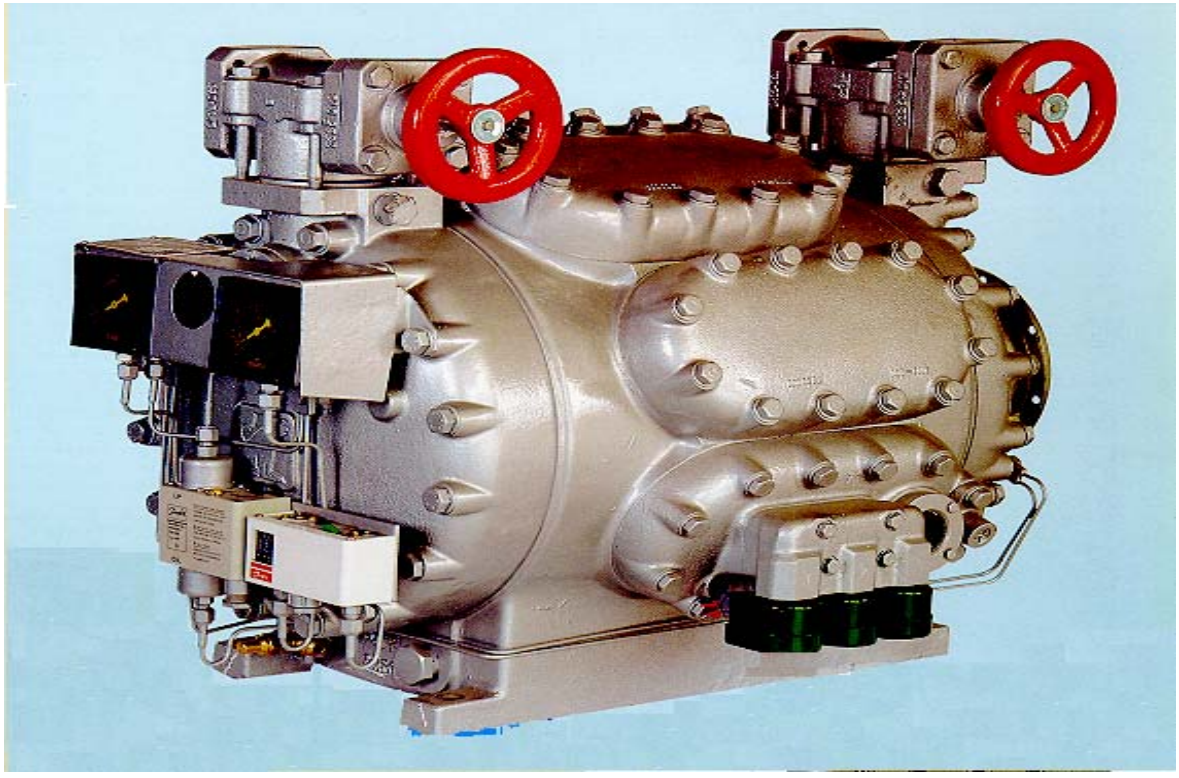
INSTRUCTION MANUAL

FOR

PISTON COMPRESSOR



CMO 24 CMO 26 CMO 28
TCMO 28 MK2

YORK®

00.12

Specifications for CMO 24-26-28 Mk2 and TCMO 28 Mk2

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

Some of these variants are discussed in this instruction manual, even if they are **not** featured on your particular unit.

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

Compressor type		
Designation		
Serial number		
Refrigerant	R717 ❑ R22 ❑ R134a ❑ R404A ❑ R507 ❑ _____ ❑	
Control	UNISAB II Control- and regulating system	
	Analogous control system	
Compressor cooling	Water cooled top and side covers	
	Thermopump	
	Air-cooled top covers and water-cooled side covers	
	Air-cooled top- and side covers + oil-cooling	
	Air-cooled top- and side covers	
Drive type	Coupling	
	V-belts	
Explosion-proof electrical design		
Additional suction filter		
Capacity regulation	With capacity regulation system	
	Without capacity regulation system	
Oil return on parallel systems		
Oil separator	With solenoid valve controlled oil return	
	With float valve controlled oil return	
Compressor used for air conditioning		
Intermediate cooling system	With internal intermediate cooling system	
	With external intermediate cooling system	

Preface

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

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

This instruction manual draws attention to typical errors which may occur during operations. The manual states causes of error and explains what should be done to rectify the errors in question.

It is imperative that the operators familiarize themselves thoroughly with the contents of this instruction manual to ensure a safe, reliable and efficient operation of the product as YORK Refrigeration is unable to provide a guarantee against damage of the product occurring during the warranty period as a result of incorrect operation.

Dismantling and assembly of compressors and components should only be carried out by authorized personnel to prevent accidents.

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

YORK Refrigeration's *General Conditions for the Supply of Components and Spare Parts* will apply.

00.07

0171-500-EN

In the space below you can enter the name and address of your local YORK Refrigeration Representative:

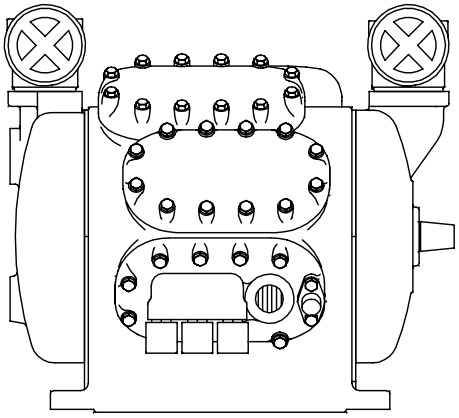
Contents

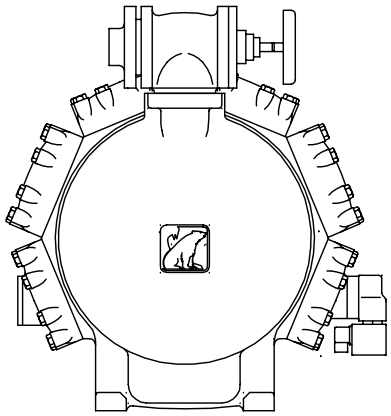
Specifications for CMO 24-26-28 Mk2 and TCMO 28 Mk2 1
Preface 2
Contents 3
Description of compressor CMO 24-26-28 & TCMO 28 Mk 2 6
Safety Precautions 8
Reciprocating compressors 8
General safety instructions and considerations 8
Handling of the compressor, areas of application, safety equipment and symbols, safety at servicing 12
Safety equipment 13
Safety symbols 13
First Aid for accidents with Ammonia 16
First aid for accidents with HFC/HCFC 17
Protecting the operator as well as the environment 18
Sound data for reciprocating and screw compressor units – all types of compressors21
Vibration data for compressors - all types 25
Compressor data for reciprocating compressor 26
Operating limits 26
R717 - Operating limits single stage compressorsCMO, SMC 100 S-L, SMC 180 . . 27
R717 - Operating limits single stage compressors SMC 100 E 28
R717 - Operating limits two-stage compressors TCMO TSMC 100 S-L-E, TSMC 18029
R22 - Operating limits single stagecompressors CMO,SMC 100 S-L, SMC 180 30
R22 - Operating limits two-stage compressorsTCMO, TSMC 100 S-L, TSMC 180 . . 31
R134a - Operating limits single stage compressors CMO SMC 100 S-L 32
R134a - Operating limits two-stage compressors TCMO TSMC 100 S-L 33
R404A - Operating limits single stage compressors CMO, SMC 100 S-L 34
R404A - Operating limits two-stage compressors TCMO, TSMC 100 S-L 35
R507 - Operating limits single stage compressors CMO, SMC 100 S-L 36
R507 - Operating limits two-stage compressors TCMO, TSMC 100 S-L 37
General operating instructions for CMO/TCMO, SMC/TSMC piston compressors 39
Starting up compressor and plant 39
Stopping and starting-up compressor during a short period of standstill 40
Stopping plant for brief periods (until 2-3 days) 40
Stopping plant for lengthy periods (more than 2-3 days) 41
Automatic plants 41
Pressure testing refrigeration plant 41
Pumping down refrigeration plant 42
Operating log 44
Servicing the reciprocating compressor 45
Pressure drop test: 45
Removing refrigerant from compressor 46
Lubricating oil 50
Lubricating oil requirements 50

General rules for use of lubricating oil in refrigeration compressors 50
Instructions for choosing lubricating oil for refrigeration compressors 50
Charging refrigeration compressor with lubricating oil 50
Changing oil in refrigeration compressor 51
Charging the compressor with oil 53
Assessing the oil 53
Visual assessment 54
Analytical evaluation 54
Procedure 54
The analysis 55
Pressure and temperature settings 57
Expected discharge gas temperatures 58
Servicing the refrigeration plant 59
Maintenance of reciprocating compressor 61
Pump-down 61
1. If the compressor is operational 61
2. If the compressor is inoperative 61
Top covers 62
Discharge valve 63
Cylinder lining with suction valve 65
Connecting rod 66
Piston 67
Shaft seal 68
Crankshaft 71
Main bearings 72
By-pass valve pos. 24 73
Suction filter 74
Cleaning of extra suction filters 74
Stop valves 75
Compressor lubricating system 77
Oil filter 78
Oil pump 80
Oil pressure valve 81
Capacity regulation and unloaded start 82
Capacity stages and regulating sequence 85
Pilot solenoid valves 86
The TCMO 28 compressor 88
TCMO with capacity regulation 88
TCMO without capacity regulation 89
Cooling of intermediate discharge gas on the TCMO 28 compressor 90
Heating rods for heating the oil in reciprocating and screw compressors 91
Stop valves pos. 23 and 42 92
Sundry clearances and check dimensions 93
Undersize Bearing Diameters for Crankshaft
Reciprocating Compressors with 4 to 8 Cylinders 94
Torque moments for screws and bolts 95

Refrigeration Plant Maintenance 97
Operational reliability 97
Pumping down the refrigeration plant 97
Dismantling plant 97
Tightness testing and pump-down of refrigeration plant 98
Trouble-shooting on the Reciprocating Compressor Plant 99
Remedying malfunctions 102
Selecting lubricating oil for SABROE compressors 111
Data sheet for listed Sabroe oils 117
List of major oil companies 138
Alignment of unit, AMR coupling 140
Fitting and alignment of AMR-type coupling 143
Boring of motor flange for AMR coupling 146
V-belt drive for piston compressor types (T)CMO and (T)SMC 147
Thermo pump cooling of R717 reciprocating compressors 149
Principle drawings 150
Oil return in parallel operation for reciprocating compressors 158
Refrigerant cooled oil cooler for CMO reciprocating compressor 161
Oil return to the compressor 167
Connections on CMO/HPO 24-26-28 170
Connections on TCMO 28 172
Water cooling of the reciprocating compressor 172
Reciprocating compressors used for air conditioning CMO 24-26-28 and SMC 104-106-108 175
Cooling of the intermediate gas 176
Ordering Spare Parts 181
Spare parts sets for compressors and units 18 6
List of parts for CMO/TCMO 0662-215
Tools for compressor CMO/TCMC 0662-147
Spare Parts drawing 0662-213/-217
Spare Parts drawing (in detail) 0662-212
Piping diagram . . . . . order specific
Wiring diagram . . . . . order specific
Dimension sketch . . . . . order specific
Cooling water diagram . . . . . order specific
Foundation . . . . . order specific
Positioning of vibration dampers . . . . . order specific

Description of compressor CMO 24-26-28 & TCMO 28 Mk 2

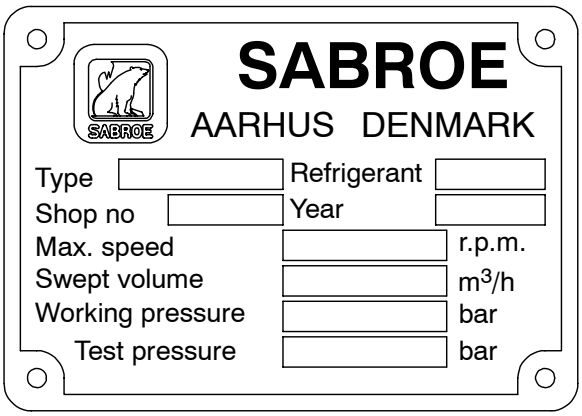




T0177142_0 V16

The CMO 2 is a reciprocating compressor with several cylinders in the same block. The first digit in the type number indicates the stage of development of the compressor. The compressor comes in 4-, 6- and 8-cylinder versions, indicated by the last digit in the type number.

The TCMO 28 is a 8-cylinder version, which compresses the gas in two stages, with 6 low-pressure cylinders and 2 high-pressure cylinders. The type can be determined by the compressor's name-plate which is located at the bottom on one side of the compressor.



T0177093_2

Similarly, the name-plate indicates the compressor's serial number, which is also stamped into the compressor housing at the top by the end cover facing away from coupling/belt drive.

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

The pistons of the compressor have a diameter of 70 mm and a stroke of 70 mm.

The pistons work in replaceable cylinder linings, inserted in the frame and located with two cylinders under each top cover.

The suction valve, which is a ring plate valve, is mounted at the very top of the cylinder lining. The discharge valve forms the top of the cylinder and is kept in place by a powerful safety spring. This spring allows the discharge valve to rise slightly by liquid strokes. This prevents overloading of the connecting rod bearings.

The crankshaft is embedded in slide bearings Able to assimilate both radial and axial forces. The oil pressure for the bearings and

the capacity regulating system is supplied from the gearwheel oil pump built into the compressor.

At the shaft end, the crankshaft is equipped with a balanced shaft seal of the slide-ring type, consisting of a cast-iron ring rotating with the crankshaft and a stationary spring-loaded carbon ring.

As standard equipment the compressors have a hydraulic capacity unloading system that forces the suction valves open, thus preventing compression. This unloading system is designed in such a way to ensure that the compressor always starts totally unloaded.

The TCMO 28 compressor is available with either a built-in intermediate cooling system or an external intermediate cooling system, which may be seen from the table on page 1 as well as from the description further on in this instruction manual.

The compressor can be delivered **without** capacity regulating functions but still with the start unloading function for totally unloaded start-up.

The capacity regulation is controlled by solenoid valves, mounted in one of the compressor side covers.

The following table shows the capacity stages at which the compressor can operate.

	25%	**33%**	**50%**	**67%**	**75%**	**100%**
CMO 24	x		x		x	x
CMO 26		x	x	x		x
CMO 28	x		x		x	x
TCMO 28		x	x	x		x

Safety Precautions

Reciprocating compressors

WARNING

Read related safety precautions before operating this machine. Failure to follow safety instructions may result in serious personal injury or death.

Important

The safety precautions for this Sabroe Refrigeration machine 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 machine.

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

a. All other manuals pertaining to the machine.

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

c. National safety laws and regulations.

General safety instructions and considerations

Personal safety

Machine owners, operators, setup men, maintenance, and service personnel must be aware of the fact 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 what activity is involved.

Know and respect your machinery. Read and practice the prescribed safety and checking procedures. Make sure that everyone who works for, with, or near you fully understands and – more importantly – complies with the following safety precautions and procedures when operating this machine.

Observe and follow safety warnings on the compressor/unit.

Use safety protective equipment. Wear clear approved eye or face protection as you work when operating parts containing refrigerant. Safety-toe shoes with slip-proof soles can help you avoid injury. Keep your protective equipment in good condition.

Never operate or service this equipment if affected by alcohol, drugs or other substances or conditions which decrease alertness or judgement.

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 to 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 members.

Report unsafe working conditions to your supervisor or safety department.

98.03
0170-123-EN

Tool safety

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

Remove hand tooling such as wrenches, measuring equipment, hammers, and other miscellaneous parts from the machine immediately after usage.

Lifting and carrying safety

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

Before lifting or carrying a compressor/unit or other parts, determine the weight and size by referring to such things as tags, shipping data, labels, marked information, or manuals.

Use power hoists or other mechanical lifting and carrying equipment for heavy, bulky, or hard to handle objects. Use hookup methods recommended by your safety department and know 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 part of another person's body. 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 other lifting mechanism.

If in doubt as to the size or type of lifting equipment, method, and procedures for 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 found to be defective or questionable.

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

Before inserting an eyebolt, be certain that both the eyebolt and the hole have the same size and type 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 machine manual or Sabroe Refrigeration for proper methods and procedures.

An electrician must read and understand the electrical schematics 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 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.

When the compressor is installed, be sure that the motors rotate in the proper indicated direction.

WARNING

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

Setup 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 machine mounted warning and instruction plates. 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 functioning correctly prior to operation of this equipment.

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, be attentive to the compressor unit process. Excessive vibration, unusual sounds, etc., can indicate problems requiring your immediate attention.

Maintenance safety

Do not attempt to perform maintenance on the compressor unit until you read and understand 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 when in doubt contact Sabroe Refrigeration. Use only Sabroe Refrigeration replacement parts; others may impair the safety of the machine.

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, lock it in the OFF position. If possible, post a sign at the disconnect switch indicating that maintenance is being performed.

Dismantle main fuses to the unit.

DANGER:
HIGH VOLTAGE

Before working on any electrical circuits, 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 appropriate Sabroe Refrigeration Field Service Representative, do NOT work with electrical power ”ON”. If such express statement or advice exists, working with electrical power ”ON” should be performed by a Sabroe Refrigeration Field Service Representative.
The customer and subsequent transferees must determine that any other person performing work with electrical power ”ON” is trained and technically qualified.
FAILURE TO FOLLOW THIS INSTRUCTION MAY RESULT IN DEATH OR SERIOUS PERSONAL SHOCK INJURY.

Whenever maintenance is to be performed in an area away from the disconnect and the disconnect 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 electrically activated when maintenance work is being performed.

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

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

An electrial technician 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 is operating and the precautions that you need to pay attention to 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.

Handling of the compressor, areas of application, safety equipment and symbols, safety at servicing

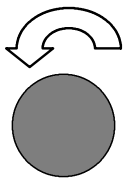
Direction of rotation

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

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

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

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



Seen towards shaft end

Handling of compressor and unit

For lifting of the compressor the large models are equipped with a threaded hole for mounting of the lifting eye. As to the weight of the compressor, this can be seen from the shipping documents.

WARNING

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

The **unit** is lifted by catching the lifting eyes welded onto the unit frame. These have been clearly marked with red paint. The **weight** of the unit can be seen from the shipping documents.

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

Areas of application of the reciprocating compressors

Compressor types:

BFO 3-4-5
CMO-TCMO,
SMC 100-TSMC 100 Mk3, S, L, E
SMC 180-TSMC 180,
HPO-HPC

Application

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

The compressor may ONLY be used:

- As a refrigeration compressor with a number or revolutions and with operating limits as indicated in this manual or according to a written agreement with SABROE.
- With the following refrigerants:
  R717 - R22[1] - R134a[1] - R404A[1] - R507[1] - R600[1] - R600A[1] - R290[1] - LPG[1]
  [1]) Exempted are the following compressors:
  SMC-TSMC 100 E (only R717)
  HPO and HPC (only R717)

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

- As a heat pump:
  - BFO 3-4-5

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

  - HPO – HPC may be used with a max. discharge pressure of 40 bar.
- In an explosion-prone environment, provided the compressor is fitted with approved explosion-proof equipment.

> **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.

Safety equipment

Emergency device

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

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

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

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

Other demands to the emergency device:

- It must be possible to operate it by means of an easily recognizable and visible manual handle, to which there is free access.
- It must be able to stop any dangerous situation, which may occur, as quickly as possible without this leading to any further danger.

Combustion motors

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

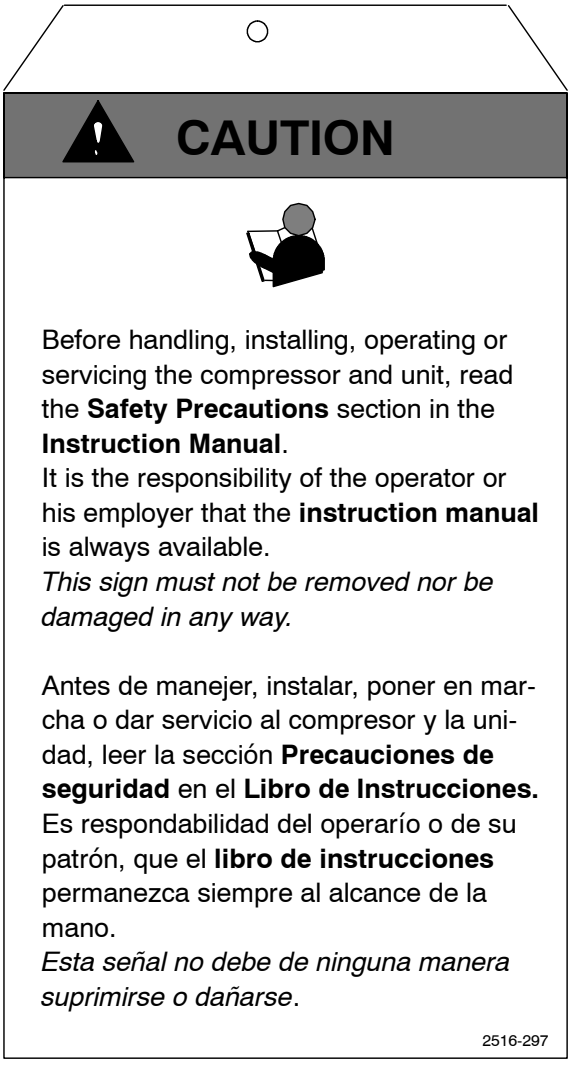
Failure to do so will involve a risk of the lubricating oil from the combustion motor mixing with the refrigerant; at worst, this may give rise to corrosion and damage the motor.

Safety symbols

Before putting a compressor/unit into operation they must be provided with warning signs corresponding to the actual design of compressor/unit and in accordance with the rules and regulations in force.

The CAUTION sign

A **CAUTION** tag is fixed on the compressor like the one illustrated below. This sign imposes upon the users to read the Safety Precautions section in the manual before handling, operating or servicing the compressor and unit.



DANGER: The high voltage sign

DANGER:
HIGH VOLTAGE

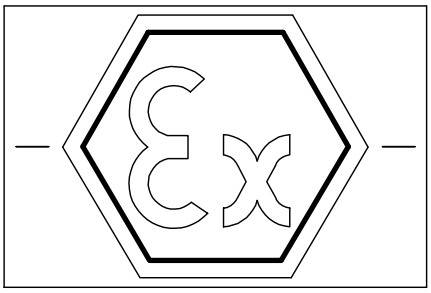
Before working on any electrical circuits, turn the machine Main Disconnect Device ”OFF” and lock it. Dismantle the main fuses to the compressor unit.
Unless expressly stated in applicable Sabroe Refrigeration documentation or by appropriate Sabroe Refrigeration Field Service Representative, do NOT work with electrical power ”ON”. If such express statement or advice exists, working with electrical power ”ON” should be performed by a Sabroe Refrigeration Field Service Representative. The customer and subsequent transferees must determine that any other person performing work with electrical power ”ON” is trained and technically qualified.

WARNING

Failure to follow this instruction may result in death or serious personal shock injury.

Explosion-proof electrical execution

If the compressor is delivered in an explosion-proof electrical execution it will, further to the SABROE name plate, be equipped with an **Ex-name plate** like the one illustrated below.



T2516273_0

The temperature of tangible surfaces

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

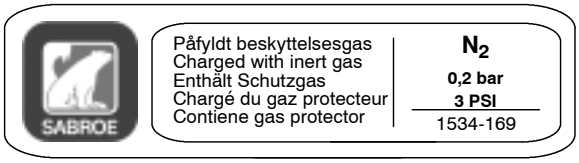
Consequently, the compressors will be equipped with **yellow warning signs** informing you that pipes, vessels and machine parts close to the warning signs during operation are so hot that your skin may be burnt from 1 second’s touch or longer.

Internal protection

Compressor blocks and units are usually delivered **without** any refrigerant or oil content in the crankcase.

In order to protect the compressors against internal corrosion, they are delivered evacuated of all athmospheric air and charged with Nitrogen (N_2) to an overpressure of **0.2 bar**.

In such cases a yellow label like the one shown below are stuck on the compressor surface.



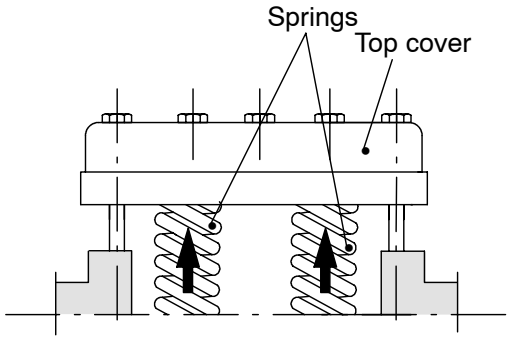
Safety at servicing

WARNING

Read related safety precautions before operating this machine. Failure to follow safety instructions may result in serious personal injury or death.

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

- Read related Safety Precautions section 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 the dismantling.
- 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 glasses and make sure to have a gas mask ready to be used in connection with the current refrigerant.
- 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.
- On dismantling top covers attention should be paid to the **very considerable spring force beneath the covers**. When screws **a** are loosened the cover must lift itself from the frame as described in the **instruction manual**.



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

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 at its own warning agent, so that no person will voluntarily remain in concentrations which are hazardous. Since ammonia is lighter than air, adequate ventilation is the best means of preventing an accumulation.

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

Basic rules for first aid

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

Inhalation

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

Eye injuries from liquid splashes or concentrated vapour

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

Skin burns from liquid splashes or concentrated vapour

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

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

Basic rules for first aid

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

Inhalation

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

Eye injuries

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

Skin injuries – Freeze burns

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

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 that we protect nature against pollution.

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

Be especially careful with the following substances:

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

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

High concentrations of refrigerant vapours are suffocating when they displace air; if high concentrations of refrigerant vapours are inhaled they attack the human nerve system.

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

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

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

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

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

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

Further, it may be said about refrigerants:

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

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

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

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

Purging a refrigeration plant

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

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

Cooling media

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

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

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

Never empty brines down a sewer or into the environment.

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

Lubricating oils

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

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

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

NOTE

This instruction provides only general information. The owner of the refrigeration plant is responsible for ensuring that all codes, regulations and industry standards are complied with.

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

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

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

The values for LW constitute an average of a large number of 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.

- **SAB 128, SAB 163, SAB 202, SV and FV:**
  Compressor block + IP23 special motor + oil separator.
- **SAB 110:**
  Compressor block + IP23 standard motor + oil separator

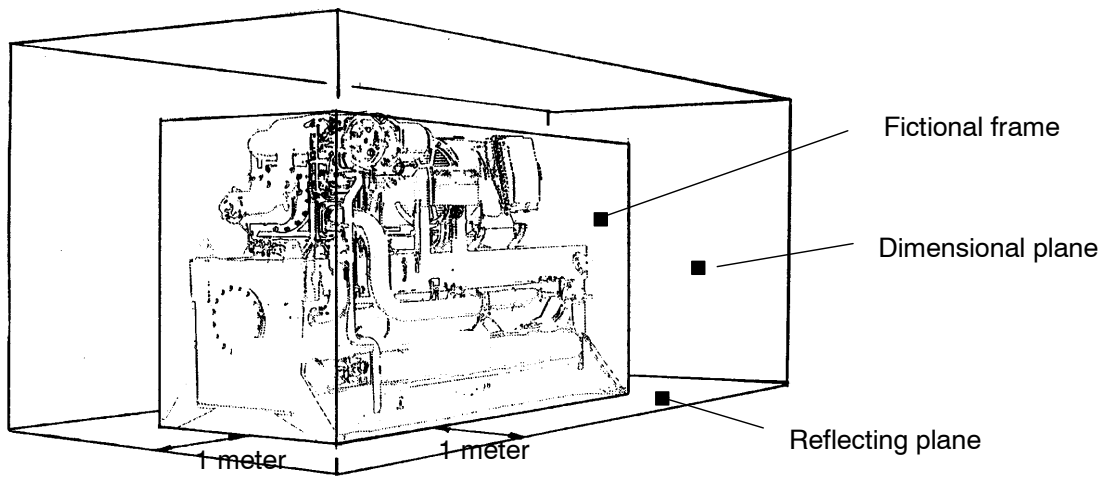
Dimensional tolerances are:

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

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

The dimensional values are stated for 100% capacity.

Fig. 1



0170-114--EN 99.02

Note the following, however:

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

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

RECIPROCATING COMPRESSORS

One-stage

Evaporating temperature = -15°C
Condensing temperature =+35°C
Refrigerant = R22/R717
Number of revolutions =**1450 rpm.**

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

Evaporating temperature = -15°C
Condensing temperature = +35°C
Refrigerant = R22/R717
Number of revolutions = **900 rpm.**

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

Two-stage

Evaporating temperature = -35°C
Condensing temperature = +35°C
Refrigerant = R22/R717
Number of revolutions =**1450 rpm.**

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

Evaporating temperature = -35°C
Condensing temperature = +35°C
Refrigerant = R22/R717
Number of revolutions = **900 rpm.**

Compressor block	LW	LP
TSMC 188	100	82

Heat pump

Evaporating temperature = +20°C
Condensing temperature = +70°C
Refrigerant = R22/R717
Number of revolutions =**1450 rpm.**

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

SCREW COMPRESSORS

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

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

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

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

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

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

Evaporating temperature = 0°C
Condensing temperature =+35°C
Refrigerant = R22/R717
Number of revolutions = **2950 rpm.**

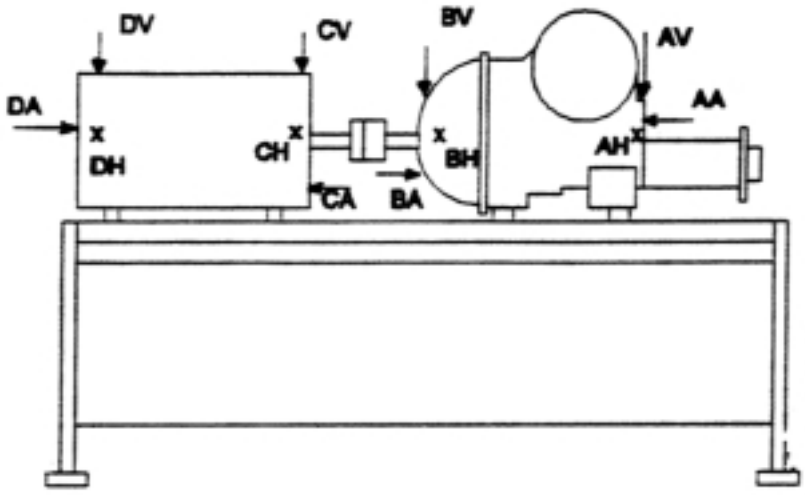
Compressor block	LW	LP
VMY 347 M	99	84
VMY 447 M	101	86
VMY 536 M	105	89

Vibration Data for Compressors - All Compressor Types

Vibration data for YORK 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 for YORK 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).



0170-115-EN 01.01

Pay attention to the following, however:

- Motors comply with EN 60034-14 (CEI/ IEC 34-14) Class N.
- When placing the unit on the vibration dampers delivered by YORK 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**.**
  - For screw compressors, if the compressor runs at a wrong V_i-ratio.
  - The pipe connections have been executed in a way that makes them force pull or push powers on the compressor unit or 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 delivered together with the order.

Compressor data for reciprocating compressor
CMO 4, CMO 24-28, TCMO 28, SMC 104-116, TSMC 108-116, SMC 186-188, TSMC 188

Operating limits

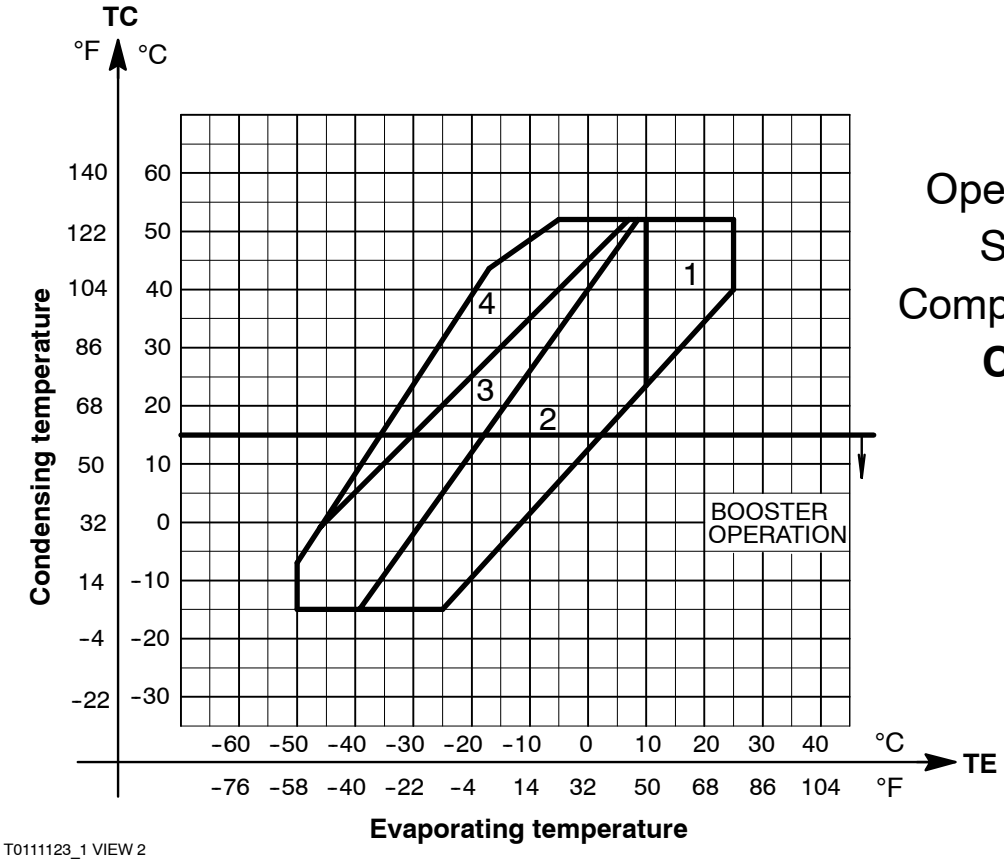
SABROE prescribes operating limits within which the compressor and any additional equipment must operate. These limits for R717, R22, R134a, R404A, R507 and R407C are shown in the following tables, together with the main data for the compressor.

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

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

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

0171-476-EN 00.05



T0111123_1 VIEW 2

R717

Operating Limits Single-Stage Compressor Type **CMO & SMC**

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

✳ SMC 188: 840-920 RPM not allowed
Included refrigerant cooled oilcooler.

