is a refrigerant shortage by checking the refrigerant level in the condenser or the receiver.
- Search for drops of oil at couplings, flanged joints, valve spindles, shaft seals, safety valves and the like.
- Ventilate in advance to remove any gaseous refrigerant from the leak searching area.
- Check that the required refrigerant pressure is present in the part of the system in question.
- Conduct the search systematically to ensure that all possible sources of leaks are checked.

Do not forget the following:

- Threaded joints and flanged joints
- Valve spindles
- Shaft seals
- Relief equipment
- Expansion valves
- Pressure transducers and pressure gauges
- Safety valves

Motor Lubrication

For electric motors, it is absolutely essential to lubricate the bearings correctly 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.

Activities during Service Inspection

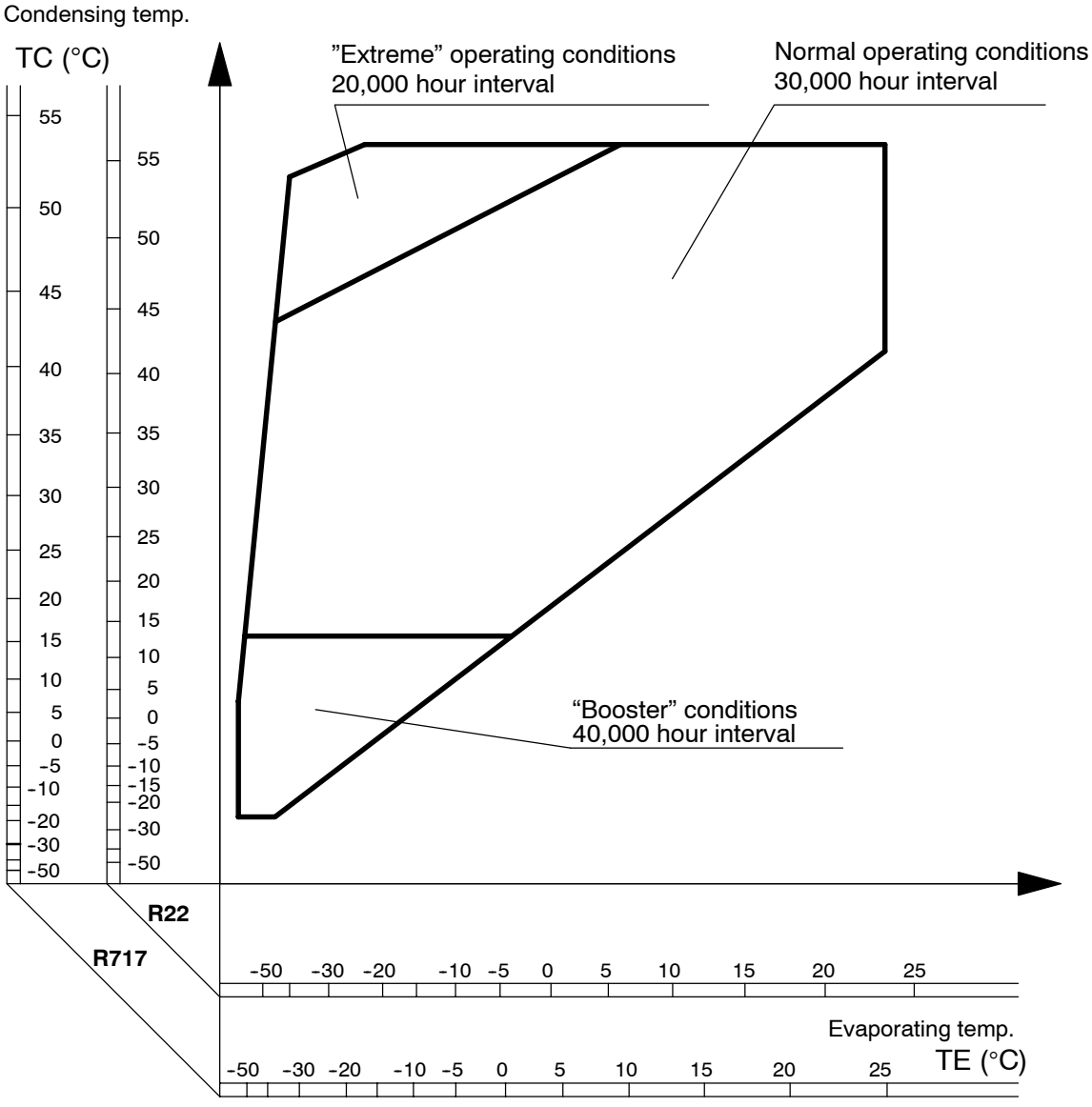
	Periodic service	Activity
1	**Daily**	1.1 External inspection and leak check. 1.2 Check oil level in oil separator. 1.3 Check pressure and temperatures. 1.4 Check for unusual vibrations or noise. 1.5 Record operating data in log book.
2	**After 50 hours' operation**	2.1 Clean suction filter. **
3	**After 200 hours' operation**	3.1 Clean compressor suction filter. ** 3.2 Take oil sample from oil separator and appraise it visually or send sample to laboratory for anlysis. Both methods are described in section entitled *Assessing the Oil*. 3.3 Replace filter cartridge in oil filter unless replaced earlier. ** 3.4 Clean all other oil filters and connections to and from compressor. ** 3.5 Check coupling and alignment of coupling. ** 3.6 Check that all screws and nuts have been tightened to correct torque. **
4	**After 1000 hours' operation**	4.1 Clean compressor suction filter. ** 4.2 Take oil sample from oil separator and appraise it visually- or send sample to laboratory for analysis. Both methods are described in section entitled *Assessing the Oil*.
5	**After 2500 hours' operation**	5.1 Clean compressor suction filter. ** 5.2 Take oil sample from oil separator and send it to laboratory for analysis as described in *Assessing the Oil*. 5.3 Fit new oil filter cartridge. ** 5.4 Clean all other oil filters and connections to and from compressor. ** 5.5 Check coupling and alignment of coupling ** 5.6 Check that pressure switches and thermostats are working correctly (see set values in instruction manual). If UNISAB II computerized control is fitted, check transducers (see instruction manual for UNISAB II).

Periodic service		Activity
6	**After 5000 hours. operation** **This service should be repeated after every 5000 hours of operation**	6.1 Clean compressor suction filter. ** 6.2 Fit new oil filter cartridge. ** 6.3 Clean all other oil filters and connections to and from compressor. ** 6.4 Check coupling and alignment of coupling (SAB 110*) ** 6.5 Check that pressure switches and thermostats are working correctly (see set values in instruction manual). If UNISAB II computerized control is fitted, check transducers (see instruction manual for UNISAB II). 6.6 Take oil sample from oil separator and send sample to laboratory for analysis as described in section entitled *Assessing the Oil*. Please see table entitled *Checking the Oil.*
7	**Major service** **Carried out as specified for the individual screw compressor type.** (See the diagram for major service)	7.1 Total compressor overhaul, including fitting new gaskets. As compressor is already open, inspect bearings and, if necessary, fit new ones. Check regulating system. ** 7.2 Overhaul and clean compressor motor. ** **NB** *Follow service schedule specified by motor manufacturer.* 7.3 Fit new oil filter cartridge. ** 7.4 Drain off compressor oil and charge with new, fresh oil. ** 7.5 Check coupling and alignment of coupling (SAB 110*) ** 7.6 Check that pressure switches and thermostats are working correctly (see set values in instruction manual). If UNISAB II computerized control is fitted, check transducers (see instruction manual for UNISAB II).

* *Check elastic intermediate part for visible oblique cracks in rubber part. In case of cracks, replace intermediate part.*

** *Recommended to be carried out by Sabroe Refrigeration's service organization.*

Major Service Intervals
SAB 110, SAB 128/163 Mk3/4, SAB 128/163R, SAB 202



Checking the Oil

Operating hours between main inspections See chart for main inspections						Service schedules Number of operating hours from initial start-up and after each main inspection (see footnote)
20,000h		30,000h		40,000h		
HCFC	R717	HCFC	R717	HCFC	R717	
						50
•	•	•	•	•	•	200
•	•	•	•	•	•	1000
•	•	•	•	•	•	2500
•	•	•	•	•	•	5000
•	×	•	×	•	×	10000
×	•	×	•	×	•	15000
⊕	⊕	•	×	•	×	20000
		•	•	•	•	25000
		⊕	⊕	×	×	30000
				•	•	35000
				⊕	⊕	40000

• It is advisable to assess the oil.

× It is advisable to assess the oil.

If this assessment is not made, the oil charge **must** be replaced with fresh oil.

⊕ The oil charge must be replaced with fresh oil.

Service schedules after initial compressor start-up.

Service schedules after each main inspection.

NB:

It is not advisable to reuse oil drawn from compressor or plant. This oil has absorbed the moisture in the air and is likely to cause operating problems.

Always turn off the power to the heating rod before draining off the oil.

12. Fault-finding Instructions

Table of Contents

Fault-finding Instructions

The purpose of this document 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.
- Suggest cause(s) and recommend actions to solve each problem.

This document is primarily intended for service engineers.

This document was produced by:

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Denmark

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 document, 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 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 screw 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.

Screw Compressor Unit as Part of Overall System

The functions performed by a screw compressor unit – and thus the errors that may occur – are often linked to the overall system (plant) in which the unit is operating.

On the low pressure side the screw 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 is responsible for 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 the 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, however, consider the situation carefully. 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 plant operating conditions.

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 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 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: “excessive suction pressure” - error code 5.
Cause codes: 2 (compressor lacks capacity) and 48 (safety valve leaky or opens prematurely). The entry keys to the subsequent section are therefore (5.2) and (5.48).

Fault Code	Observed Fault	Probable Causes
1	Excessive suction pressure	2, 28, 48, 49.
2	Suction temperature is too low	31, 32.
3	Suction pressure is too low	1, 14, 27, 28, 29, 30, 33, 40, 42.
4	Compressor starts and stops too frequently, at low-pressure cut-out	1, 14, 27, 28, 29, 30, 33, 39, 42, 49.
5	Excessive suction pressure	2, 48.
6	Compressor starts and stops too frequently, at high-pressure cut-out	38, 41, 43, 44.
7	Excessive condensing pressure	22, 23, 24, 26, 38, 41, 43, 44.
8	Condensing pressure too low	2, 22, 23, 24, 26.
9	Oil pressure too low	5, 11, 25, 31, 32.
10	Oil temperature too high	13, 18, 19, 20, 37, 48.
11	Oil temperature too low	21, 50.
12	Excessive pressure drop across oil filter	19.
13	Excessive capacity - aut. controls out of order	3, 4,12, 53, 54
14	Insufficient capacity - aut. controls out of order	3,4, 53, 54
15	Falling oil level in reservoir	15, 16, 17.
16	Oil foams vigorously during idle period	31, 32.
17	Oil reservoir sweating during idle period	47, 50.
18	Abnormal noise from compressor	5, 7, 8, 9, 10, 31, 32, 48, 52.
19	Compressor motor will not start	6, 12, 13, 19, 34, 35, 36, 40, 41, 45, 46, 47, 53, 54
20	Compressor runs continuously	2, 4, 42, 48, 49.
21	Liquid in suction line	1, 31, 32.

Code	Cause	Code	Cause
1	Compressor has excessive capacity	26	Water filter clogged
2	Compressor lacks capacity	27	Filter before valve in liquid or suction line clogged
3	Solenoid valve in regulating system fails to open	28	Excessive suction gas superheating
4	Timer or other automatic control out of order	29	Freezing of thermostatic expansion valve
5	Excessive capacity when decreasing temperature	30	Thermostatic expansion valve has lost its charge
6	Capacity regulation not set for 0%	31	Excess flow through expansion valve (liquid in suction line)
7	Loose foundation bolts	32	Loose or misplaced sensor
8	Misalignment of motor and compressor	33	Solenoid valve in liquid or suction line not opening
9	Friction between rotors and housing or defective bearings	34	Oil filter needs cleaning - pressure cut-out has cut
10	Loose bolts in coupling	35	Oil pressure too low - pressure cut-out has cut
11	Oil pressure regulating valve set too low	36	Oil too hot - oil thermostat has cut
12	Oil pump out of order	37	Oil thermostat set too high
13	Oil too hot - oil thermostat cut out	38	High-pressure cut-out set too low
14	Too much oil circulating in system (evaporators)	39	Low-pressure cut-out set too high
15	Filter in solenoid valve in oil return line clogged	40	Low-pressure cut-out shut off
16	Solenoid valve in oil return out of order	41	High-pressure cut-out shut off
17	During initial start-up, some of the oil will be led out into the plant	42	Insufficient charge in plant
18	A valve in the oil line is being throttled	43	Too much charge in plant
19	Oil filter clogged	44	Air or non-condensable gases in system
20	Insufficient water through oil cooler	45	Fuses blown
21	Excessive oil cooling - oil too cold	46	Thermal relay reset
22	Insufficient water or air through condenser	47	Main switch interrupted
23	Condenser tubing clogged by sludge or scale	48	Safety valve leaky or opening prematurely
24	Cooling water too hot	49	Evaporator soiled or iced up
25	Too much water through condenser	50	Heating element blown
		52	Liquid in suction line
		53	Motor defect
		54	Error in frequency transformer

Remedying Malfunctions

1. Excessive suction temperature

1.2	Inadequate capacity	Increase capacity
1.28	Excessive superheating of suction gas	Check and regulate thermostatic valves on evaporators
1.48	Safety valve leaky or opening prematurely	Check condensing pressure and adjust or repair safety valve

2. Suction temperature too low

2.31	Liquid in suction line	Regulate expansion valves or float valves
2.32	Loose or misplaced sensor	Check whether sensors are making good contact with suction pipe and whether positioned correctly

3. Suction pressure too low

3.1	Excessive capacity	Reduce compressor capacity
3.14	Too much oil in evaporators	Draw oil off evaporators
3.27	Filter in liquid line clogged	Examine and clean filters in liquid lines
3.28	Excessive superheating of suction gas	Regulate expansion valves
3.29	Freezing in thermostatic expansion valve	De-ice thermostatic expansion valve with hot wet cloths and run liquid from receiver through drying filter **Note**: *Never add methanol to system to avoid freezing, as this will give rise to corrosion and chemical attacks in compressor, etc.*
3.30	Thermostatic expansion valve has lost its charge	Valve fails to open - change valve
3.33	Solenoid valve in liquid or suction line not opening	Coil may have blown - change coil
3.42	Insufficient charge	Charge more refrigerant to plant

4. Compressor starts and stops too frequently at low-pressure cut-out

4.1	See point 3.1	
4.14	See point 3.14	
4.27	See point 3.27	
4.28	See point 3.28	
4.29	See point 3.29	
4.30	See point 3.30	
4.33	See point 3.33	
4.39	Low-pressure cut-out set too high	Adjust pressure cut-out
4.42	See point 3.42	
4.49	Evaporator soiled or iced up	Clean or defrost evaporator

5. Excessive suction pressure

5.2	Compressor lacks capacity	Regulate compressor capacity
5.48	Safety valve leaky or opening pre-maturely	Adjust or repair valve

6. Compressor starts and stops too frequently at high-pressure cut-out

	See point 7	

7. Excessive condensing pressure

7.22	Insufficient water or air through condenser	Regulate water supply or clean condenser
7.23	Condenser tubing clogged by sludge or scale	Clean condenser tubing
7.24	Cooling water too hot	Procure colder cooling water or reduce compressor capacity
7.26	Water filter clogged	Clean water filter
7.38	High-pressure cut-out set too low	Adjust pressure cut-out
7.43	Too much charge in plant	Draw fluid off into empty vessel
7.44	Air or non-condensable gases in system	Blow air out at condenser

8. Condensing pressure too low

8.2	Compressor lacks capacity	Check whether compressor capacity corresponds to load on plant. Regulate water supply to condenser.
8.25	Too much water through condenser	Adjust water supply

9. Oil pressure too low

9.5	Excessive capacity during temperature decrease	Excessive capacity during temperature decrease (run-down) may result in liquid being sucked along in suction line. This liquid may cause oil in oil reservoir to foam vigorously so that oil pressure drops, thus stopping machine. Before re-starting, check whether there is liquid in oil reservoir. This liquid must be boiled off using heating element or by heating oil reservoir with hot water or steam. The plant must therefore be run- down at reduced capacity.
9.11	Oil pressure regulator set too low	The regulator is set for 2.5 kp/cm as prescribed by the manufacturer, but must be checked during operations.
9.31	Excess flow through expansion valve (liquid in suction line)	See comments under point 9.5
9.32	Loose or misplaced sensor	Loose sensor on expansion valve may cause liquid throughflow to suction line - see also comments under point 9.5.