Thermopump:

Top and side covers are cooled by injected refrigerant.
Oilcooling is included in the system
For Booster: liquid supply at intermediate pressure

Water cooled:

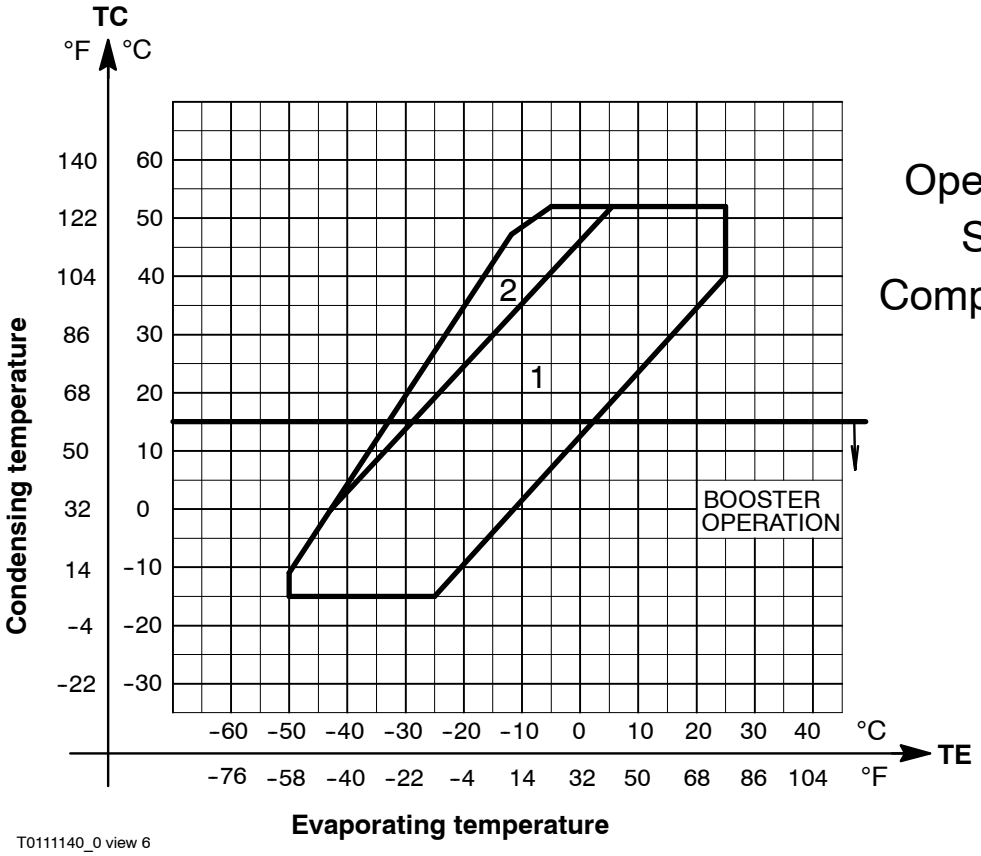
Top and side covers are water cooled.
Oil cooling is included in the system

NB: Discharge temperature must not exceed 150°C at full or part load

Min. 50% capacity (101) Min 50°C suction super heat

R717

Operating Limits
Single-Stage
Compressor Type
SMC100E



TYPE	AREA	rpm max.	rpm min.	COOLING	NOTE
SMC100E	1	1500	700	Thermopump or water cooled	
	2				1

Thermopump:
Top and side covers are cooled by injected refrigerant.
Oilcooling is included in the system
For Booster: liquid supply at intermidiate pressure

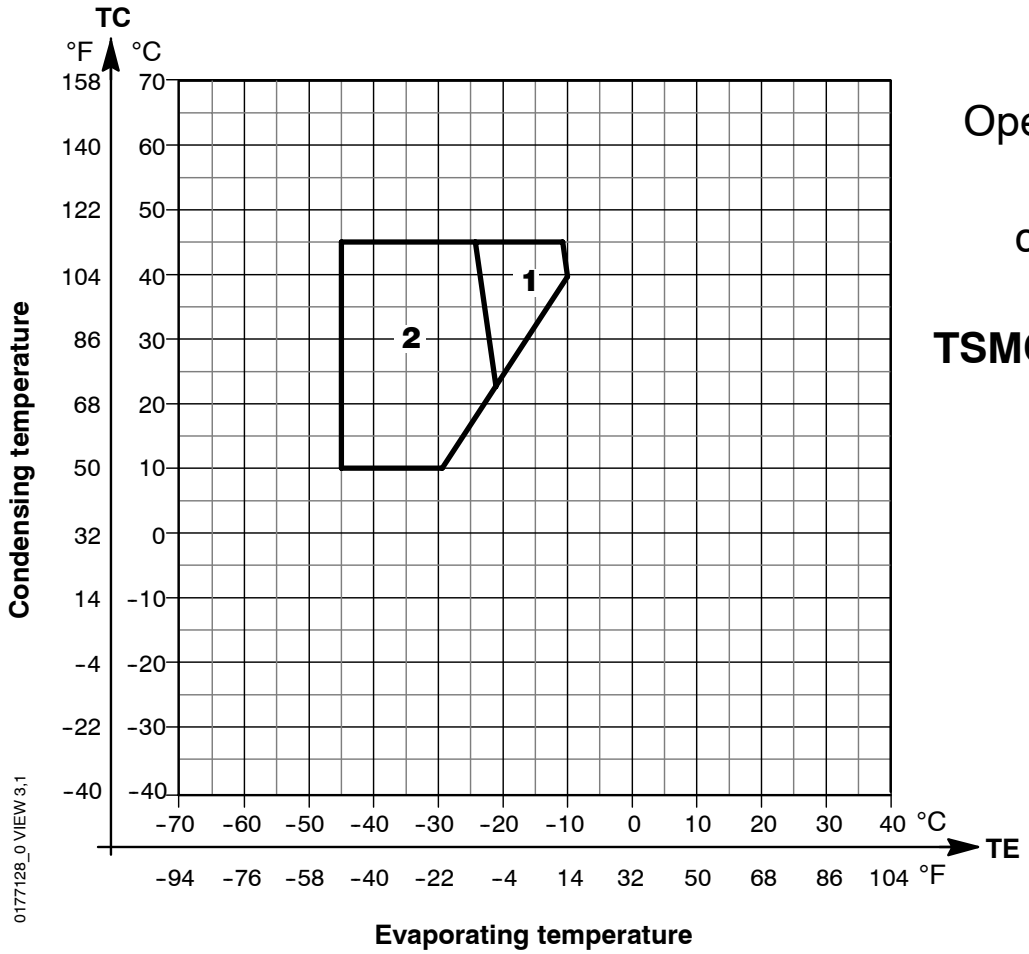
Water cooled:
Top and side covers are water cooled.
Oil cooling is included in the system

NB: Discharge temperature must not exceed 160°C at full or part load

Min. 50% capacity (101) Min. 50°C suction super heat

R717

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



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

Oil cooling is always necessary.

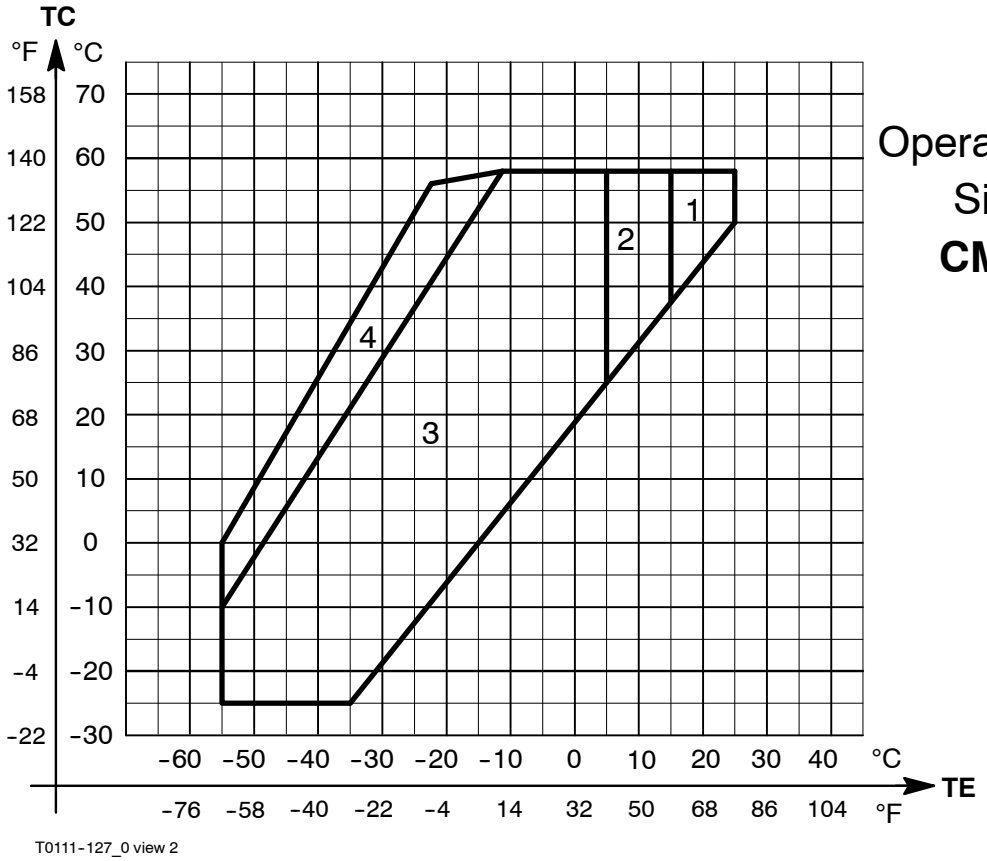
Thermopump:
Only the HP Stage top covers are cooled by a thermo pump
Oil cooling included in the system

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

Part-load operation:

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

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



T0111-127_0 view 2

R22

Operating Limits
Single stage
CMO & SMC

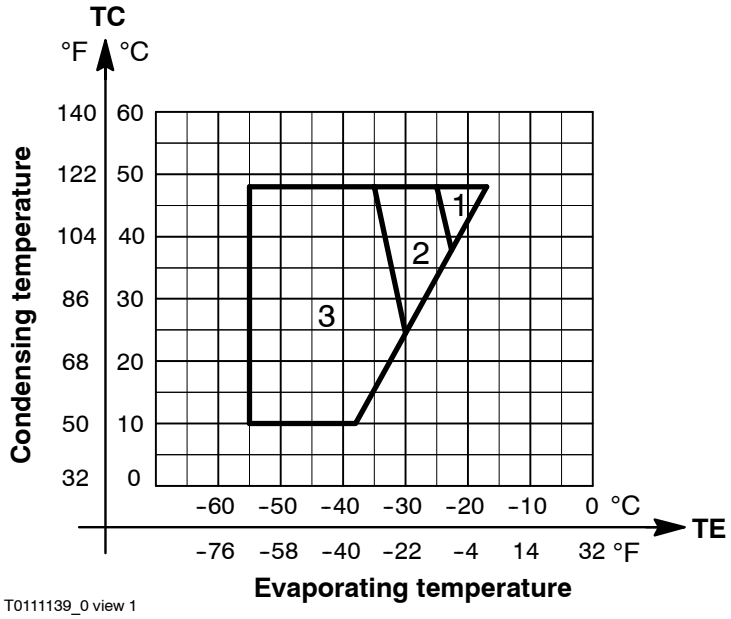
TYPE	AREA	rpm max.	rpm min.	OIL COOLING REQUIRED 1)	REMARKS
CMO20	1	1500	900	No	
	2	1500		No	
	3	1800		At less than 50% capacity	
	4	1800		yes	
SMC100S	1	1000	700	No	
	2	1200		No	
	3	1800		At less than 50% capacity	
	4	1800		yes	
SMC100L	1				2)
	2	1000	700	No	
	3	1200		At less than 50% capacity	
	4	1200		yes	
SMC180	1-2				2)
	3	750	450	At less than 50% capacity	
	4			yes	

Top covers: Air cooled only

1) When required there is a free choice between A or B
   - except SMC 180 where only A may be selected.

   A: Water cooled side covers
   B: Built in refrigerant cooled oil cooler with thermostatic expansion valve

2) Not applicable



T0111139_0 view 1

R22

Operating Limits two-Stage Compressortype **TCMO & TSMC**

TYPE	AREA	rpm max.	rpm min.	OIL COOLING REQUIRED 1)	REMARKS
TCMO	1-2	1500	900	no	
	3	1800			
TSMC100S	1	1000	700	yes	2)
	2	1200			
	3	1800			
TSMC100L	1				Not applicable
	2	1000	700	yes	2)
	3	1200			
TSMC180	1-2				Not applicable
	3	750	450	yes	2)

Top covers: Air cooled only

1) When required there is a free choice between A or B
- except SMC 180 where only A may be selected.

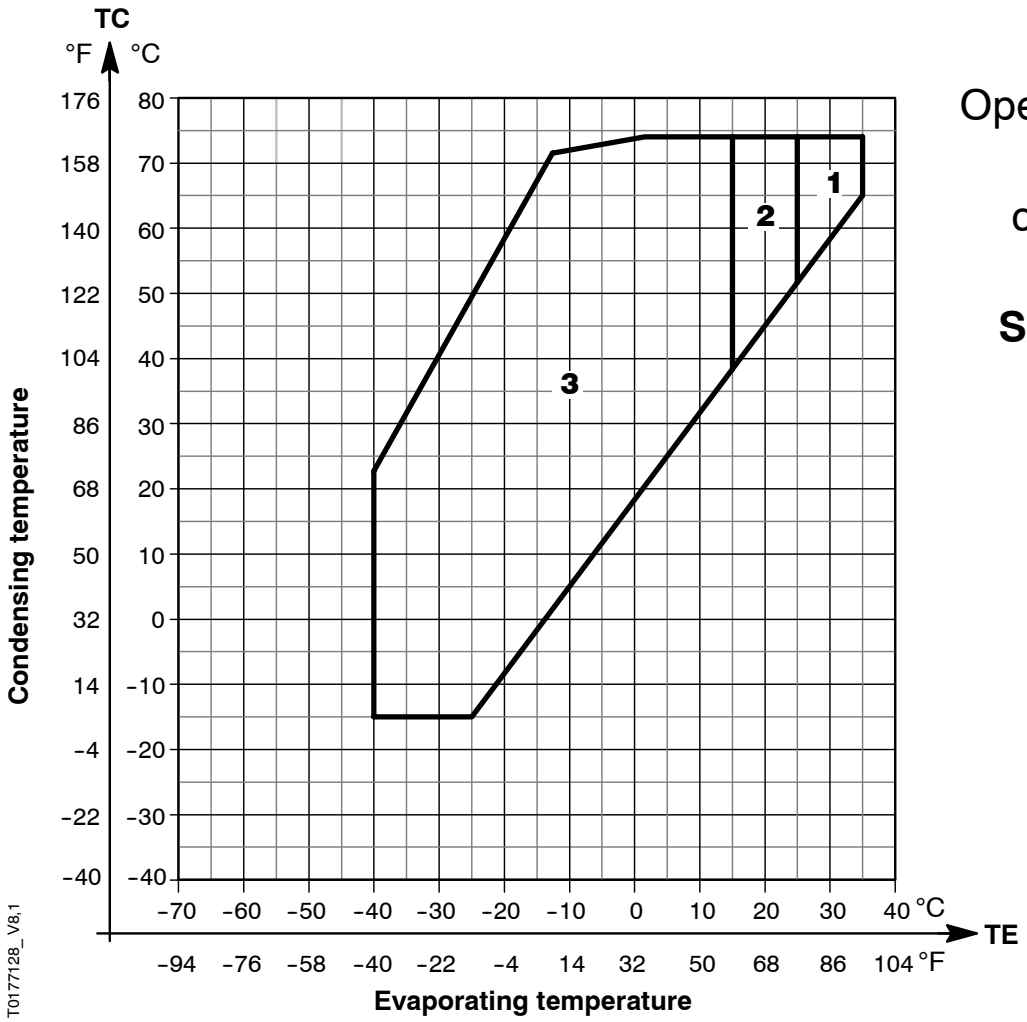
A: Water cooled side covers

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

2) By-pass equipment required to maintain intermediate temperature at minimum load.
(see price list specification)

R134a

Operating limits
single stage
compressors
CMO
SMC 100 S-L



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

Top covers: Air-cooled design only.

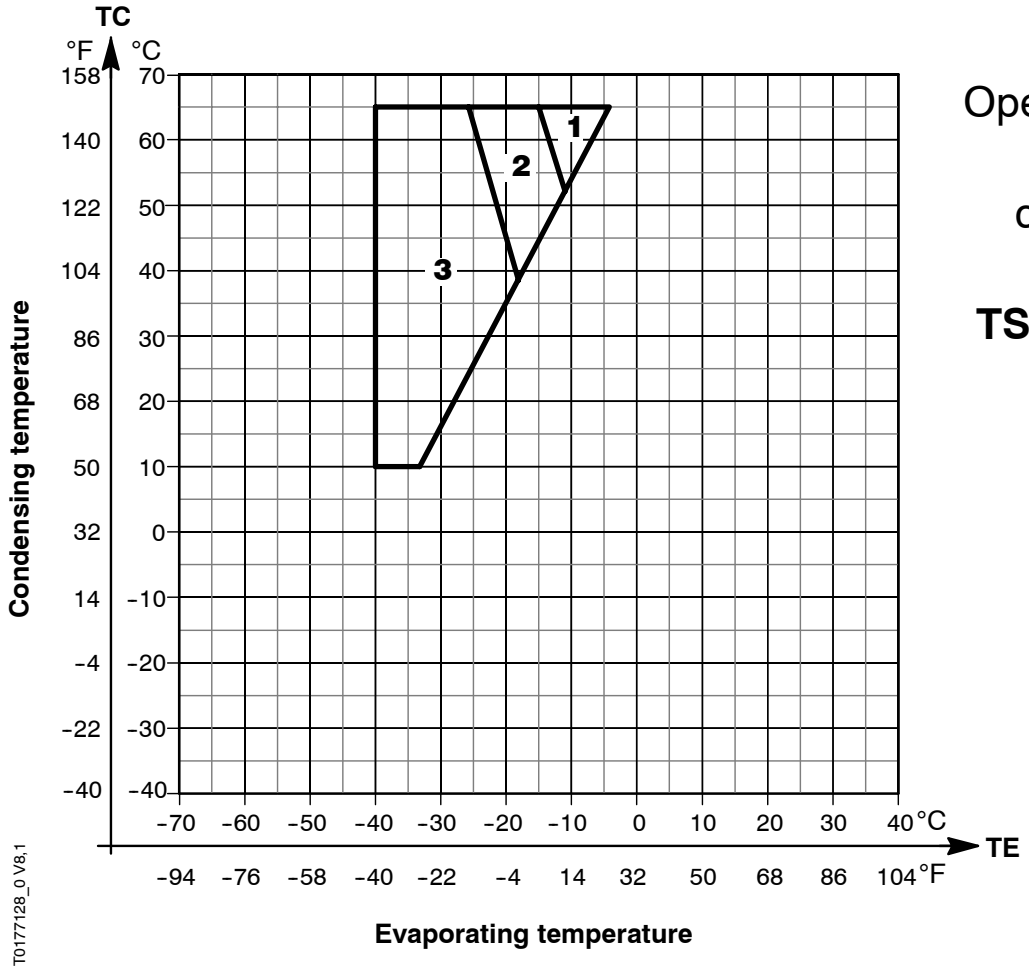
1) When oil cooling is required there is a free choice between **A** and **B**.

A: Water-cooled side covers

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

R134a

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



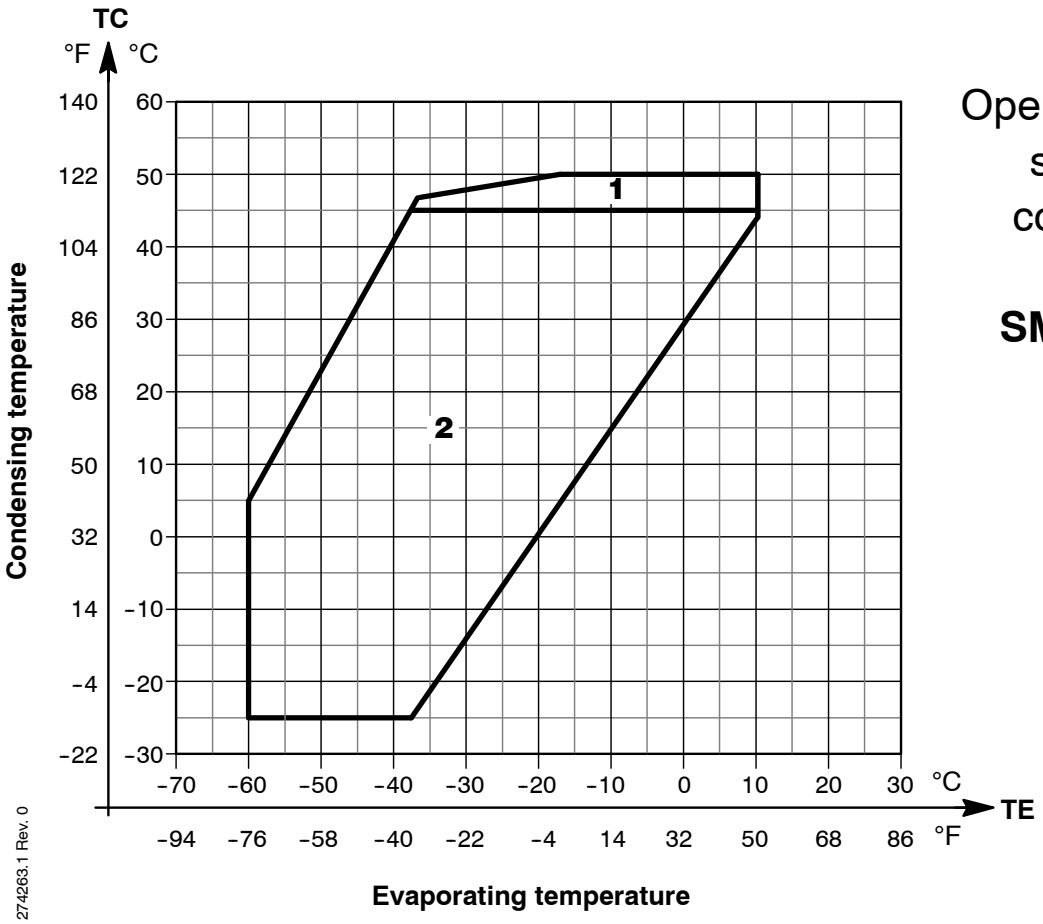
Type	Area	rpm		Oil-cooling required [1]	Note
		max	min		
TCMO 28	1-2	1500	900	1)	
	3	1800			
TSMC 100 S	1	1000	700	1)	2)
	2	1200			
	3	1500			
TSMC 100 L	1				Not applicable
	2	1000	700	1)	2)
	3	1200			

1) **Oil cooling:**
Not required.
Top- and side covers:
Only air-cooled.

2) **Part-load operation:**
By-pass equipment required to maintain i termediate temperature at minimum load.

R404A

Operating limits
single stage
compressors
CMO
SMC 100 S-L



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

Top covers: Air-cooled design only.

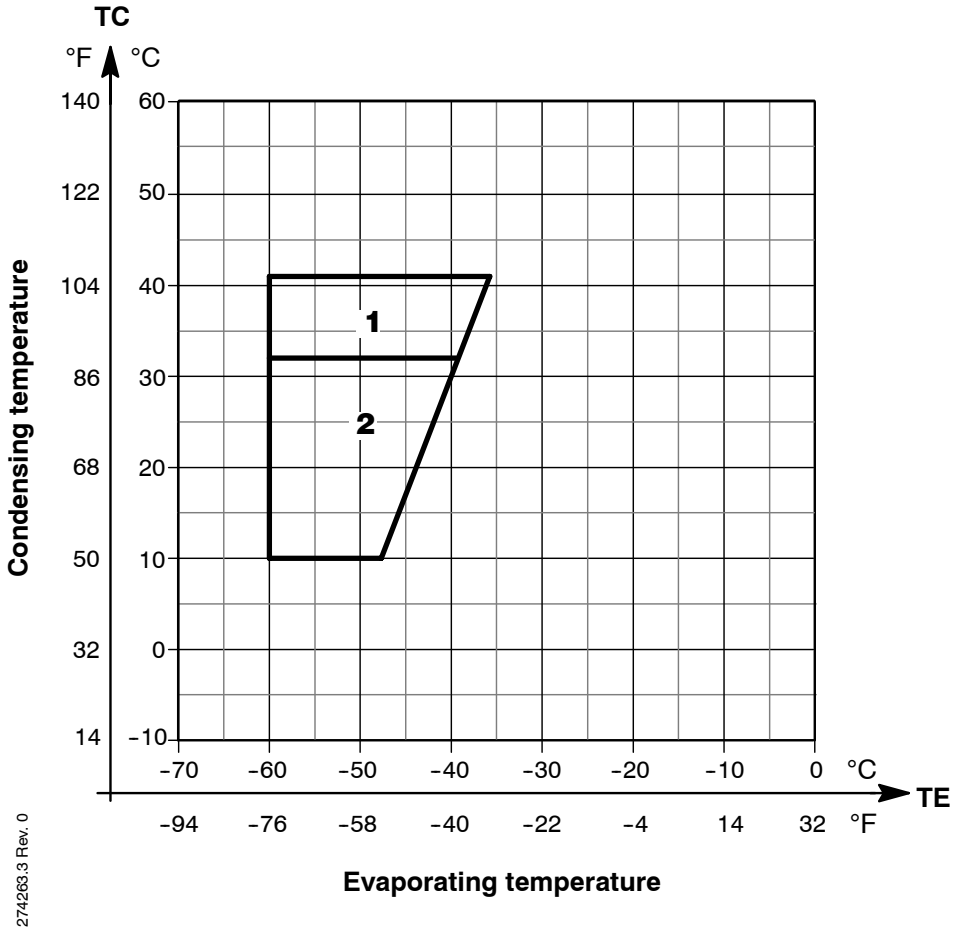
1) When oil cooling is required there is a free choice between **A** and **B**.

A: Water-cooled side covers

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

R404A

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



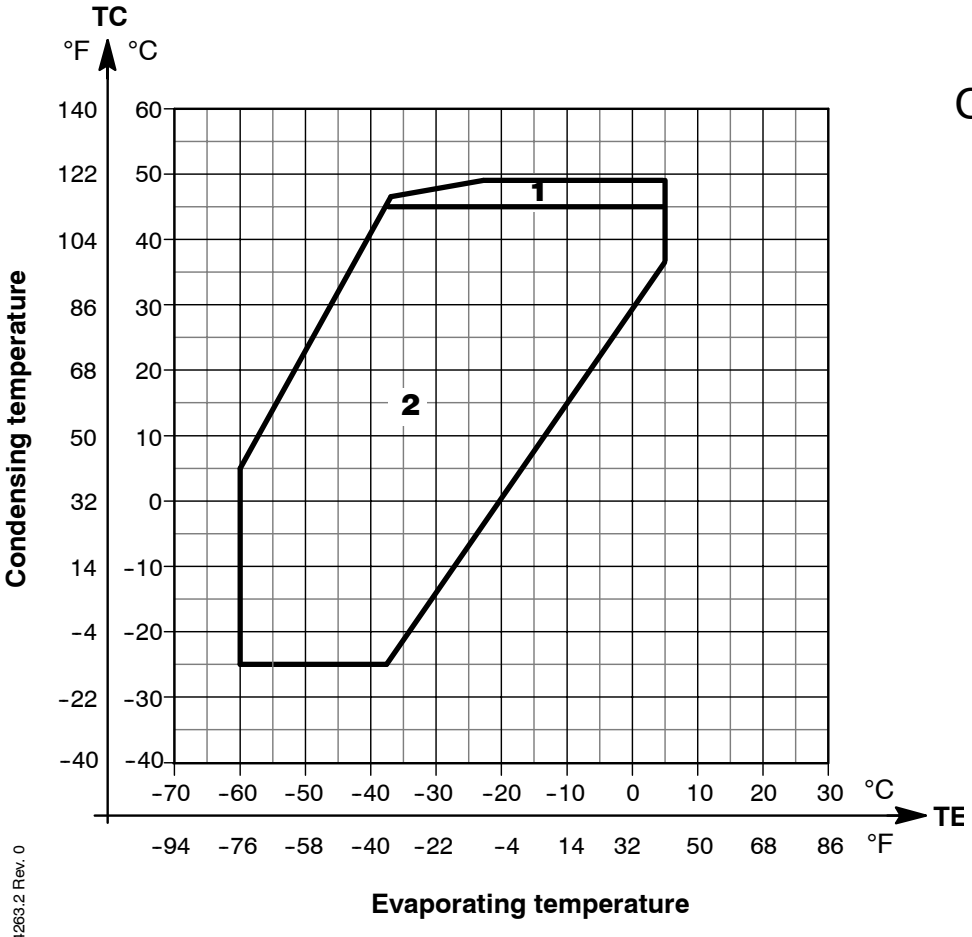
Type	Area	rpm		Oil-cooling required [1]	Note
		max	min		
TCMO 28	1	1800	900	1)	
	2				
TSMC 100 S	1	1200	700	1)	2)
	2	1500			
TSMC 100 L	1	1000	700	1)	2)
	2	1200			

1) **Oil cooling:**
Not required.
Top- and side covers:
Only air-cooled.

2) **Part-load operation:**
By-pass equipment required to maintain i termediate temperature at minimum load.

R507

Operating limits
single stage
compressors
CMO
SMC 100 S-L



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

Top covers: Air-cooled design only.

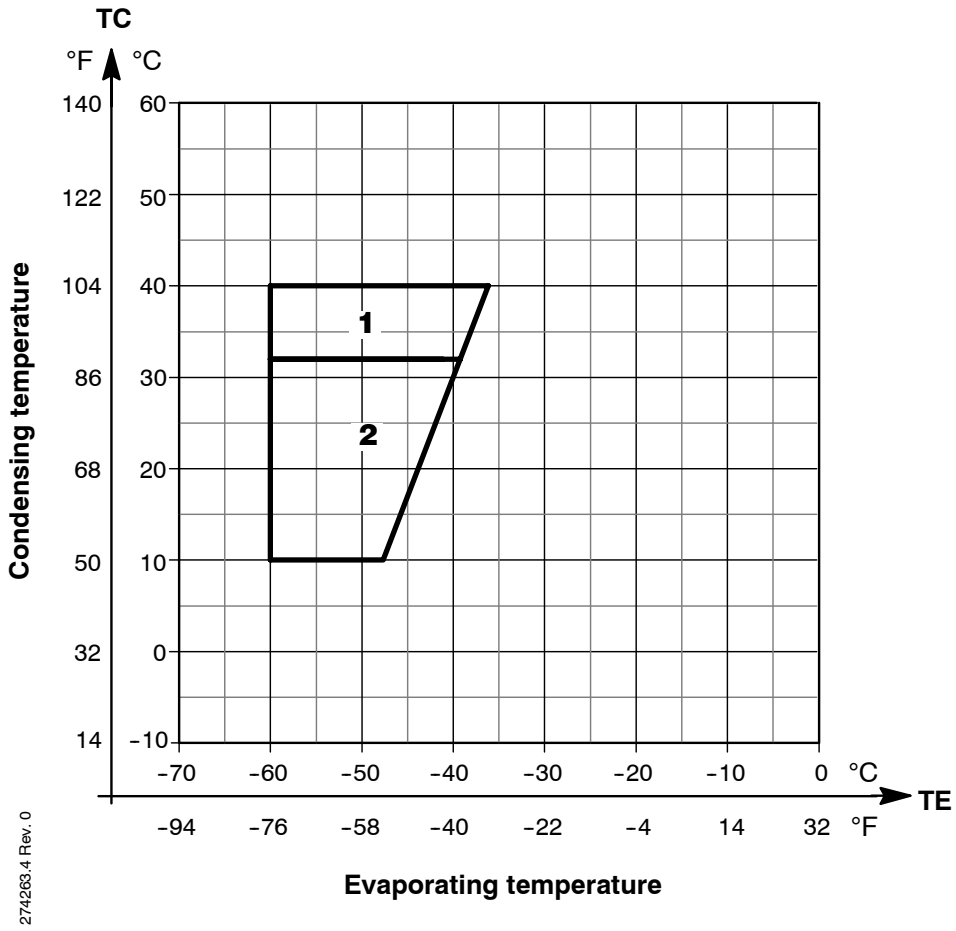
1) When oil cooling is required there is a free choice between **A** and **B**.

A: Water-cooled side covers

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

R507

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



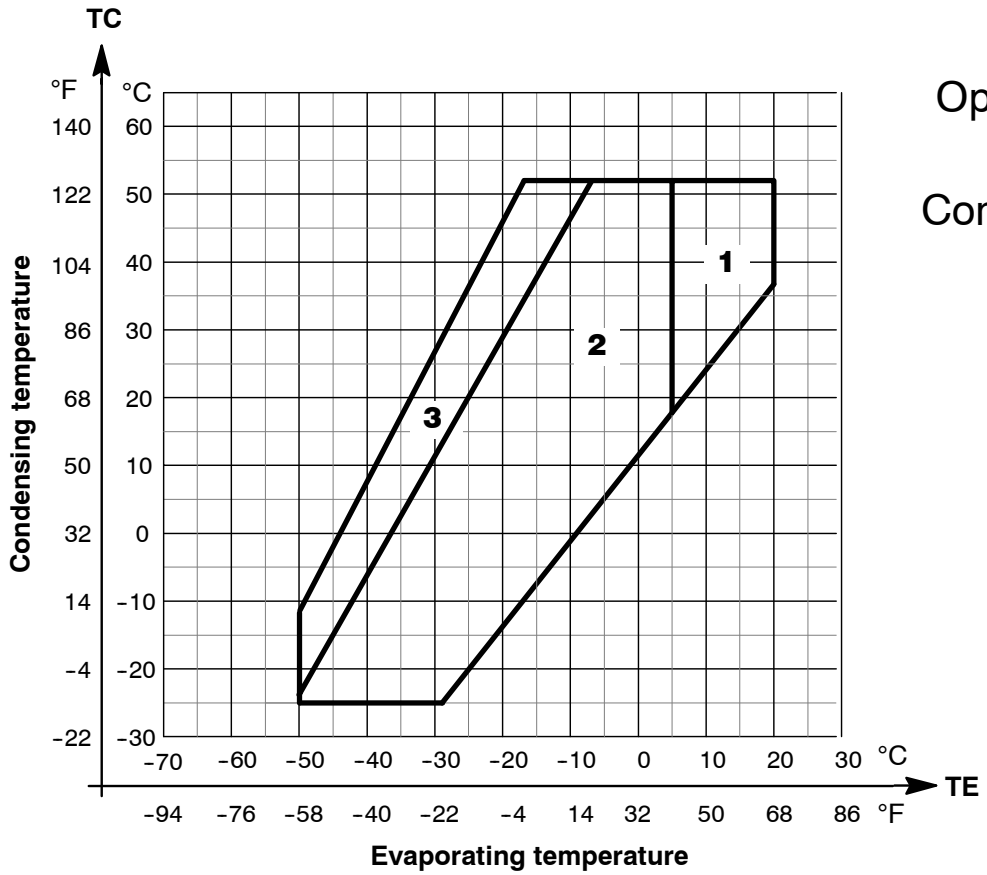
Type	Area	rpm		Oil-cooling required [1]	Note
		max	min		
TCMO 28	1	1800	900	1)	
	2				
TSMC 100 S	1	1200	700	1)	2)
	2	1500			
TSMC 100 L	1	1000	700	1)	2)
	2	1200			

1) **Oil cooling:**
Not required.
Top- and side covers:
Only air-cooled.

2) **Part-load operation:**
By-pass equipment required to maintain i termediate temperature at minimum load.

R407C

Operating Limits one-Stage Compressor type **CMO & SMC**



T245411_0 view 2

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

Top covers: Air-cooled design only.

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

A: Water-cooled side covers

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

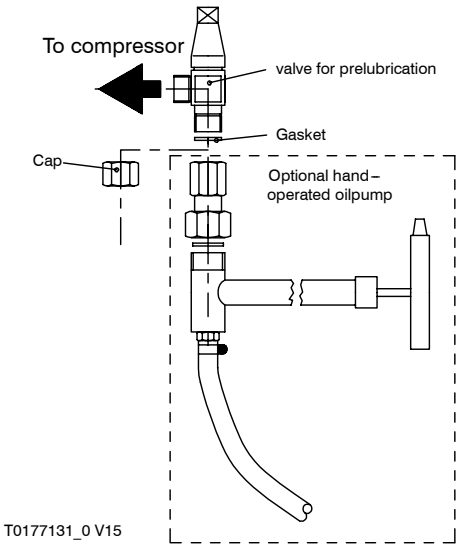
General operating instructions for CMO/TCMO, SMC/TSMC piston compressors

Starting up compressor and plant

- Before the initial start-up of the compressor following a lengthy stand-still period of several months, the compressor must be **prelubricated**. Hereby, the **bearings** are lubricated and the **oil system** filled up with oil before the compressor is set running.
  Carry out the **prelubrication** by connecting the oil pump to the **prelubricating valve** which in the more recent SMC-TSMC-HPC compressors is connected to the shaft seal housing pos. 6A and on the CMO-TCMO-HPO to the cover pos. 86H or 87K. As prelubricating pump we recommend SABROE's hand-operated oil pump part no 3141-155, which is mounted as shown in fig. 1.

96.06
0171-461-EN

Fig. 1



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

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

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

- In order to avoid excessive pressure reduction in the compressor on start–up, the suction stop valve **must** be opened a few turns, as there is otherwise a risk of oil foaming in the crankcase.

- Open all other stop valves except for the main valve in the liquid line and possible by-pass valves serving other purposes.

- Check that the time relay 3K13 keeps the solenoid valve in the oil return line closed for 20-30 mins. after start-up of the compressor.

- Start compressor motor and check suction and oil pressures.

- Carefully continue opening suction stop valve to its full open position.

- Open main valve in liquid line.

- If the oil in the crankcase foams, or knocking noises are heard from the compressor because droplets of liquid are being fed in with the suction gas, throttle suction stop valve immediately.

- The compressor is now operating.
  Increase capacity stepwise, allowing the compressor to adjust to new conditions before switching to next stage.
  Check carefully whether oil is foaming and whether oil pressure is correct.

- Check whether oil return from oil separator is working. (Pay attention to any clogging of filter and nozzle.)
  The pipe should normally be warm.

- Do not leave plant for first 15 minutes after start-up and **never** before it has stabilized.

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

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

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

If the compressor is cooled by means of cooling water, the water flow must always be stopped during periods of standstill.
This is normally done by means of a solenoid valve in the water inlet line to the compressor.
Connect the solenoid valve to the start/stop relay of the compressor motor.

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

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

- Shut off liquid supply to evaporators for a few minutes before stopping the plant.

- Stop compressor and shut off suction and discharge stop valves. Close valve in oil return.

- Stop condenser cooling, pumps, fans and any compressor cooling.

- Cut off power supply to both master and control currents.

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

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

Automatic plants

- Refrigeration plant should normally be put into operation as described in the Start-up section.Once started, switch over to automatic operation.
- Special instructions for automatic plant in question should be followed to the letter.
- The following should be checked daily, even on automatic plants:

- correct oil charging,
- automatic oil return,
- correct oil pressure,
- suction and condenser pressures, discharge pipe temperature,
- correct setting of safety automatics.

Pressure testing refrigeration plant

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

Pressure test the plant with one of the following:

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

> **Important**
>
> The plant compressors must not be used to pressurize the plant.
>
> Water or other fluids must **not** be used for pressure testing.

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

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

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

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

- The entire unit must be pressure tested in accordance with the local regulations for pressure testing.
- The test pressure must **never** exceed the disign pressure.
- If it is required that the compressor should be pressure tested together with the unit or with the plant, the testing pressure must **not** exceed:
  For reciprocating compressors:
  HP side: **24 bar**
  LP side: **17.5 bar**
- Please observe that manometers, pressure controls, pressure transmitters and other control equipment are **not** exposed to testing pressure.
- Afterwards, reduce pressure to **10 bar** for a period of **24 hours** - as an initial tightness test - as a tightly sealed plant will maintain this pressure throughout the period.

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

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

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

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

Pumping down refrigeration plant

Following pressure testing, the refrigeration plant must be evacuated in order to eliminate atmospheric air and moisture. Evacuation must be carried out on all types of refrigeration plant, regardless of the type of refrigerant with which the plant is to be charged.

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

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

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

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

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

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

Important

Never use the refrigeration compressor to evacuate the plant.

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

It is recommended to carry out evacuation as follows:

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

Operating log

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

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

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

At the same time, attention should be paid to the following:
(tick these off in the log, if you wish)

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

Servicing the reciprocating compressor
Reciprocating compressors CMO/TCMO, SMC/TSMC 100 and SMC/TSMC 180

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

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

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

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

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

Pressure drop test:

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

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

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

- where pressure valve ring plates are in bad contact with their seats (Pos. 20C against Pos. 20A and 19H);
- with defective seal Pos. 19T; (not CMO)
- with defective seal Pos. 19K;
- because cylinder lining and top cover have been tightened without long mounting stopper having been fitted. Cylinder lining is thus resting on rocker arms, Pos. 15A; (not CMO).
- on safety valve, because valve cone does not fit tightly against seat, or outer O-ring Pos. 24B or inner O-ring Pos. 24C is defective. *(See Safety valve section.)*

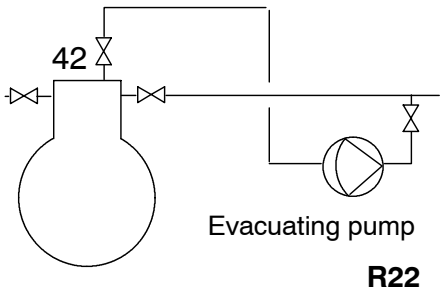
During pressure drop testing, pay attention to any piping connections to the discharge side of the compressor, which may have an influence on the test result.

0171-462-EN 99.05

Removing refrigerant from compressor

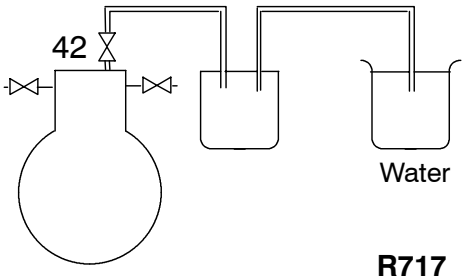
Before the compressor can be dismantled, the refrigerant must be removed from the compressor, which can be done in the following ways:

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



R22

- On the R717 compressor, adopt the following method:



R717

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

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

Note:

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

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

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

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

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

Lubricating oil

Lubricating oil requirements

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

General rules for use of lubricating oil in refrigeration compressors

- 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 necessary to switch to another brand of oil, this must be done at the same time as completely changing the oil in the compressor and tapping off all oil from the refrigeration plant.

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

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

Note:

It is inadvisable to reuse oil which has been drawn from a compressor or plant. This oil will have absorbed moisture from the air and may cause operating problems.

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

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

Instructions for choosing lubricating oil for refrigeration compressors

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

Charging refrigeration compressor with lubricating oil

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

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

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

Note:

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

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

Note:

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

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

Note:

Since halocarbon refrigerants such as R22 mix with refrigeration oils, there will always be a good portion of oil blended with the refrigerant in the plant. Often, therefore, it is necessary to refill with refrigeration oil after starting up for the first time and after charging with fresh refrigerant.

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

Changing oil in refrigeration compressor

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

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

  Then open suction stop valve a few turns, filling compressor with refrigerant gas. In the case of R717, it will suffice to blast the compressor through by carefully opening suction stop valve while purge valve Pos. 42 is open. See section on *Environmental protection,* however. When smelling R717, close purge valve.

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

Charging the compressor with oil

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

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

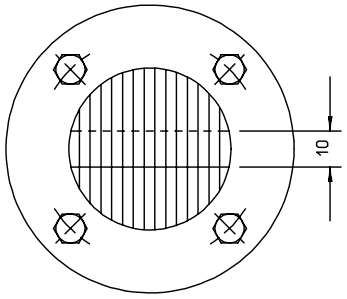
As a rule, the compressor should be charged with oil after the plant is started for the first time, as some of the oil – especially on an HCFC installation – will be absorbed by the refrigerant in the plant.

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

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

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

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



T0177162_0

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

Assessing the oil

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

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

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

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

Visual assessment

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

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

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

The analysis

The following 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	0.2	-	0.05	0.2	-
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	W%	MM 490 (5µm)	-	0.05		-	0.05	-	-	0.05	-
Oxidation	abs/cm	IR,1700-1720 /cm	-	5	-	-	5	-	-	5	-
Nitration	abs/cm	IR,1627-1637 /cm	-	5	-	-	5	-	-	5	-
Nitro Compounds	abs/cm	IR,1547-1557 /cm	-	0.5	-	-	0.5	-	-	0.5	-
Maximum values for metal content in the oil											
Lead	ppm	ICP	-	10	-	-	10	-	-	10	-
Copper	ppm	ICP	-	10	-	-	10	-	-	10	-
Silicium	ppm	ICP	-	25	-	-	25	-	-	25	-
Iron	ppm	ICP	-	100	-	-	100	-	-	100	-
Chromium	ppm	ICP	-	5	-	-	5	-	-	5	-
Aluminium	ppm	ICP	-	10	-	-	10	-	-	10	-
Tin	ppm	ICP	-	10	-	-	10	-	-	10	-

1): TAN (Total Acid Number) is only reported for non-ammonia-applications

2): SAN (Strong Acid Number) is only reported for non-ammonia-applications

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

- Whether the oil can still be used – without taking any further action.
- Whether the oil can be used after it has been filtered through a very fine filter.

  If this is necessary, the oil must be pumped directly from the compressor unit through a 3 micron filter and back to the unit. The system must be completely closed, to prevent the oil being affected by moisture in the air.
- Whether the oil is no longer fit for use.

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

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

			Refrigerant					
			R22	R134a	R404A	R507	R717	
Safety equipment	Safety valve on the compressor	HP	x	x	x	x	x	24 bar (standard)
								22 bar (special)
		IP	x	x	x	x	x	12 bar
	High and intermediate cut-out	KP 5 (KP15)	x	x	x	x	x	Set so that the compressor stops at a pressure 2 bar lower than the safety valve setting.
	Low-pressure cut-out	KP 1 (KP15)	x	x	x	x	x	Set to a pressure with saturation temp. 5°K lower than the lowest evaporating temperature.
	Oil pressure cut-out	MP 55	x	x	x	x	x	3,5 bar [1]
	Discharge pipe thermostat	KP 98	x	x	x	x		* 120 °C
							x	* 150 °C
	Oil thermostat	KP 98	x	x	x	x	x	80 °C
Control equipment	Thermostat for compressor cooling	KP 77	x	x	x	x	x	55 °C
	Thermo valve for compressor cooling	T(E) X T(E) Y T(E) F	x	x	x	x		Normally set at 4 °C superheat. Change to min. 10 °C superheat
	Injection valve for intermediate cooling	TEAT		x	x	x		Factory set. 45 °C See below.
			x				x	Factory set. ** 75 °C See below.
		T(E) X	x					Adjust to min 10°C superheat
		TEA					x	Adjust to min 10°C superheat
	By-pass valve	PMC + CVC	x	x	x	x		-25 °C
							x	-15 °C
	Oil pressure regulating valve		x	x	x	x	x	4.5 bar [2]

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

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

Adjust the TEAT valves so that the expected discharge pipe temperature (-5°C/+10°C) is achieved at 100% compressor capacity.
Increase the opening temperature 10°C by turning the spindle 5 turns clockwise.
NB: Factory setting must always be increased by min. 10°C.

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

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

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

96.04
0170-012-EN

Expected discharge gas temperatures

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

0170-105-EN 96.02

Servicing the refrigeration plant

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

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

- the desired temperatures are observed,
- the oil pressure and discharge pipe temperature on the compressor are correct,
- the condenser pressure is not excessively high, and
- the plant otherwise works as it is supposed to.

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

97.07
0171-470-EN

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

	Check	Interval	Activity
Refrigerant	Refrigerant change	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 plant's initial operation period. They must therefore be tightened and checked.
Automatic controls	Safety pressure controls Automatic operating controls Alarms	Periodically	Adjust operating point and check the function. Replace switch system if sticking.
Electric motor	Lubrication of electric motors	Periodically	Clean and lubricate according to supplier's instructions. At temperatures lower than -25°C, use special lubricant.
	Alignment of coupling V-belt drive		Check in accordance with the instructions of the instruction manual. Tighten loose V-belts, if any, or replace by new ones.
Condenser	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 needed	Problem-free operation is conditional on the evaporator being kept free of ice. Defrost as and when required.
	Oil draining (ammonia plant)	Periodically	Check evaporator, intermediate cooler, receiver, etc. for oil accumulation. Exercise caution; use a gas mask

Maintenance of reciprocating compressor CMO 24-26-28 Mk2, TCMO 28 Mk2

General

When the compressor requires maintenance, it is important to follow the instructions given below. In order to make sure that the compressor is working correctly, the gauge measurements and screw torques must be strictly adhered to.

Before opening the compressor, it is expedient to ensure that you have spares of those seals and gaskets to be stripped down or dismantled. An O-ring which has been exposed to oil and heat for any length of time may have expanded so much as to prevent it being refitted.

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

0171-358-EN 98.07

Pump-down

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

1. If the compressor is operational

Run the compressor at minimum capacity at normal operating temperature.

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

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

The suction pressure must be lowered slowly enough to give the refrigerant dissolved in the oil time to escape without the oil foaming. This is of great importance in compressors running on HFC/HCFC. An ammonia compressor can stand having the pressure reduced somewhat more quickly without the oil foaming.

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

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

2. If the compressor is inoperative

- Leave heating rod in crankcase connected for a couple of hours before compressor is due to be opened in order to heat up oil. Warm oil does not contain as much refrigerant.
- Suction stop valve must be open while heating rod is connected.
- Keep discharge stop valve closed.
- Close suction stop valve and disconnect heating rod.
- Equalize pressure in compressor through purge valve Pos. 42.
- Once pressure has been equalized to atmospheric, compressor is ready for opening. Remember to make sure that power cannot be inadvertently connected, thereby starting the motor.
- Remove all fuses, if any.

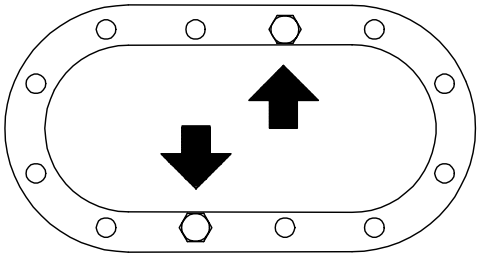
Dismantling and assembly

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

Top covers

Dismantling of top cover

Loosen and dismantle screws Pos. 2C, however with exception of the two screws shown on drawing.



T0177142_0 V9

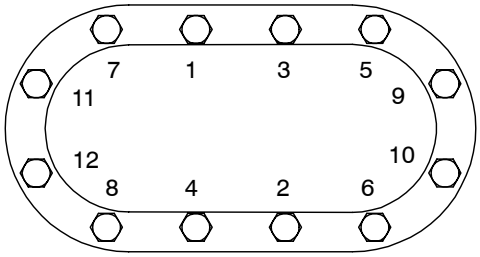
Loosen these screws approx. 1 mm and check that the cover lifts off the gasket.
But if the cover remains fastened to the gasket, loosen it by a blow on the side with a soft hammer **while keeping the two screws fitted**. Pay attention to the powerful spring pressure under the top cover. After dismantling of the two screws – unscrew alternately – the top cover can be removed.

Mounting of top cover

Check that gasket pos. 2B is **intact** and – if necessary – check that the **clearance volume** has been adjusted as described later in this instruction.

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

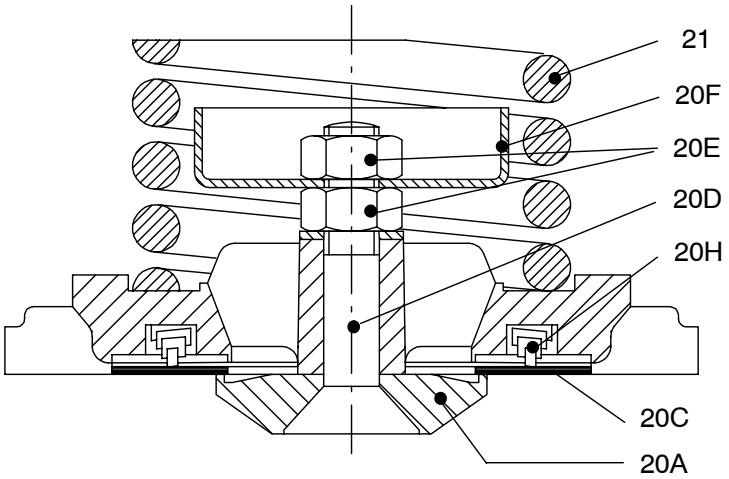
Finally, cross-tighten all screws with the prescribed torque in the following sequence:



T0177142_0 V9

Discharge valve

Pos. 20



T0177142_0 V2

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

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

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

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

Discharge valve types:

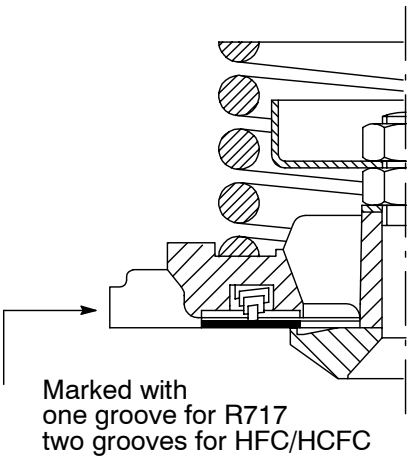
Depending on which refrigerant the compressor is operating on, various discharge valves must be used in order to achieve optimum function.

Marking

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

Refrigerant R717:
All discharge valves are marked with **one groove.**

Refrigerants HFC/HCFC:
All discharge valves are marked with **two grooves.**



Dismantling

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

Assembling

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

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

- Tighten bottom nut Pos. 20E to torque of 3,2 Kpm ≅ 31 Nm.

  If necessary, exert counterpressure with 3 mm Allen key on bolt head.
- Fit spring guide Pos. 20F and tighten top nut to same torque: 3,2 Kpm ≅ 31 Nm.

Leak testing of discharge valve

This is done by means of the pressure drop test, as described elsewhere in this instruction manual. Please see list of contens.

Service life of discharge and suction valves

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

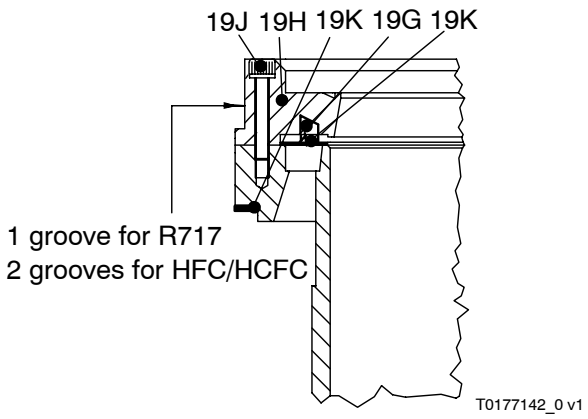
It is difficult to give altogether precise times for such replacements, as the durability of the valve ring plates depends on the following factors:

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

When the valve ring plates are changed, the valve springs should also be replaced.

Cylinder lining with suction valve

Marking of suction valve stop



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

The cylinder lining and suction valve form an integral unit and can be dismantled by removing screws Pos. 19J.

Extracting cylinder lining

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

Dismantling suction valve

Dismantling the screws Pos. 19J enables the suction valve stop Pos. 19H and ring plate Pos. 19F to be removed from the cylinder lining.

Mounting suction valve

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

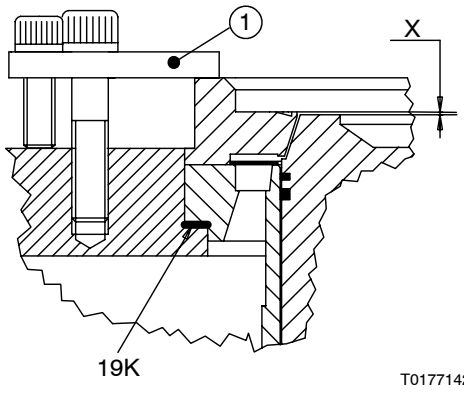
Perform the assembly in reverse order to that described above. Note the following, however:

- Before tightening screws 19J, ensure suction valve plate can be moved freely in its guide. Tighten screws Pos. 19J to a torque of 7.6 Nm.

Inserting cylinder lining

- Rotate crankshaft to position piston at top dead centre.
- Check that gasket Pos. 19K is in position on frame.
- Lubricate piston, piston rings and cylinder face with clean refrigerating machine oil. Likewise, grease O-ring Pos. 19M on HP cylinder of TCMO compressor with clean refrigerant oil.
- Rotate piston rings on piston so as to stagger ring gaps at 180° to each other. Press cylinder lining down over piston carefully. The chamfering on the cylinder interior will catch the piston rings and squeeze them to the diameter of the cylinder. If possible, fit cylinder in same place from which it was taken.
- Press cylinder lining down by hand and without using rotating movements, however, it will not bear against gasket Pos. 19K until discharge valve pos. 20, safety spring Pos. 21 and top cover have been mounted.

- In order to be able to check the size of the clearance volume. However, it is necessary to press cylinder lining down against gasket Pos. 19K, using of 2 tightening bars no. 1 to be mounted diagonally above the cylinder lining. To be used as shown on the following drawing.



- Using a depth gauge, measure the distance "**x**" from discharge valve seat to the top of the piston, with this in its top position.

  The correct "**x**" measure must be between:

  x min. = 0.8 mm
  x max. = 1.2 mm

Adjustment of "**x**" measure is done by inserting one or more gaskets Pos. 19K which, as indicated in the parts lists, come in two sizes, 0.5 and 0.8 mm.

Next, mount discharge valve Pos. 20, spring Pos. 21, and top cover. Before this, check gasket Pos. 2B.

Connecting rod

Connecting rod Pos. 17 consists of a light metal alloy which, besides its excellent strength properties, is also well-suited as bearing material.

Thus, the bearing surfaces of the connecting rod work directly on the crankshaft and the bearing surfaces of the gudgeon pin.

At the HP cylinder in the TCMO compressor a needle bearing Pos. 17K is fitted. The needle bearing can – in a vice or hydraulic press – be squeezed out from into the connecting rod. Apply soft jaws in the vice and use tools that do not damage the parts.

As indicated in the parts lists the connecting rods for the HP and LP stages each have their own part number and can further be delivered with short measures on the big end bearing, for use at repairs, if any. See section on: *Undersize bearing diameters for chankshaft.*

Fitting connecting rod

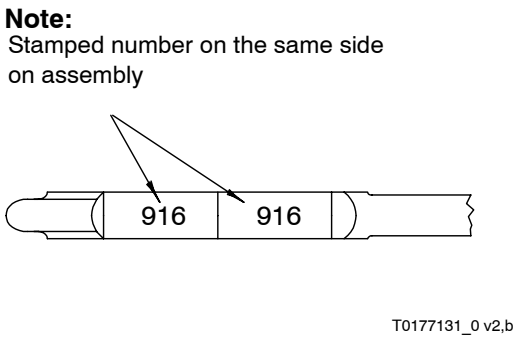
Before fitting the connecting rod in the compressor stand, piston and piston rings must be fitted onto the connecting rod. See the following sections. In addition, the two connecting rod bolts Pos. 17C must be fitted as shown in the spare parts drawing.

- Introduce connecting rod down through top cover opening in frame and guide into position on crankshaft manually. Take care so that connecting rod bolts do not leave marks in crankshaft journals.
- Position connecting rod interior through lateral opening on frame, and fit nuts Pos. 17H.

Note:

The two parts of the connecting rod are numbered with the same number; this is only of importance when assembling. Parts with different numbers must not be assembled and it is important that the numbers are fitted in the same direction as shown in Fig. 1.

Fig. 1



- Tighten nuts Pos. 17H alternately with increasing torque and finish off with torque wrench.
  Torque: 20 Nm.

Piston

The piston is made of aluminium and equipped with a **piston ring** and **an oil scraper ring**.

Fitting piston rings in piston

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

Note:

*At the ring opening the oil scraper ring is marked **TOP**. This mark **must** face the piston top.*

Assembling and stripping down piston and connecting rod

Adopt the following procedure when assembling piston and connecting rod:

- Fit one of the circlips pos. 18E into bore reserved for piston pin.
- Heat piston to 70°C in oil or on hotplate.
- Guide connection rod (TCMO - with inserted needle bearing) into place in the piston pin without using tools.
- Fit the other circlip Pos. 18E.

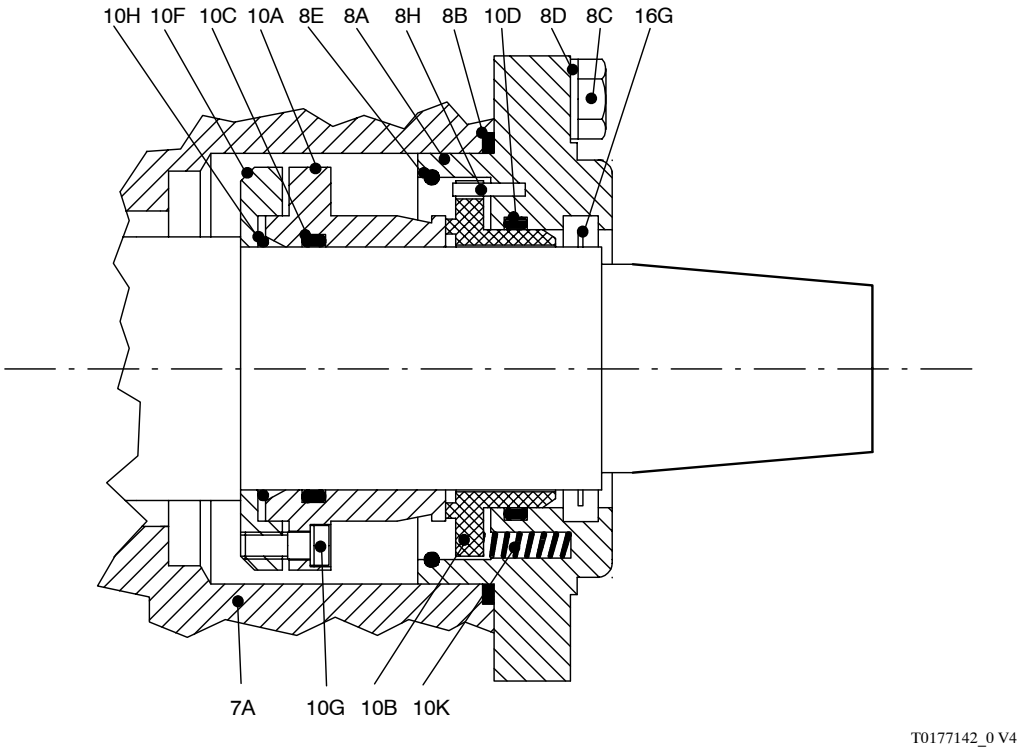
Dismantling is done in opposite order. However, do not heat the piston, but press out the piston pin using a punch.

Procedure for removing piston and connection rod

- Bleed compressor of oil and refrigerant and safeguard against any inadvertent start-up.
- Disconnect any water hoses and other pipe connections to top and side covers.
- Dismantle top and side covers.
- Remove spring Pos. 21, discharge valve and cylinder lining.
- Remove nuts Pos. 17H; following this, the bottom part of the connecting rod can be taken out by hand.
- Piston and connecting rod can then be lifted out through the top cover opening on the frame.

Shaft seal

Fig. 2



Pos. no.	Shaft seal
7 A -1	Bearing cover
8 A -1	Shaft seal cover
8 B -1	O-ring dia. 98.02 x 3.53
8 C -1	Hexagon screw M8 x 30
8 D -1	Locking washer
8 E -1	Circlip
8 F -1	Retention pin
10 A -1	Slide ring (cast iron)
10 B -1	Slide ring (special carbon)
10 C -1	O-ring dia. 53.57 x 3.53
10 D -1	O-ring dia. 63.09 x 3.53
10 F -1	Tightening flange
10 G -1	Allen screw M5 x 16
10 H -1	Circlip
10 K -1	Spring
16 G -1	Oil throw ring

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

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

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

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

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

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

When the shaft seal is operating, a tiny amount of oil drifts out between the slide faces to lubricate them. An oil throw ring Pos. 16G has therefore been fitted to prevent this oil migrating along the axle to the transmission linkage.

The oil splash ring ejects the oil into the groove in the shaft seal cover Pos. 8A. Via internal channels, the oil comes out under the shaft seal and through a plastic hose, it is collected in a plastic bottle.

1. Dismantling and stripping down shaft seal

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

Note:

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

1.2. Dismantle shaft seal cover Pos. 8A by alternately loosening bolts 8C so as to displace shaft seal cover outwards without jiggling. This will avoid damage to internal parts of the shaft seal.

1.3. Once the spring force is equalized and the bolts removed, the shaft seal cover can be taken off the shaft end by hand. Take care so that no damage is done to the carbon slide ring Pos. 10B which comes out with it.

1.4. The carbon slide ring Pos. 10B can be extracted by dismounting circlip pos. 8E as follows:

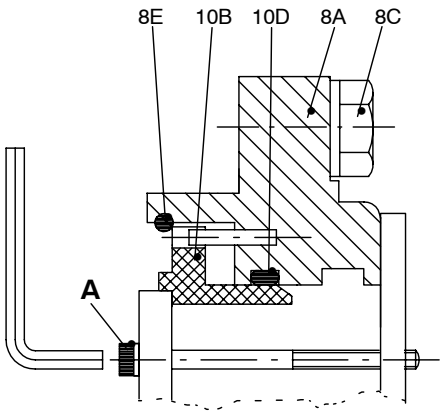
Mount tool no. 2 as illustrated in fig. 3 and tighten screw A so that the carbon slide ring does not touch the locking ring.

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

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

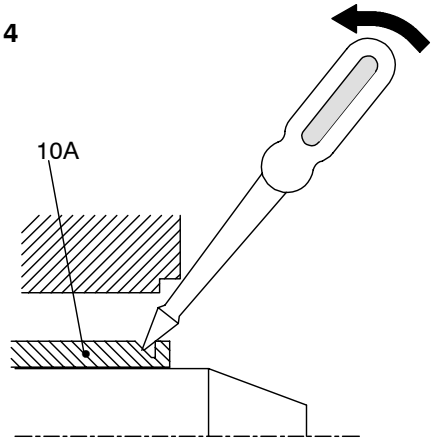
After removing tool no. 2, the carbon slide ring pos. 10B, O-ring pos. 10D and springs pos. 10K (see fig. 2) can now be dismantled.

Fig. 3



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

Fig. 4



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

Assembling and mounting shaft seal

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

2. Unit with slide ring, Pos. 10A

2.1. Before fitting slide ring 10A, tighten screws 10G until there is approx. 2 mm spacing and parallelism between the two flanges. Check also that locking ring 10H is mounted as shown in the drawing and O-ring 10C is in position.

2.2. Position slide ring 10A on shaft and ensure tightening flange makes contact with shaft shoulder.

2.3. Crosswise, tighten screws Pos. 10G alternately with Allen wrench from tool kit. The torque is specified in the instruction manual.

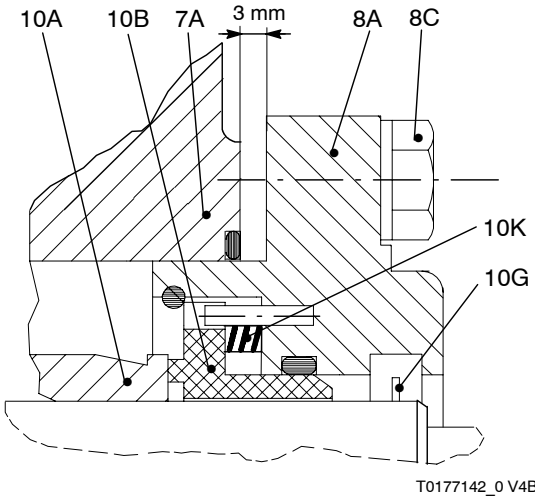
3. Unit with shaft seal cover Pos. 8A

3.1. Mount O-ring 10D and the ten spiral springs 10K in shaft seal cover 8A, then position carbon slide ring 10B carefully. Rotate carbon slide ring so slot fits in over retention pin 8H.

3.2. With tool no. 2-1 fitted as shown fig. 3 press carbon slide ring 10B against springs with your fingers and fit circlip 8G. Take care that the surface of the carbon slide ring remains undamaged.

3.3. Give the complete shaft seal cover an extra oiling on the slide surface of the carbon slide ring and guide it over the shaft. Pay attention to O-ring Pos. 8B.

3.4. By gently pressing the shaft seal cover and the carbon ring against slide ring Pos. 10A without compressing the springs Pos. 10K, measure the distance from shaft seal cover Pos. 8A to bearing cover pos. 7A (see sketch). By a subsequent careful tightening of the screws Pos. 8C the shaft seal cover should only be tightened about 3 mm before achieving contact between Pos. 8A and 7A.



In case the movement is bigger, check whether the tightening flange Pos. 10F has been pushed completely up against the crankshaft shoulder as described in sections 2.2 and 2.3.

3.5. Make sure that the screws Pos. 8C are evenly tightened cross-wise. Hereby damage of the carbon slide ring is avoided. Tighten screws Pos. 8C to prescribed torque, acc. to table in instruction manual.

3.6. Mount oil throw ring Pos. 16G, as shown in drawing.

3.7. After mounting coupling half or V-belt disk, it must be possible to turn the crankshaft easily by hand.

Crankshaft

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

At the centre and end of the crankshaft, the oil channels are blanked off with 3 blind plugs.

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

Dismantling crankshaft

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

- Bleed compressor of oil and refrigerant and safeguard against inadvertent start-up.
- Dismantle top and side covers.
- Dismantle all cylinder linings.
- Extract all pistons and connecting rods.
- Pull off V-belt pulley or coupling half .
- Dismantle shaft seal cover and shaft seal.
- Dismantle pressure cut-outs and pipes to manometers, or piping connections to UNISAB.
- Dismantle oil filter as well as its bracket Pos. 59A.
- Dismantle end cover, pos. 4A.
- Dismantle bearing cover with oil pump Pos. 5A at screws Pos. 5C, then pull out bearing cover. It is not necessary to dismantle oil pump Pos. 11 from bearing cover. it is also normally not necessary to support the crankshaft.
  Now pull out crank from the frame, supporting it by hand through one of the side openings.

Inspection

- Check bearing journals at connecting rods of wear and tear and, if necessary, measure diameter of journals. Max. wear of the journals appear from section *Various clearances and adjustment measurements*.

  In most instances, the permissible play in the bearing can be obtained by replacing the connecting rods.