10. Oil temperature too high

10.13	Thermostat cut out	See section *Pressure and temperature settings* for set point. The reason for the oil overheating must be found in the following points
10.18	Valve in oil line being throttled	Check whether all valves are open
10.20	Insufficient water or refrigerant through oil cooler	Check whether valves are open or whether water filter or oil cooler need cleaning
10.48	Safety valve leaky or opening prematurely	Adjust or repair valve

11. Oil temperature too low

11.21	Excessive cooling of oil	Regulate oil cooling
11.50	Heating element in oil reservoir out of order	Change heating element

12. Excessive pressure drop across oil filter

12.19	Oil filter clogged	Change filter element

13. Excessive capacity - automatic controls out of order

13.3	Solenoid valve in regulating system fails to open	Change valve or coil
13.4	Timer or other automatic control out of order	Change or fix
13.12	Auxiliary pump out of order	When compressor stops, auxiliary pump must ensure capacity regulation is set for 0% capacity so that compressor is ready for restart. Check whether pump is energized or whether pump or motor is out of order.
13.53	Motor defective	Replace or repair.
13.54	Error in frequency transformer	In case of error in frequency transformer the combined lamp/push-button positioned on the outside of the control board will be activated Try to reset frequency transformer by pushing button. If this does not help, please contact Sabroe Refrigeration.

14. Insufficient capacity - automatic controls out of order

14.3	See point 13.4	
14.53	See point 13.53	
14.54	See point 13.54	

15. Falling oil level in reservoir

15.15	Filter for solenoid valve in oil-return line clogged	Clean filter
15.16	Solenoid valve in oil return out of order	Oil return line must be hot during operation.
15.17	During initial start-up, some of the oil will be let out into the plant	Particularly on HCFC plants some of the oil will circulate in the plant. When the system is balanced, top up with oil, if necessary.

16. Oil foaming vigorously during standstill

16.31	Excess flow through expansion valve (liquid in suction line)	Check expansion valve
16.32	Loose or misplaced sensor	Check sensor positioning

17. Oil reservoir sweating during standstill

17.47	Main switch interrupted	If compressor is stopped and current interrupted at main switch, any refrigerant in oil reservoir will evaporate. As heating element in oil reservoir has also been cut off, heat needed for evaporation must be taken from surroundings. The oil will therefore go very cold and will require heating up before restarting.
17.50	Heating element blown	See point 17.47

18. Abnormal noise from compressor

If any abnormal noise is coming from the compressor, the machine must be stopped immediately, and the cause found and remedied before restarting.

18.5	Excessive capacity during run-down	Excessive capacity during run-down may result in liquid being sucked along into compressor suction line. Therefore, operate at reduced capacity during run-down.
18.7	Loose foundation bolts	Tighten bolts
18.8	Misalignment of motor and compressor	Adjust alignment
18.9	Friction between rotors. Friction between rotors and defective bearings	Do not start compressor. Open and repair.
18.10	Loose bolts in coupling	Stop compressor and tighten bolts
18.31	Liquid in suction line	Check and adjust valves with excess throughflow
18.32	Loose or misplaced sensor	Check sensor positioning
18.48	Safety valve opens	Check opening pressure of safety valve

19. Compressor motor will not start

19.6	Capacity regulation not set for 0%	See under points 13.3-13.4 and 13.12
19.12	Auxiliary pump out of order	See under point 13.12
19.13	Excessive oil temperature	See under point 10
19.19	Oil filter clogged	Clean oil filter. Reset pressure cut-out
19.34	Differential oil pressure cut-out has cut	Clean oil filter. Reset pressure cut-out
19.35	Oil pressure too low	See under point 9
19.36	Oil too hot	See under point 10
19.40	Low-pressure cut-out interrupted	Compressor will restart after rise in suction pressure sufficient to re-activate pressure cut-out - see point 3 also.
19.41	High-pressure cut-out interrupted	See under point 7
19.45	Fuses blown	Check cause and change fuses
19.46	Thermal relay has interrupted	Check cause of overloading
19.47	Main switch interrupted	Switch power on
19.53	See point 13.53	
19.54	See point 13.54	

20. Compressor runs continuously

20.2	Compressor lacks capacity	See under point 13.54
20.4	Timer or other automatic control out of order	See under point 13.54
20.42	Insufficient charge on plant	Top plant up with refrigerant
20.48	Safety valve leaky or opening prematurely	See point 10.48
20.49	Evaporator soiled or iced up	Clean or defrost evaporators

21. Liquid in suction line

21.1	Compressor has excessive capacity	Reduce capacity
21.31	Excess flow through expansion valve	Adjust expansion valve
21.32	Loose or misplaced sensor for expansion valve	Check sensor positioning and rectify

13. Service Instructions

Table of Contents

Service Instructions

The purpose of this document 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.

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Safety Precautions

Danger !

Risk of injury to personnel and damage to equipment! In addition to the safety precautions in this document, 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.

Safety Measures

Danger !

The paragraphs that follow present some important safety considerations for this type of screw compressor unit. Before starting service work, study carefully the general safety instructions/regulations that apply to this series of screw compressor units. Failure to follow these instructions/regulations can lead to personal injury and 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 screw 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 screw 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 parts of the system.

Hot and Cold Surfaces

A screw compressor unit contains both hot and cold system parts. Always wear and use the recommended safety items.

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

Qualification Requirements

Before carrying out the measures set forth in this document, all personnel must have carefully studied the instructions issued for the screw compressor unit.

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 and are described in detail in:

- Document 0662-734 for SAB 128 Mk4
- Document 0662-744 for SAB 163 Mk4

Service Schedules for Screw Compressors

Good and careful servicing of the 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, these instructions indicate the service tasks to be carried out.

Preparations before Compressor Inspection

Before dismantling any part of the compressor or unit for inspection or repair, **the pressure must be reduced to atmospheric pressure**. This is done as follows:

- Regulate the compressor down to its lowest capacity stage and stop it.
- Close all stop valves in the piping connections to the unit except for suction stop valve pos. 20, which must remain open until the pressure in the unit has been equalized to suction pressure.
- Close suction stop valve pos. 20.
- Any excess pressure in the unit is equalized to atmospheric pressure through stop valve pos. 24. See *Key to Piping Diagrams* in Section 4, Technical Description and Section 3, Safety Precautions – *Protecting the Environment*.
  The heating element in the oil separator must remain connected until the pressure is completely equalized, thus *boiling* the refrigerant out of the oil.
- Remove the **main fuses** for the compressor motor in order to prevent it from starting up inadvertently.

Compressor and unit are now ready for inspection and dismantling, if required.

Replacement of Oil Filter

In case only the oil filter has to be replaced, follow the procedure described in *Preparations before Compressor Inspection* as well as the description under *Oil Filter* later in this section.

Cleansing of Oil in Unit

The most critical time for an oil filter is right after initial start-up of the compressor.

Although an effort should be made to keep the plant free of any impurities when assembled, experience shows that it is difficult to avoid impurities in tubes and vessels.

These impurities will be conveyed by the suction gas to the suction filter, where large impurities are intercepted. Small impurities will pass through the filter and be conveyed to the oil separator where they are suspended in the oil. From here they are taken to the unit lubricating system and absorbed by the oil filter.

These impurities may necessitate a replacement of the oil filter cartridge shortly after initial start-up.

It is equally important to check the oil regularly as specified in Section 6, Technical Data – *Assessing the Oil.*

Oil purification may be done by using a three micron filter in a **closed system.** During this

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process the oil must not come into contact with oxygen and moisture in the air.

In addition, it is important that all pressure and temperature levels be kept within the specified values and that filters be kept clean. Provided inspection is carried out according to the schedules prescribed in Section 11, Maintenance Instructions - *Activities during Service Inspection*, the compressor and unit will work efficiently and have a long service life.

Checking the Oil

See Section 11, Maintenance Instructions.

Major Service Intervals

See Section 11, Maintenance Instructions.

Activities during Service Inspection

See Section 11, Maintenance Instructions.

Oil Charge SAB 128/163R

Fig. 13.1

Oil Cooler Type	Litres		Oil Separator Litres		Compr. Pipes Litres		Total, Unit Litres	
	SAB 128	SAB 163	SAB 128	SAB 163	SAB 128	SAB 163	SAB 128	SAB 163
OOSI 1614	11	11					80	103
OOSI 2114	20	20					89	112
OOSI 2714		31						123
OOSI 3214		48						140
OWSG 1615	25		60	80	9	12	87	
OWSG 1619		25						117
OWSG 2115	39						97	
OWSG 2119		39						131
OWSG 2719		63						155

Oil Charge (US gal)

Oil Cooler Type	US gal		Oil Separator US gal		Compr. Pipes US gal		Total, Unit US gal	
	SAB 128	SAB 163	SAB 128	SAB 163	SAB 128	SAB 163	SAB 128	SAB 163
OOSI 1614	2.9	2.9					21.1	27.2
OOSI 2114	5.3	5.3					23.5	29.6
OOSI 2714		6.2						32.5
OOSI 3214		12.7						37.0
OWSG 1615	6.6		15.8	21.1	2.4	3.2	23.0	
OWSG 1619		6.6						30.7
OWSG 2115	10.3						25.6	
OWSG 2119		10.3						34.6
OWSG 2719		16.6						40.9

Comment: Be sure always to have approx. 25% extra oil available to refill at first start-up.

Servicing the Refrigeration Plant

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

Compressor and condenser must be able to work satisfactorily, safety devices must be intact and the evaporator must function under load, ie:

- 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.

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	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. Replace the drying filter regularly.

	Check	Interval	Activity
Refrigerant	Refrigerant charge	Periodically	Inadequate charge results in reduced plant capacity and often leads to an excessively high discharge pipe temperature.
	Leak detection		The plant must be searched regularly for leaks. Flanges and joints *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.
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 or replace with new ones.
Condenser	Corrision	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 conditional on the evaporator being kept free of ice. Defrost as and when required.
	Oil draining (ammonia plant)	Periodically	Check evaporator, intermediate cooler, receiver, etc. for oil accumulation. Exercise caution; use a gas mask.

Maintenance of Compressor Disassembly and Assembly

Service work on the screw compressor must be carried out by professional, well-trained staff acquainted with the compressor.

These instructions describe complete compressor disassembly and assembly, although this will not always be required.

When dismantling the compressor, the parts should be marked to ensure that they can be remounted in the same position as before.

The torque moments for screws and bolts stated in Section 21 – Appendices must be strictly observed.

Preparations before Disassembly

A description is given below of complete compressor disassembly, inspection and reassembly.

Partial disassembly and inspection can be undertaken while the compressor is secured to the base frame. To allow a complete disassembly, however, the compressor must be lifted off the base frame. For further details, see *Sequence of Disassembling the Compressor* later in this section.

It is important that dismantling and handling of the various parts is carried out as described in these instructions in order to avoid damage when restarting the compressor.

Therefore, read the instructions carefully before commencing the work.

As O-ring gaskets have a tendency to expand when exposed to oil and refrigerant, it is useful to have an extra set of gaskets ready before starting the work. See the list of spare part sets in this instruction manual.

Tools

Apart from having the necessary tools at hand, see document *0662-734* and *0662-744*, it is an advantage to place the compressor on an iron plate when dismantling it completely. This will allow for easy removal of oil leaking from the compressor during the dismantling process.

It is also recommended to position the compressor in a spacious room, which is clean and free of dust.

Elimination of Refrigerant Gas

Shut off the suction and discharge stop valves and eliminate the refrigerant gas as described in Section 3, Safety Precautions – *Protecting the Operator as well as the Environment.*

Removal of Various Accessories

When working on the compressor, the power to the compressor motor must be cut off and it must be ensured that the compressor cannot start inadvertently (if necessary, remove the main switches).

Dismantling of Following Parts

1. Coupling between compressor and motor.

2. Flanges connecting the compressor suction and discharge sides to plant and oil separator
(in case of total disassembling).

3. Oil piping connected to the compressor.

   There may be oil in these pipes. They should therefore be loosened carefully to allow for collection of this oil.

   When the oil pipes have been removed, they must be stored without being bent or damaged.

4. Electrical connections to the compressor block.

The position numbers in the following sections refer to the spare parts drawing.

Draining Oil from Compressor

After the oil pipes have been dismantled, there may still be quite a large amount of oil in the compressor. Most of the oil can be removed by unscrewing the threaded plug pos. 24 on the lower side of the compressor while this is suspended eg in a crane.

Note:

For cleaning and drying compressor parts, ***do not*** *use twist or* ***any other*** *fluffy cloth.*

Disassembling of Compressor

Sequence of disassembling:

Parts to be disassembled	Point
Oil filter	1
Suction filter	2
Shaft seal	3
Slide for V_i regulation	4
Suction cover and bearings in compressor shaft end	5
Rotors and bearings in compressor discharge end	6
Compressor Protecting System	7

The individual points are described below.

Reassembling of Compressor

Clean all parts carefully before reassembling. Examine the parts for damage and wear and replace with new parts, if necessary.
Examine all gasket rings to see if they can be reused. If in doubt, replace with new parts.

Before remounting, lubricate all parts, including screws, with clean fresh refrigeration oil.