  Normally, the journals are only slightly worn at main bearings, but during complete overhauls they should be measured.

  By wear and tear beyond the plays stated, the crankshaft can normally be ground to 0.5 mm undersize.

  Main bearings and new connecting rods with a 0.5 mm undersize can be supplied to the ground down crank, as stated in the parts list.

Drawing for grinding of crankshaft to undersize can be requested from SABROE.

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

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

Refitting crankshaft

Refit the crankshaft in the reverse order to that for dismantling.

Note the following, however:

- After positioning the crankshaft in the frame, mount main bearing cover Pos. 5A with a gasket Pos. 5B as a shim.
- Before refitting bearing cover, position and rotate oil pump coupling on pump shaft so that the retaining pins on the crankshaft engage the two nylon bushings.
- Check end play of crankshaft by pressing the shaft against the main bearing Pos. 6E, and measure clearance in the other bearing, using a feeler gauge.

  The permissible end play appears from section *Various clearances and adjustment measurements*.

  Adjustment of end play is achieved by means of the gasket Pos. 5B.

  The gasket can be supplied in the following thicknesses, as per the spare parts list:

  0.25 mm 0.50 mm 0.75 mm 1.0 mm

Main bearings

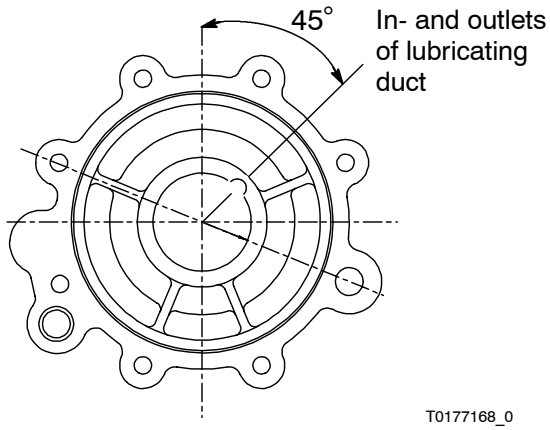
Main bearings Pos. 5E and 6E consist of a steel bushing with collar, coated with a thin layer of white metal inside the bushing and on the collar.

The bushings can be squeezed out and replaced by new ones and require no finishing once assembled.

When pressing in new bushings, the in- and outlets of the lubricating duct for bushing at shaft seal end, pos. 6E, should be positioned as illustrated on the drawing. The cover is shown from the inside and as fitted on the compressor.

The bushing at the oil pump end of the compressor, pos. 5E, must be placed so that the in- and outlets of the lubricating duct are facing upwards.

Main bearing bushings can be supplied for ground down crankshaft.
See spare parts list.



By-pass valve pos. 24

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

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

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

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

Further, the by-pass valve is independent of the pressure on the compressor suction side. Consequently, it only opens when the pressure on the discharge side exceeds the set pressure in relation to atmospheric.
Thus, watch out that hole pos. B does not get covered or clogged.

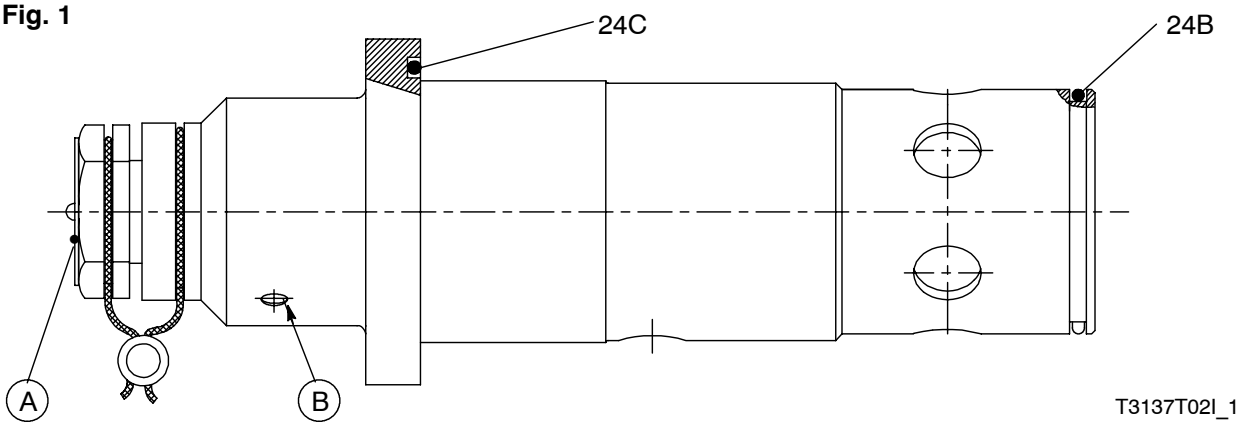
In case the pressure on the discharge side exceeds the set pressure so that the by-pass valve opens, the valve will remain open until the pressure on the discharge side has fallen to approx. half the set pressure. The valve then closes automatically. However, at great differential pressures across the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

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

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

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

Fig. 1

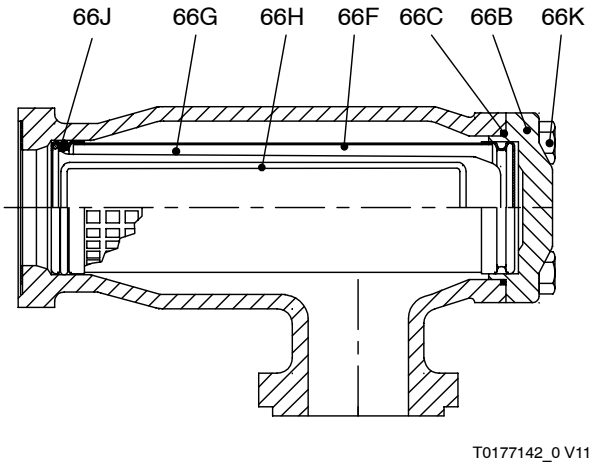


Suction filter

On the inside of the end cover Pos. 7A the compressor is equipped with a plate shaped suction filter Pos. 7G with a very large filtering area. By non contaminated refrigeration plants it is therefore not necessary to clean suction filters between main overhauls.

If the plant is not completely clean, the compressor will normally be equipped with an extra suction filter as described below.

Extra suction filter



The extra suction filter consists of an independent filter housing fitted on the compressor between end cover Pos. 7A and suction stop valve Pos. 66A.

Remove filter strainer Pos. 66F as described below. On delivery of the compressor, the filter has a filter bag insert Pos. 66G, retaining very small dirt particles coming with the suction gas from the refrigeration plant.

The filter bag is kept in place by a supporting spring Pos. 66H and must be used for the first 50 operating hours of the compressor. In normally clean plants it may then be removed together with the supporting spring.

In case the filter is badly soiled after the 50 operating hours mentioned, it is recommended to fit a new filter bag for another 50 operating hours. Similarly, a filter bag should be fitted for a period of 50 hours after major repair works on the refrigeration plant.

Cleaning of extra suction filters

After evacuation af the compressor, dismantle cover Pos. 66B, ectract filter strainer Pos. 66F.

If filter bag Pos. 66B is fitted, it must be removed and renewed as previously described. The filter should be cleaned in a cleansing fluid with a suitable stiff brush, however, without damaging the filter mesh.

Blow dry the filter strainer with compressed air. Give the filter a regular cleaning in accordance with the stated servicing dates.

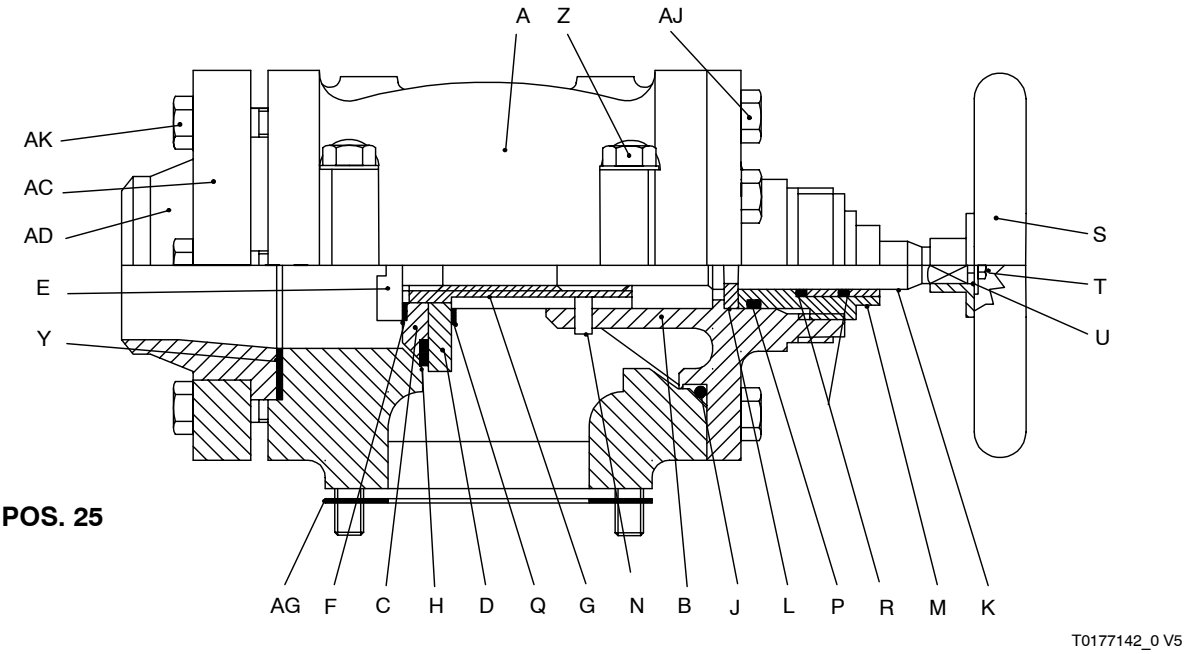
Note:

It is important to keep the suction filter clean and in good order as a soiled or clogged filter reduces the capacity of the compressor.

By total clogging there is also the risk that the filter may burst and severely contaminate the compressor.

When refitting of the filter, O-rings Pos. 66J and 66C must be in place and in good order. Tighten screws Pos. 66K to the torque moment prescribed in the table.

Stop valves



POS. 25

The suction and discharge stop valves Pos. 25 are used to isolate the compressor from the refrigeration plant.

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

Dismantling of valve

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

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

Note:

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

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

Reassembling of valve

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

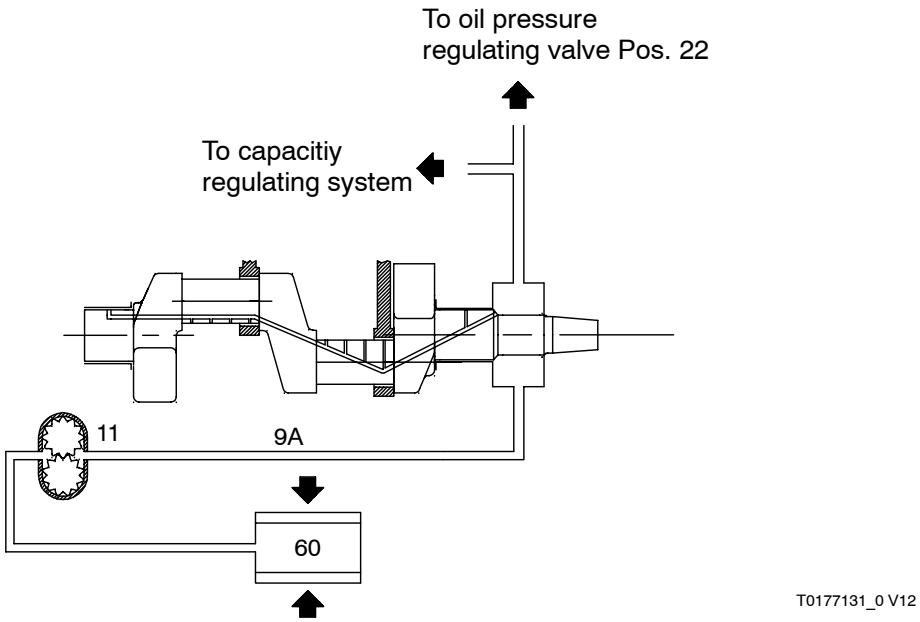
- Before mounting the complete valve insert, the valve cone with threaded piece Pos. 25G must be screwed right into the valve neck Pos. 25B.
- The O-ring Pos. 25J may have expanded under the influence of the oil in the plant and will normally have to be replaced by a new one.

  The stop valve has a so-called **retroseal,** which enables the packing screw joint Pos. 25M to be serviced even when there is excess pressure in the valve housing.

Adopt the following procedure:

- Using handwheel, **open** valve completely to achieve a seal between valve cone and valve throat. The gasket Pos. 25Q acts as a sealing element.
- The packing screw joint Pos. 25M can now be unscrewed for inspection or replacement of O-rings Pos. 25R and 25P. Lubricate all parts thoroughly with oil before reassembling.

Compressor lubricating system



The oil system has two functions: The oil lubricates and cools all movable parts in the compressor and it works as a hydraulic system for regulation of the compressor pumping capacity. A description follows later.

The oil pump pos. 11M sucks oil from the crankcase, through filter element Pos. 60, past the magnetic filter located inside the filter element. The pump forces the oil through an internal pipe Pos. 9A an on to the shaft seal housing.

The filter element Pos. 60 is a disposable filter which cannot be cleaned. See description of *Oil filter.*

The shaft seal housing acts as a distribution chamber for the oil. The oil pressure in the shaft seal housing is adjusted by means of the oil pressure regulating valve Pos. 22, which is mounted on the one side cover.

The regulation valve can be adjusted from the outside by means of a screwdriver.

Clockwise rotation incrases the pressure; **anticlockwise** rotation lowers the pressure.

Excess oil is returned to the crankcase.

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

- Through the hollow-bored chrankshaft to lubricate main and connection rod bearings. Lubrication of piston pin bearings is done by splash lubrication through a countersunk hole in the top of the connecting rod.
- To the oil differential pressure cut-out and pressure gauge. The effective oil pressure can be read straight off the pressure gauge (the suction pressure gauge of the compressor). In case the compressor is fitted with UNISAB, the oil pressure is taken through external pipe connections to the control box.
- Through internal oil pipes the oil is taken to the regulating cylinders, Pos.12, for unloaded start and capacity regulation.

Oil filter

All oil to the lubricating system of the compressor is filtered through an oil filter, fitted in the crankcase.

The filtration element is a filter cartridge, pos. 60 A on Fig. 1, which cannot be cleaned and therefore must be replaced by a new one once the filter capacity is used up.

It is important therefore, to keep a spare filter cartridge in store at all times. It is also recommendable to have gaskets, pos. 59C and pos. 60B, available before replacement of filter cartridge.

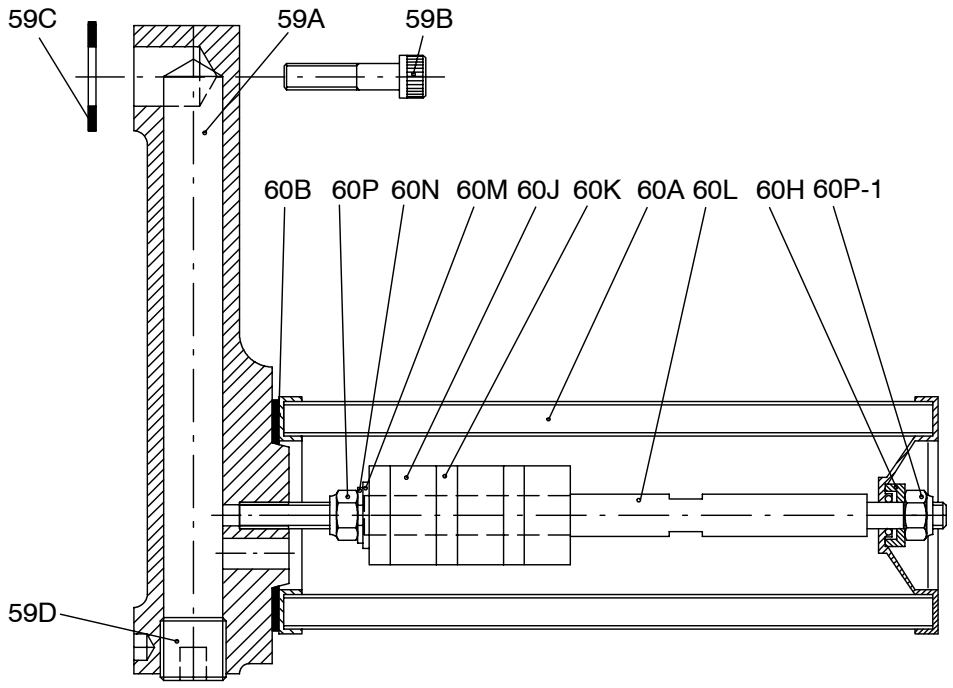
The filtered oil also passes a magnetic filter Pos. 60J-K, where any small iron particles are caught, before the oil flows to the oil pump.

Changing filter cartridge

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

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

Fig. 1



The compressor must be discharged of oil and the pressure adjusted to atmospheric pressure before the oil cartridge can be removed from the compressor. Cf. The sections Removing Refrigerant from Compressor and Changing Oil in Refrigeration Compressor for further information on this point.

Important

Before the compressor is opened, make sure that it cannot operate. This is ensured by removing the motor main fuses. In addition, make sure that the heating cartridge is switched off.

The easiest method of dismantling the oil filter is via the left-hand side cover opening (the end of the compressor on which the manometers/UNISAB are mounted). Dismantle the oil filter by removing the screws, pos. 59B. **Mind the gasket, pos. 59C.**

If a refrigerant-cooled oil cooler is mounted in the compressor, this should be dismantled together with the oil filter. Cf. the section Refrigerant-cooled Oil Cooler for CMO Reciprocating Compressor.

Replace the filter cartridge by dismantling the self-locking nut, pos. 60P-1 and the washer, pos. 60H.

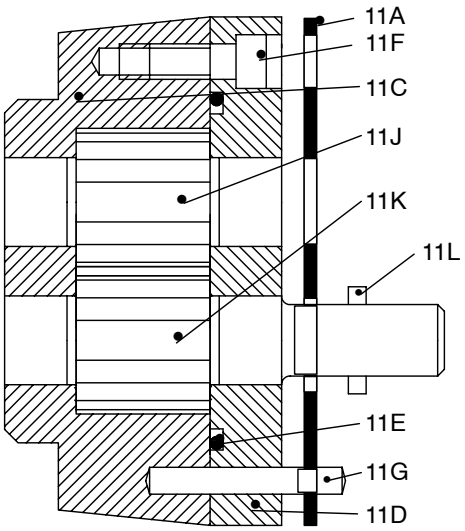
Before mounting a new filter cartridge, clean the magnetic filter, pos. 60J-K, and the centre shaft, pos. 60L, with a clean cloth **without disassembling the parts any further.**

Filter Cartridge, pos. 60A, cannot be cleaned and must therefore be replaced by a new unused one.

Mount the oil filter in the following order:

- Mount the gasket, pos. 60B
- Mount the filter cartridge, pos. 60A, the washer, pos. 60H and the self-locking nut, pos. 60P-1 as shown in fig. 1.
- Tighten the self-locking nut carefully without deforming the filter cartridge.
- Insert the complete oil filter together with the oil cooler (if mounted). Cf. Refrigerant-cooled Oil Cooler
- Mount gasket, pos. 59C, and fasten oil filter with the screws, pos. 59B.
- Mount the side cover. Fill up with new refrigerant machine oil and carry out start procedure as described in this manual.

Oil pump



The oil pump is a gearwheel pump directly coupled onto the end of the crankshaft.

Power is transferred via 2 retention pins Pos. 16J fitted at the end of crankshaft and one pin 11M equipped with teflon bushings.

On compressors with normal rotating direction (indicated by an arrow on end cover at shaft seal end) the oil pump is mounted with the driving gearwheel at the bottom, as shown on the drawing.

If, because of the driving motor, the compressor must have a reverse direction of rotation, the oil pump must be turned 180° to take the driving gearwheel to top position. Before mounting the oil pump in its new position, dismantle oil pump cover Pos. 11D from pump house Pos. 11C and turn it 180°. In this way the in- and outlet gates of the oil pump remain in front of their respective connections to bearing cover Pos. 5A. Holes for guide pins to the oil pump in this new position have been bored whereas threaded holes for clamping have not. Hereby, wrong mounting on compressors with normal direction of rotation is avoided.

If you wish to change the direction of rotation, turn pump as described, and mark and bore off 4 new holes for tightening screws.

Thread M8 and effective thread depth 13 mm. Depth of hole for core drill max. 16 mm.

A compressor ordered for reverse direction of rotation is mounted with the pump in the correct position.

Dismantling of oil pump

1. Dismantle all outer pipes and end cover Pos. 4A by the pump.
2. Remove screws Pos. 11B, after which only the guide pins Pos. 11G keep the pump in place.

Normally, the oil pump has a very long life, thus repairs on it do not pay, instead it should be replaced by a new one.

Remounting of oil pump

On remounting of oil pump, turn shaft until retaining pin Pos. 11L catches the groove in retaining pin Pos. 11M. Pay attention to gasket Pos. 11A.

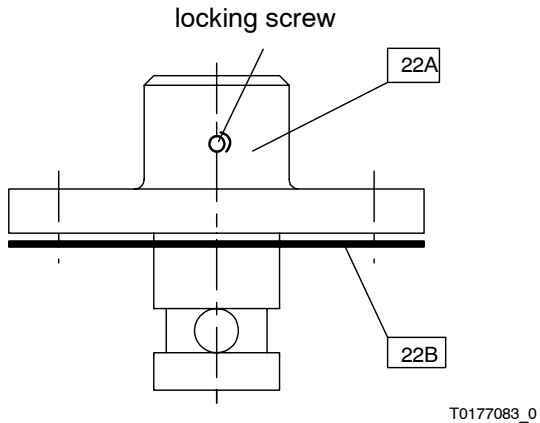
Oil pressure valve

The oil pressure valve Pos. 22 regulates the oil pressure in the compressor. Mounted in the cover Pos. 87A, it connects directly with the oil preessure chamber in the shaft seal housing.

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

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

Fig. 1



Adjustment

Oil pressure: 4.5 bar.

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

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

Service

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

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

Capacity regulation and unloaded start

The same type of regulating system is used in both CMO and TCMO compressors. It should be pointed out, however, that on the CMO compressors all cylinders are connected to the regulating system whereas only part of the TCMO cylinders can be connected to this system.

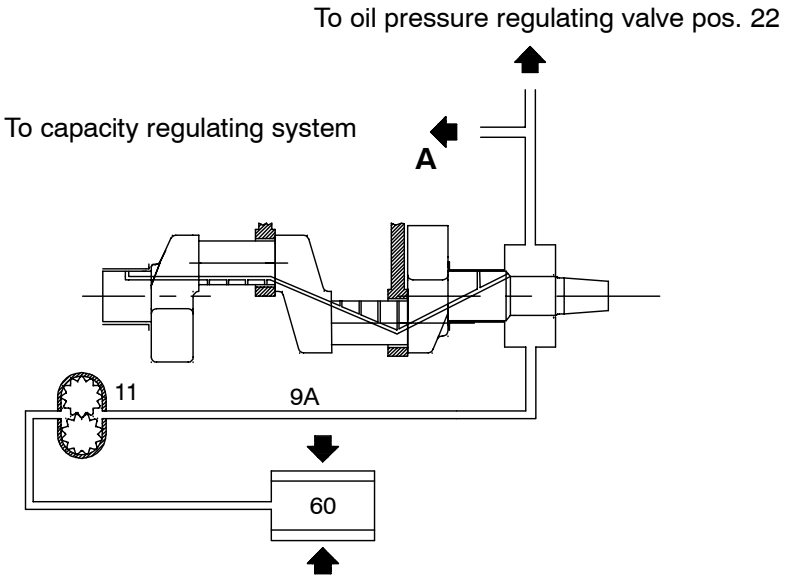
The regulating function

The purpose of the regulating system is to adapt the compressor capacity to the need for cooling of the refrigeration plant. This is achieved by unloading cylinders or by putting them to work. This is achieved by guiding the suction valve fitted on each cylinder.

Further, the regulating system must force the suction valves open at compressor standstill or during its starting-up phase. In this way the motor is started with as little resistance from the compressor as possible as there is no compression of gas in the cylinder. Once the motor has reached its maximum moment, the regulating system starts loading the compressor with capacity.

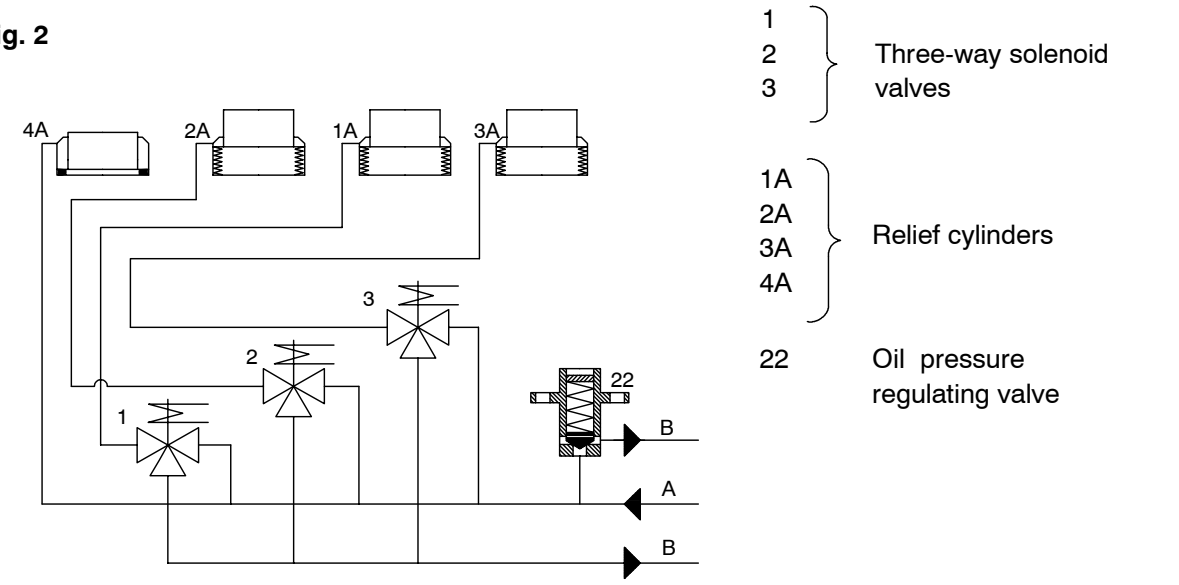
Fig. 1 illustrates how the regulating system is connected to the lubricating system of the compressor. As shown in fig. 2 the unloading cylinders are controlled by three 3-way solenoid valves. Oil pressure regulating valve pos. 22 is set to maintain a constant oil pressure of 4.5 bar in the oil system.

Fig. 1



Function

Fig. 2



One way of achieving capacity unloading is to swith off the current to solenoid valve no. 1. This shuts off the oil pressure to unloading cylinder no. 1A and at the same time the 3-way function of the solenoid valve opens, hereby connecting the unloading cylinder to the crankcase.

The springs in the unloading cylinder squeezes the oil out of the unloading cylinder. The piston in the unloading cylinder moves upwards and forces the suction valve open in order to prevent compression in the compressor cylinder.

The TCMO compressor is not equipped with an unloading mechanism at the HP stage and on 2 LP cylinders. Thus, the torque of the electric motor must be sufficient before the oil pressure in the compressor starts loading compressor capacity.

Dismantling of unloading cylinder

As the unloading cylinder is not exposed to any particular wear and tear, it will rarely have to be dismantled. It can be dismantled as one unit by removal of Allen screws Pos. 12A, but in order to get to the screws, cylinder linings, pistons, connecting rods must be dismantled, and possibly the crankshaft must be removed.

Once screws pos. 12A have been dismantled on both unloading cylinders, lift them out of the recess and pull them apart in order that oil pipe pos. 62A and gaskets pos. 62H may be released.

Disassembling of unloading cylinder

Press bottom piece Pos. 12C slightly into cylinder Pos. 12E and pull out circlip Pos. 12J from its track by a rotating movement.

Once the circlip has been removed, the parts can be pulled apart.

Assembling of unloading cylinder

By assembling of unloading cylinder, the two sealing rings must be positioned as shown on spare parts drawing.

During mounting of circlip pos. 12J it is a good idea to push bottom piece pos. 12C into the cylinder pos. 12E in a vice with soft jaws.

Note:

On assembling the unloading cylinder, make sure that the two threaded holes in the bottom piece pos. 12C are on a level with the hole for oil supply to the cylinder pos. 12E.

Mounting of unloading cylinder in the compressor

1. Lubricate O-ring pos. 62H with refrigerant machine oil.
2. Turn the two unloading cylinders pos. 12 so that the oil inlet holes are facing each other and place them in the compressor block.
3. Press the two unloading cylinders against each other, guiding them to engage with oil pipe pos. 62A. **Take care not to damage O-rings pos. 62H.**
4. Press the two unlading cylinders down into the recess in the block and tighten with screws pos. 12A and washers pos. 12B.

Capacity stages and regulating sequence

Capacity stages

The CMO compressors can be capacity regulated in 4 stages with the various percentages of full capacity as shown in the table below.

Compressor	Capacity in %			
CMO 24	100	75	50	25
CMO 26	100	67	50	33
CMO 28	100	75	50	25
Solenoid valve no	1	2	3	

The TCMO compressors have no unloading cylinders on two HP and two LP cylinders, and thus they can be capacity regulated as shown in the following table.

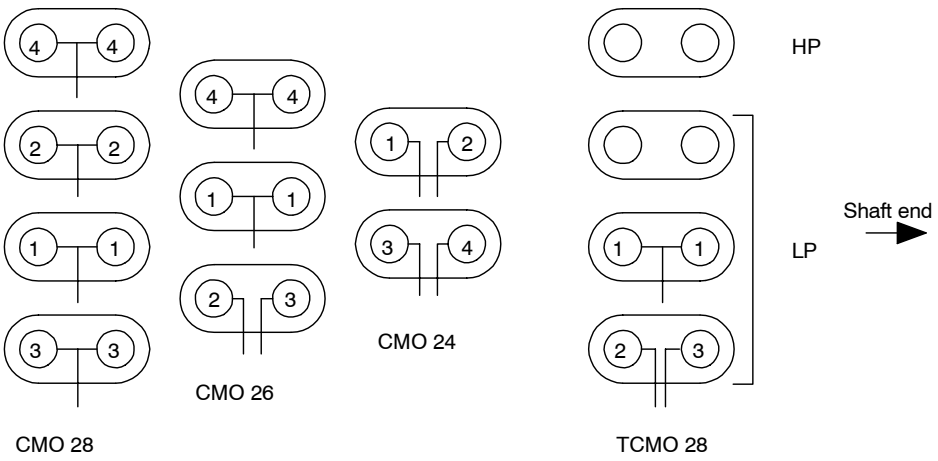
Compressor	Capacity in %			
TCMO	100	67	50	33
Solenoid valve no	1	2	3	

Regulating sequence

Unloading takes place in numerical order with rising figures, whereas **loading** takes place in reverse order with falling figures.

The sequence of unloading of the cylinders is shown on the following principle diagram, fig. 3.

Fig. 3

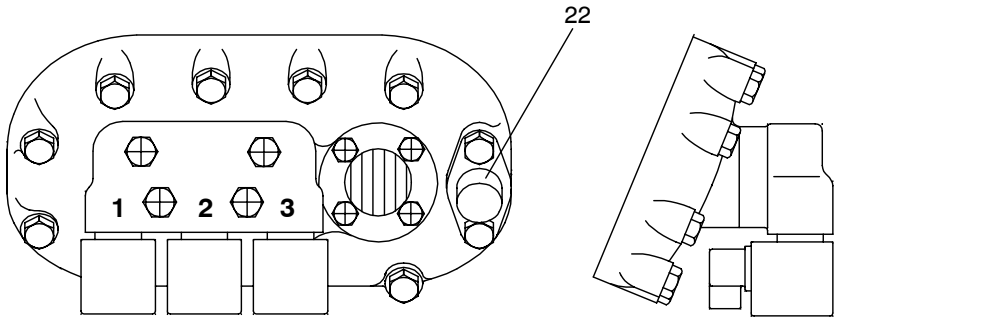


T0177142_0 V10

Pilot solenoid valves

Fig. 4 shows the position of the solenoid valves on the side cover.

Fig. 4



T0177142_0 V17

From the chamber under the oil discharge valve Pos. 22 the oil flows through a bored channel in the side cover to the valve block. Here oil is distributed through **channel A** to each single solenoid valve.

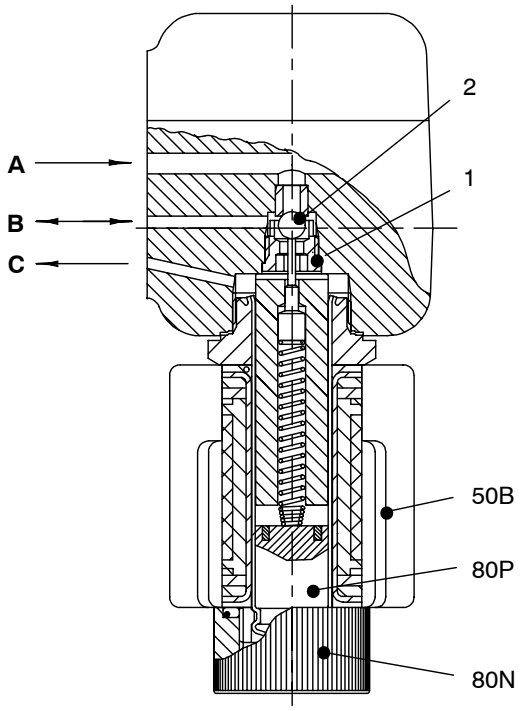
- **Channel B** connects the solenoid valve with the relevant unloading cylinder.
- **Channel C** takes the oil back to the crankcase from the unloading cylinders.

At a dead coil the relevant compressor cylinder hereof is unloaded. The solenoid valve **closes** between channels **A** and **B** and **opens** between channels **B** and **C**. Hereby, the oil pressure in the unloading cylinder is equalized to the pressure in the crank case.

At an energized coil the relevant compressor cylinder is working. The solenoid valve **opens** between channels **A** and **B** and **closes** between channels **B** and **C.**

Fig. 5 shows a cross-section of the solenoid valve.

Fig. 5



p9034_0.d23

Dismantling and assembly of solenoid valves

When electricity has been switched off to the solenoid coil, hand screw pos. 80N can be dismantled and coil pos. 50B pulled out across armature tube pos. 80P.

The armature tube can now be unscrewed and each part in the tube be dismantled. Nozzle no. 1 can be unscrewed by means of an Allen screw. However, take care that you do not lose the small steel ball pos. 2.

At assembly tighten the nozzle and the armature tube with 10 and 50 Nm, respectively. There is **no** gasket in connection with the nozzle.

The TCMO 28 compressor

The TCMO 28 compressor is available in 2 versions: **with or without built-in capacity regulating system.** (Please refer to page 1 to see which compressor version you have). The systems are illustrated in the following schematic drawings, fig. 1 and 2.