1. Oil Filter

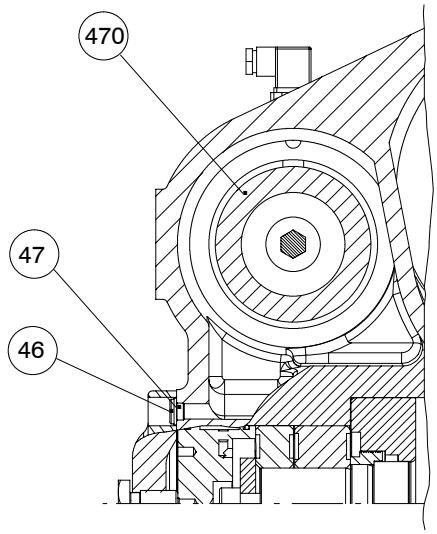
The oil filter pos. 470 is a replaceable filter cartridge fitted in the compressor block as shown in the spare parts drawing.
Along with the consumption of the filtering capacity of the filter cartridge, the pressure loss across the filter will increase. This is registered by two pressure transducers pos. 752 and pos. 753.

Make sure that a new filter cartridge is available as the replaced oil filter **cannot be cleaned**.

Before removing the filter cartridge from the compressor block, stop the compressor.Equalize the pressure to atmospheric pressure. Furthermore, **empty the oil filter housing of oil.** This is done by unscrewing the threaded plug pos. 46 – see piping diagram as well as Fig. 13.2.

This drainage is best carried out when there is still excess pressure in the compressor.

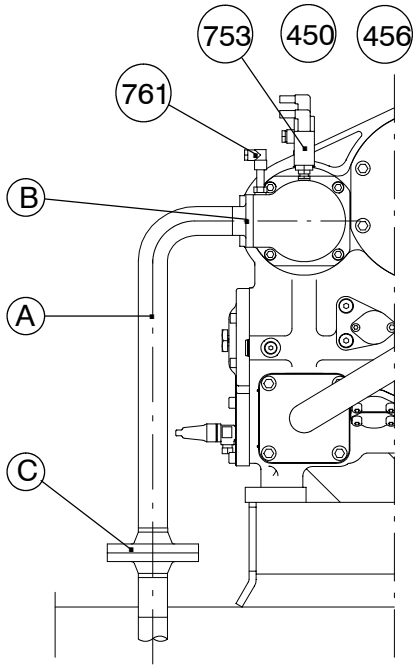
Fig. 13.2



1.1. Removal and Cleaning

After the pressure in the compressor has been equalized to atmospheric pressure, dismantle oil pipe pos. A at flanges B and C as illustrated in Fig. 13.3.

Fig. 13.3



1.1.1. Next, dismantle the electrical connection pos. 753 and the temperature transmitter pos. 761.

1.1.2. By removing the screws pos. 456, the cover pos. 450 with the oil cartridge pos. 470 and the O-ring pos. 452 can be extracted from the oil filter housing.

1.1.3. By dismantling the nut pos. 455, the filter cartridge pos. 470 can be pulled out across the spindle pos. 458.

1.1.4. **Do not dismantle** the magnetic filter pos. 460, but wipe it with a clean piece of cloth.

1.2. Mounting of Oil Filter Cartridge

1.2.1. After cleaning the cover pos. 450 and 471 on the inside, mount the filter cartridge pos. 470 and the O-ring pos. 453 and 472. Secure the parts with the nut pos. 455.

1.2.2. Position the complete cover pos. 450 with the O-ring pos. 452 in the compressor and tighten with the screws pos. 456.

1.2.3. Mount the oil pipe pos. A and secure it to the flanges B and C as illustrated in Fig. 13.3. If considered necessary, replace the O-ring in flange **B** and the gasket in flange **C**. See part numbers in *Spare Parts List - Document 0662-731/741* in the section on *Oil System - Flange Connection*.

1.2.4. Next, fit the electrical connection coupling to the pressure transducer pos. 753 and the temperature transmitter pos. 761.

2. Suction Filter

The suction filter is built into the compressor housing above the rotors.

The purpose of the filter is to collect the impurities conveyed from the evaporator system with the suction gas.

Experience shows that a good deal of impurities are collected in the filter during the initial period following start-up of a new refrigeration plant.

Consequently, it is important to clean the suction filter after 200 hours of operation from the initial start-up of the compressor.

In case this is not done, there is a risk that the suction filter may burst due to an excessive differential pressure across the filter.

2.1 Removal of Suction Filter

Before removal of the suction filter, the compressor protection system must be dismounted. The protection system is fitted on the compressor block with two flange connections.

2.1.1. Remove the screws pos. 702 and 716 and dismount the protection system.

2.1.2. Dismount the suction filter cover pos. 718 by removing the eight screws pos. 734.

2.1.3. Pull out the suction filter pos. 170. **Take care when removing the filter so dirt from the filter does not enter the compressor.**

2.1.4. Clean the suction filter in an oil detergent. Blow dry and clean it with compressed air.

2.2 Mounting of Suction Filter

After cleaning the suction filter pos. 170, check that the filter mesh is undamaged.
Mount suction filter as follows:

2.2.1. Before mounting the suction filter, check that the non-return valve works correctly. Check that the suction chamber is clean.
Replace O-ring pos. 719.

2.2.2. Mount the filter insert in the suction chamber. Mount the cover pos. 718 with the screws pos. 734.

3. Shaft Seal for SAB 128 and SAB 163 Mk4

Fig. 13.4

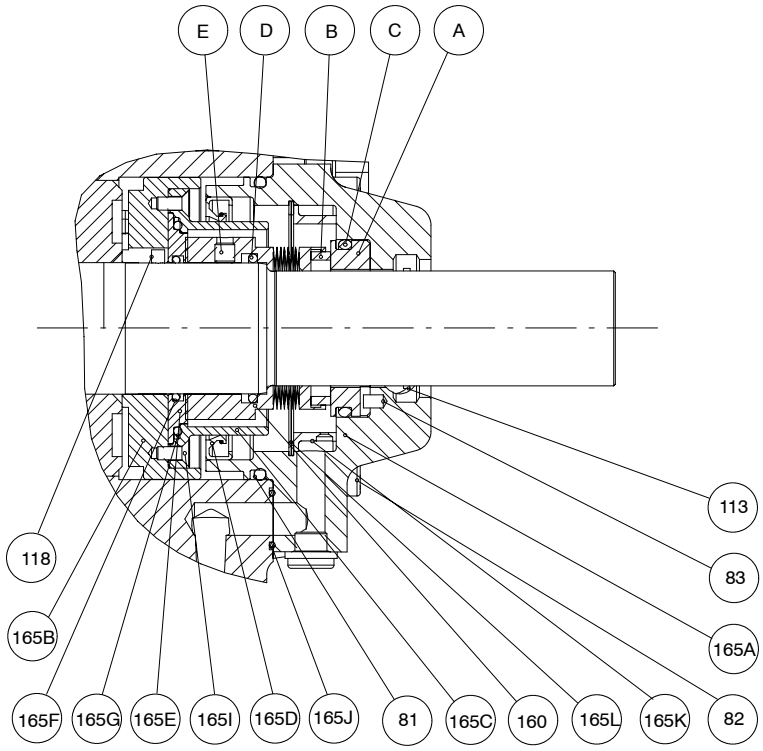


Fig. 13.5 SAB 128

Pos. no.	Designation	Quantity
165AA	Shaft seal cover, Male	1
165AB	Shaft seal cover, Female	1
165B	Balance piston	1
165C	Slide ring with wear bushing	1
165D	Radial shaft seal	1
165E	Inner ring	1
165F	O-ring, 39.34 x 2.62	1
165G	O-ring, 59.99 x 2.62	1
165I	Countersunk screw M4 x 10	4
165J	O-ring, 14 x 1.78	1
165K	Oil distribution ring	1
165L	Spirolox ring	1

Fig. 13.6 SAB 163

Pos. no.	Designation	Quantity
165AA	Shaft seal cover, Male	1
165AB	Shaft seal cover, Female	1
165B	Balance piston	1
165C	Slide ring with wear bushing	1
165D	Radial shaft seal	1
165E	Inner ring	1
165F	O-ring 50.52 x 1.78	1
165G	O-ring 69.52 x 2.62	1
165I	Countersunk screw M6 x 12	4
165J	O-ring, 14 x 1.78	1
165K	Oil distribution ring	1
165L	Spirolox ring	1

The shaft seal pos. 160 as illustrated in Fig. 13.4 is mounted at the compressor shaft. The shaft seal must ensure that refrigerant and oil from the inside of the compressor do not escape into the atmosphere both when the shaft is rotating and when it is standing still. The shaft seal has therefore two sealing systems, the *primary shaft seal* and the *lip seal arrangement* as described in the following.

Primary Shaft Seal

The shaft seal is of the slide ring type. It consists of a slide ring made of special carbon and mounted in the rotating part of the shaft seal pos. B. It rotates together with the shaft and slides against a steel ring pos. A, which is inserted in the shaft seal cover pos. 165A. The sliding surfaces of the two rings are surface-ground and lapped together, thus ensuring the desired tightness both when the compressor is and is not in operation.

It is therefore important to be very careful with the lapped sliding surfaces as even the smallest scratch will reduce the tightness of the shaft seal.

The shaft seal is mounted and dismounted as described in the following. The rotating part pos. B is secured to the compressor shaft by means of three pointed screws pos. E. The *outer and inner O-rings* pos. C and D ensure tightness between the shaft seal and the shaft seal cover pos. 165A and the compressor shaft respectively.

Lip Seal Arrangement

When the compressor has not been in operation for a long period of time, the oil in the shaft seal chamber, which helps to keep the shaft seal gas-tight, will drain away from the chamber, making it possible for small amounts of refrigerant to leak from the shaft seal.

To avoid this situation, a sealing ring pos. 165D must be used. This ring ensures that the oil stays in the shaft seal chamber. In this way there will always be a thin oil film between the two sliding surfaces of the shaft seal and thus complete gas-tightness between the inside of the compressor and the atmosphere.

The sealing ring pos. 165D is mounted in the shaft seal cover pos. 165A and seals against the *sliding ring pos. 165C,* as illustrated in Fig. 13.4.

Dismounting of Shaft Seal and Lip Seal Arrangement

- Depressurize the compressor - as described in the instruction manual - and dismantle the coupling.
- Remove all the screws pos. 82 and pull out the shaft seal cover. If the cover sticks, it can be pushed out by mounting two of the screws pos. 82 in the two threaded holes of the cover.

Note: ***Only SAB 128***

The two threaded holes are not threaded all the way through. It is therefore advisable to insert a steel pin (diameter 8 x 40 mm) before mounting the screw.

- The steel slide ring pos. A and the sealing ring pos. 165D will come out with the cover and can then with great care be pressed out of the cover. The oil splash ring will also come out with the cover and can be removed manually.

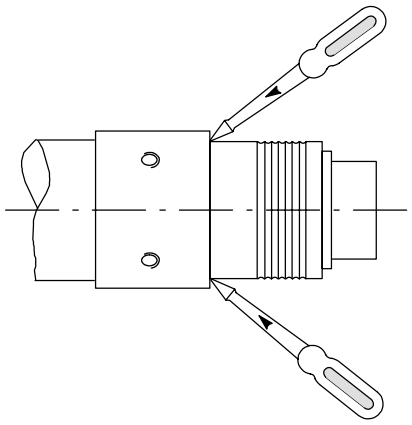
- Dismount the four countersunk screws pos 165I.
- Pull out the slide ring 165C by means of two long M4 screws (SAB128) or M6 screws (SAB 163), which are mounted in the two threaded holes in the flange. The O-ring pos. 165G can now be removed manually.
- Now there is enough space to loosen the three pointed screws pos. E approx one turn by means of the shortened Allen key - size 3 mm - which is included in the shaft seal set.
- When the three pointed screws have been loosened, the rotating part - with the carbon ring - can be pulled out over the shaft. Tools will usually not be necessary.
- By fitting the above-mentioned two long screws (M4 or M6) in the threaded holes of the balance piston pos. 165B, the piston can now be pulled out manually. The *inner ring pos. 165E and the O-ring pos. 165F* will come out with the piston and can then be removed manually.

Mounting of Shaft Seal and Internal Oil Seal

After cleaning the shaft seal parts and the compressor shaft and checking them for scratches and marks, oil all surfaces with the same type of oil which is used in the compressor. Now the shaft seal and the oil seal are ready to be mounted.

- First place the balance piston pos. 165B (see Fig. 13.4) on the compressor shaft and turn it so that the pin pos. 118 catches the key groove of the balance piston.
- Mount the O-ring pos. 165F in the inner ring pos. 165E. Press the inner ring on to the compressor shaft. Keep pressing until the ring rests on the balance piston.
- Fit the O-ring pos. 165G in the inner ring, eg by means of a little grease.
- Mount the rotating part of the shaft seal (the one with the carbon ring) and push it all the way to the recess on the shaft. Do not put any pressure on the carbon ring. Use instead two screwdrivers as illustrated in Fig. 13.7. Tighten the rotating part by means of the three pointed screws pos. E. Check that the O-ring pos. D has been mounted in the rotating part.

Fig. 13.7

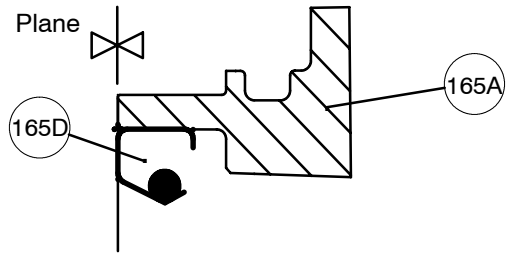


- Mount the slide ring pos. 165C and tighten it by means of the four countersunk screws pos. 165I.

Before mounting the shaft seal cover pos. 165A on the compressor block, carry out the following:

- Press the sealing ring pos. 165D into the shaft seal cover. It must be turned as illustrated in the drawing Fig. 13.8 and must only be pressed so far into the shaft seal cover that the two surfaces are flush with each other as shown in Fig. 13.8.

Fig. 13.8



- Mount the O-ring pos. C on the cast iron seat pos. A and place the cast iron seat in the shaft seal cover so that the pin pos. 83 catches the key groove of the seat.
- Fix the O-ring pos. 81 to the shaft seal cover and the O-ring pos. 165J in the internal oil channel.

- Place the shaft seal cover on the compressor shaft and move it carefully forward until it touches the rotating part. Before the screws pos. 82 are tightened, there must be a gap of 3-4 mm between the two flanges as shown in Fig. 13.9.

  It is recommended to cross-tighten the screws pos. 82 so that the shaft seal is not damaged due to uneven tightening. Tighten the screws to the torques indicated in the instruction manual.