TCMO with capacity regulation

Unloaded start system:
Unloaded start of the compressor is obtained partly by lifting suction valve plates on the four low pressure cylinders, partly through a by-pass line with solenoid valve H**,** connecting the high pressure chamber with the intermediate pressure chamber.

The solenoid valve H must be connected to the star-delta starter of the motor in order to energize the valve coil (open valve) whenever pilot voltage is connected and the motor starter is in star position.

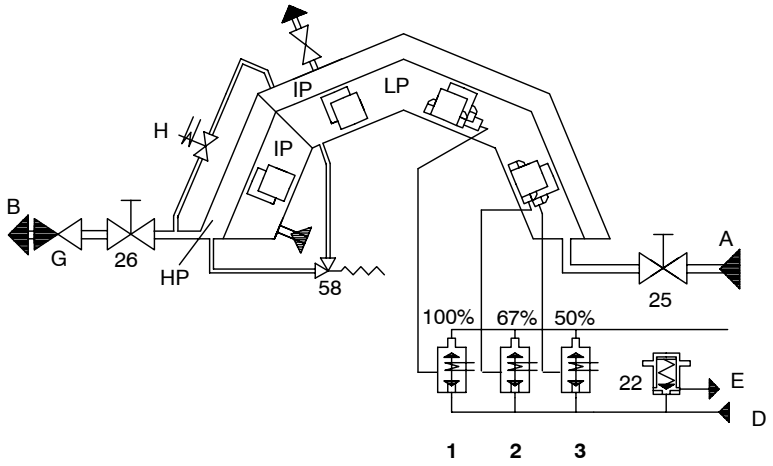
Whenever the motor starter switches to its delta position, the current to the solenoid valve H is disconnected and is closes.

Further, the solenoid valve must be controlled by the capacity regulating system of the compressor so that when the compressor capacity is regulated down to 50% or lower, solenoid valve H will open.
This prevents the intermediate pressure in the IP chamber from getting too low.

At compressor start, the pressure in the HP chamber is usually equalized to intermediate or suction pressure as non-return valve G closes against the discharge side of the plant.

To be on the safe side open solenoid valve H on starting the compressor, hereby equalizing any excess pressure in the HP chamber to the pressure in the IP chamber. At the same time the four cylinders on the LP side have been unloaded. All these factors put together result in a proper start unloading of the compressor.

Fig. 1



A: LP suction gas inlet
B: HP discharge gas outlet
D: Oil pressure connection
E: Oil return to crankcase

Capacity regulation

Capacity regulation takes place by lifting the suction valve plates on four of the six LP cylinders. The stagewise unloading appears from fig.1 and from the sketch earlier on.

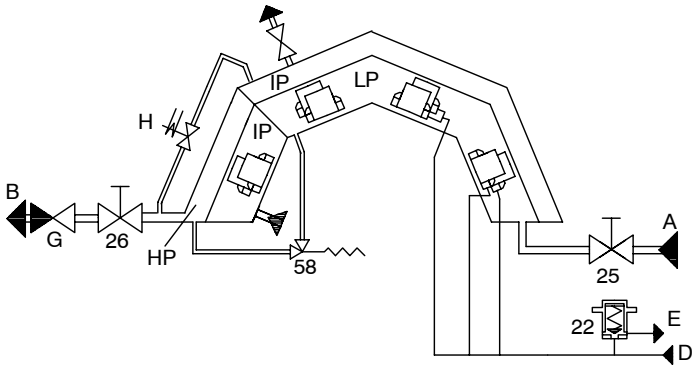
Solenoid valve no 1 unloads two cylinders, thus reducing capacity to 67%.
Solenoid valve no 2 further unloads one valve, thus reducing capacity to 50%.
Valve no 3 unloads one more cylinder, reducing capacity to 33%, which is the lowest capacity at which the compressor is able to work.

Unloading takes place in numerical sequence with rising figures, whereas loading takes place with falling figures.

When the LP-cylinders are unloaded, a balance no longer exists in the cylinder ratio between HP- and LP-cylinders. In order to keep the intermediate pressure at a suitable value under these circumstances, **solenoid valve H must open together with unloading stage 2 and remain open also during unloading stage 3.**

TCMO without capacity regulation

Fig. 2



A: LP suction gas inlet
B: HP discharge gas outlet
D: Oil pressure connection
E: Oil return to crankcase

Unloaded start system:

Unloaded start of the compressor takes place partly by means of lifted suction valve plates on four LP-cylinders, partly through a by-pass line with solenoid valve H, connecting the HP chamber with the IP intermediate pressure chamber.

The solenoid valve must be connected to the star-delta starter so as to energize the valve coil (open valve) at standstill and with the starter in star position. With the motor starter in delta position, the valve coil must be de-energized (closed valve).

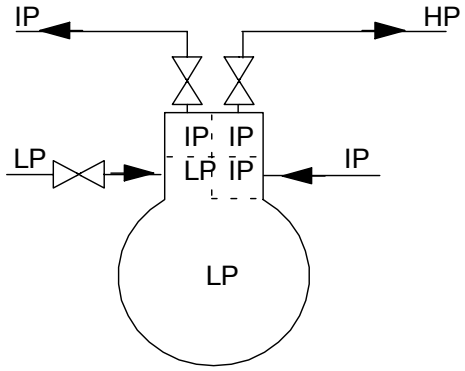
At start-up of compressor the HP-chamber must have been unloaded to intermediate pressure. For this purpose a non-return valve G has been fitted in the disharge pipe in order to prevent flashback of the condensing pressure into the HP-chamber.

At start-up, the four LP cylinders are unloaded until the oil pressure has built up.

Cooling of intermediate discharge gas on the TCMO 28 compressor

The TCMO 28 compressor compresses the refrigerant gas in two stages with 6 LP-cylinders and 2 HP-cylinders, respectively.

Each stage has its own suction and pressure chamber. The HP stage suction chamber and the LP stage pressure chamber is connected by means of an external piping.



In this piping, called the intermediate pipe, the intermediate pressure gas is cooled by means of 1 of the following 3 systems:

- Cooling of the intermediate pressure gas by means of an intermediate cooler.
  The gas is carried to a vessel with liquid from the condenser. The superheated gas from the LP stage is carried through the refrigerant liquid and this reduces the superheat considerably.

- Cooling of the intermediate gas by means of liquid injection into the intermediate pipe.
  Liquid refrigerant is mixed with the intermediate gas and reduces the superheat when it evaporates.

- The injection system can also incorporate a plate heat exchanger in which the liquid for injection into the intermediate pipe subcools the liquid to the evaporating system.

  When these systems are used the superheat must not fall below 10K.

Please refer to the section *Cooling of the intermediate gas* for further information.

Heating rods, pos. 30

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

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

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

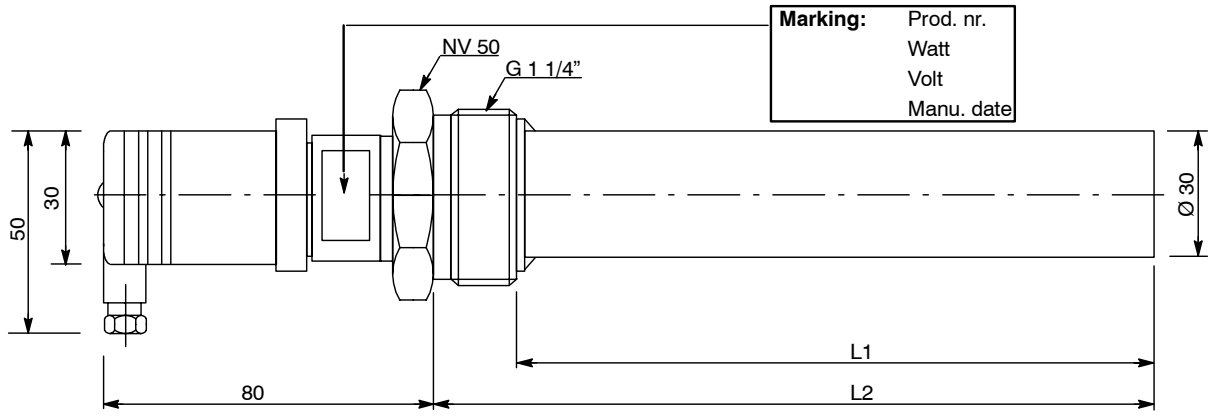
As illustrated on the drawing the heating rod consists of an electric heating element, incorporated in a dia. 30 mm pipe. The entire heating cartridge is screwed on tight at the G 1 $^1/_4$" thread.

Note:

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

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

98.05
0170-017-EN



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

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

Stop valves pos. 23 and 42

Fig. 1

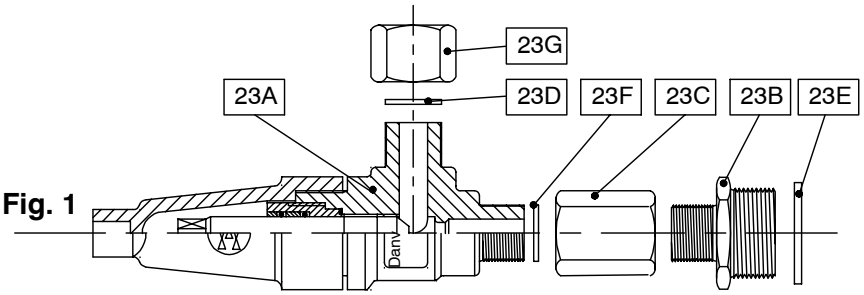
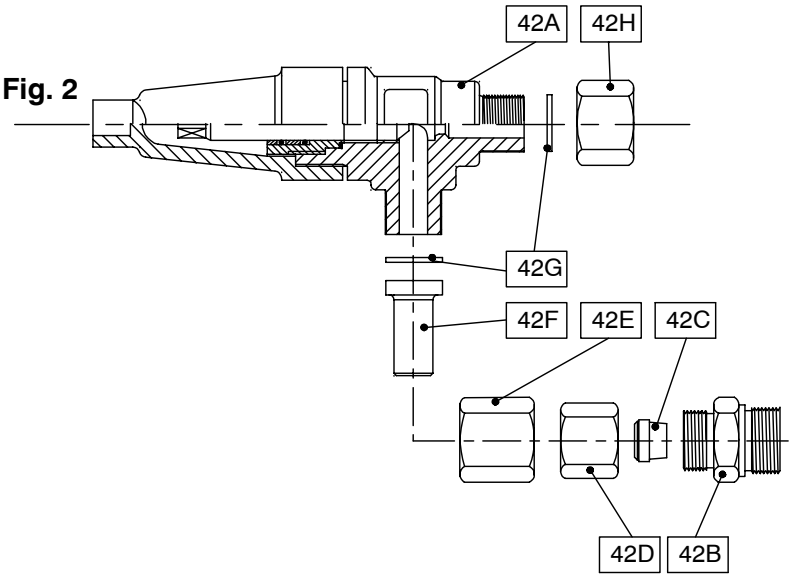


Fig. 2



T0177156_0

95.03

0171-463-EN

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

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

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

The valves are equipped with a blank nut pos. 23G/42H that prevents dirt from penetrating the valves whenever they are not used.

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

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

Sundry clearances and check dimensions

Bearing clearance

All measurements stated are in mm

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

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

Crankshaft end-play

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

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

Piston ring gap

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

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

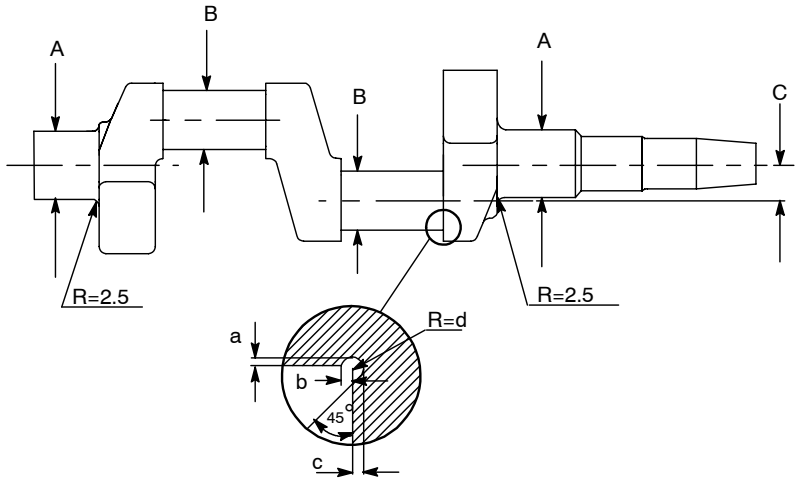
Dimensions of crankshaft bearing journal

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

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

91.04
0171-901-EN

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



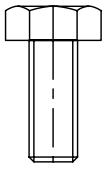
T0177137_0

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

Undersize bearings: See SABROE spare parts list.

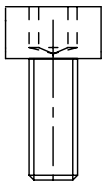
96.05
0171-904-EN

Torque moments for screws and bolts



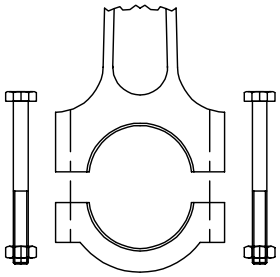
Metric thread (ISO 8.8)

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



T0177082_0

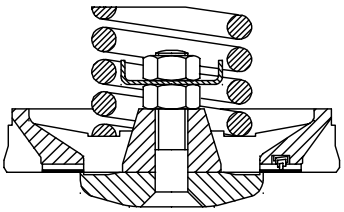
Connecting rods with UNF thread

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

Bolts for top-, side- and end covers

Compressor	T/CMO		HPO		T/SMC 100	HPC	T/SMC 180
Location	Top/side covers	End covers	Top/side covers	End covers	Top/side and end covers	Top/side and end covers	Top/side and end covers
M	M12	M14	M12	M14	M14	M14	M20
Kpm	8.6	13.7	13.2	20.3	13.7	20.3	42.7
ft.lbf.	63	100	95	147	100	147	310
Nm	85	135	130	200	135	200	420

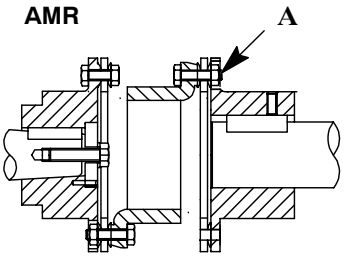
0171-465-EN 00.10



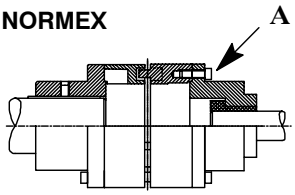
Bolt on discharge valve

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

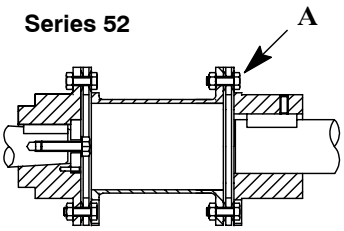
AMR



NORMEX



Series 52



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

Refrigeration Plant Maintenance

Operational reliability

The prime causes of operating malfunctions to the plant are:

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

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

0171-464-EN 94.05

Pumping down the refrigeration plant

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

1. Open suction and discharge stop valves on compressor.
2. Close liquid stop valve after condenser or receiver so that liquid refrigerant can be collected in the tank. Any solenoid valves in the liquid line should be opened by force, adjusting the thermostat to its lowest position so that the liquid line can be bled of refrigerant. Adjust any constant-pressure valves to bring evaporator pressure down to atmospheric.
3. Start up the compressor. Adjust regulating system to lower suction pressure.
4. **Keep a close eye on the suction pressure gauge!** When the suction pressure is equal to atmospheric, stop the compressor and quickly shut off the discharge stop valve. Shut off any stop valve in the oil return line.

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

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

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

Dismantling plant

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

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

3. **Note:**
   *If the piping system is colder than the surroundings, there is a considerable risk of damp precipitation (condensation) on cold plant parts. Plant components to be dismantled **must** be warmer than the ambient temperature.*
4. No two points in the system should be opened at the same time.
5. Plug, close or at least cover opening with oiled paper or suchlike.
6. Be aware of the possibility of filters being very moist.

Tightness testing and pump-down of refrigeration plant

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

Afterwards, pump down in order to eliminate air and moisture. In this regard, consult the section *on Evacuation*.
Otherwise, follow the instructions given in the separate instruction manual on plant components.

Note:

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

Trouble-shooting on the Reciprocating Compressor Plant

Operating condition

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

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

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

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

Using the trouble-shooting chart

In the following chart, each individual error option is indicated by a code number in the lefthand column, the error being briefly described in the next column. The third column states code numbers for the possible **causes** of the error.

The code numbers refer to the subsequent chart.

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

See the following example for the correct procedure.

Example

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

Cause codes:
26 (Liquid in suction line)
32 (Too much coolant/air to condenser)
39 (Expansion valve produces too little superheating)

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

91.05
0170-335-EN

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

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

Remedying malfunctions

1. Compressor fails to start

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

2. Compressor starts and stops too often

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

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

3. Compressor starts but stops again immediately

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

4. Compressor operates continuously

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

5. Abnormal noise from compressor

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

6. Too little capacity on compressor

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

7. Liquid stroke in compressor during start-up

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

8. Liquid stroke in compressor during operation

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

9. Excessive condenser pressure

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

10. Too low condenser pressure

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

11. Excessive suction pressure

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

12. Too low suction pressure

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

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

13. Oil temperature too low

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

14. Excessive discharge pipe temperature

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

15. Too low discharge pipe temperature

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

16. Excessive oil temperature

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

17. Oil level in crankcase falling

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

18. Heavy oil foaming in crankcase

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

19. Crankcase sweating or frosting up

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

20. Capacity regulation oscillating

20.18	Oil foaming in crankcase	See point 18.

21. Impossible to bleed plant

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

Selecting Lubricating Oil for SABROE Compressors

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

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

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

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

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

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

General

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

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

To obtain the best lubrication, the oil must:

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

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

Stratification

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

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

0170-151-EN 99.02

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

Plants with several different compressor types/makes

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

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

Selecting the lubricating oil

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

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

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

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

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

Oil types and oil companies

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

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

It is of course possible to use similar oils from other oil companies, and in this connection, the *Data Sheet for Sabroe Oils* may be helpful.

Please note, however, that YORK Refrigeration has not tested any other oils than our own brand, and hence we cannot

answer for the quality, the stability or the suitability of other oils for any purposes. The oil company in question is thus solely responsible for the quality and suitability of the oil delivered, and if any problems are experienced with these oils in the compressors or in the refrigeration plant, the oil supplier should be contacted directly.

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

Pay particular attention to the following aspects:

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

    Reciprocating compressors:

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

    Max. permitted oil temperature = Setting point for alarm

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

    Screw compressors:

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

    Max. permitted oil temperature = setting point for alarm

    Min. permitted oil temperature = setting point for alarm
  - Condensing pressure
  - Evaporating pressure
- Oil viscosity in the compressor during operation and under the influence of:
  - Refrigerant type and solubility of refrigerant in the oil
  - Operating temperatures
  - Vapour pressure in the oil reservoir

    Reciprocating compressor: Suction pressure and oil temperature in the crankcase.

    Screw compressor: Discharge pressure and gas temperature.
- Compatibility with the neoprene O-rings: the aniline point gives an indication of how the O-ring material reacts to the oil.
  At an aniline point less than approximately 100°C the material tends to swell, and at an aniline point higher than approximately 120°C it tends to shrink.

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

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

Attention is drawn to the following viscosity limits during operation:

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

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

Use of mineral oil

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

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

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

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

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

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

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

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

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

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

How to use the oil recommendation diagrams:

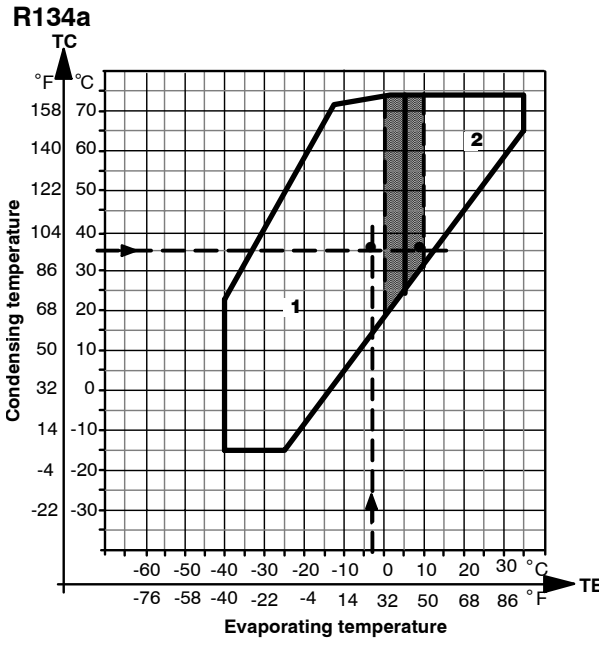
To determine the **code number,** first refer to the *Oil recommendation diagram* for the refrigerant and compressor type and then plot the proposed operating conditions.

Example (recip. compressors):

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

Please observe !

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



By referring to the *Oil recommendation table* placed at the bottom of each *oil recommendation diagram*, it is possible to select the **code number** for the appropriate oil type. In the example above, a **oil code number** E5 can be selected.

Code no	Area no	
	1	2
E5	▲	
E9		▲

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

Changing oil on Sabroe compressors

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

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

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

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

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

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

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

Oil changing intervals

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

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

Oil recommendation diagram symbols:

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

Data Sheet for Listed Sabroe Oils

Typical data for lubricating oils for Sabroe compressors

Sabroe code	Viscosity 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 big difference between polyolester-based lubricants from various suppliers, it is not possible to present typical data for these oils. When using another oil brand than the one recommended by YORK Refrigeration, please contact the oil supplier to select the correct oil type.							
E5								
E9								
E11								

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

List of part numbers for available Sabroe oils

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

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

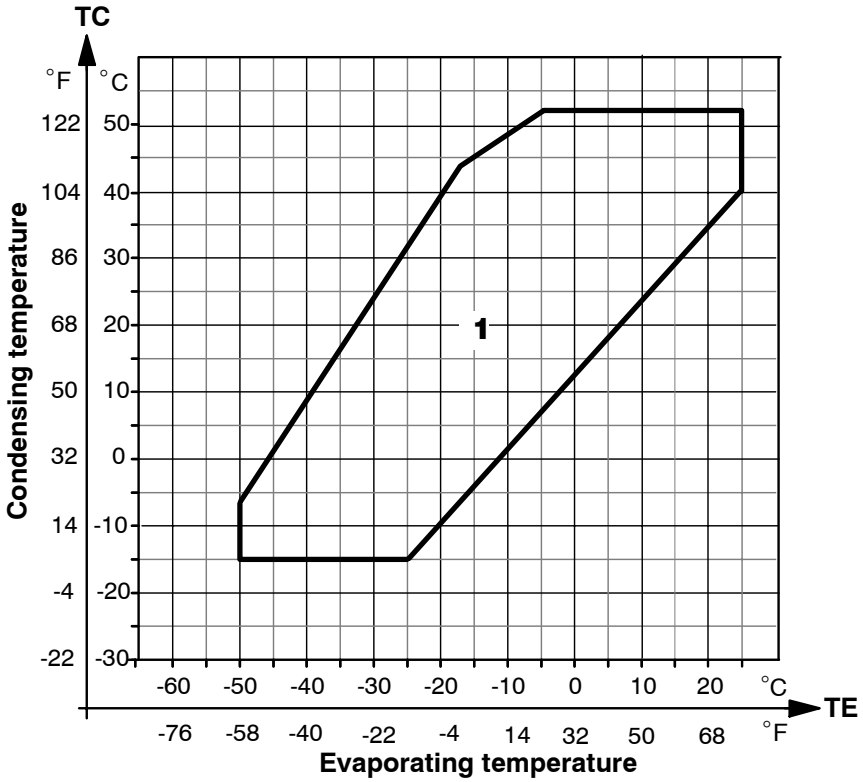
The oils recommended by the former Stal Refrigeration correspond to the following oils:

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

R717

one-stage reciprocating compressors

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



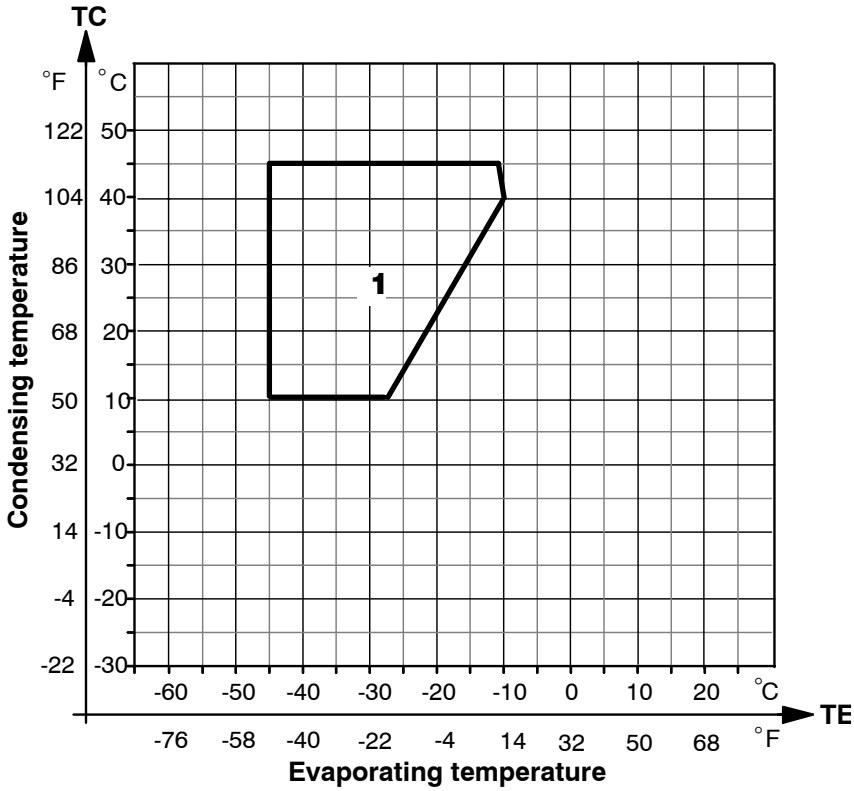
Note: YORK Refrigeration recommends that the use of M oils is restricted to moderately loaded compressors and that the oil quality is monitored carefully via regular oil analyses.

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

☆ : In case you wish to change from mineral oil

R717

two-stage reciprocating compressors



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

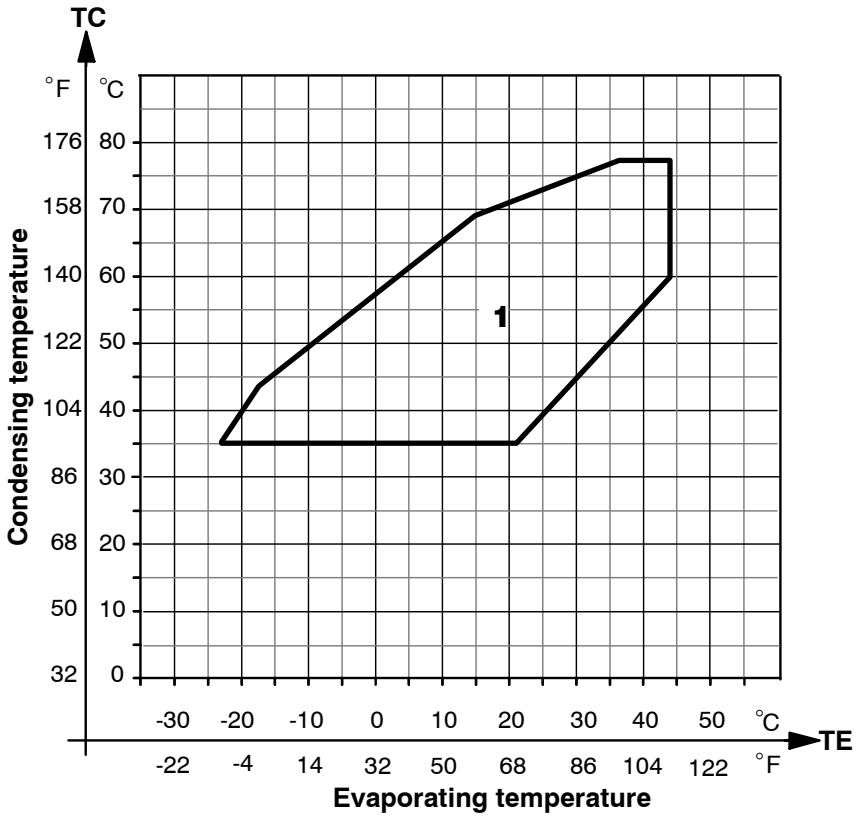
Note: YORK Refrigeration recommends that the use of M oils is restricted to moderately loaded compressors and that the oil quality is monitored carefully via regular oil analyses.

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

☆ : In case you wish to change from mineral oil

R717

HPO and HPC reciprocating compressors



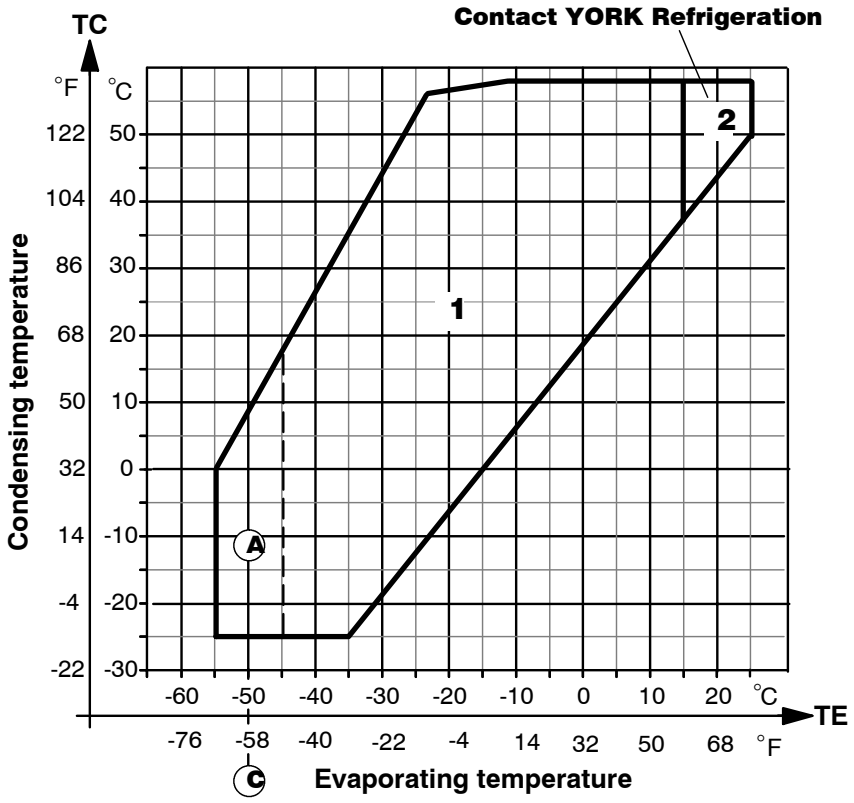
Code no	Area no 1
PAO 5	▲

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

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

R22

one-stage reciprocating compressors



Code no	Area no 1
A 3	▲

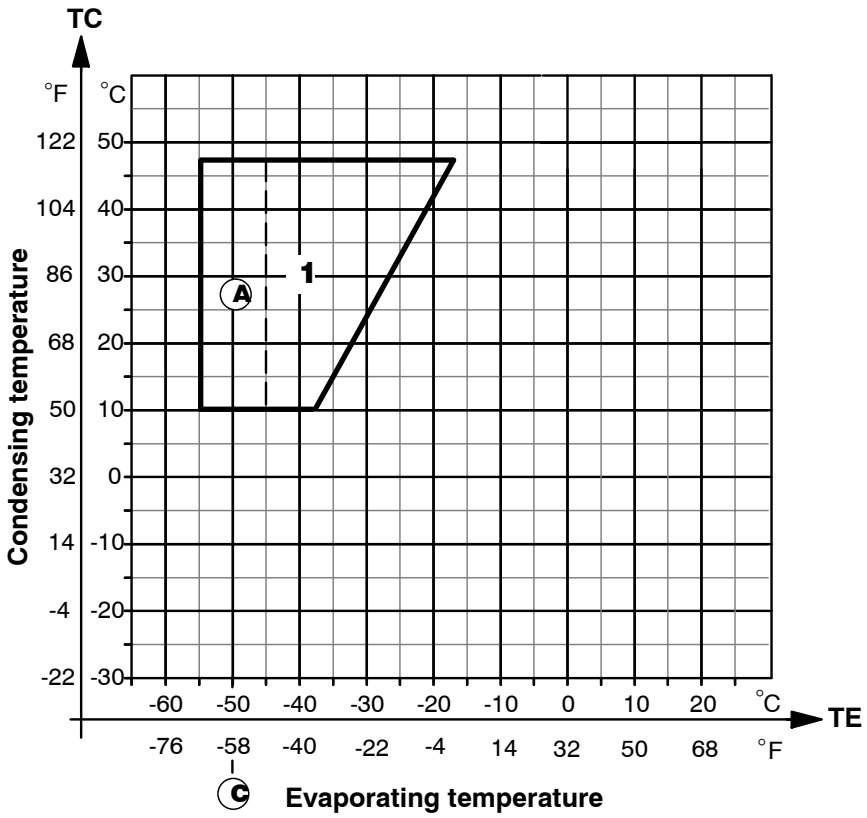
▲ : In case of a new plant. Very suitable.

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

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

R22

two-stage reciprocating compressors



Code no	Area no 1
A 3	▲

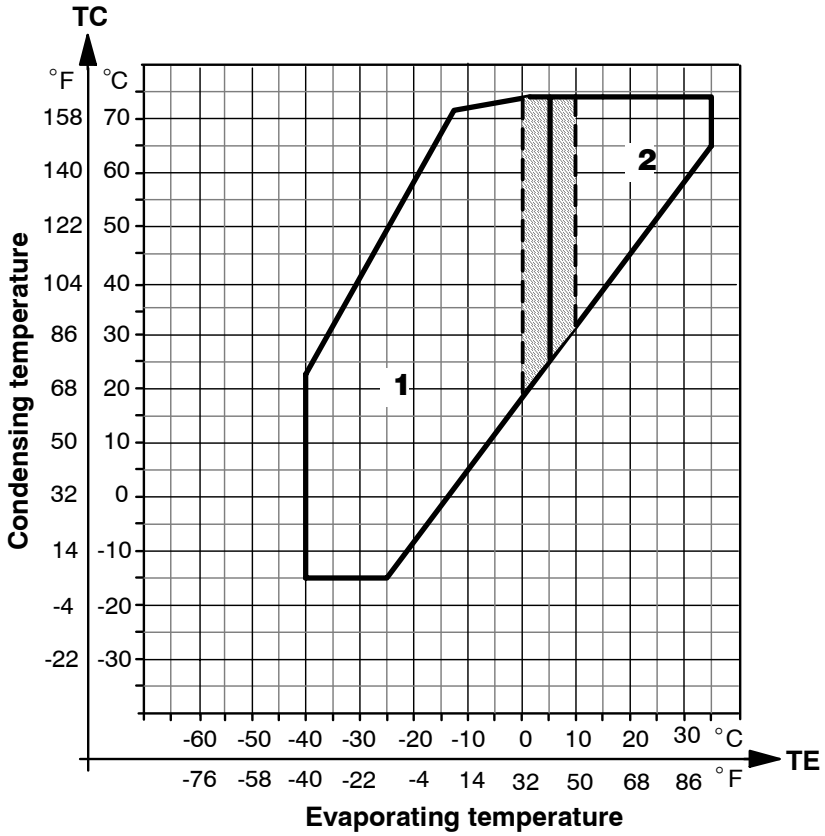
▲ : In case of a new plant. Very suitable.

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

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

R134a

one-stage reciprocating compressors



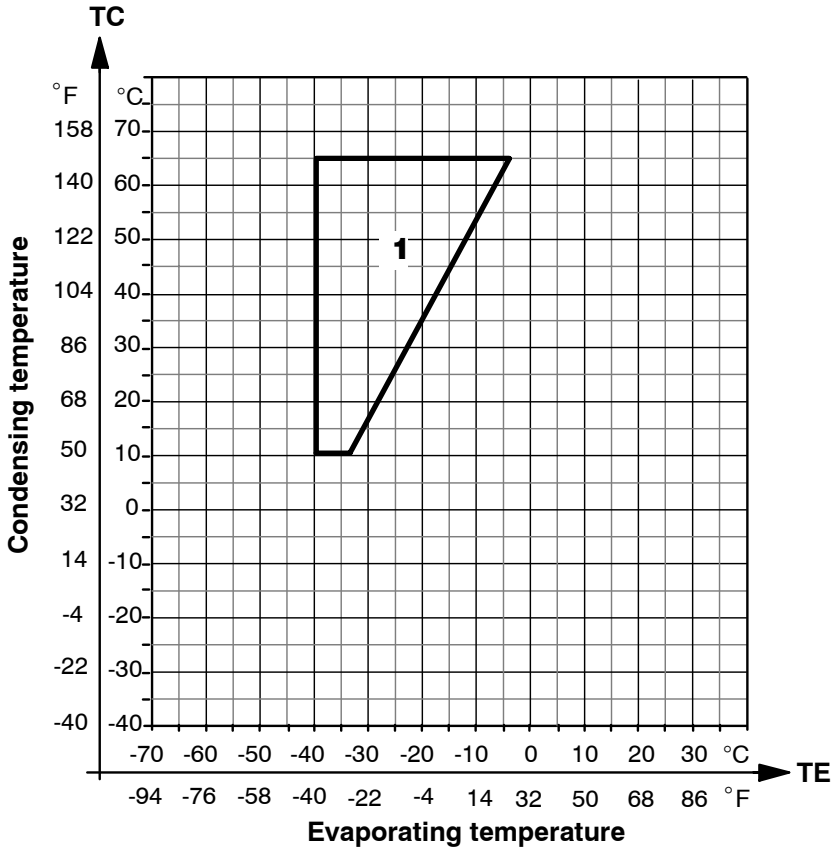
Code no	Area no	
	1	2
E 5 E 9	▲	▲

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

▒ : Zone in which both oils are useable

R134a

two-stage reciprocating compressors

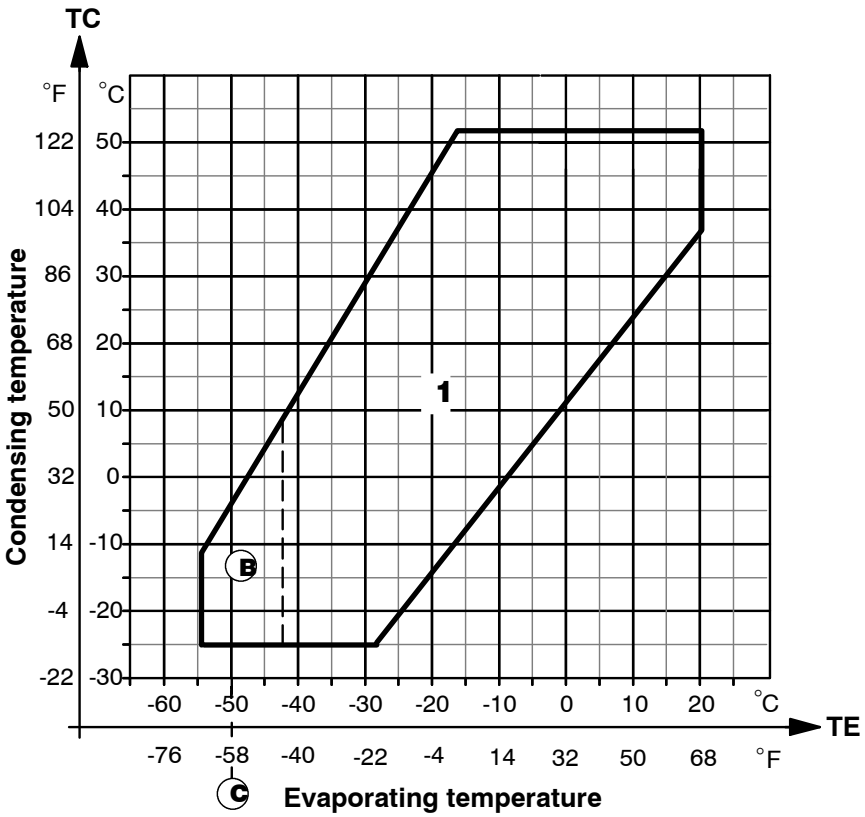


Code no	Area no 1
E 5	▲

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

R407C

one-stage reciprocating compressors



Code no	Area no 1
E 3	▲

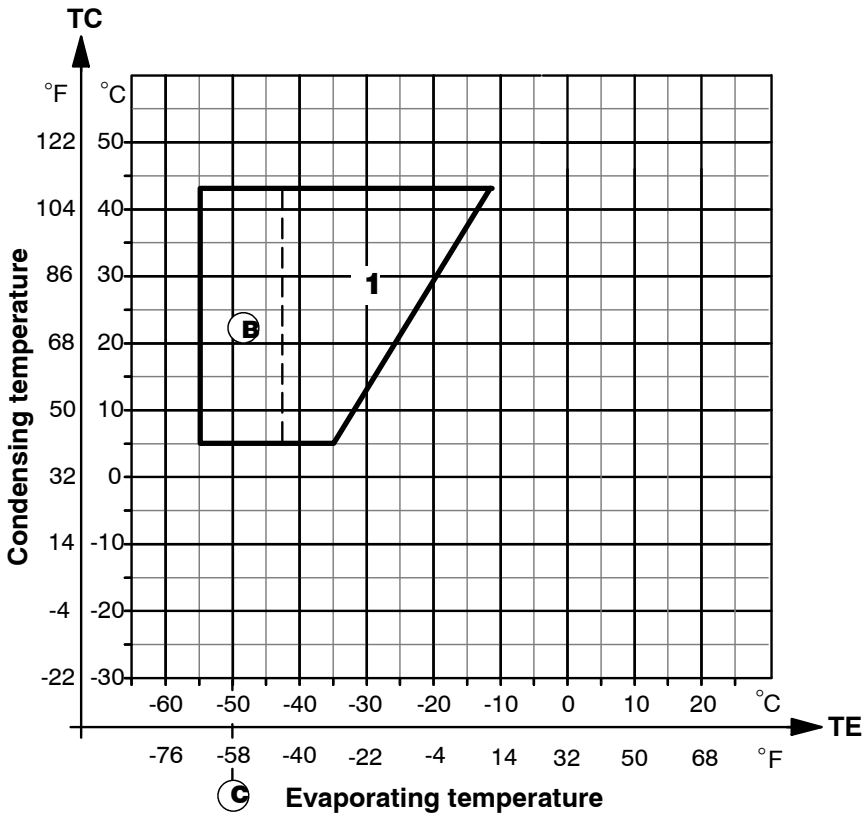
▲ : In case of a new plant. Very suitable.

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

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

R407C

two-stage reciprocating compressors



Code no	Area no 1
E 3	▲

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

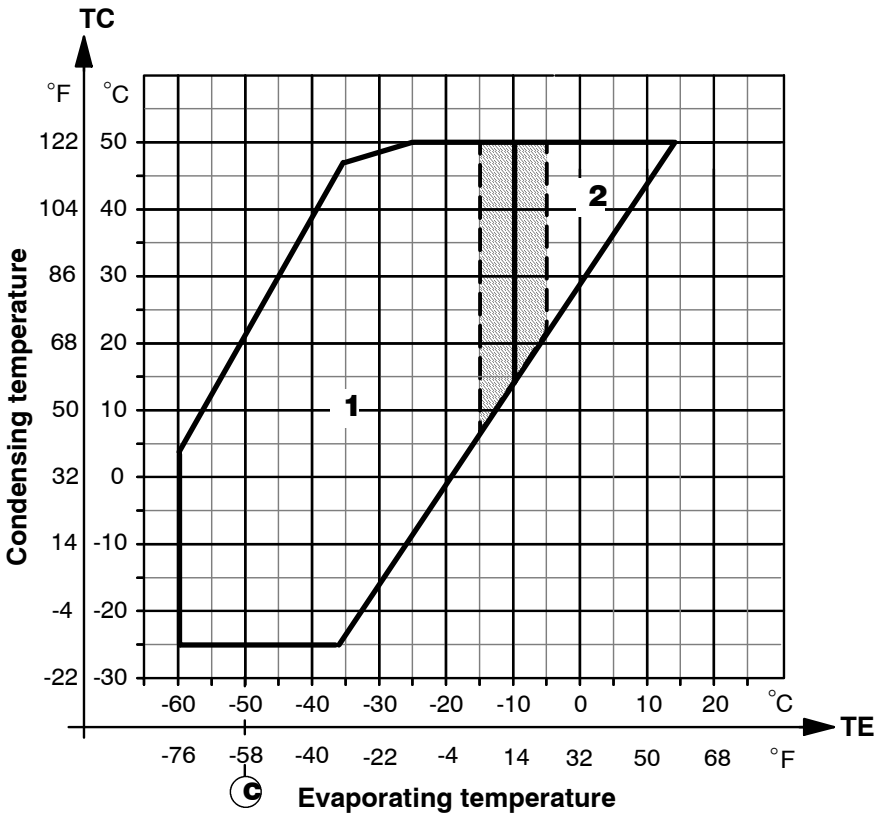
B : Max oil concentration in liquid phase: contact YORK Refrigeration

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

R404A

one-stage reciprocating compressors

Code no	Area no	
	1	2
E 3	▲	
E 5		▲



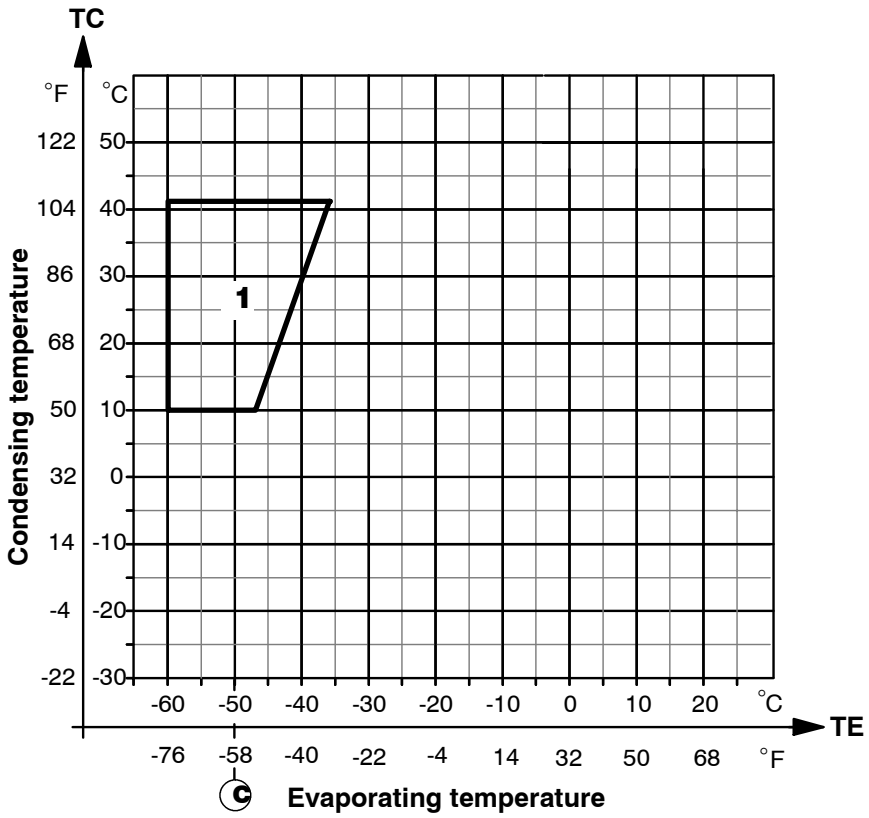
▲ : In case of a new plant. Very suitable.

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

▒ : Zone in which both oils are useble

R404A

two-stage reciprocating compressors



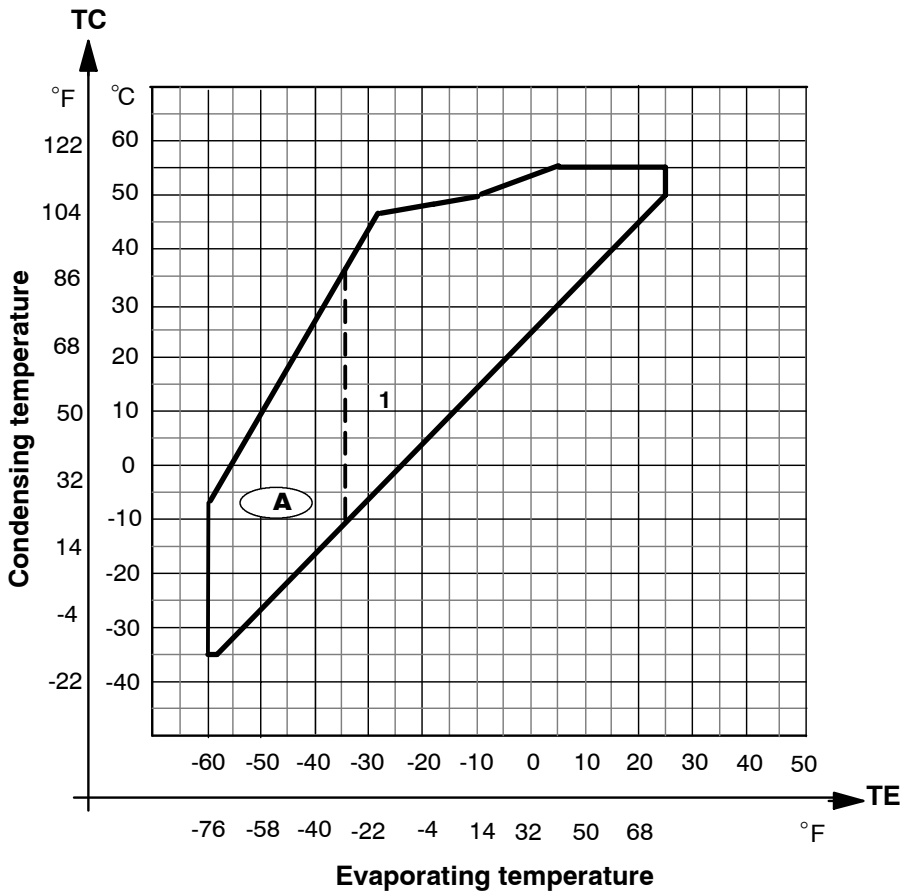
Code no	Area no 1
E 3	▲

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

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

R410A

HPO og HPC reciprocating compressors



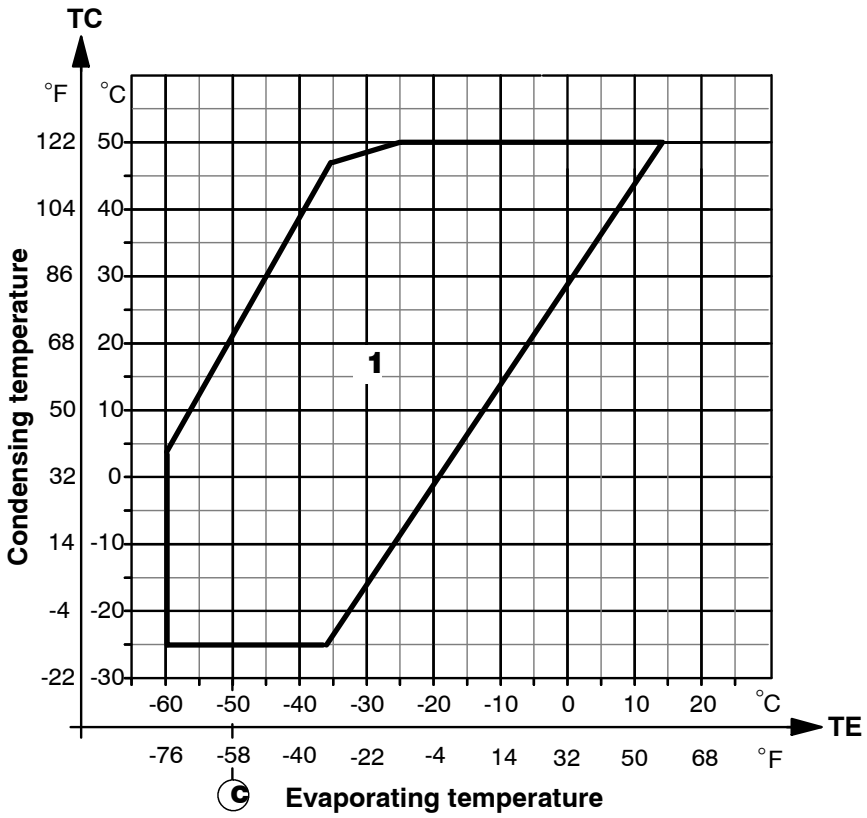
Code no	Area no 1
E 5	▲

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

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

R507

one-stage reciprocating compressors



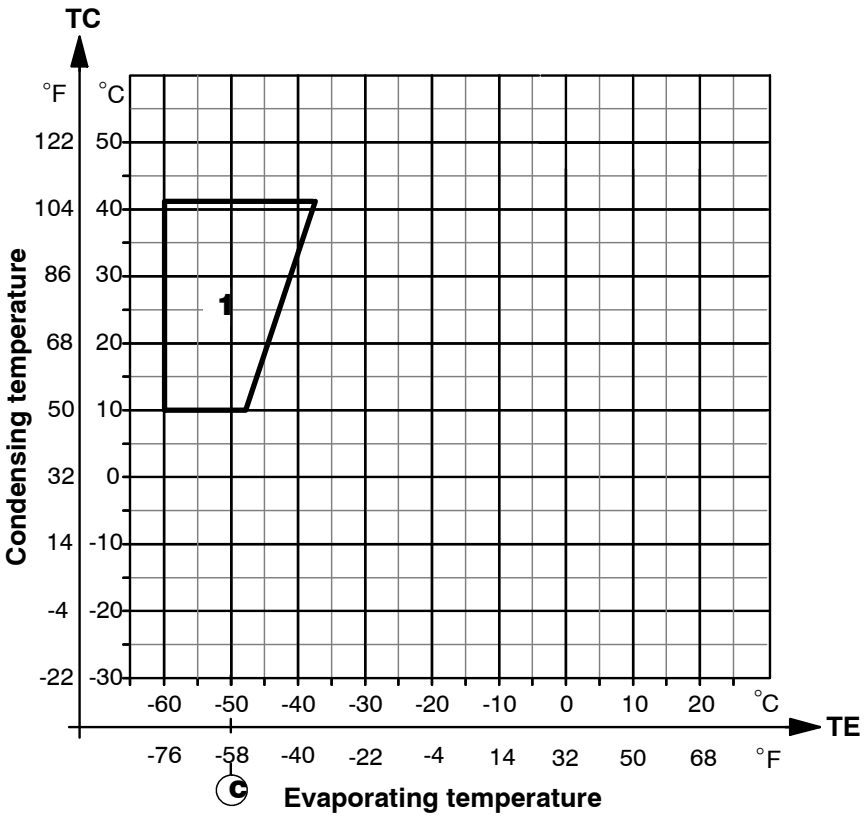
Code no	Area no 1
E 5	▲

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

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

R507

two-stage reciprocating compressors



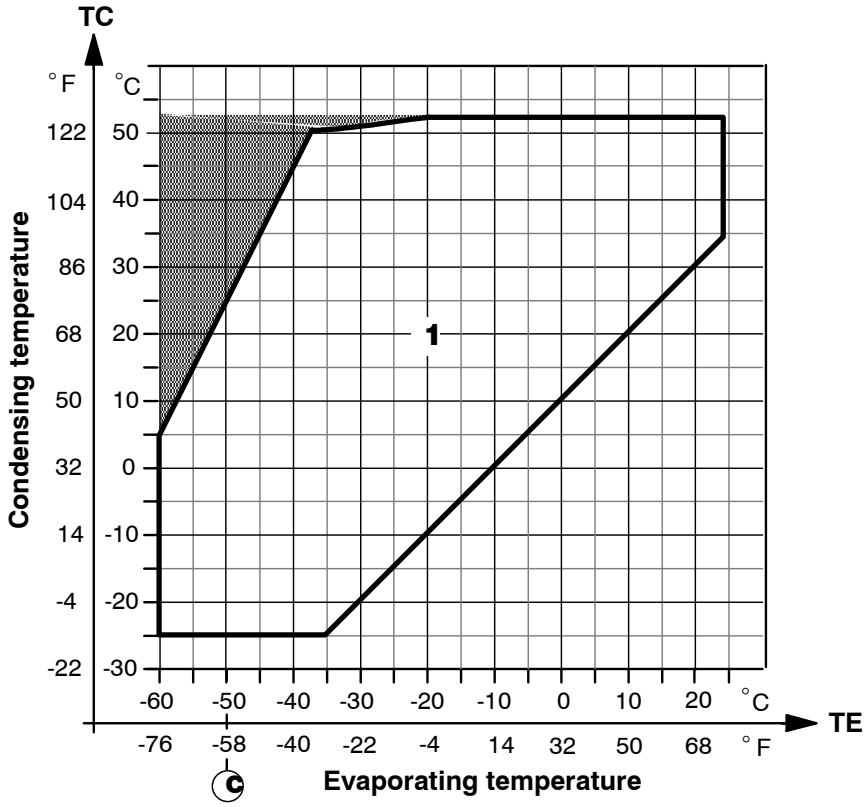
Code no	Area no 1
E 5	▲

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

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

R717

screw compressors



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

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

HLI: Calculation must be performed using COMP1

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

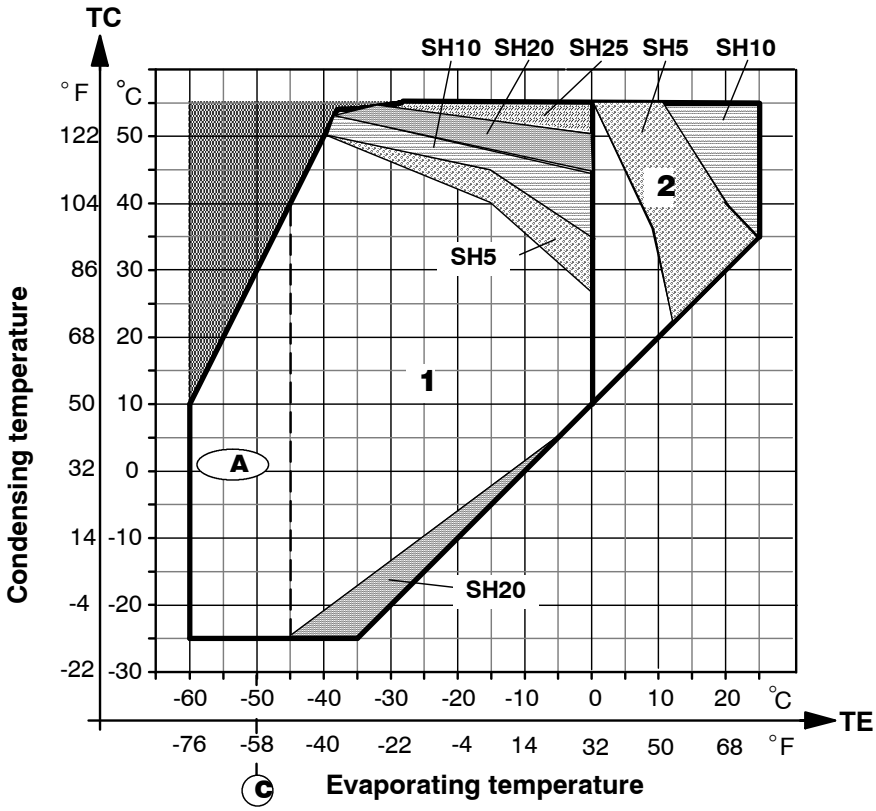
☆ : In case you wish to change from mineral oil

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

▒ : Calculation must be performed using COMP1.

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 YORK Refrigeration for an update on the requirement for superheat.

HLI: Calculation must be performed using COMP1.

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

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

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

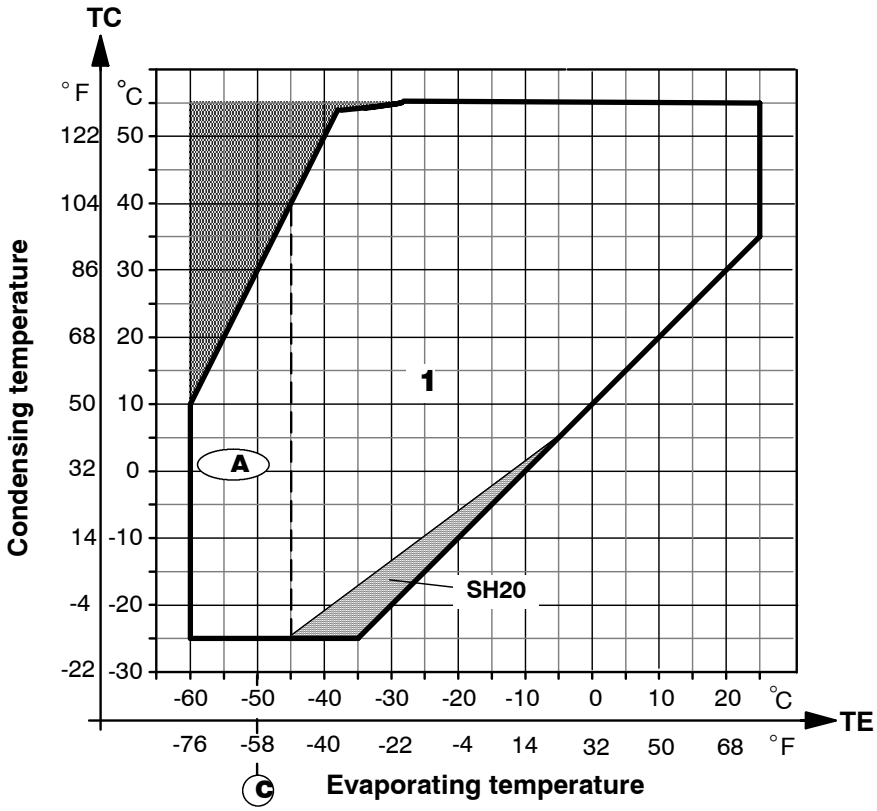
***** : Dry expansion systems only. Flooded systems to be considered individually: contact YORK Refrigeration

SH : Suction gas superheat, K (Kelvin)

▒ : Calculation must be performed using COMP1

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 YORK Refrigeration for an update on the requirement for superheat.

HLI: Calculation must be performed using COMP1.

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

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

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

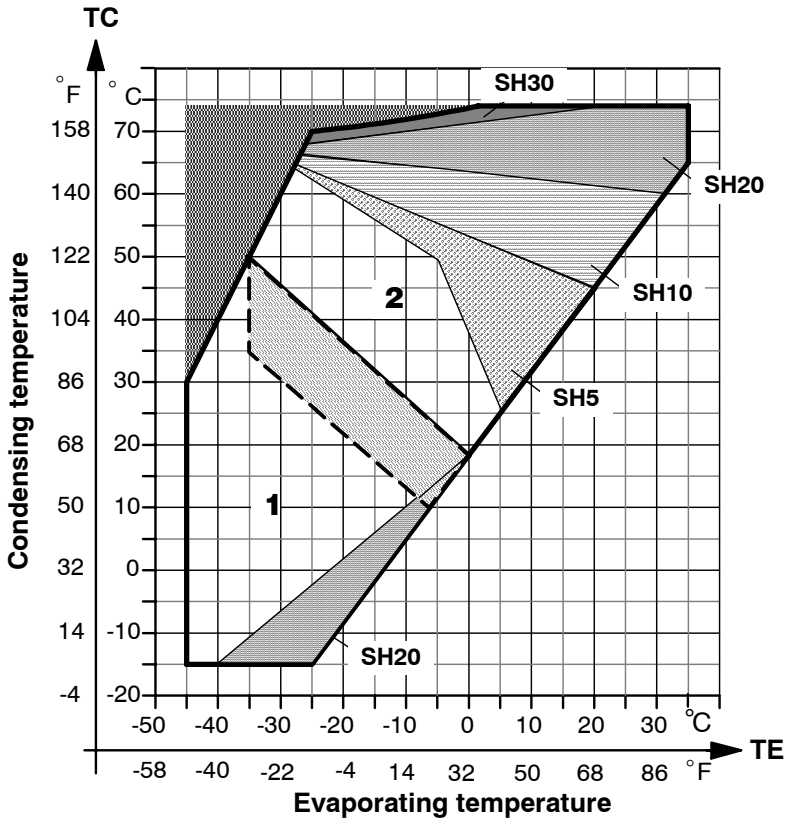
***** : Dry expansion systems only. Flooded systems to be considered individually: contact YORK Refrigeration

SH : Suction gas superheat, K (Kelvin)

▒ : Calculation must be performed using COMP1

R134a

screw compressors



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

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

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

HLI: Calculation must be performed using COMP1.

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

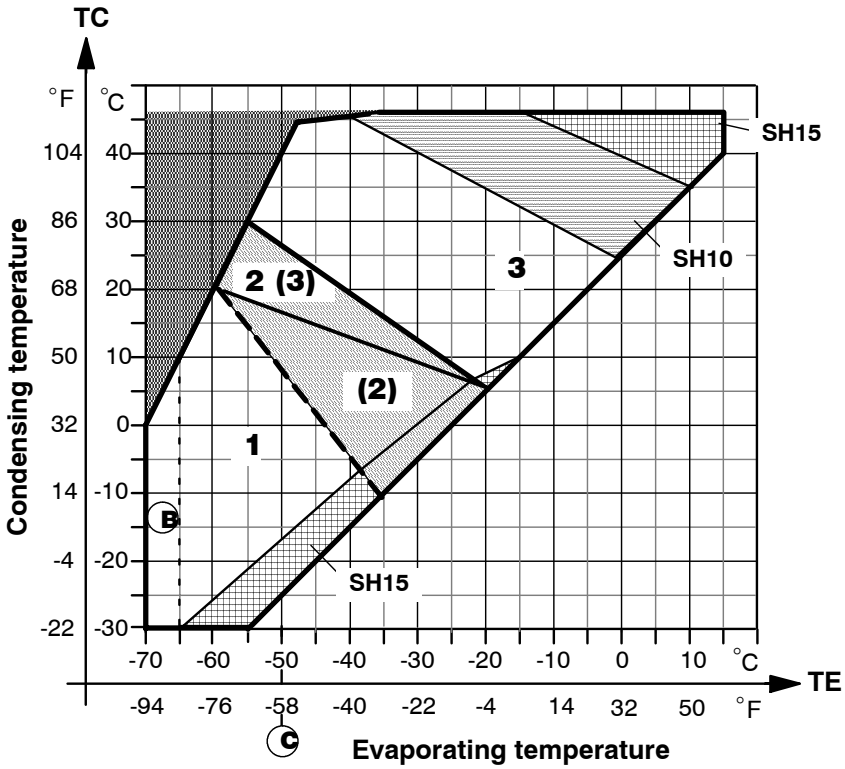
SH : Suction gas superheat, K (Kelvin)

: 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 YORK Refrigeration for an update on the requirement for superheat.

HLI: Calculation must be performed using COMP1.

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

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

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

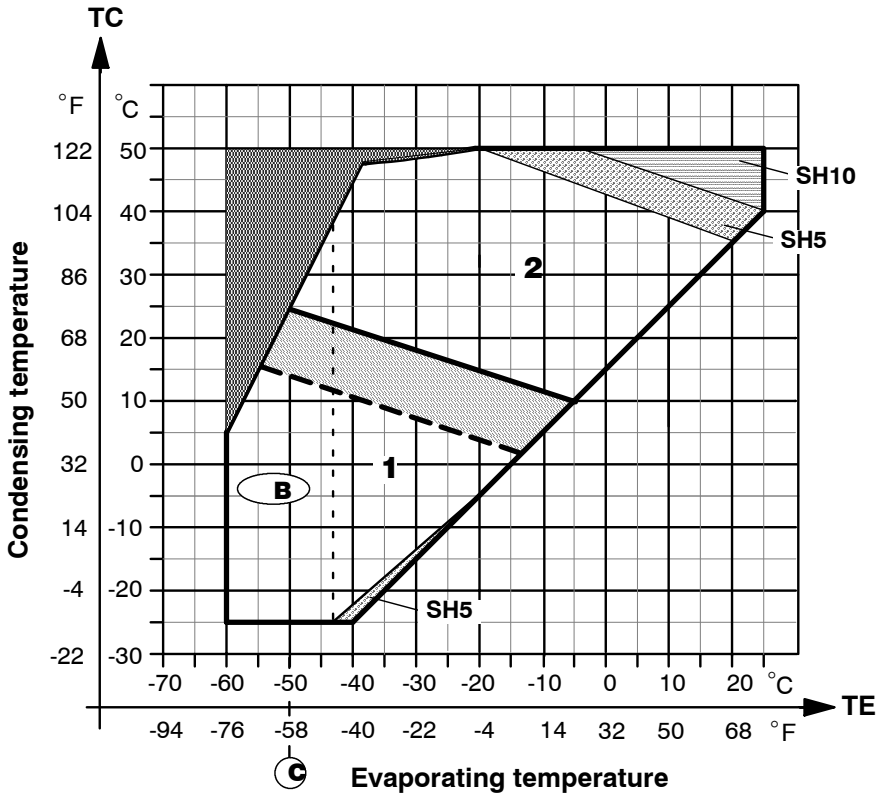
SH : Suction gas superheat, K (Kelvin)

: 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 YORK Refrigeration for an update on the requirement for superheat.

HLI: Calculation must be performed using COMP1.