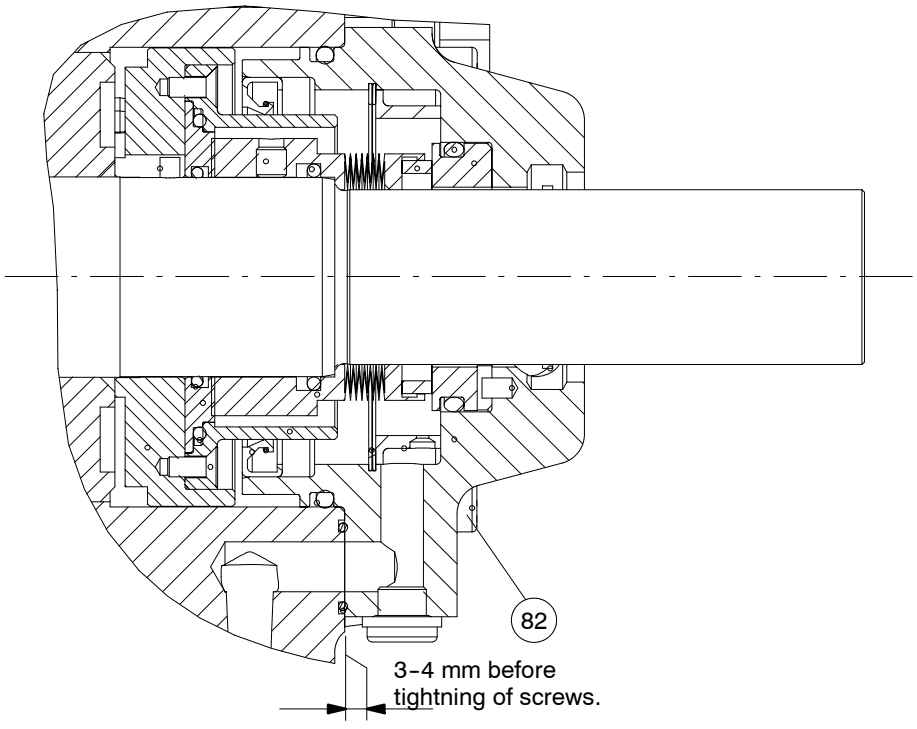
- Mount the oil splash ring pos. 113. Fit the coupling for the motor as described in the instruction manual. Turn the compressor shaft manually to check that it is able to rotate freely.

Cap Cover

After dismantling the screws pos. 92, dismount the cap cover pos. 90 by fitting two of the screws in the threaded holes in the cap cover flange. Thus the cap cover can be pushed out. Remounting of the cap cover is carried out in the same way as the shaft seal cover.

Before mounting the cover, clean the nozzle pos. 95 with compressed air. Check O-ring pos. 96 and replace it if necessary.

Fig. 13.9



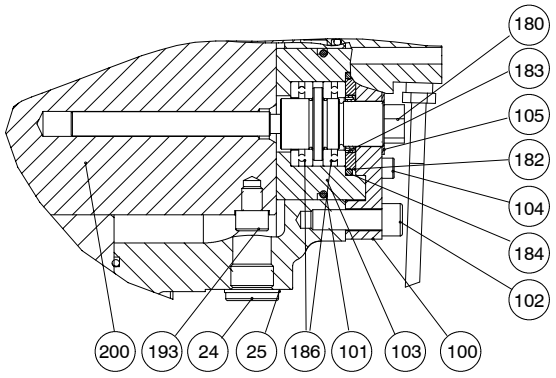
4. Slide for V_i Regulation

The purpose of the V_i regulating system is to regulate the built-in compressor volume ratio so that the compression ratio is equal to the pressure ratio between the condensing pressure and the evaporating pressure in the refrigeration plant. The system works by dislocating the slide pos. 200, thus changing the size of the compressor discharge port. This change increases - or decreases - the compression chamber and consequently the compression ratio.

V_i Adjustment

Adjustment of the V_i slide position is described in Section 4, Technical Description. The pos. numbers in Fig. 13.10 refer to the spare parts drawing.

Fig. 13.10



Dismantling

After dismantling of the screws pos. 102, unscrew the slide cover pos. 100 and the bearing housing pos. 103 by turning the spindle pos. 180 **anti-clockwise.**

- When the spindle has been unscrewed completely from the thread in the slide pos. 200, the arrangement can be removed manually.
- By dismantling the screws pos. 104, the cover pos. 100 is dismantled from the bearing housing pos. 103. The sealing rings pos. 182, 183 and 184 can be removed by hand.
- Push the spindle pos. 180 and the ball bearings pos. 186 out of the bearing housing, pos. 103.
- Do not remove the arrangement from the compressor until the suction cover pos. 20 has been dismantled.
- The screw pos. 193 functions as a slide stop and should usually not be dismantled.

Mounting

Assembly is carried out in reverse order and attention must be paid to the following:

- Insert the ball bearings, which must be well greased with ball-bearing grease, in the bearing housing pos. 103 with the spindle collar pos. 180 in between. Avoid **knocking** on the bearings.

- Before assembling of the slide cover pos. 100 and the bearing housing pos. 103, place the sealing rings pos. 182, 183 and 184 as shown in the drawing. The open side of the sealing ring pos. 183 must face the ball bearing. Assembling is carried out by means of the screws pos. 104.

– Check that the spindle is easily turned.

- Mount the whole unit in position by screwing the spindle into the slide pos. 200 until the slide cover pos. 100 rests against the suction cover pos. 20.

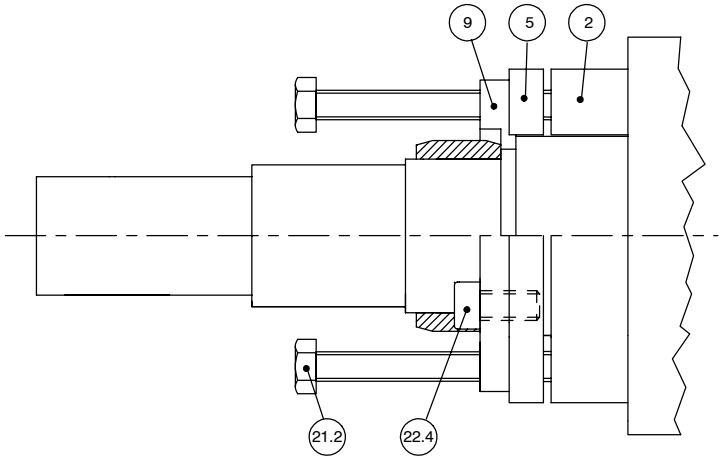
  Pay attention to the O-ring pos. 101. Secure with the screws pos. 102.

5. Suction Cover and Bearing in Compressor Shaft End

Before the suction cover pos. 20 can be dismantled, the following parts must be removed as described earlier:

- Shaft seal cover pos. 80 and shaft seal
- Cap cover pos. 90
- Slide stop cover pos. 100

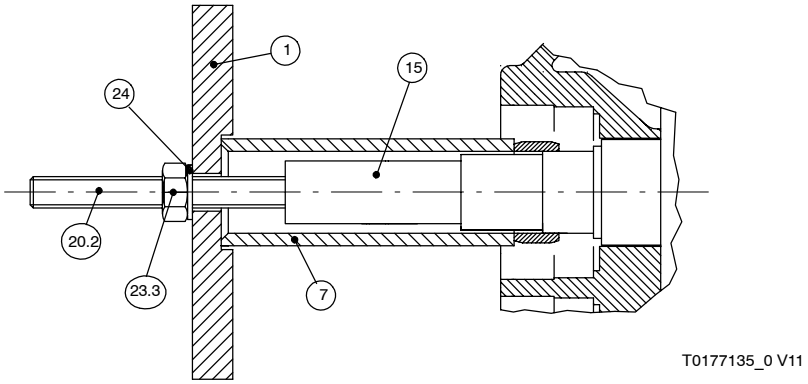
Fig. 13.11



Dismantling

- Knock out the guide pins pos. 22 with the tools nos. 55 and 56,.
- Dismantle the screws pos. 23.
- Carefully pull out the suction cover above the shaft ends. The outer rings of the roller bearings pos. 111 will come out with the cover.
- Knock the outer rings with the rollers out of the cover with a punch. **They cannot be reused.**
- After dismantling the retention pin pos. 118, pull out the roller bearing inner ring of the rotors as shown in Fig. 13.11. The numbers in the drawing refer to the tools list.
- Mount punch pos. 15 on the short shaft end (rotor end).
- Lock the rotors as shown in Fig. 13.15.

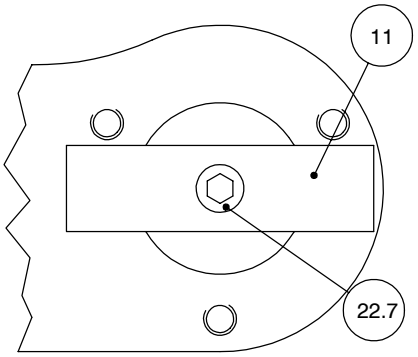
Fig. 13.12



Mounting

- Mount locking tool no. 11 on the rotor end where the roller bearing inner ring is to be positioned as shown in Fig. 13.13.

Fig. 13.13



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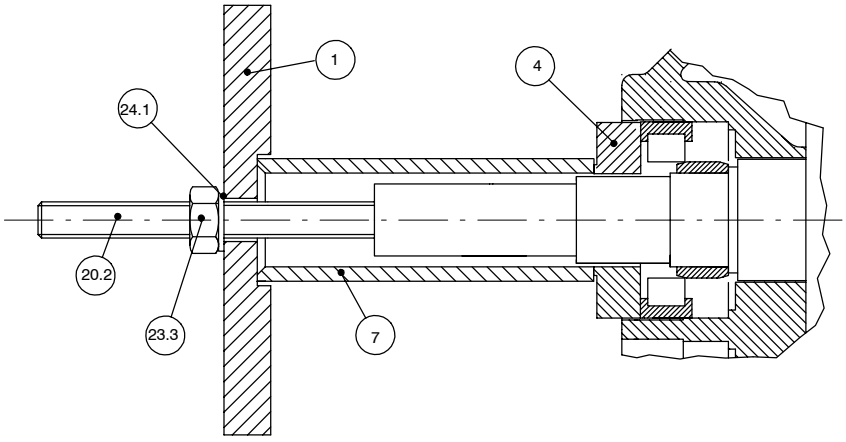
- Press on the roller bearing inner ring with the tools as shown in Fig. 13.12. Remember to grease the shafts with **Molykote grease**. Tighten to 70 Nm.

  Always mount new roller bearings.

- Mount driving pin pos. 118 on the rotor shaft in which the shaft seal is to be mounted.
- Mount the suction cover pos. 20 with the guide pins pos. 22 and tighten the screws pos. 23. Pay attention to the O-ring pos. 21 as well as the two small O-rings pos. 26 for internal oil channels.
- Press the outer rings with rollers into position as shown in Fig. 13.14. Remember to use tool no. 4 as shown in the drawing.
- Dismantle locking tool no. 11.
- Now mount the remaining parts as mentioned at the beginning of this section.

Fig. 13.14



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6. Rotors and Bearings in Compressor Discharge End

Before the rotors can be removed from the compressor, the parts mentioned under point 5 must be disassembled. Proceed as follows:

6.1 Dismantling

6.1.1. Loosen the four locking screws pos. 45 and slacken the two adjusting screws pos. 44 three to four turns.

6.1.2. Dismantle the cover pos. 40 by removing the screws pos. 43.

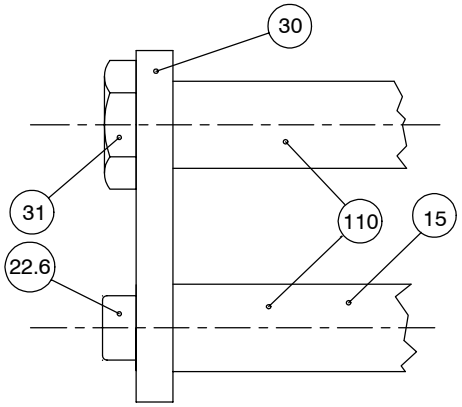
6.1.3. Pull out the two inner covers pos. 151 and 153 by means of the screws no. 22.3, which must be mounted in the threaded holes of the covers.

Be careful not to lose the two locking pins pos. 119.

6.1.4. Now dismantle the screws pos. 115 and remove the clamps pos. 114.

When dismantling the screws pos. 115, lock the rotors in order to prevent them from rotating. For this purpose use arrangement Fig. 13.15 in the rotor shaft end.

Fig. 13.15

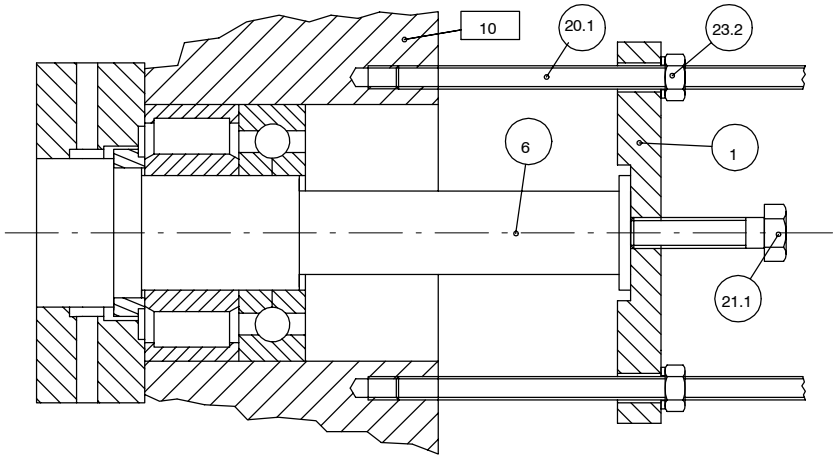


Remember to dismantle the tools again before pressing out the rotors.

6.1.5. It is now possible to push out the rotors - one at a time - by means of the tools shown in Fig. 13.16.

Screw the four long threaded journals no. 20.1 from the tools set into the threaded holes used for securing the cover pos. 40.

Fig. 13.16

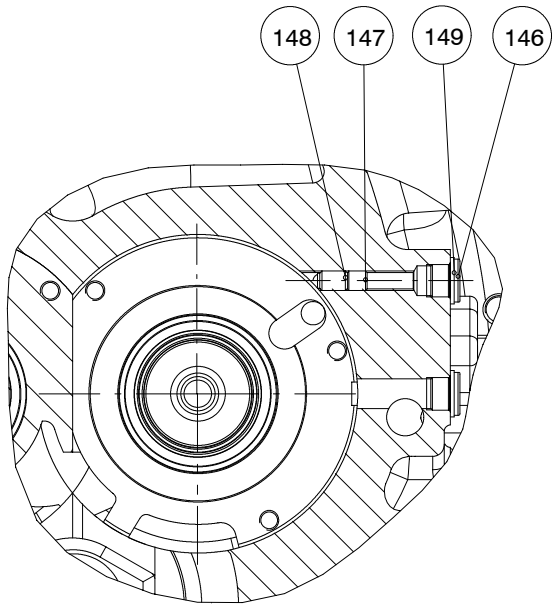


Press the rotors loose - one at a time with screw no. 21.1 and remove them manually. The bearing inner rings will also be loosened from the rotors as they cannot pass the discharge ports pos. 140 and 141.

6.1.6 Loosen the discharge ports pos. 140 and 141 by removing the screws pos. 142.

- The discharge ports are adjusted by means of the adjusting screw pos. 148 and the locking screw pos. 147 (see spare parts drawing).

Fig. 13.17



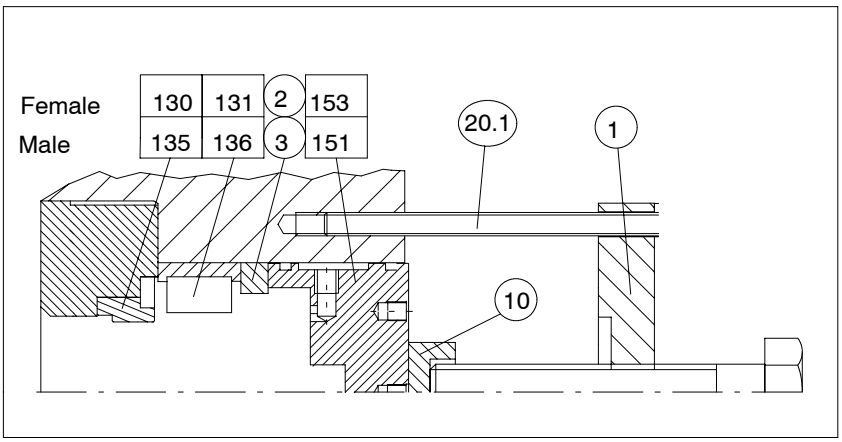
Start by dismantling the blank-off screw pos. 146 together with the gasket pos. 149. Next, dismantle pos. 147 and loosen pos. 148 with key no. 51.2. There is only one set of screws pos. 146/147/148 per discharge port.

Note:
It is essential to loosen the screws pos. 148 before pressing out the discharge ports as described in the following.

6.1.7 Press out the outer rings of the main bearings and the discharge ports pos.140 and 141 by means of the tools shown in Fig. 13.18.
Normally, the bearings should **not** be reused.
Note, that O-rings pos. 152 and 154 are **not** mounted.

6.1.8 Remove the balance piston pos. 130 and 135 from the discharge port manually.

Fig. 13.18



6.2 Mounting

6.2.1 Before positioning the discharge ports pos. 140 and 141 in the rotor housing, check that they are free of burrs and marks in particular on the surfaces which are going to rest against the rotor housing.

Check the rotor housing for similar defects on the corresponding contact surfaces.

6.2.2 Push the discharge ports into place in the rotor housing and tighten the screws pos. 142 and the steel gaskets pos. 143.

- Tighten the screws pos. 142 to half the torque (see table of torque moments in Section 21, Appendices) to make sure that the discharge ports are in close contact with the rotor housing end surface.
  Loosen the screws and retighten them slightly to facilitate the subsequent adjustment.

  Mount the slide pos. 200 and tighten the adjusting screw pos. 148 loosely in the two discharge ports.

- While pushing the slide pos. 200 back and forth, tighten the screws pos. 148 **one after the other** until the slide is moving **smoothly** back and forth.

- Now fit the locking screw pos. 147 and tighten it to 32 Nm.

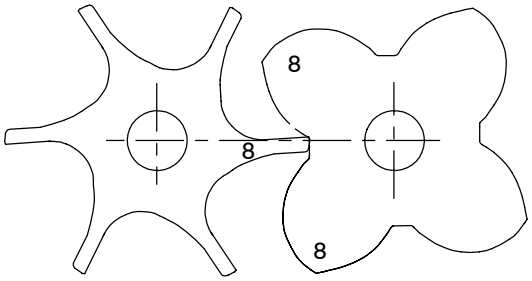
- Mount and tighten the blank-off screw pos. 146 as well as the gasket pos. 149.

- Finally, tighten the screws pos. 142 to the prescribed torque.

  Remember that the steel gaskets pos. 143 are not to be reused, but replaced with new ones in order to obtain tightness.

6.2.2 Before inserting the rotors pos. 110 in the rotor housing, it is recommended that the V_i slide pos. 200 is positioned in the rotor housing to support the rotors.

Fig. 13.19



The rotors are marked with a number on the end surface that faces the compressor suction end.

The marking must have the same number on both rotors. When mounting the rotors, the catching between the rotors must be as shown in Fig. 13.19.

(The number ”8” is an example).

It is also extremely important that the male and female rotors are positioned in the rotor housing as indicated in the spare parts drawing and cast on the end cover pos. 20.

6.2.4 The bearing systems at the compressor discharge end consist of the following parts for each rotor:

	Female rotor Pos.	**Male rotor** Pos.
balance piston	130	135
roller bearing	131	136
special ball bearing	132	137
set of adjustment ring	133	138

The adjustment sets consist of the following rings:

Thickness +0 −0.01	**Number of rings**	
	Male Dia.70/90 mm	**Female** Dia.80/100 mm
0.49	1	1
0.52	1	1
0.55	1	1
0.58	1	1
0.61	1	1
0.64	1	1
0.67	1	1

In case of replacement, all bearings **must** be replaced.

6.2.5 Grease the shaft ends with Molykote grease and position the balance pistons pos. 130 and 135 manually. The balance pistons must turn as indicated in the spare parts drawing.

6.2.6 With the tool arrangement shown in Fig. 13.20, press the roller bearing inner rings into position.

Mount the roller bearings with the bearing manufacturer’s marking facing ***outwards.***

On the female rotor, turn tool no. 7 as shown in Fig. 13.20. On the male rotor, **the conical end** of the tool must be facing the bearing.

Before mounting the bearings, lock the rotors at the opposite end as shown in Fig. 13.16.

Tighten the nut no. 23.3 with torque wrench no. 40.2 to 70 Nm.

Fig. 13.20

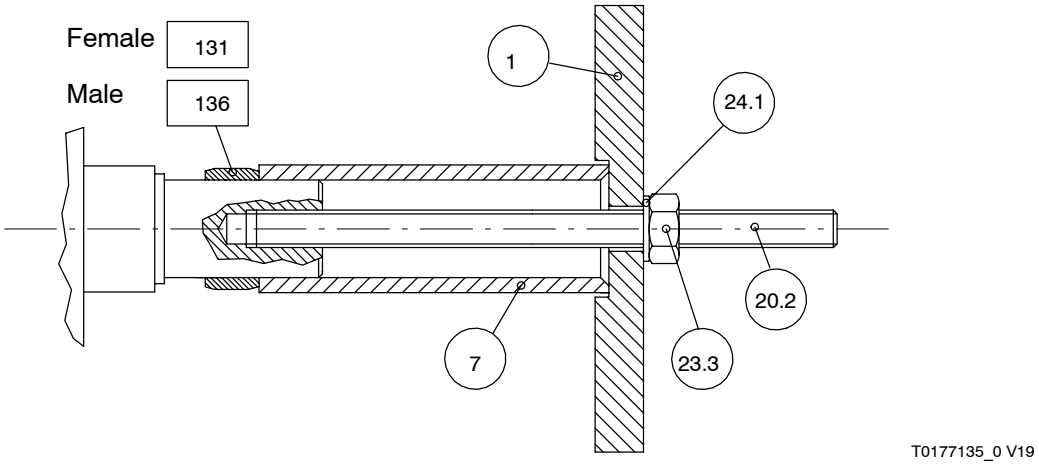
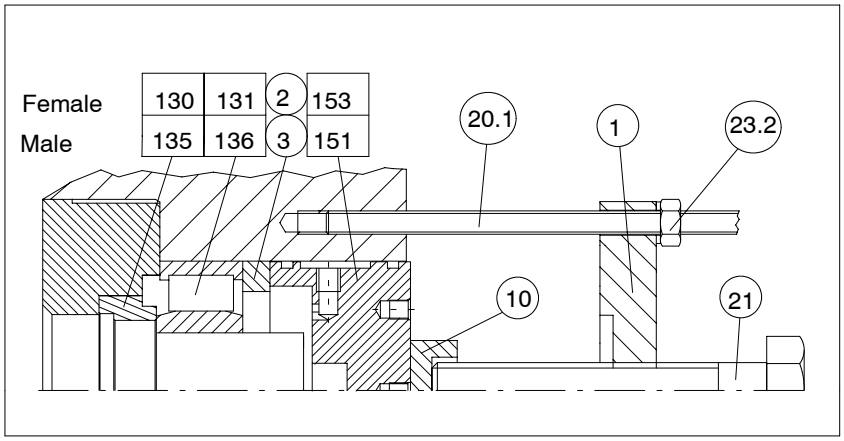


Fig. 13.21



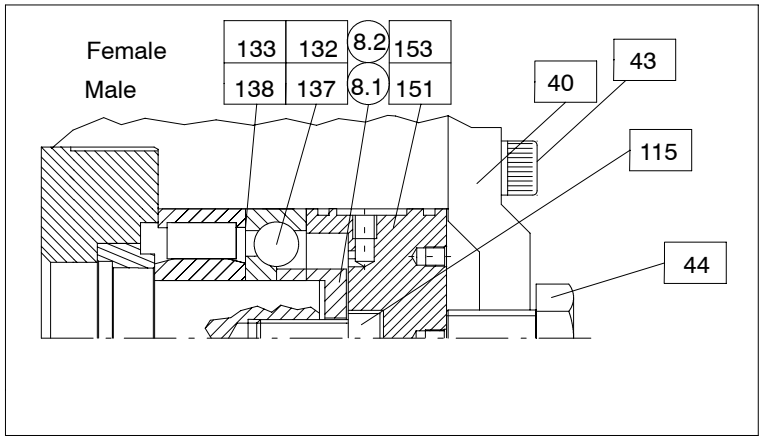
6.2.7 Press the roller bearing outer rings pos. 131/136 in position with tools shown in Fig. 13.21.
The factory marking must face **outwards.**

6.2.8 Press the innermost ball bearing inner ring pos. 132/137 into position by means of the same tool arrangement as shown in Fig. 13.20.

Tighten the nut no. 23.3 to 70 Nm. The factory marking must face **inwards.**

Note that the O-ring pos. 152/154 is not mounted when the thrust covers pos. 151/153 are used as mounting tools.

Fig. 13.22



6.2.9. After removing the above tool arrangement, mount the following as shown in Fig. 13.22.

a: Insert the ball bearing outer rings pos. 132/137 manually. Place them in the same position as the mounted inner rings.

b: Tools no. 8.1 on the male rotor and 8.2 on the female rotor and tighten with the screws pos. 115:

- 100 Nm for SAB 128 Mk2 and 3.
- 225 Nm for SAB 163 Mk2 and 3.

c: Mount the thrust covers pos. 151 and 153.

d: Secure the cover pos. 40 with the screws pos. 43.

e: Mount the adjusting screws pos. 44, but do not tighten them.

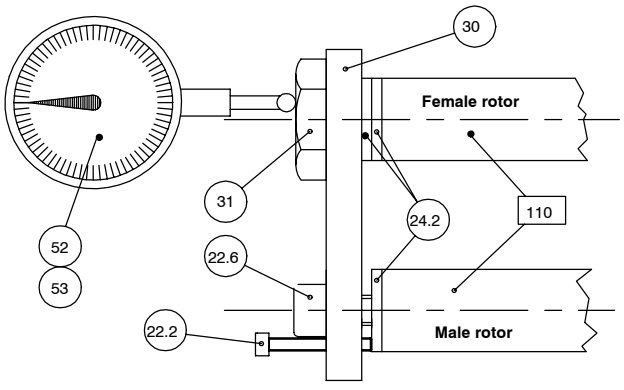
f: Dismantle the locking tools.

6.3 Adjustment of Axial Clearance of Rotors

After the bearings have been mounted as described in the previous section, the axial clearance of the rotors can be adjusted with a tool arrangement Fig. 13.23, which is mounted on the rotor shaft ends.

Start by adjusting the female rotor.

Fig. 13.23



Adjustment

6.3.1 Screw in the screw no. 22.6 manually until tool no. 30 has the same distance to both shaft ends as shown in Fig. 13.23. Tighten the screw no. 22.2 to 14 Nm, whereby the female rotor is pressed against the discharge port pos. 141. The adjusting screw pos. 44 must be loose.
Set dial meter on ”0”.

6.3.2 Now screw in the adjusting screw pos. 44 at the female rotor and tighten to **32 Nm.** Read the dial meter and note the difference. The difference indicates how much the rotor can be moved axially.

a: By way of example this movement could be 0.630 mm.

b: As the correct movement must be between 0.05 and 0.10 mm, the average figure is 0.075 mm. This figure is deducted from the measured value:

0.630-0.075 = 0.555 mm

6.3.3 From the adjusting set pos. 133, select the adjusting ring whose thickness comes closest to the calculated value. In the example above the calculated value is 0.55 mm. The thickness is stamped on the rings.

6.3.4 By inserting the selected adjusting ring as shown in Fig. 13.22 (pos. 133) and repeating the adjustment mentioned in section 6.3.2, it is certain that the movement remains within the mentioned tolerances (0.05 and 0.10 mm). The **exact measure** is noted down for later application (see point 6.3.10).

The exact measure for a female rotor can eg be 0.061 mm after the adjustments in sections 6.3.3 and 6.3.4.

To be able to insert the adjusting rings, the following must be done:

- Loosen the adjusting screw pos. 44
- Dismantle the cover pos. 40
- Take out the thrust cover pos. 153
- Take out the ball bearing outer ring manually together with the balls.

The remaining parts of the tool arrangement **are not dismantled.**

6.3.5 After the adjustment, loosen the adjusting screw pos. 44 and dismantle the cover pos. 40, the thrust cover pos. 153 and the tool no. 8.2 (see Fig. 13.22).

6.3.6 By means of the tools shown in Fig. 13.20, mount the outmost ball bearing inner ring and tighten the thrust plate pos. 114 with the screw pos. 115.

Tighten the screw to :

- 70 Nm for SAB 128 Mk2 and 3
- 225 Nm for SAB 163 Mk2 and 3

6.3.7 Insert the locking pin pos. 119 in the groove of the ball bearing outer ring, turning it so that the groove faces downwards.

6.3.8 Position the O-ring pos. 154 on the thrust cover pos. 153 and fit the screw no. 22.3 on the thrust cover and lock with the nut no. 23.1.

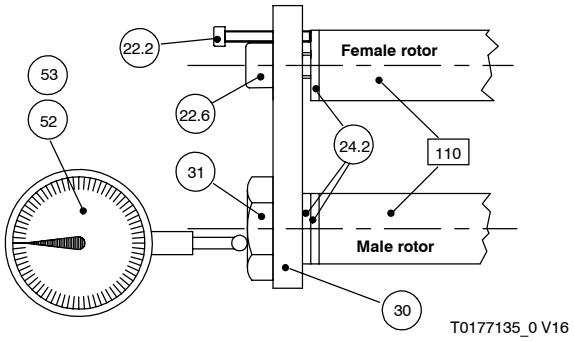
Place the thrust cover in position and turn the screw no. 22.3 until the groove in the thrust cover catches the locking pin pos. 119. This can be registered by the cover being carefully

pressed inwards during the turning. Thus it can be pressed in a little further when the locking pin catches the groove in the thrust cover.