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

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

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

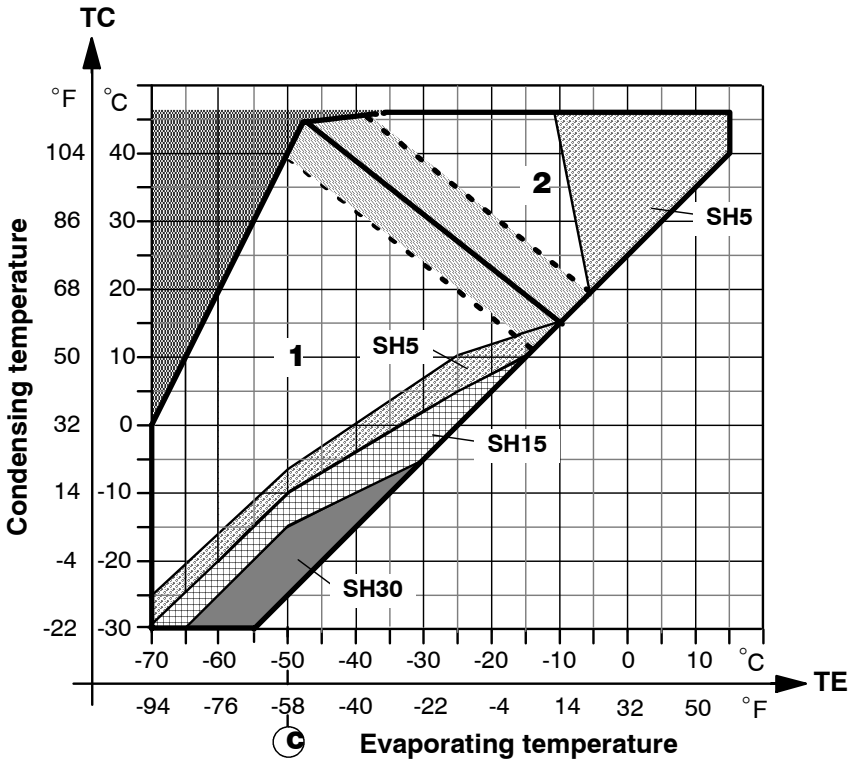
SH : Suction gas superheat, K (Kelvin)

: 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 YORK Refrigeration for an update on the requirement for superheat.

HLI: Calculation must be performed using COMP1.

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

Ⓒ : Min suction temperature –50°C: at 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 YORK Refrigeration and are therefore NOT approved by YORK Refrigeration either. The following list reflects the information provided by the companies themselves. The assessment of durability and suitability of specific oils for specific purposes are entirely at the companies' own discretion. Oils tested and approved by YORK Refrigeration can be found in the *"List of part numbers for available Sabroe oils".*

Oil	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	●				●

Alignment of unit, AMR coupling

Where the compressor and motor are directly interlinked, an AMR coupling is used; this is a torsionally rigid coupling with enough radial and axial flexibility to assimilate small movements between the two machines.

In order to ensure compressor and motor a long life as well as noise- and vibration-free operation, compressor unit and coupling need to be aligned with care. Misalignment of the compressor unit or coupling may produce stresses and vibrations which can be transmitted to the compressor and motor bearings and thus cause major damage.

Vibrations may be caused by the following:

- Distortion between compressor unit and foundation.
- Distortion between compressor and base frame.
- Distortion between motor and base frame.
- Strains from pipe connections between compressor and plant.
- Misalignment of coupling linking compressor and motor.
- Untruth in compressor or motor shafts.
- Untruth in coupling.
- Imperfect balancing of coupling.
- Imbalance in compressor or motor.

The points up to and including coupling alignment are the responsibility of the fitter setting up the unit. The other points must be checked by the compressor or motor manufacturer prior to delivery. The following sections will deal with the individual points concerning the fitter.

Alignment of unit with foundation

Whenever installing a unit directly onto the foundation or machine floor, it should stand free of stresses and press down evenly on all supports.

The unit can be installed in the following ways:

- on vibration dampers
- straight onto a foundation, using foundation bolts.

Whichever method is used, the unit must be aligned **before** hooking the connection pipes up to the installation.

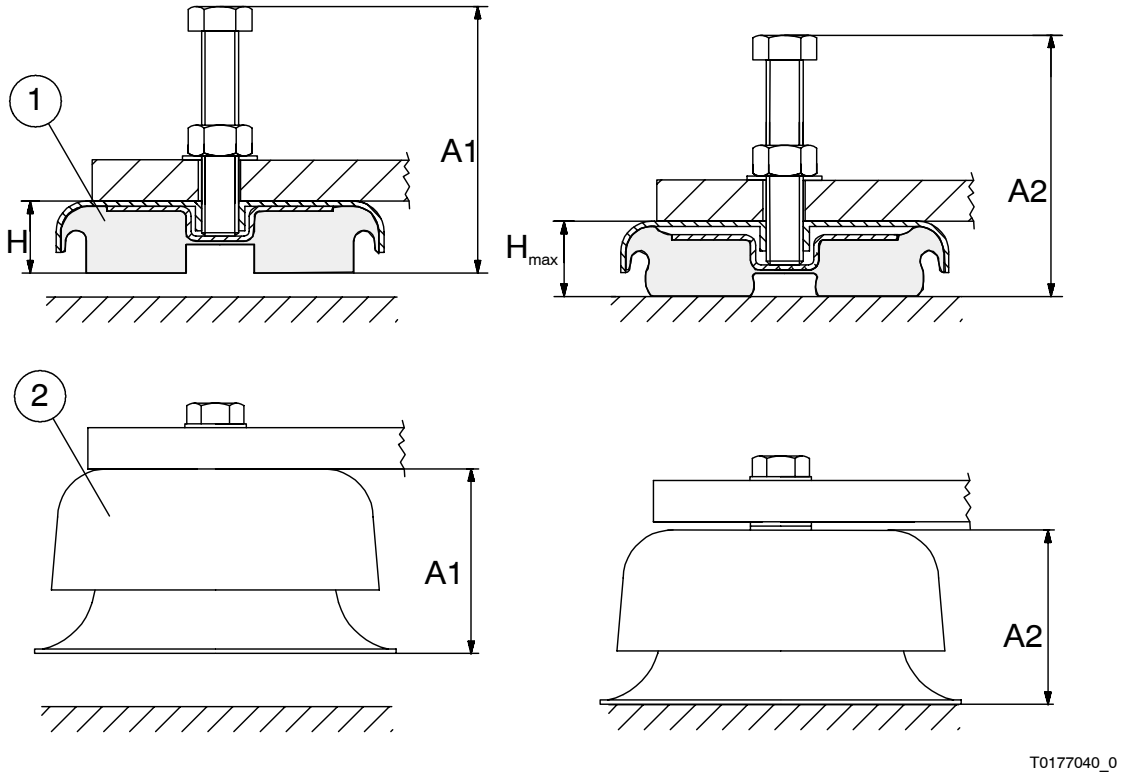
Vibration dampers are supplied as shown at the top or bottom of drawing T0177040, depending whether the compressor unit is intended for use on land or at sea.

The purpose of the vibration dampers is to diminish the vibrations from the compressor unit to the foundation. In addition, the marine vibration dampers serve to cushion vibrations from the foundation to the compressor unit, at the same time securing the unit to the foundation.

It is imperative that the vibration dampers be placed correctly, as shown in the completed drawing forwarded to customer or distributor. This drawing is valid **only** for the unit in question .

95.03
0171-460-EN

Installation on vibration dampers



The vibration dampers supplied are marked with a code, for instance LM6-60. LM6 indicates the size; 60 indicates the rubber hardness and is therefore an expression of bearing and damping ability.

When using vibration dampers, the machine room floor is assumed to have the necessary bearing stregth and to be level enough to enable adjustment of the vibration dampers to be made within the adjusting measurements stated on the drawing submitted.

In order for the individual vibration damper to cushion properly, a sufficient load must be imposed. Measure A1 and H in an unloaded and A2 in a loaded set-up, as shown in drawing T0177040.

	Industrial type ①	Marine-type ②
Flexion A1-A2	min 1,0 max 2,0	min 3,0 max 5,0
Height adjustment	H_{max} = H+12	with disks supplied as shown

The flexion of a damper is adjusted by increasing or decreasing the load in relation to the other supports. The foot can be raised by screwing the adjusting rod down or inserting more disks between damper and foot (marine design), thereby increasing load and hence also the flexion.

Once the installation has cooled down, check during operation that the flexion of the dampers is still correct!

Installing directly on foundation

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

When the foundation has been cast - with the holes shown for foundation bolts - and has set, place the unit in position, allowing it to rest on beams levelled at a suitable height so that the foundation plates are recessed slightly into the foundation.

Check that the foundation plates are right next to the base frame. This can be achieved by binding them to the resting surfaces of the base frame with steel flex.

The concrete cast down around the foundation bolts should contain only a small amount of water, so that it can be well tamped around the bolts. Low water content produces no contraction of the setting concrete.

10-14 days should be allowed to elapse before removing the beams and tightening the nuts for the foundation bolts.
Before that, however, remove the steel flex and check that there is no space between the base frame and the foundation plates. If there is, place shims between the plates before tightening.

Alignment of compressor with base frame

Check that the entire footing of the compressor makes full contact against the milled-off faces of the base frame.

Perform this check with the bolts loosened. If slip occurs at one or more resting surfaces, shim up before tightening. If unaligned, there is a risk of stresses occurring in the compressor frame, which will damage the bearings.

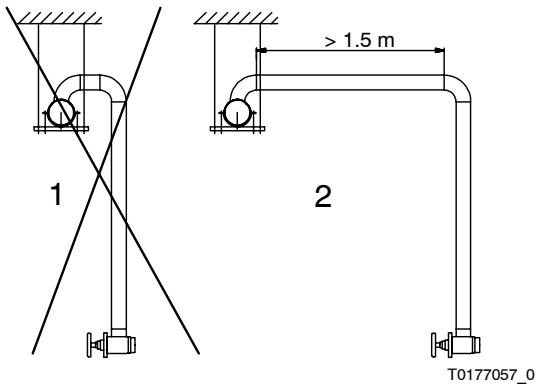
Alignment of motor with base frame

Check the contact faces of the motor against the base frame in the same way as for the compressor.

Stresses from piping connections

In order to prevent stress being transmitted from piping connections between unit and plant, pipes must be laid so as not to generate compressive stresses or tensile strains in the event of expansions or contractions due to temperature changes. Steel piping expands approx. 1 mm per metre per 100°C.

We recommend that piping be laid as shown in example 2 of the sketch. Example 1 demonstrates too rigid pipe laying.



Final alignment of compressor and motor can be performed once all piping has been connected to the unit.

FOR JOHN CRANE TSK METASTREAM T SERIES COUPLINGS, PLEASE REFER TO THE METASTREAM FITTING, OPERATIONS AND MAINTENANCE INSTRUCTIONS, ATTACHED ON THE END.

Fitting and alignment of AMR-type coupling

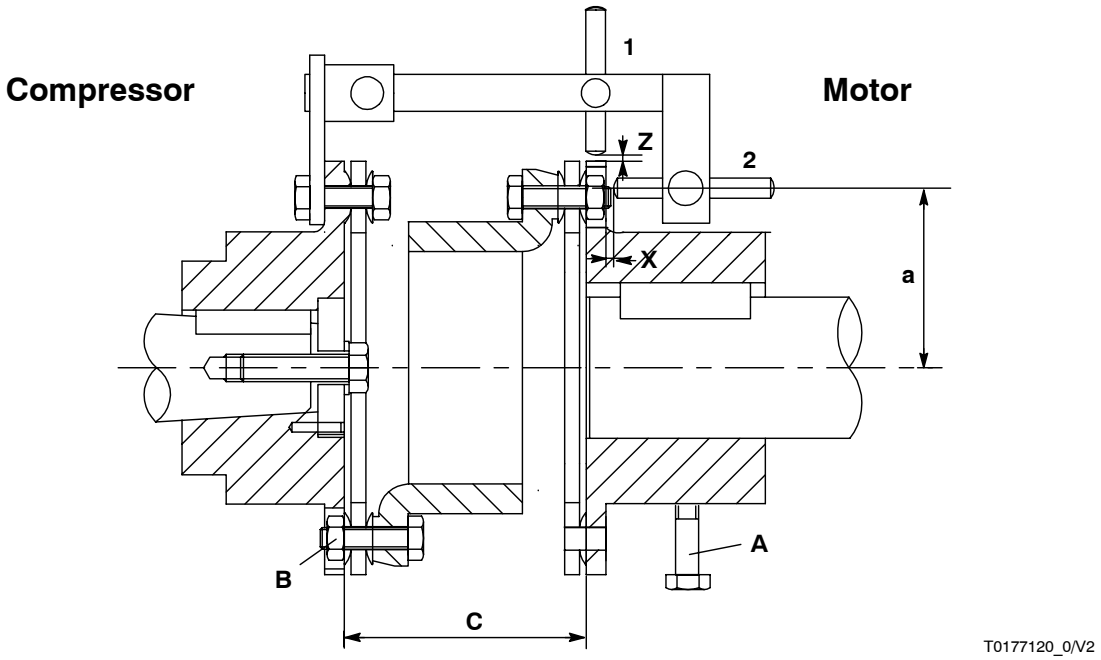
Installation and alignment

In principle, alignment involves manoeuvring the motor so as to make the shaft form an extension of the crankshaft.

Important

Before any work on the coupling, ensure that the compressor motor cannot be started inadvertenly.

Fig. 1



Compressor	AMR type of coupling	Distance C nominal* mm	Torque moment A Nm	Torque moment B Nm	Max. variation measured with a feeler gauge at a 180° turning of the af coupling Pos. 1 Horizontal max. mm	Pos. 1 Vertical min./max. mm	Pos. 2 max. mm
HPO/CMO 2	225	76,0		34	0,1	0,1/0,2	0,1
HPC/SMC 104-108	312 S	103,5	147	55	0,2	0,1/0,3	0,2
SMC 112-116	350 S	114,5	147	128	0,2	0,1/0,3	0,2
SMC 180	450 S	149,0	295	275	0,3	0,1/0,4	0,3

* See Final mounting, pt. 4

Preliminary installation

- Check tightening of coupling flange on compressor.
- Tighten 8 coupling bolts securing lamellar segments to intermediate piece to prescribed moment stated in table. It is worthwhile doing this before placing the intermediate piece in position.
- Mount retaining plate from coupling screen onto compressor and insert support ring for coupling screen over motor flange.
- Insert coupling intermediate piece. Create space between flanges either by shifting entire motor or just motor coupling flange. **The intermediate piece should only be secured to the compressor flange. Do not insert the last four bolts in the motor flange until the coupling has been aligned.**
  As the compressor shaft rotates during the alignment procedure, the motor must turn with it, as the bolts in the intermediate piece engage in the free holes in the motor coupling flange.
- Line up motor so that free holes in motor feet are right over threaded holes in base frame.
- Shift motor coupling flange to make up distance ”C” in table. See fig. 1.
- Tighten two bolts in coupling hub.
  On CMO units, the motor flange must be correctly positioned before putting the motor into place.
- Tighten measuring pin on coupling flange of compressor, as shown in drawing.

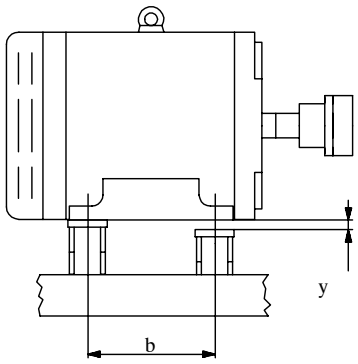
Alignment

Check that the motor with loose bolts stands with all four feet on the base frame. Insert any liner plates needed where there is an air gap beneath the feet. Tauten the bolts slightly.

Achieving parallel shafts in horizontal plane

- Turn coupling so that alignment gauge is in upper position. See fig. 1.
- Guide measuring pin (Pos. 2) towards coupling flange, using a 1.0 mm feeler gauge, and fix pin. Remove feeler gauge.
- Rotate coupling 180° and measure change in distance from measuring pin to flange, using feeler gauges. This change is called ”x”.
- Insert shims of thickness ”y” either under **both** front feet or **both** rear feet, thereby tilting motor in direction required. Shim thickness ”y” is calculated using the following formula (see drawings):

$$y = X \bullet \frac{b}{2 \times a}$$



- After tightening motor bolts, repeat measurement and compare result with values in table under Pos. 2.

Achieving correct centre height

- Turn coupling so that alignment gauge faces vertically down.
- Guide measuring pin (pos. 1) towards coupling flange, using a 1.0 mm feeler gauge, and fix pin. Remove feeler gauge.
- Rotate coupling 180° and measure increase in distance ”z” from one millimetre using feeler gauges.
- Then lift motor by placing shims of thickness equal to half value of ”z” **under all four feet.**
- After securing motor, repeat measurement and compare result with table values in pos. 1 vertical. Remember that the centreline of the motor shaft must be at least 0.05 mm higher than the centreline of the compressor, corresponding to a minimum of 0.1 mm distance less at the top position of the alignment gauge.

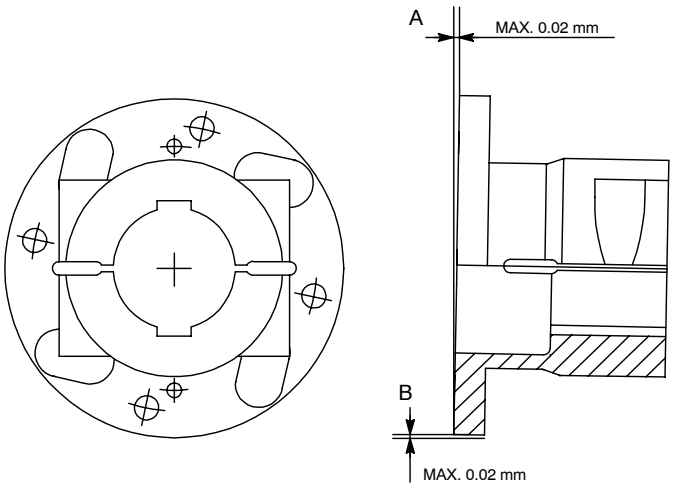
Achieving parallel shafts in vertical plane

- The motor is now positioned at its correct height. What now remains is to push and turn the motor at the level on which it is already lined up.
- Turn coupling so that alignment gauge faces out to one side horizontally.
- Guide both measuring pins towards coupling with a 1.0 mm feeler gauge in between.
- Turn coupling 180° and, using feeler gauges, measure deviations from one millimetre at both pins.
- Moving and turning motor and repeating this measurement, align motor in accordance with pos. 1 horizontal and pos. 2 in table. Remember that the motor must be firmly secured during any measurements.

Final installation

- Tighten foundation bolts on motor (see torque table).
- Fit four bolts into motor coupling flange so that *thin* shims are placed between flange and lamellae, with rounded side facing lamella. There are no *thin* shims on couplings for CMO and HPO.
- Tighten bolts to torque specified in table.
- Readjust flange distance ”C” so that lamellae are aligned, by moving motor flange on shaft and fastening motor flange.
- Check alignment of coupling in horizontal and vertical planes for pos. 1 and pos. 2.
- Dismantle measuring pin and tighten screw to prescribed torque.
- Fit coupling guard.
- Once normal operating temperature has been achieved, double-check coupling alignment.

Boring of motor flange for AMR coupling



T0177131_0 V12

92.03

010-502-EN

Unless the necessary data for the motor are known prior to dispatch, the motor flange for the AMR coupling will not be supplied in ready bored form.

In such case, the motor flange is supplied prebored and balanced.

Finish-boring is done as follows:

- Secure flange in lathe or jig-boring machine. Observe following tolerances for alignment purposes:

Max. axial eccentricity measured at point A	0.02 mm
Max. axial eccentricity measured at point B	0.02 mm

- The bore should then be made to the relevant dimensions and to the following tolerances:

  H8 for AMR 312, 350 and 450,
  H7 for AMR 225.

- Cut keyways.
  For reasons of balance, coupling AMR 312, 350 and 450 must be executed with the two keyways shown.

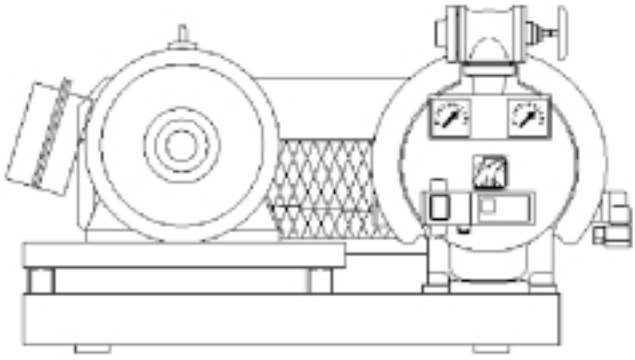
- Make the width of the keyway to a tolerance of H7.

- The keyway must be deep enough to allow a clearance between parallel keys and hub of 0.2-0.3 mm.

Max. boring diameter:

Compressor	CMO - TCMO - HPO	SMC - TSMC 100 - HPC	SMC - TSMC 180
Coupling size	AMR 225	AMR 312 - 350	AMR 450
Max. bore	60 mm	95 mm	110 mm
Boring tolerance	H7	H8	H8

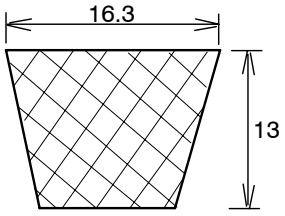
V-Belt Drive for CMO/TCMO Reciprocating Compressors



By letting the electromotor drive the compressor by means of a V-belt drive, the speed of the compressor can be selected so that its max. capacity corresponds to the capacity requirements of the plant.

The V-belts are referred to as **SPB Red Power**. Their cross-sectional dimensions are shown in fig. 1.

Fig. 1



The V-belts are of an excellent quality. Under normal operating conditions they do not require any service and are moreover shape-permanent, which means that they can be characterised as **S = C plus**, which is stamped on the outside of the belts, see fig. 2. Furthermore, the V-belts are made with so narrow tolerances that they can be fitted immediately, which means that it is not necessary to check beforehand whether the belts match.

However, it is not recommended to fit a new V-belt together with used and worn belts. Instead it is recommended to mount a new set of V-belts.

Fig. 2 S = C plus SPB 2650

A V-belt drive which has been mounted and adjusted correctly will usually have a service life of approx. **20,000 operating hours.**

00.12
0171-594-EN

Transmission Ratio

Table 1 shows the pulley diameters used for CMO/TCMO units. With these diameters the compressor speeds mentioned in columns 3 and 4 can be achieved. Column 5 shows the length of the V-belts which must be used for the different combinations of belt pulley diameters. The length of the V-belts is stamped on the outside of the belts as shown in fig. 2.

Table 1 - Standard Programme for V-Belts and Pulleys for CMO/TCMO

Standard V-Belt Pulley Diameter mm		Compressor Speed Compared to Motor Speed		Length of V-belts
Compressor	Motor	50 Hz 1460 rpm rpm	60 Hz 1760 rpm rpm	
250	132	876	929	2120
	140	934	985	2120
	150	992	1056	2120
	160	1051	1126	2120
	170	1168	1197	2120
	180	1308	1267	2120
	200	1460	1408	2120
	224	1548	1576	2120
	250	1635	1760	2120
	265	1752		2240
	280			2240
	300			2240

Power Transmission

A correctly dimensioned V-belt drive must be able to transmit the max. power of the motor, which corresponds to the **nominal capacity** of the motor, which is stamped on the name plate. The number of V-belts for which the belt drive is dimensioned must, therefore, always be mounted. This can be checked by means of the following rules:

- **The motor pulleys** are always delivered with the number of grooves corresponding to the number of V-belts which **must** be used to transmit the max. power of the motor to the V-belt drive in question, thus indicating how many V-belts **must** be mounted.
- **The compressor pulleys,** however, are only delivered with four grooves. Thus it may occur that there are more grooves on the compressor pulley than on the motor pulley.

Servicing and Alignment of the V-Belt Drive

A V-belt drive which has been aligned correctly will have a service life of **approx. 20,000 operating hours.** After the first adjustment, it is only necessary to check the belt drive according to the *Service Checks* as stated in the *Instruction Manual.*

Dismantling of the Belt Drive

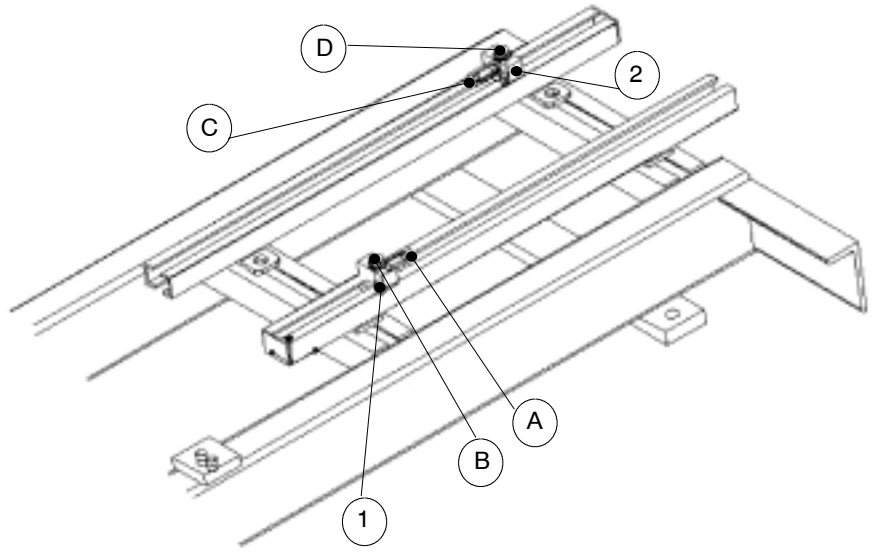
Before removing the safety guard, make sure that the motor cannot start unintentionally, e.g. due to an error in the regulating system.

The best safety is achieved by dismounting the electric main fuses to the motor!

The belt drive is dismantled first by moving the motor towards the compressor, which is done in the following way:

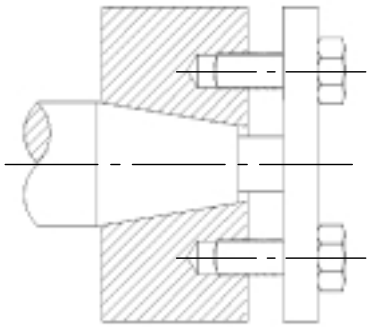
- Loosen the adjusting screw pos. A on the washer placed at the foot of the motor nearest the compressor. See fig. 3.
- Loosen the washer at the screw pos. B and push it towards the compressor.
- Loosen the screws securing the motor to the base frame. Now push the motor towards the compressor.
- It is now possible to dismount the V-belts manually without damaging them.

Fig. 3



The compressor pulley is dismounted by means of the remover 3183-059 from the general compressor tool set. The remover is used as shown in fig. 4.

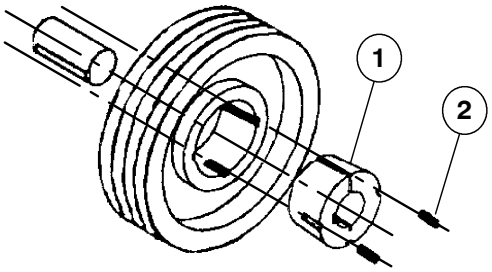
Fig. 4



By tightening the screws one after the other, the belt pulley can be removed from the cone of the shaft seal and lifted out manually.

The motor pulley is mounted on the motor shaft by means of a bushing, pos. 1, as shown in fig. 5. On the outside the bushing is shaped like a cone and fits the boring in the belt pulley.

Fig. 5



Inside the bushing is machined so that it fits the dimensions of the motor shaft. The bushing can be placed on the motor shaft manually. **Never beat the bushing onto the motor shaft as the impact may damage the bearings in the motor.**
The bushing is tightened to the motor shaft by tightening the screws pos. 2, fig. 5, as described later in this section.

Dismount the motor pulley in the following way:

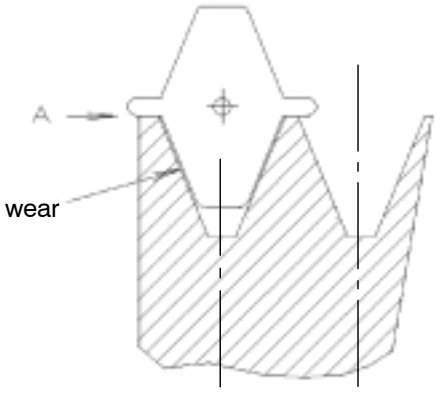
- Unscrew the two or three screws (depending on the size of the belt pulley), pos. 2.
- Mount one or two of the screws (depending on the size of the belt pulley) in the hole/s where there is a thread only in the side of the holes facing the bushing.
- By tightening the screw/s one after the other, the belt pulley will be pushed over the conical bushing. At the same time the bushing will loosen its grip on the motor shaft.
- The belt pulley and the bushing can now be removed manually.

Control of V-Belts and Belt Pulleys

On a V-belt in good condition, the outside fabric must not be worn through. The belts must not be frayed and there must be no visible cracks in the surface. It is **not** recommended to replace a few of the V-belts with new belts in a belt drive. Instead all of the V-belts should be replaced. In case of abnormal wear on the belts, it should be checked whether the grooves in the belts are damaged.

In time the belt pulleys will wear on the two conical surfaces in the belt grooves and should, therefore, be checked every time the belts are replaced. This is done by means of a measuring gauge, which is placed in the belt grooves, several places in each groove. When holding a flashlight behind the measuring gauge, it is easy to see if a belt pulley is worn as shown in fig. 6. It is recommended to replace the belt pulley when the two surfaces of the measuring gauge make full contact with the outer diameter of the belt pulley (marked with an **A** in fig. 6) and when a light can be seen between the measuring gauge and the conical surfaces of the groove. If the grooves are damaged in any other way, it should be considered to replace the belt pulleys.

Fig. 6 - Wear on Belt Grooves



The measuring gauge is available from our After-Market Service Department and has the following **Part no. 1622.001.**

Mounting and Adjusting of the V-Belt Drive

Modern V-belt drives are very sturdy and effective, but require on the other hand a correct installation and adjustment.

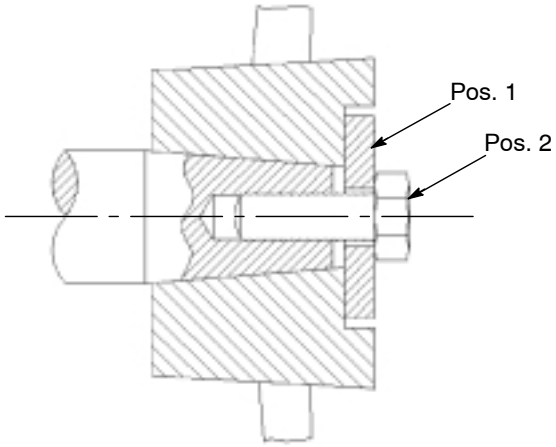
Before mounting the V-belt drive, it is necessary to clean and degrease all machined surfaces of the belt pulleys, shafts and bushing. Then proceed as follows:

The Compressor Pulley

- Place the compressor pulley on the conical shaft and turn it so that the key on the shaft faces the key groove.

- Mount the washer, pos. 1, and the screw, pos. 2, as shown in fig. 7 and tighten them to a torque of **130 Nm.**

Fig. 7

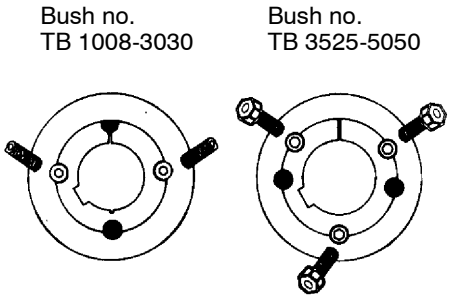


The Motor Pulley

- First place the motor pulley on the motor shaft. Then turn the bushing so that the key on the shaft enters the key groove of the bushing.
  It must be possible to fit the bushing manually. It is **not** recommended to beat at the bushing as this procedure may damage the bearings of the motor.

- Turn the belt pulley so that all the threaded holes in the pulley face the smooth holes in the bushing as is shown in fig. 8.

Fig. 8



- Oil the two or three socket cap screws, fig. 8, and mount them in the above-mentioned holes. **Tighten the screws exactly so much that it is still possible to move**

the belt pulley and the bushing on the shaft.

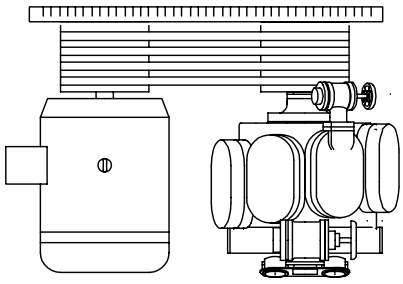
Mounting of V-Belts

- Mount the V-belts corresponding to the number of grooves on the motor pulley. Move the motor away from the compressor by means of its slide rails and align it so that the motor and compressor shafts are parallel.
  If there are more grooves on the compressor pulley than on the motor pulley, **the free groove must be furthest from the compressor. Never force the belts over the belt pulleys** as this can easily damage the belts.

- Tighten the screws securing the motor to the base frame exactly so much that it is still possible to move the motor on the slide rails. Mount the washer shown in fig. 3 and tighten the screw, pos. 1.

- Align the motor pulley by means of a straight-edge as shown in fig. 9 so that it is flush with the compressor pulley. Tighten the socket cap screws on the motor pulley fig. 8. **Please note** that when tightening the screws, the belt pulley is drawn across the conical bushing and is thus no longer flush with the compressor pulley. It is, therefore, recommended to place the motor pulley a little within the alignment with the straight-edge and to check the alignment after the screws have been tightened. If the compressor pulley is wider than the motor pulley, the straight-edge can be placed on the side of the belt pulleys facing the motor/compressor.

Fig. 9



To achieve a correct centering of the belt pulley, the tightening must be carried out with a torque wrench. All the screws must be tightened first to **1/3 torque**, then **2/3** and finally **full torque** as stated in table 2. **It is not recommended to tighten the screws to a larger torque than stated in the table.**

The number of the bushing is stamped into its large end surface.

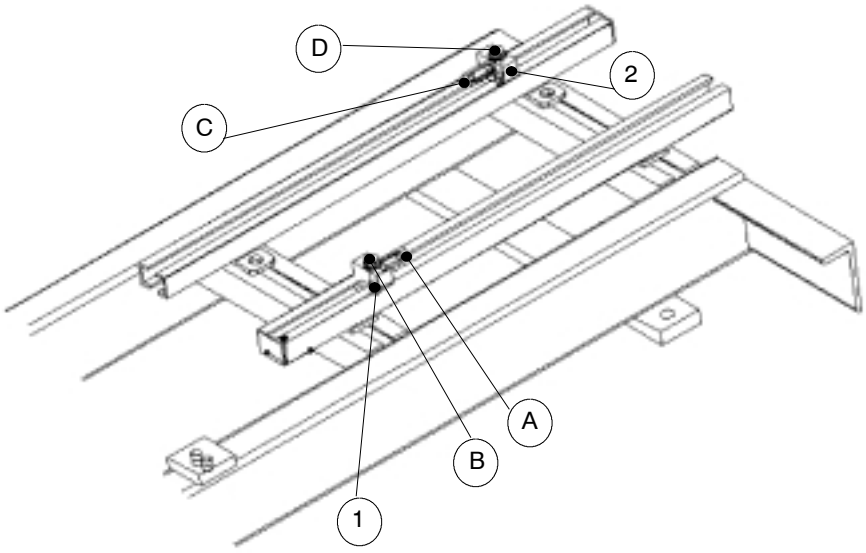
Tabel 2

Bushing No.	Hexagon Key Size mm	No. of Screws	Max. Torque Nm
1008, 1108	3	2	5,7
1210, 1215, 1310, 1610, 1615	5	2	20,0
2012	6	2	31,0
2517	6	2	49,0
3020, 3030	8	2	92,0
3525, 3535	10	3	115,0
4040	12	3	172,0
4545	14	3	195,0
5050	14	3	275,0

Mounting of the V-Belt Drive

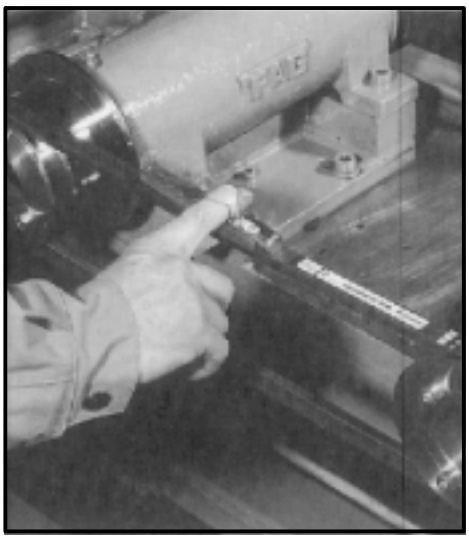
The two washers must be mounted as shown in fig. 10.