6.3.9 Mount the cover pos. 40 and secure it with the screws pos. 43. Remember that the adjusting screws pos. 44 must be loose.

Adjust the **male rotor** in the same way as described in sections 6.3.1 to 6.3.9 by mounting the adjusting tools shown in Fig. 13.24.

Fig. 13.24



Final Adjustment

After both rotors have been adjusted and the **exact measures** have been noted down, the rotors are ready for the **final adjustment**.

6.3.10 Compare the exact measure for each of the rotors with the measures in column 1 of the following table. Column 2 indicates the **final adjust ment measure.**

For instance, the exact measure of 0.062 mm for the female rotor will be between 0.061 and 0.065, which leaves a **final adjustment measure** of 0.05 mm.

Exact measures between mm 1	Final adjustment measures mm 2
0.050-0.055	0.040
0.056-0.060	0.045
0.061-0.065	0.050
0.066-0.070	0.055
0.071-0.074	0.060
0.075-0.079	0.065
0.080-0.084	0.070
0.085-0.089	0.075
0.090-0.094	0.080
0.095-0.100	0.085

With the adjusting tools mounted as shown in Fig. 13.24 and the dial meter set at ”0”, tighten the adjusting screw pos. 44 while reading the dial meter. The dial meter indicator must move **the final adjustment measure.**

6.3.11 After this final adjustment, lock the adjusting screws pos. 44 with the pointed screws pos. 45.
The adjustment of the male rotor is now completed.

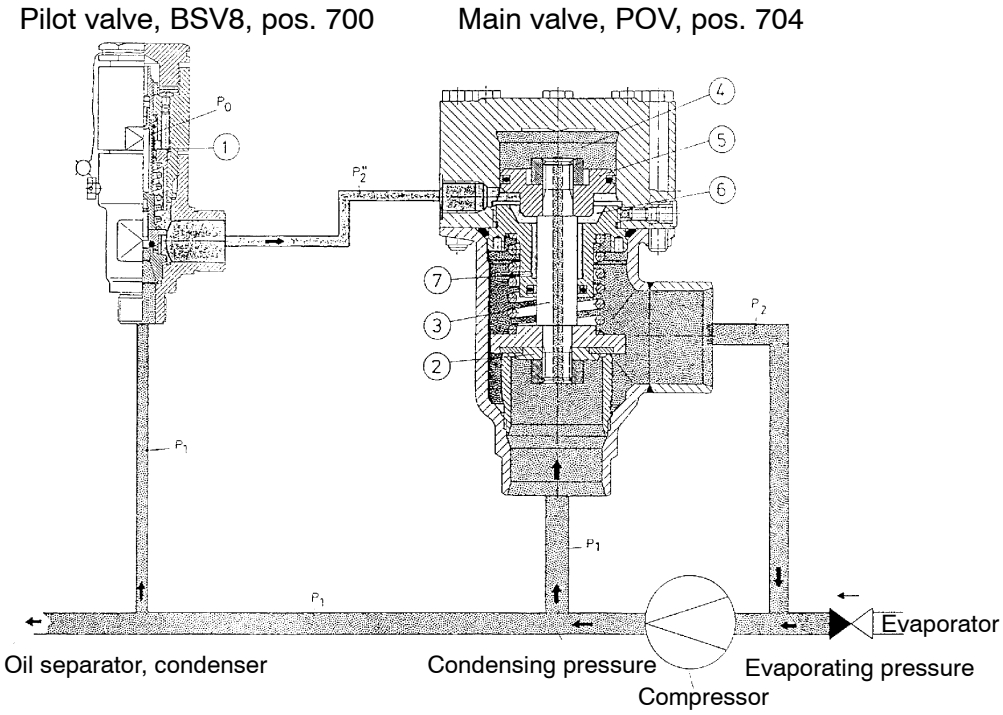
6.3.12 Then mount the adjusting tools as shown in Fig. 13.23 and described in section 6.3.1. Repeat the adjust ment described in sections 6.3.10 and 6.3.11 for the female rotor.

6.3.13 Check manually that the rotors are easily turned.

7. Compressor Protection System

To protect the compressor against too high levels of pressure, it has a built-in protection valve, type POV, pos. 704 which is controlled by the pilot valve, type BSV8, pos. 700. The protection system is shown in Fig. 13.25 and described in the following.

Fig. 13.25



Functional Description

The pilot valve shown in Fig. 13.25 is actuated by the high pressure P_1. The valve is fitted with a stainless metal bellow ①. The reference pressure in the bellow is the atmospheric pressure P_0. The effective area of the bellow is exactly equivalent to the area of the valve seating, meaning that the back pressure P_2" does not affect the opening pressure of the valve.

The main valve is a normally closed valve. The high pressure P_1 affects the lower side of the valve cone ② propagating up through the piston rod ③ to the upper chamber ④ of the valve, producing a pressure on the piston ⑤. The area of the piston is larger than the area of the valve seating. Together with the force of the spring this will keep the valve closed.

When the pressure P_1 reaches the set pressure of the pilot valve, the valve will open. The pressure P_2" of the pilot line and lower chamber ⑥ of the main valve will increase. The pressure of the lower chamber is limited by flow through the nozzle ⑦. When the flow through the pilot valve exceeds the capacity of the nozzle, the pressure of the chamber ⑥ will increase, provided that the main valve is open. When the pressure P_1 is reduced, the pilot valve will close, and the pressure P_2" is equalized through the nozzle ⑦. The spring will then close the main valve. The closing time is $\leq$ 30 seconds, depending on the size

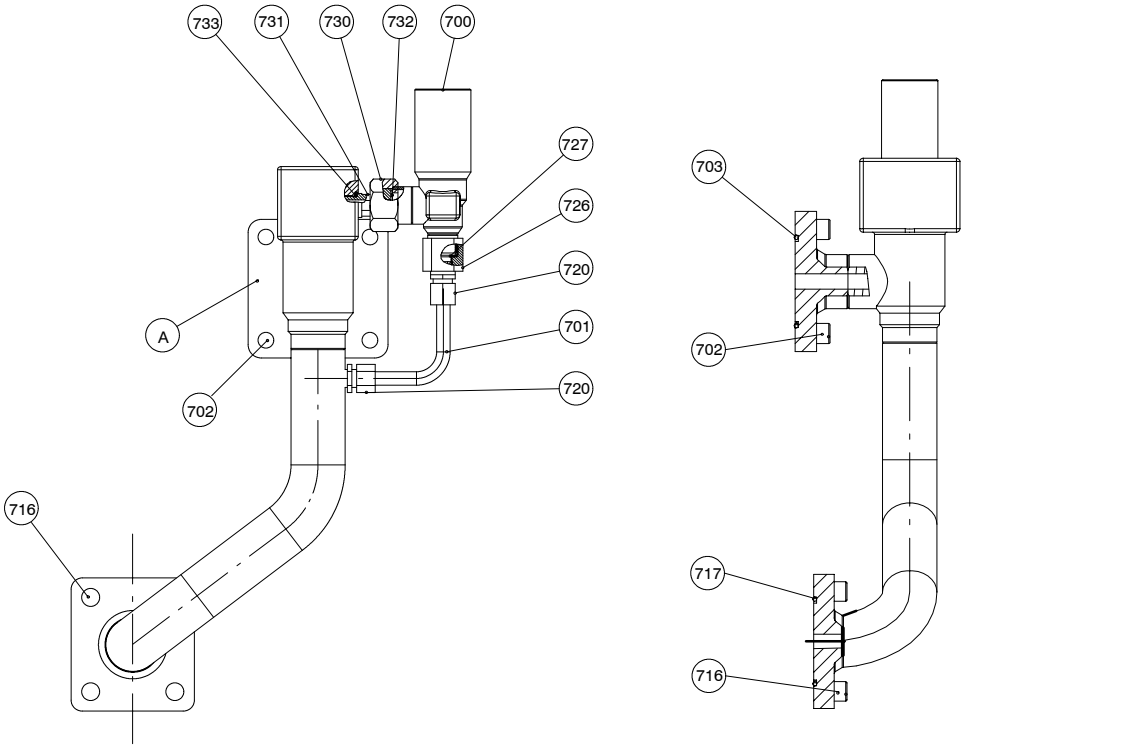
of the nozzle. The spring is dimensioned so that a differential pressure level (P_1-P_2) of 7 bar will open the valve completely.

7.2 Dismantling of Protection System

By dismantling the screws pos. 702 and 716 as shown in Fig. 13.26, the complete safety system can be lifted off the compressor. **Take care not to damage the O-rings pos. 703 and 717**.

Any further dismantling of the system is usually not necessary. Sabroe Refrigeration recommends not to disassemble the various component parts.

Fig. 13.26



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7.3 Control of Opening Pressure

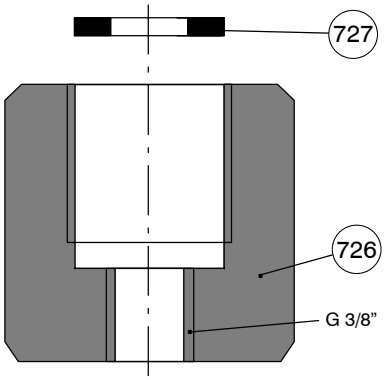
Control of the operation and opening pressure of the protection system should be carried out according to local regulations. Note the following:

7.3.1 Isolate the compressor unit at the stop valves and evacuate the refrigerant. Make sure that the unit cannot be started unintentionally and that there is no excess pressure in the system.

7.3.2 Dismantle the complete protection system by means of the screws pos. 702 and pos. 716.
Take care not to damage the O-rings pos. 703 and 717.

7.3.3 Dismantle the pilot valve pos. 700 by loosening the nuts pos. 720. Then dismantle the nuts pos. 726 and pos. 730.

Fig. 13.27



7.4 Testing of Pilot Valve pos. 700

7.4.1 The pilot valve is usually tested in a test bench. However, it can be connected to a pressure source by means of a high-pressure hose. The connection nut shown as pos. 726 in Fig. 13.27 has a 3/8” thread. A pressure gauge should be used.

7.4.2 By slowly increasing the pressure, check that:
a: the pilot valve remains tight until the opening pressure is reached.
b: the valve opens at the pressure indicated on the name plate.
By opening entirely for the air supply, check that the pilot valve is able to open to full lifting height.

7.5 Testing of Complete Protection System

7.5.1 When testing the complete system, mount the pilot valve as shown in Fig. 13.26. Keep the pressure hose in place as described in section 10.4.1.

7.5.2 When opening for the pressure source, the pilot valve will open at the pressure checked in section 10.4.2. This will activate the main valve pos. 704, which can be checked by glancing through the flange A – Fig. 13.26.

7.6 Remounting of Protection System

7.6.1 When remounting the pilot valve, use new pipe sections pos. 701.
It is also recommend to use new fittings pos. 720, 727 and 732.

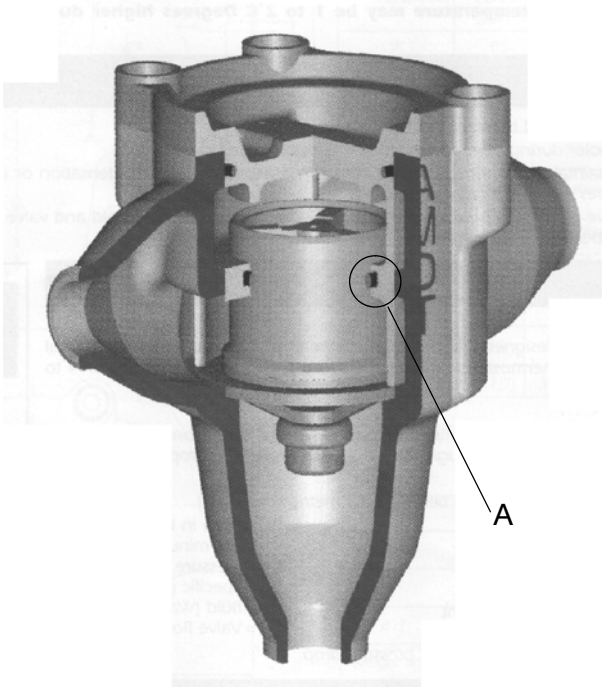
7.6.2 When remounting the complete system on the compressor, position the O-rings pos. 703 and 717 and tighten the screws pos. 702 and 716 as prescribed.

7.6.3 After charging refrigerant to the system, check that the system is not leaking.

Oil temperature regulating system SAB 110, 128, 163, 202 and VMY 536

In the above screw compressor units where the oil system is cooled by either a refrigerant-cooled oil cooler, type OOSI, or a water-cooled oil cooler, type OWSG, the oil temperature is usually regulated by a **thermostatic three-way valve** as illustrated in fig. 1.

Fig.1



This thermostatic three-way valve is used in the following dimensions:

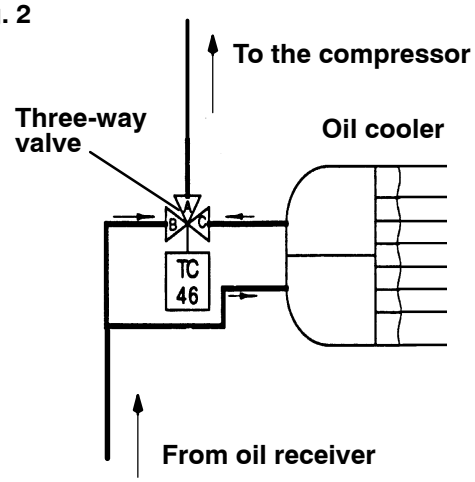
Compressor unit	Valve dimension	Welded connection
SAB 110	RT3	DN 25
SAB 128	RT3	DN 25
SAB 163	RT5	DN 40
SAB 202	RT6	DN 50
SAB 330	RT6	DN 50
VMY 536	RT6	DN 50

The valve dimension can be read from the name plate on the valve cover.

Function

The valve pos. 46 is fitted in a bypass piping system as shown in fig. 2.

Fig. 2



As shown in fig. 3 and 4, the valve works by letting a built-in thermo element, pos. 1, regulate a cone, pos. 2, so that cold and warm oil is mixed to the set temperature.

In fig. 3 the thermo element is shown in its cold position, ie the flow of cold oil has been shut off whereas the flow of warm oil is completely unobstructed. Fig. 4 illustrates the opposite situation in which the thermo element is in its warm position, thus shutting off the flow of warm oil.

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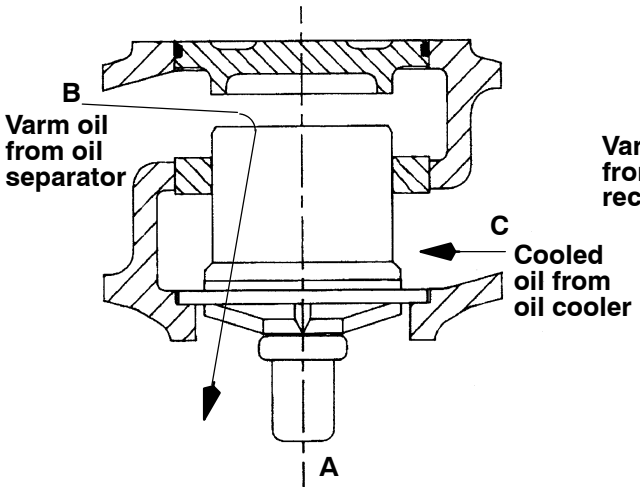
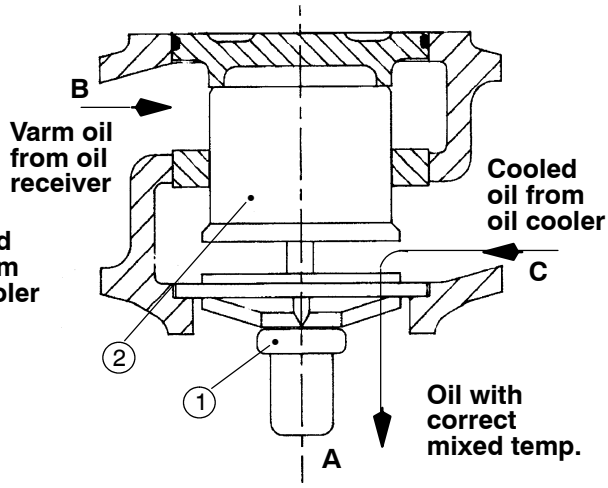
During operation the thermo element will adjust the regulating cone so that the two oil flows are mixed to the set oil temperature and leave the valve through connecting branch A.

Fig. 3



Thermo element in cold position

Fig. 4



Thermo element in warm position

The thermo element is factory set to maintain a mixed oil temperature of **48°C,** allowing for a few degrees' deviation. It **cannot be readjusted**.

Service

Generally, it is not necessary to dismantle a well-functioning three-way valve as it does **not** contain any gaskets or wearing parts that must be replaced at fixed intervals.

Dismantling

Apply the following procedure:

- After the pressure in the piping system has been equalized to atmospheric, unscrew the four Allen screws that keep the cover fixed to the valve housing.
- The cover, which reaches down into the valve housing to keep the thermo element in a fixed position, is best dismantlled by turning it slightly and then lift it up by means of a big screwdriver.
  Watch out ! There may still be oil in the system.
- Remove the thermo element from the valve housing manually.

Assembly

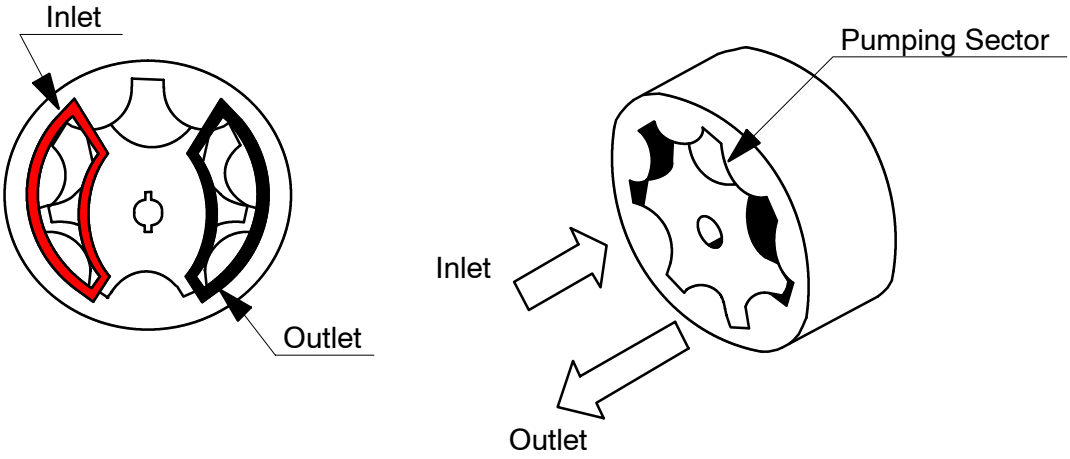
Assembly of the valve is done in the reverse order. Attention should be paid to the following:

- The O-ring, fitted in the cover, should be replaced by a new one. See section *Spare Parts Survey* in this manual.
- **No** sealing ring should be fitted between the inner guideway of the cover and the valve cone.
- In case the three-way valve does not regulate the oil temperature correctly, the thermo element and cone can be replaced as one entire unit. See section *Spare Parts Survey* in this manual.

Oil pump pos. 63

The gerotor is a positive displacement pumping unit consisting of just two elements. The inner rotor has one less tooth than the outer and has its centerline positioned at a fixed eccentricity from the centerline of the outer element.

Fig. 13.28



Start-up

The pump must only run without oil flow for brief periods.

Checking Rotating Direction of Motor

Before initial start-up of the oil pump, remember to check the rotating direction of the motor. The rotating direction is indicated on the electric motor with an arrow. Seen through the motor shield of the motor, the motor must rotate **anti-clockwise**.

Service

Service of the oil pump must be carried out as described in the following.

Warning!

Failure to follow these instructions could result in serious bodily injury or death.

Do not attempt to work on any Tuthill pump installation before completing the steps below.

Disconnect the drive so that it cannot be started while work is being performed.

Review the Material Safety Data Sheet (MSDS) applicable to the liquid being pumped to determine its characteristics and the precautions necessary to ensure safe handling.

Vent all pressure within the pump through the suction or discharge lines.

All Tuthill pumps contain residual ISO 32 lube oil from the factory production test. Determine if this is compatible with the fluid you are pumping. If the fluid is incompatible, consult the factory.

Disassembly of Seal

1. Deburr shaft especially around the keyway area.
2. Hold the pump in a vice, cover down and unscrew seal plug and remove from shaft (this may be tight due to the bearing).
3. Gently remove carbon carrier and spring from the shaft. Then the drive ball and spring plate can be removed.
4. Remove static seal plate from bearing housing (this may be tight due to the O ring)
5. Inspect rotor, if badly scored in seal or bearing area, rotor should be replaced. Also check seal faces for the same scoring. Remove 0–rings and check for deformation, again replace if there is any doubt.
6. Clean all parts thoroughly and replace static seal plate.
7. Refit spring plate and drive ball ensuring that the ball seats correctly into the hole in the shaft.
8. Replace the spring and carbon carrier on the shaft and push down gently until spring is down to the spring plate.
9. Ensuring that the groove on the carbon carrier is in line with the drive ball, then refit seal plug and screw down.

Disassembly of Pump

1. Deburr shaft especially around the keyway area.
2. Hold the pump in a vice, cover down and unscrew seal plug and remove from shaft (this may be tight due to the bearing).
3. Gently remove carbon carrier and spring from the shaft. Then the drive ball and spring plate can be removed.
4. Remove static seal plate from bearing housing (this may be tight due to the O ring)

5. Hold body in the vice with the shaft pointing downwards. Remove the 4 off 6mm cap head screws and remove the cover by pulling upwards, place to one side.

7. The inner rotor is attached to the shaft so both can be removed together by pulling on the end of the shaft. Once they are out then remove the outer rotor.

8. The individual parts must now be inspected for damage. The keyway in the end of the rotor must be in good condition and there must not be any deep scratches or grooves on the following surfaces:

a. The ID surface of the housing.

b. The OD of the outer rotor.

c. Both faces of outer rotor.

d. The OD of the inner rotor.

e. Both faces of the inner rotor.

f. The surfaces of the cover.

g. Areas on the shaft of the rotor where the seal and the bearing seats.

Inspection

Check cover, housing, inner and outer rotor for wear, chipped or broken teeth. Drop off in capacity is generally caused by the abrasive action of foreign materials in the oil, resulting in endplay of both the rotors.

Check for side movement in the shaft assembly, as this indicates potential bearing failure.

Reassembly of Pump

1. Clean all parts thoroughly using great care to eliminate dirt.

2. Take the body with the seal area facing downwards and push the shaft and inner rotor into the bores ensuring that it is pushed down onto the bottom face. Once these are in place the outer rotor over the inner rotor ensuring that the teeth mesh with no problems.

3. Place the cover onto the shaft (the cover will only fit one way due to the offset on the cover and the bore in the body).

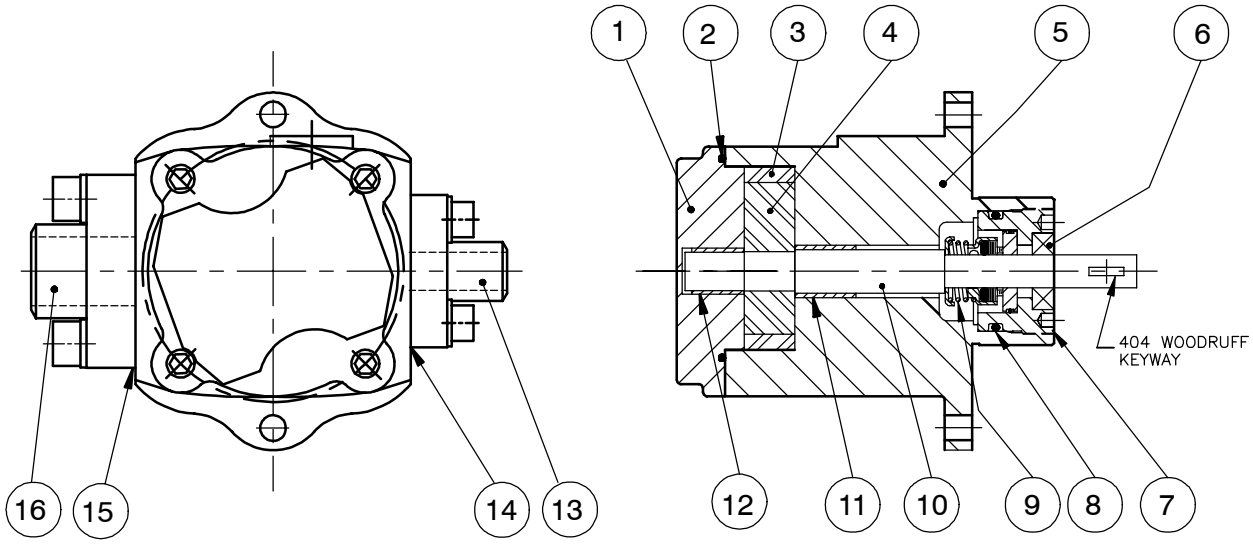
4. Hold the body in a vice with the shaft facing upwards and make sure that the shaft turns freely.

5. Refit spring plate and drive ball ensuring that the ball seats correctly into the hole in the shaft.

6. Replace the spring and carbon carrier on the shaft and push down gently until spring is down to the spring plate.

7. Ensuring that the groove on the carbon carrier is in line with the drive ball, then refit seal plug and screw down.

Fig. 13.29



1. Cover
2. O-ring
3. Outer gear
4. Inner gear
5. Body
6. Bearing
7. Housing plug
8. O-ring
9. Seal assy.
10. Shaft
11. Bush
12. Bush
13. Flange
14. O-ring
15. O-ring
16. Flange

NOTE : Sabroe Refrigeration only carries pos. 2 and pos. 9 as spare parts for the pump. See spare parts survey for SAB 128 and SAB 163 Mk4.

Mounting and Dismounting of Coupling

Mounting

Assemble the coupling as shown in Fig. 13.30 and mount it on the compressor and motor shafts as described in the following:

- When mounting the coupling, pay attention to the measurements C and E in the table below, Fig. 13.31.

Fig. 13.30

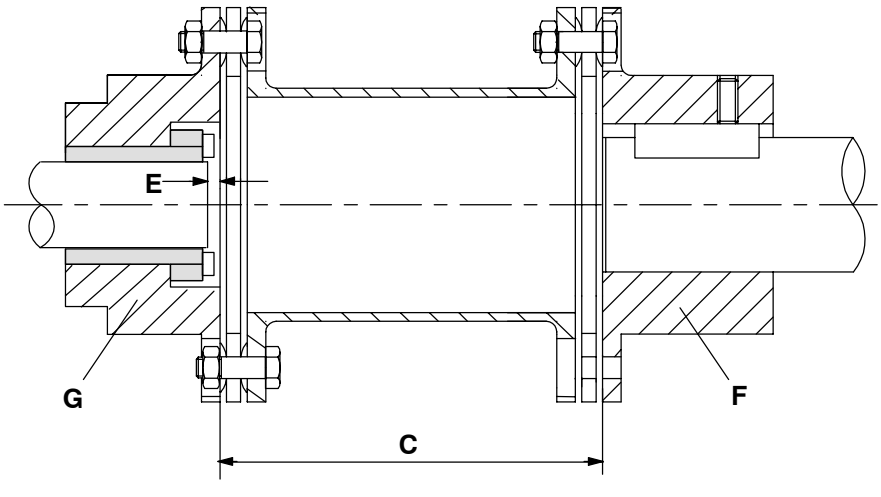


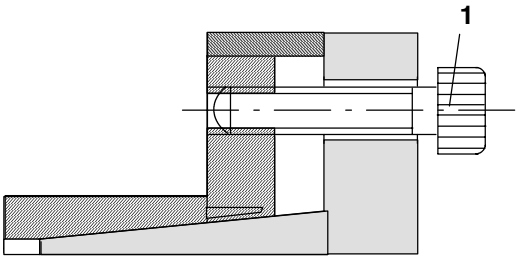
Fig. 13.31

Compressor Type	Coupling Type	Bolt Dimension Spanner	C mm	E mm
SAB 128	225	1/2”	127 ± 0.5	14 ± 0.5
SAB 163	262	9/16”		$10\ ^{+1.0}_{0}$

- Before mounting the coupling on the compressor shaft, clean the coupling flange, the individual parts in the bushing and the rotor shaft.
- Lubricate all parts with a little refrigerant machine oil. Do **not** lubricate with Molybdenum, high-pressure oil or grease.
- It is recommended to press on the coupling flange on the motor by means of a threaded rod with nut and tightening bar.
- **Do not strike the coupling flange as this may damage the bearings.**

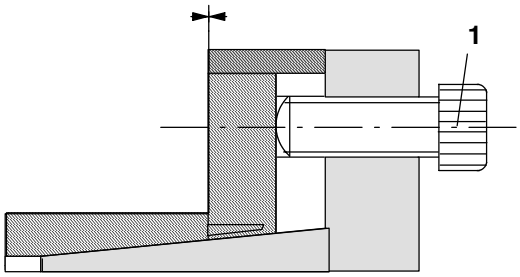
- Fasten coupling flange to the motor and compressor shafts with pointed screw and tongue connection.
- If the coupling is supplied **without boring** because the motor is unknown at the time of delivery, the coupling flange must be balanced according to ISO 1940 G 2.5 to a max. of 6000 rpm without tongue, but with the pointed screw.
- Assemble bushing as shown in Fig. 13.32 and loosen screws pos. 1 **1 turn.**

Fig. 13.32



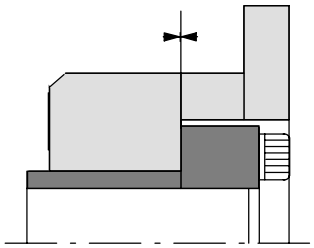
- Mount some of the screws pos. 1 in the dismantling holes with thread as shown in Fig. 13.33. Adjust manually so that the surfaces are even as indicated by the mark ✛.

Fig. 13.33



- Mount the bushing in the coupling flange and push it right to the bottom marked ✛ as shown in Fig. 13.34.

Fig. 13.34



- Remove the screws from the dismantling holes and remount them in the bushing as shown in Fig. 13.33. Tighten the screws manually.
- By means of the torque key, **cross-tighten** all screws pos.1 by first tightening them to **half of the torque M_S** and then to M_S as indicated in the following table.

Torque M_S

Compressor type	Screws pos.1 Quantity x Dim.	Torque M_S [Nm]
SAB 128	8 x M6	15
SAB 163	8 x M8	35

Keep tightening the screws to the torque M_S until none of the screws can be turned anymore.

Dismounting of Coupling Flange

Dismounting of the coupling flange from the compressor shaft is carried out in the following way:

- Loosen screws pos. 1 a few turns.
- Mount screws pos. 1 in the dismantling holes as shown in Fig. 13.33 and **cross-tighten** them evenly until the two taper rings have been pressed apart and have loosened the coupling flange from the shaft.
- Remove coupling flange with bushing.

Dismantling of Coupling

When dismantling the coupling, it is important to note the positions of bolts, washers and nuts as they must be refitted in the same order. Tie a string or a piece of thread through one of the bolt holes in the coupling discs to avoid that the plates are turned in relation to each other and to the flange.

Mounting

- Mount the two coupling parts, motor flange F and compressor flange G as described earlier, see Fig. 13.34.
  Pay attention to the measurement E as shown in Fig. 13.30, and table Fig. 13.31.
- Mount motor and compressor and secure to the base frame as described.
  Check distance C as shown in table Fig. 13.31.
- Mount the coupling intermediate sections and the two flexible discs and secure with the bolts as shown in Fig. 13.30. The torque moment is shown in the table below, Fig. 13.36.

  However, do not mount the bolts that secure the flexible discs to the motor flange until the alignment has been completed.

Alignment Procedure

The series 52 coupling is aligned as described in the following. The accuracy whereby the coupling must be aligned is indicated in the table below, Fig. 13.35.

In principle, the alignment is a question of moving the motor so that its shaft is placed in continuation of the compressor shaft.

Fig. 13.35

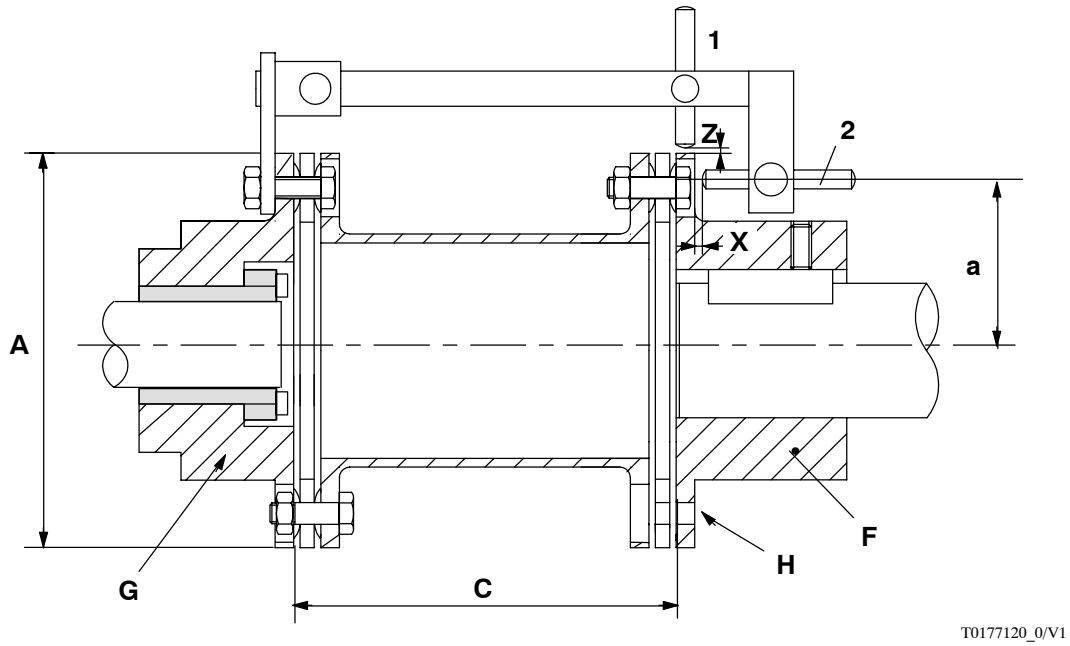


Fig. 13.36

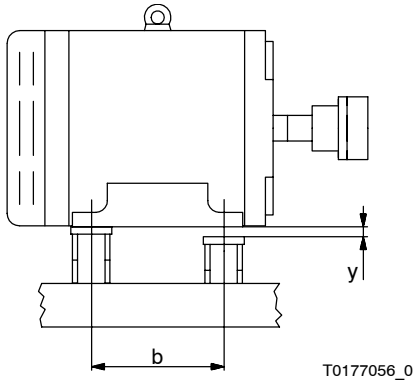
Coupling No	Dia. A mm	Distance C mm	Torque moment Nm	Max variation at 180° rotation		
				Pos. 1		Pos. 2
				Horizontal mm	Vertical mm	mm
225 262	145 168	127± 0.5	34 41	0 - 0.05	0 - 0.10	0 - 0.10

Parallel Shafts on a Horizontal Level

1. Turn the coupling so that the alignment tool is in top position.
2. Guide measuring pin pos. 2, Fig. 13.35, towards the coupling flange with a 1 mm feeler gauge in between and secure the pin. Remove the feeler gauge.
3. Turn the coupling 180°. Motor and compressor are turned at the same time. Measure with feeler gauge how much the distance from the measuring pin to coupling part has changed. The change is called X.
4. Measure the distance **b** between the feet of the motor as shown in Fig. 13.37. Measure the distance **a** from the middle of pin 2 to the centre line of the motor as shown in Fig. 13.35.
5. Insert liners with thickness **Y** either under both front feet or both rear feet, tilting the motor at the desired end. Use the following formula for calculation of the liner thickness:

$$Y = X \cdot \frac{b}{2a}$$

Fig. 13.37



6. After having tightened the motor bolts, repeat the measuring and compare the result with the table values.

Parallel Displacement to Correct Centre Height

1. Turn the coupling so that the alignment gauge faces downwards.
2. Guide the measuring pin pos. 1, Fig. 13.35, towards the coupling part with a 1 mm feeler gauge in between. Secure the pin and remove the feeler gauge.
3. Turn the coupling 180° and measure with feeler gauge how much the distance has increased. The increase is called Z.
4. Then lift the motor by placing liners with half the thickness, i.e. Z/2, under **all four** feet.
5. After securing the motor, repeat the measuring and compare the result with the table values.

Parallel Shafts on a Vertical Level

1. Turn the coupling so that the alignment gauge faces horizontally to one side.
2. Move both measuring pins towards the coupling with a 1 mm feeler gauge in between. Lock the pins and remove the feeler gauges.
3. Turn the coupling as close to 180° as allowed by the cap cover and measure with feeler gauge the deviations from the **original one millimetre** on both pins.
4. Moving and turning the motor sideways with the adjustment screws and repeating the measuring, align the motor in accordance with the table.
   Remember that the motor must be secured during each measuring.

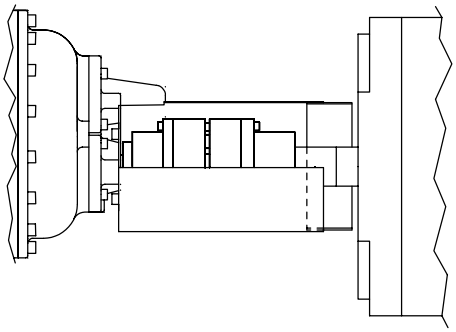
Final Installation

1. Tighten the fixing bolts on the motor.
2. Dismantle the alignment tool.
3. Mount bolts between the flexible discs and the coupling flange of the motor. Tighten all bolts to the torque moment indicated in table below Fig. 13.35.
4. Check distance C.
5. Once the coupling alignment has been carried out correctly, fit the outer shell of the coupling guard on the adaptor plate which is secured on the compressor shaft seal cover.

   Push the outer shell, which is placed inside the inner shell, so far towards the driving motor that access to the rotating parts is made **impossible**. See Fig. 13.38.

6. Recheck the coupling with a compressor still warm from operation and with pressure on piping connections.

Fig. 13.38



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Refrigeration Plant Maintenance

Operational Reliability

The main reasons for operating malfunctions of the plant are:

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

In the following some information is given about how to keep contaminants out of the refrigeration system and at the same time facilitate day-to-day supervision of the plant.

Pumping down the Refrigeration Plant

Before dismantling any parts of the refrigeration plant for inspection or repair, the plant must be pumped down.

1. Open suction and discharge stop valves on the compressor.
2. Close the liquid stop valve after the condenser or receiver so that liquid refrigerant can be collected in the receiver. Any solenoid valves in the liquid line must be opened by force so that the liquid line is emptied 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 pressure, stop the compressor and shut off the discharge stop valve. Shut off any stop valves in the oil return line.

   If the receiver has an extra stop valve in the feed line, it can be closed. Practically the entire refrigerant charge will then be shut up in the receiver.

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

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

Dismantling Plant

To prevent moisture from penetrating into the refrigeration plant during repairs, 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 pressure.

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3. **Note:**
   *If the piping system is colder than the surroundings, there is a considerable risk of damp precipitation (condensation) on the cold plant parts. Plant components to be dismantled **must** be warmer than the ambient temperature.*
4. No two points in the system should be opened at the same time.
5. Plug, close or at least cover the opening with oiled paper or the like.
6. Note that filters may be very moist.

Tightness Testing and Pumping down the Refrigeration Plant

Before refrigerant is recharged to the part of the refrigeration plant which has been opened, the section must be pressure tested as described in the section entitled *Pressure Testing*.

Pump down in order to eliminate air and moisture. See the section on *Evacuation*. Otherwise, follow the instructions given in the separate instruction manual on plant components.

Note:

If the oil in oil separator of the screw compressor has been in contact with the atmospheric air for a long period of time, it must be replaced with fresh oil of the same grade and make.

Ordering Spare Parts

When placing an order for 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 the type of refrigerant be used.

2. Part No

Spare parts drawings and parts lists in the Service Manual contain the following spare part indentification:

a) Spare part no – a reference number, which makes it easier to find a part in the drawing and the parts list.
b) Designation of the part.
c) Part no – a 7-digit number.

When ordering spare parts, please state the designation and part number. If in any doubt, state the spare part no too.

3. Forwarding instructions

When ordering spare parts, please state the forwarding address, and the address to which the invoice is to be sent. If appropriate, please state the name of your local bank, method of transport and required delivery date.

4. Classification certificate

If requiring a certificate from a classification authority, please state this on the order as the inspection and issuing procedures take extra time and incur extra expenses.

5. Quotation No

If a quotation no has been stated during earlier correspondence, please refer to this when placing your order – it will help us to identify and execute your order quickly.

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Spare Part Sets for Screw Compressor and Unit.

It is always an advantage to have a stock of spare parts for both compressor and unit. In this way the customer or a Sabroe Refrigeration service engineer is able to carry out the necessary replacements without wasting time waiting for new spare parts to arrive.

On contacting Sabroe Refrigeration's local representative, you may receive specifications for the following spare part sets for compressor and unit.

Compressor Block:

- **Standard set of spares**
  This set contains a representative selection of O-rings and gaskets.
- **Certificate set of spares**
  Besides the parts contained in the **standard set of spares,** this set also includes bearings and shaft seal.

Basic Unit:

- **Standard set of spares:**
  This set includes the following spare parts for the components mentioned below:
  - *Oil separator:*
    O-rings, gasket
  - *Service valves:*
    Gaskets, O-rings
  - *Capacity regulating system:*
    Gaskets, O-rings
  - *Pressure outlet stop valve:*
    Gaskets
  - *Suction inlet stop valve:*
    O-rings, sealing rings, gaskets, teflon ring
  - *Safety valve:*
    Gaskets, cone, O-rings
  - *Oil by-pass system:*
    Gaskets, teflon ring
  - *Oil pump:*
    O-rings
- **Certificate set of spares**:
  Besides the parts contained in the **standard set of spares,** this set also includes spare parts for the components mentioned below:
  - *Coupling:*
    Screws and discs
  - *Oil separator:*
    Sight glass, oil separator element, heating element
  - *Capacity regulating system:*
    Solenoid valve
  - *Safety valve:*
    Spring
  - *Solenoid valves:*
    Coils
  - *Oil pump:*
    Shaft seal, filter

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20. Final Disposal

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Final Disposal

The purpose of this document is to describe how to safely dispose of this equipment or part of it.

This document is primarily intended for the de-commissioning engineers and authorities.

This document was produced by:

Sabroe Refrigeration
Chr. X's Vej 201
DK-8270 Hoejbjerg
Denmark

General

Safety Precautions

Danger !

Before dismantling the plant, read Section 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, eg 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, eg 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 eg 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

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Appendices

The purpose of this document is to collect all relevant instructions for products delivered from sub-supplier and which are used in the Sabroe product in question.

This document was produced by:

Sabroe Refrigeration
Chr. X's Vej 201
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Denmark

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 section includes data sheets, instructions of components and tables of torque moments.

1. List of torque moments

2. Controlling equipment
   - Pressure transducer, AKS32R, AKS2050, AKS3000, AKS3050
   - Temperature sensor P2208
   - Pressure cut-outs, type KP1, KP5, MP55
   - Thermostats, type KP61-81
   - Thermostatic injection valve, type TEAT
   - Transmitter(s)

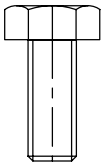
3. Valves
   - Valves type SCV 40-200 /SCV / STV 250-300
   - Non return valve, type NRVA
   - Main expansion valve, type PMFL
   - Pilot controlled regulator, type PM1

4. Filter
   - Filter, type FIA

5. Piping diagram . . . . . order specific
   Wiring diagram . . . . . order specific
   Dimension sketch . . . . . order specific
   Placing of vibration dampers . . . . . order specific
   Other instructions . . . . . order specific

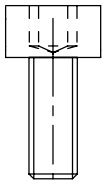
Note: *This instruction material may include descriptions of components which are not part of the product in question.*

Torque moments for screws and bolts



Metric thread (ISO 8.8)

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



Metric thread (ISO 12.9)

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

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