Fig. 10



- By tightening the adjustment screw **A** and loosening the adjustment screw **C** the motor is moved away from the compressor, but still **kept parallel with the compressor,** which can be checked by means of the straight-edge.
- As the belt drive is tightened, the belt tension is measured by means of a **tension tester** as shown in fig. 11.

Fig. 11

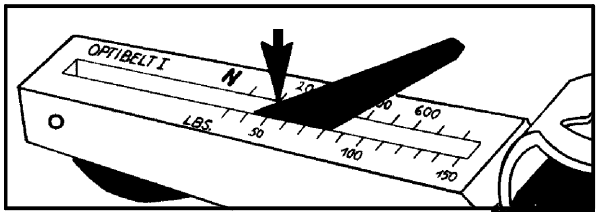


- Press the indicator on the tension tester down into the scale shown between the belt pulleys.

- Press the tension tester with **only one finger** slowly down towards the V-belt until hearing or feeling a click. Do not press after the click.

- Read the belt tension in the intersection between the scale and the indicator as shown in fig. 12.

Fig. 12



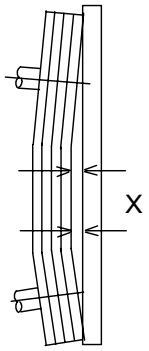
- By further tightening of the belt tightener and repeated measurements, the belt drive is tightened to the prescribed belt tension as stated in **tables 3 and 4.**
  It is important to rotate the belt drive two or three times before measuring the tension so that the belt tension is distributed on the full length of the belts.

- After the first start-up, let the belt drive run for **15 to 30 minutes** whereupon the tension is checked and if necessary tightened to the value stated in the column *New V-Belts.*
  In connection with subsequent control and adjustment, use the belt tension values in the column *Remounting.*

- When tightening the belt drive, it may be advantageous to make the belt drive point a little as shown in fig. 13 as the belt tension will decrease a little after a few hours' operation. The two belt pulleys will thus align and become parallel. Max. deviation must be:

Belt Pulley Diameter mm	Max. Deviation mm
112	0.5
224	1.0
450	2.0

Fig. 13



- When the belt drive has been tightened, the screws securing the motor to the slide rails must be tightened.

- Finally, the belt guard and the electric fuses to the motor must be mounted.

Note:

Never start the compressor unit until the belt guard has been mounted.

Tables 3 and 4

Besides being divided into min. and max. values, the **belt tension N (Newton)** in tables 3 and 4 consists of **two columns**, which are used as follows:

New Belts

This tension is used the **first time** a new set of belts is mounted.

Remounting

This tension is used in connection with used V-belts or for the control of the belt tension after an operating period.

Table 3 CMO/TCMO, 4-pole 50 Hz Motor

Motor Pulley Diameter mm	Belt Tension N			
	New V-Belts		Remounting	
	Min.	Max.	Min.	Max.
150	500	550	350	400
160	500	550	350	400
170	600	700	400	450
180	600	700	400	450
200	700	800	500	550
224	700	800	500	550
250	700	800	500	550
265	800	900	550	600
280	700	800	500	550
300	700	800	500	550

Table 4 CMO/TCMO, 4-pole 60 Hz Motor

Motor Pulley Diameter mm	Belt Tension N			
	New V-Belts		Remounting	
	Min.	Max.	Min.	Max.
132	500	550	350	400
140	500	550	350	400
150	550	600	400	450
160	500	550	350	400
170	600	700	400	450
180	600	700	400	450
200	700	800	500	550
224	700	800	500	550
250	700	800	500	550

Structure of the thermo pump

Together with the cooling cover, pos. 98Q, the side cover, pos. 98A, forms a pump vessel, pos. 98, which is supplied with heat from the oil bath in the crankcase. The cooling cover is equipped with cooling fins in order to provide a satisfactory thermal contact with the oil.

As illustrated in the principle drawings, the pump vessel has the following three pipe connections:

- Connection **pos. A** which is linked to the compressor suction side and which can be blocked by means of solenoid valve pos. 98G. Used to lower the pressure in pump vessel pos. 98. Part of the pumping cycle.
- Connection **pos. B** emerges from the receiver or the priority tank and goes right to the valve block pos. 80 which is of the same type as the one described in the section on: **Solenoid valve controlled oil return** in this instruction manual.
  Please, note that the size of orifice pos. 80l must be 3.3 mm.
- Connection **pos. C** is connected to the top covers and the oil cooler pos. 98T through a number of nozzles pos. 98M.

Filling and evacuation of the pump vessel is controlled by two level sensors, pos. 98C, which by means of the control box, pos. 98B, control the solenoid valves, pos. 98G and pos. 98H, so that they are open and shut simultaneously. The thermo pump is safeguarded by the following systems:
(See *principle drawing*)

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

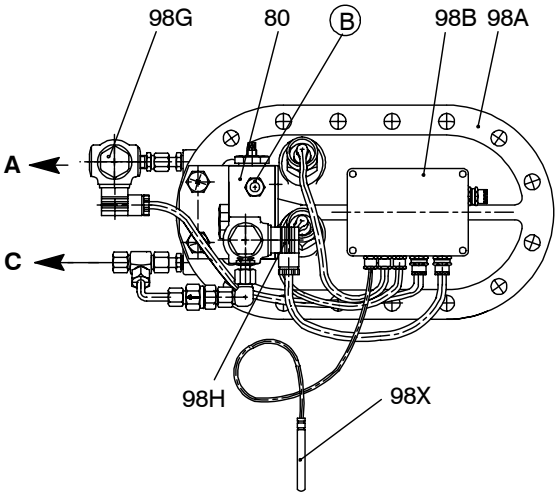
Fasten the sensor to the discharge pipe right next to the discharge stop valve by means of two clips. **Ensure a proper thermal contact.**

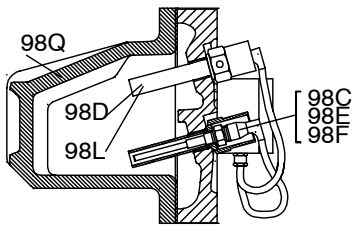
The thermostat is factory set to start up the thermo pump once the discharge gas temperature is **above 80°C**.

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

Please, notice that the pipe connection pos. D to the plant evaporating side must be made at a spot where there is no risk of the liquid flowing back to the compressor. Connection should, f.inst., be made to the liquid separator or the evaporator.

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





T3185085_5

Description of pumping cycle

Filling of pump vessel

As soon as the liquid leaves the bottom level sensor, the control box will activate the solenoid valves pos. 98H in valve block pos. 80 and pos. 98G.

Hereby, solenoid valve pos. 98G opens in the pipe connection to the compressor suction side and the pressure in the pump vessel decreases slightly. At the same time solenoid valve pos. 98H opens and refrigerant liquid starts flowing to the pump vessel through pipe connection B.

Evacuation of pump vessel

When the top sensor has registered that the liquid has reached the top level both solenoid valves will be closed by the control box.

The pressure in the pump vessel now rises as a consequence of the heat impact from the compressor oil and - when exceeding the pressure on the compressor discharge side - will make the refrigerant flow through the pipe connections to the top covers and the oil cooler.

At the top covers the refrigerant expands through the nozzles pos. 98M directly into the hot discharge gas, with immediate cooling of the discharge gas.

The oil cooler (not always required) is a heat exchanger in which the expanding refrigerant - after cooling of the oil - is taken to the compressor discharge side.

Once the liquid in the pump vessel has returned its lowest level, it is registered by the bottom sensor and the control box opens the two solenoid valves for a new pumping cycle.

Capacity regulation of thermo pump

On reducing the compressor capacity it becomes necessary also to reduce the cooling effect of the thermo pump. This is done as follows:

SMC 104-106-108, TSMC 116
CMO 24-26-28

The pipe connection from the pump vessel to the top covers is on its way divided into two pipe lines. In one of these pipe lines a solenoid valve, pos. 98U, is fitted.
This solenoid valve is connected to the the capacity regulating system of the compressor and closes when the compressor capacity has been reduced, as indicated in the following table:

Compressor capacity	Solenoid valve pos.98U	
	open	closed
SMC 104	100%	50%
SMC 106	100-67%	33%
SMC 108	100-75%	50-25%
TSMC 116	100-83-67%	50-33%
CMO 24	100-75%	50-25%
CMO 26	100-67%	50-33%
CMO 28	100-75%	50-25%

SMC 112-116

On the SMC 112-116 two thermo pumps have been mounted as shown on the principle drawings.

The total capacity of the thermo pumps is adapted to the compressor capacity by a power disconnection of the thermo pump

positioned at the compressor shaft end and marked *X* on the principle drawing.

The disconnection is achieved through the connection of the thermo pump via terminals 5 and 6/7 or 8 to the capacity regulating system of the compressor. The supply voltage to the thermo pump must be switched off once the compressor capacity has been reduced to the values indicated in the table below.

Compr. capacity	Thermo pump at compr. shaft end	
	working	not working
SMC 112	100-83-67%	50-33%
SMC 116	100-87-75-63%	50-37-25%

The pipe connections are shown on the principle drawings on the previous pages.

When the compressor is stopped the current to the thermo pump is cut off, closing the solenoid valves pos. 98H and pos. 98G.
At the same time solenoid valve pos. 98V opens and drains the liquid in the thermo pump back to the evaporating side of the plant. See the previously mentioned point **b**.

Checking the pumping cycle

On dismantling the cover plate on the control box four light diodes are made visible (2 green and 2 red ones).
One of the green diodes that is connected to the top level sensor is switched on for a relatively short period, i.e. from the moment the sensor has registered the upper liquid level and until evacuation of the vessel has lowered the level below the sensor.

Similarly, the other green diode for the bottom sensor will only be switched off from the moment the bottom level has been registered and until the liquid rises once more on filling of the vessel.

At the bottom level a time lag of a few seconds has been built in order to prevent the solenoid valves from clattering in the event of any lapping in the vessel.

One of the red diodes, LD3, lights up once the temperature of the discharge gas rises above 80°C. The other red diode LD4 lights up when the relay to the solenoid valves has closed.

Functional testing

When stop valve in valve block pos. 80 is closed the functioning of the pump may be tested as follows:

- Roll off the rubber cap on the external part of the level sensors so that the part without insulation can be touched with a finger.

Note

It is quite safe to touch the level sensors at this point as the voltage is extremely weak.

- Touching the sensor alters its capacity as if the sensor were surrounded by liquid in the pump vessel.

  By touching the sensors in the order in which they are usually surrounded by liquid at increasing liquid level it is possible to check whether the solenoid valves receive any voltage and open when the sensors are released.

Possible sources of error

In case the above tests should reveal that one or both of the diodes do not light up when touched, this may be due to:

1. No voltage to the control box.

2. Loose power connection.

3. Defective control box.
   (To be replaced by a new one)

In case both diodes switch on and off correctly but the built-in relay is not working, replace the control box.

If the diodes light up and the relay is working, the error may be found in the solenoid valves:

1. Loose connections to the solenoid valves.

2. Burnt coils in the solenoid valves.

3. Some other malfunction in the solenoid valves.

If the above-mentioned sources of error are not present and the thermo pump still fails, the reason may be:

1. Closed stop valve in the liquid line.

2. Clogged filter in the liquid line.

3. Dirt in the solenoid valves.

4. Flash-gas in the liquid supply pipe or liquid shortage.

5. A very low differential temperature between oil and condensing temperature.

6. Clogged nozzles pos. 98M.

Both diodes are constantly lit

If one or both diodes are constantly lit, even with no liquid on the sensor, this may be due to a conductive connection between the inner and the outer part of the level sensor rod.

Outside the side cover the level sensor rod is protected by O-rings and a protective cap preventing water and moisture from making contact.

An oil drop may have slipped inside the side cover. In this case it is recommended to strip down the sensor rod and clean the parts. On mounting make sure that the sensor rod centers in the sensor tube.

If, after remounting, the error persists, the control box must be replaced.

Ensuring liquid to the thermo pump

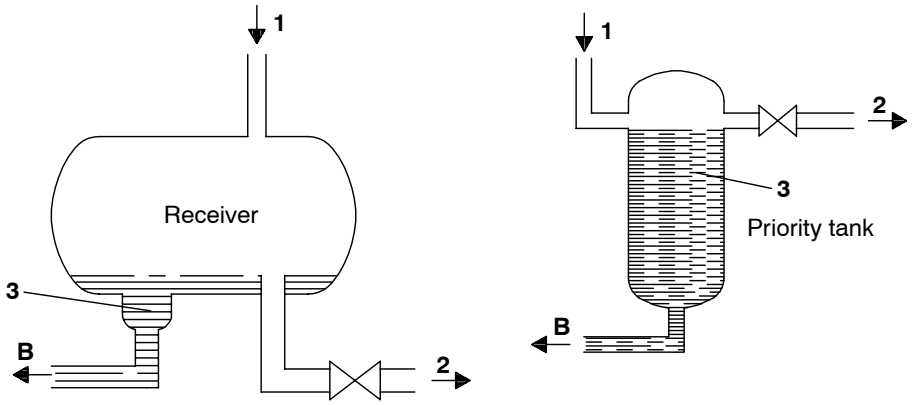
The thermo pump must always be ensured liquid from the plant, no matter whether the plant lacks liquid or some other factor prevails.

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

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

This safety is achieved by either taking the liquid directly from the receiver, pipe connection B or by building a **priority tank** into the liquid line of the plant (see drawing).
The liquid volume A of the priority vessel must be minimum 10 litres per thermo pump.

The liquid tube from the priority vessel to the thermo pump must be dimensioned to prevent the formation of flash gas along the way.



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

T0177101_0/4

Stopping a compressor equipped with a thermo pump

When the compressor is stopped there must still be a pilot current on the unit so that the solenoid valve pos. 98V is kept open until the pump vessel has been emptied of liquid.

At the same time, stop valve pos. 98Y is kept open.

Opening of compressor for repair

Pump down of the compressor must take place with the thermo pump system set out of function and after the pump vessel has been emptied as described above.

During pump down close stop valve in valve block pos. 80 and pos. 98Y.

Cleaning of filter in the liquid supply line

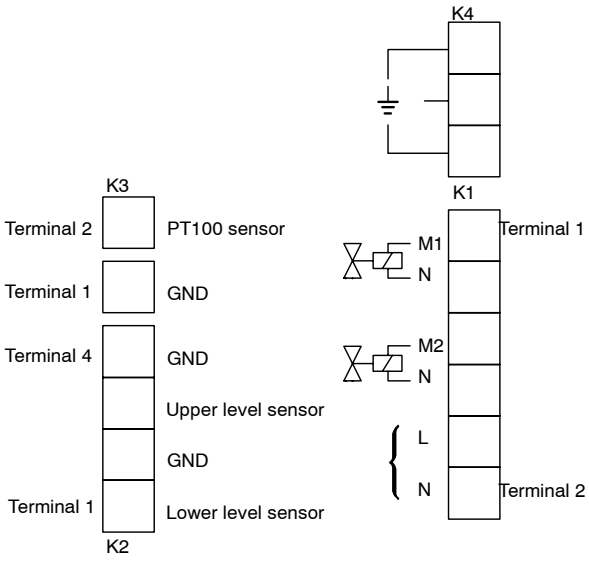
Pump down the compressor before opening the filter in the liquid supply line for cleaning.

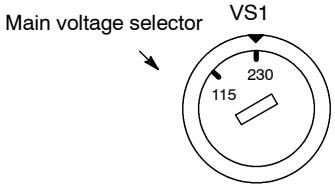
Power connection

The control box is geared for 3 different voltages:

	110V -	50/60Hz
	220V -	50/60Hz
	240V -	50HZ

The control box contains a terminal strip as shown in the sketch below.





Oil return in parallel operation for reciprocating compressors

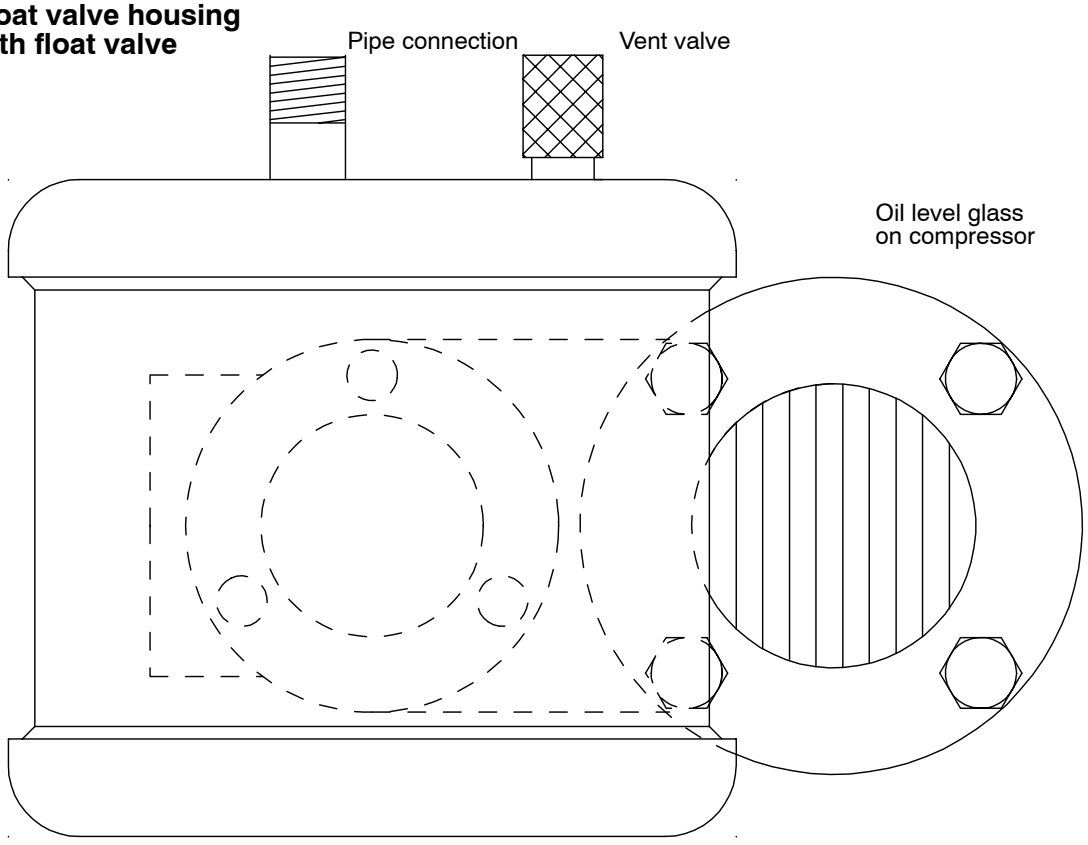
On halocarbonic piston compressors operating in parallel on the same plant, it is important to regulate the oil return flow to the crankcases of the compressors so that they have the same oil level.

This is achieved by using an oil distribution system as described in this instruction.

Each compressor is fitted, via an intermediate piece, with a mechanical float which regulates the oil level in the crankcase.

This intermediate piece is mounted between the compressor frame and the oil level glass, as shown in the drawing. This allows visual inspection of the oil level in the crankcase.

Float valve housing with float valve

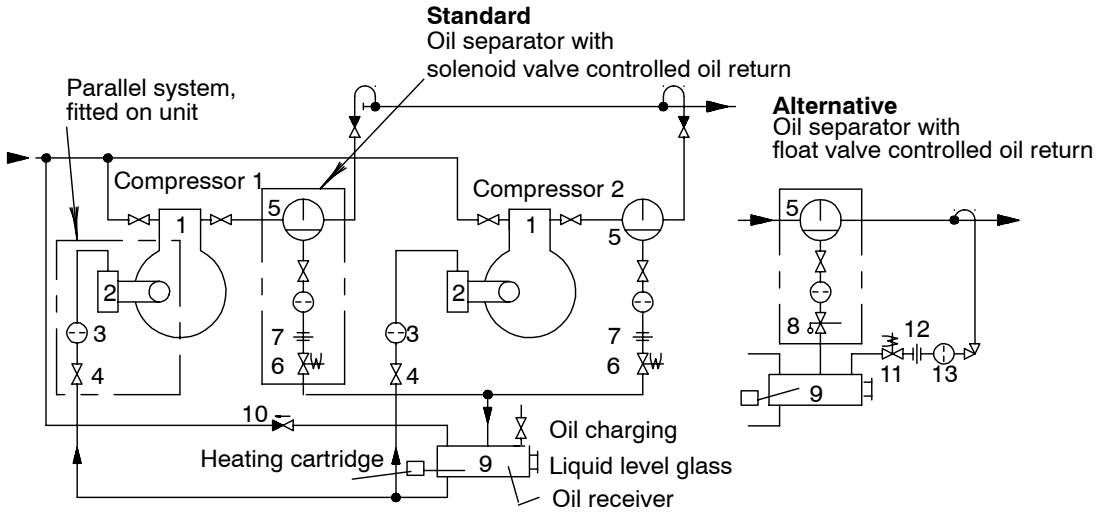


T0177089_0/2

95.06

0171-474-EN

Schematic diagram



1.	Compressor	8.	Float valve for oil separator
2.	Float valve for parallel operation (1374-005)	9.	Oil receiver
3.	Filter	10.	Non return valve, 1 bar
4.	Stop valve	11.	Solenoid valve for driving pressure line
5.	Oil separator	12.	Nozzle dia. 0.4mm for driving pressure line
6.	Solenoid valve for oil separator	13.	Filter for driving pressure line
7.	Nozzle for oil separator		

Function

The piping diagram is based on each compressor pos. 1 being equipped with an oil separator pos. 5, from which the oil via solenoid valve pos. 6 and nozzle pos. 7, or through float valve pos. 8, is conveyed to an oil tank pos. 9.

The nozzle size for pos. 7 is stated in the section on *Oil Separator.*

The oil tank pos. 9 must have a volume equal to approx. 50% of the total oil volume to be contained in the compressors.
However, it should never be filled more than halfway with oil, corresponding to approx. 25% of the total oil quantity.

There should be an oil level glass on the oil tank and a heating element to ensure warm, and hence refrigerant free, oil.

From the oil tank, an oil pipe is drawn directly to the mechanical float pos. 2 controlling the oil level in the crankcase.

From the top of the oil tank pos. 9, a pipe is routed to the suction side of the plant.

A non-return valve pos. 10 is inserted in the pipe, opening at a differential pressure of 1 bar. Note the flow direction. A pressure 1 bar higher than the suction pressure in the plant is thus obtained in the oil tank. This is sufficient to pump the oil through the float valve without generating any foaming in the float valve housings.

Note:

After the initial starting up of the float system, the float housing must be ventilated in the following way. See drawing of float housing.

Unscrew the cap on the vent valve and activate the spring-loaded valve in the branch by pressing it down with a screwdriver or similar.

If the **float-valve controlled oil return Pos. 8** is used, the oil tank must - in order to maintain the driving pressure at 1 bar - also be connected to the discharge side of the plant, as shown in the schematic diagram.

In the pipe connection to the discharge side, mount a 0.4 mm diameter nozzle Pos. 12 and a solenoid valve Pos. 11, which must be open also when only one compressor is operating.

Refrigerant cooled oil cooler for CMO reciprocating compressor

Under certain operating conditions – as indicated on the diagram on operating limits in this instruction manual – cooling of the compressor oil is required.

On page 1 is stated whether the actual compressor has a built-in refrigerant cooled oil cooler.

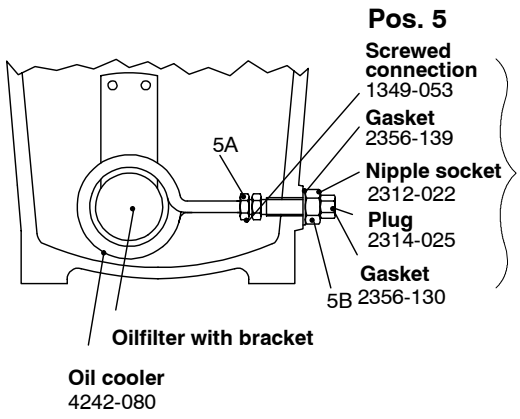
As shown in fig. 1 the oil cooling system consists of a spiral of smooth steel pipes placed round the oil filter.

Via the cutting ring joints pos. 5, the spiral is connected to the external pipings, as illustrated in fig. 2A an 2B.

Connection, **pos. B**, pipe dimension OD 10 mm, emerges from receiver or priority vessel and is conveyed to valve block pos. 80 which is the same type as the one described in section entitled: *Solenoid controlled oil return* of this instruction manual.

Please, note that nozzle size pos. 80l must be 3.3 mm.

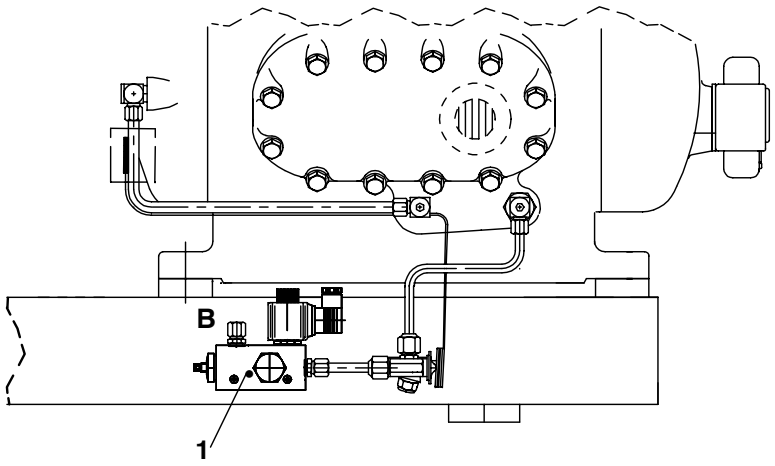
Fig. 1



4242-087

Oil cooling system R22

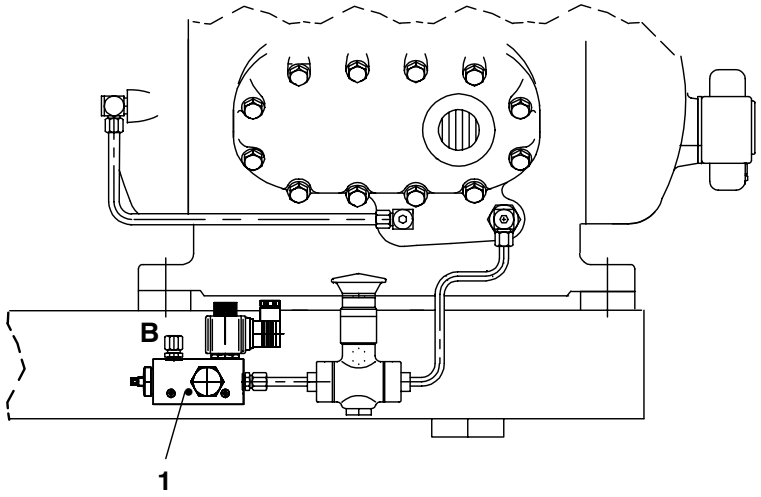
Fig. 2A



97.03
0171-356-EN

Oil cooling system R717

Fig. 2B



Connect oil cooling system to the liquid system of the refrigeration plant where a point at liquid refrigerant is always present, and carry out pipe connection so that no gas bubbles will occur in the liquid before the expansion valve.

Pipe dimension is shown on fig. 3 and 4. **A priority vessel** may possibly be used as described under *Ensuring liquid supply to Thermopump* in section *Thermopump system for cooling*.

Function

The valve arrangement Pos. 1 has a built-in stop valve with which the cooling system can be cut off from the refrigeration plant. The arrangement also contains a filter that can be taken apart and cleaned as described earlier.

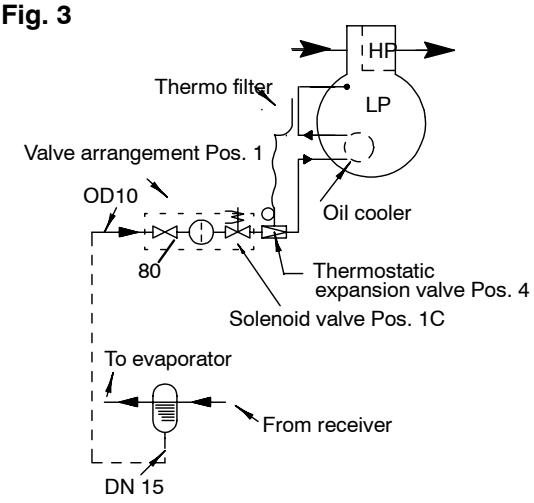
The liquid will pass the solenoid valve which is electrically coupled to thermostat KP77. This opens the solenoid valve whenever the oil temperature is above 55°C. (See table : *Pressure and temperature settings)*

Adjustment of liquid flow to the oil cooler takes place through the expansion valve which for R22 compressors is a thermostattic expansion valve with thermo sensor placed on the discharge pipe of the oil cooler as shown in fig. 3.

For R717 it is a thermostatic injection valve with thermo sensor placed at the compressor discharge branch as shown in fig. 4.

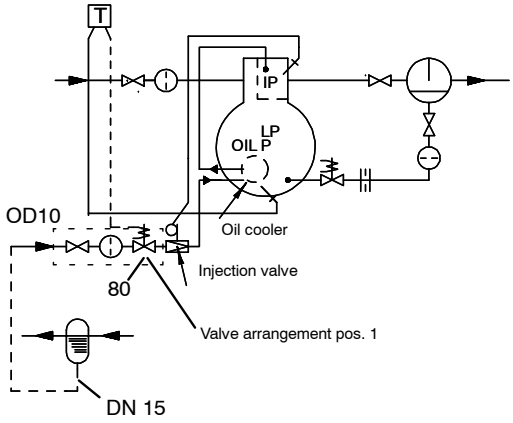
CMO 2 compressors for R22

Fig. 3



CMO 2 compressors for R717

Fig. 4



Adjustment

Adjustment of the thermostatic expansion valve for R22 appears from table: *Pressure and temperature settings.*

The thermostatic injection valve for R717 is factory set to begin opening at +75°C discharge gas temperature and to be completely open at +95°C.

Dismantling oil cooler

In order to facilitate the replacement of oil filter cartridge, see section on *Oil Filter*, it is recommended to dismantle oil cooling spiral as described in the following:

Dismantling:

After evacuation of the compressor as described previously, dismantle the two union nuts Pos. 5A, after which the cooling spiral can be pulled out from the screwed connections together with the oil filter. See fig. 1.

Mounting:

On remounting cooling spiral, counter pressure must be exerted on the outside on Pos. 5B when tightening union nut Pos. 5A. See fig. 1.

Oil Separator and Oil Return on CMO 24-26-28 and TCMO 28

Application

The purpose of the oil separator is, under all operating conditions, to separate the oil conveyed out of the compressor with the discharge gas in order that it may be returned to the compressor crankcase.

However, with the hot discharge gas some oil is going to leave the oil separator - **the so-called oil consumption**.

With a normal standard oil separator the oil consumption will be approx. 35 to 45 ppm (parts per million) for R717 compressors.

The oil consumption is, however, dependent on the discharge gas temperature which at rising temperatures often results in an increased oil consumption. Further, oils with a low **flame point** can lead to an increased oil consumption in the R717 compressors.

For HCFC compressors the oil consumption is of minor importance as the oil normally returns to the compressor from the plant.

Your compressor may be delivered with a **normal standard oil separator,** of which the various types are shown in fig. 1, 2 and 3, or a **fine filter oil separator** as shown in fig. 4.

With due regard to the **normal discharge gas temperature** and a high **flame point** the fine filter oil separator separates the oil from the discharge gas down to approx. 10 ppm in R717 refrigeration plants.

97.03

0171-336-EN

Fig. 1

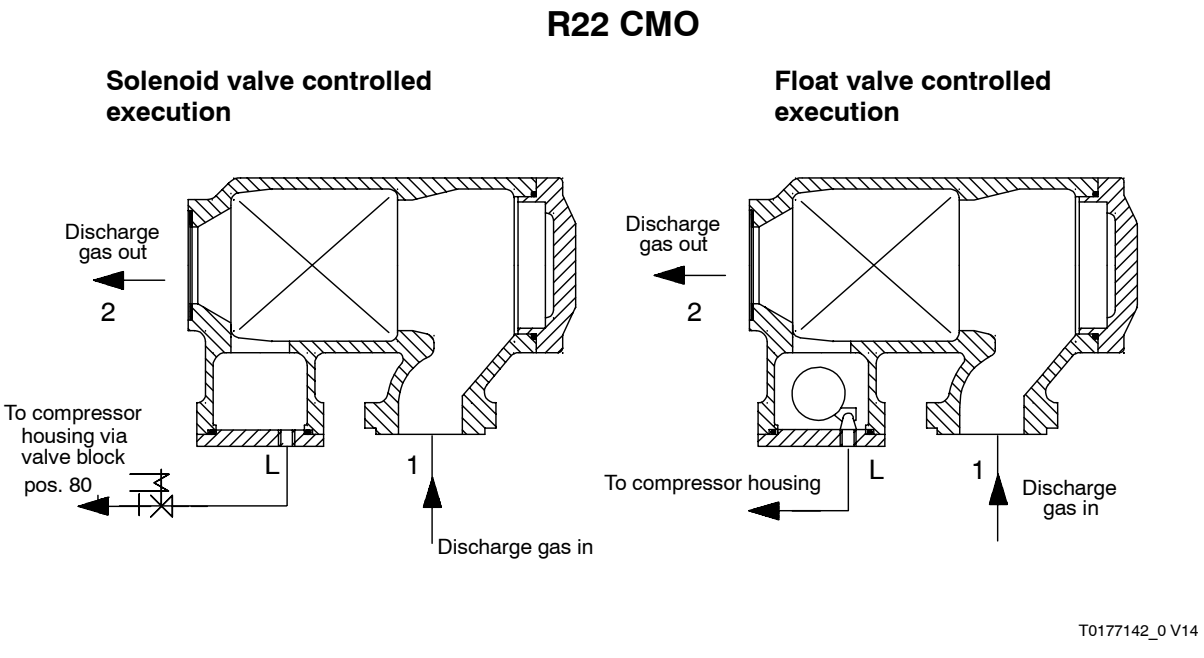


Fig. 2

R22-R717 TCMO

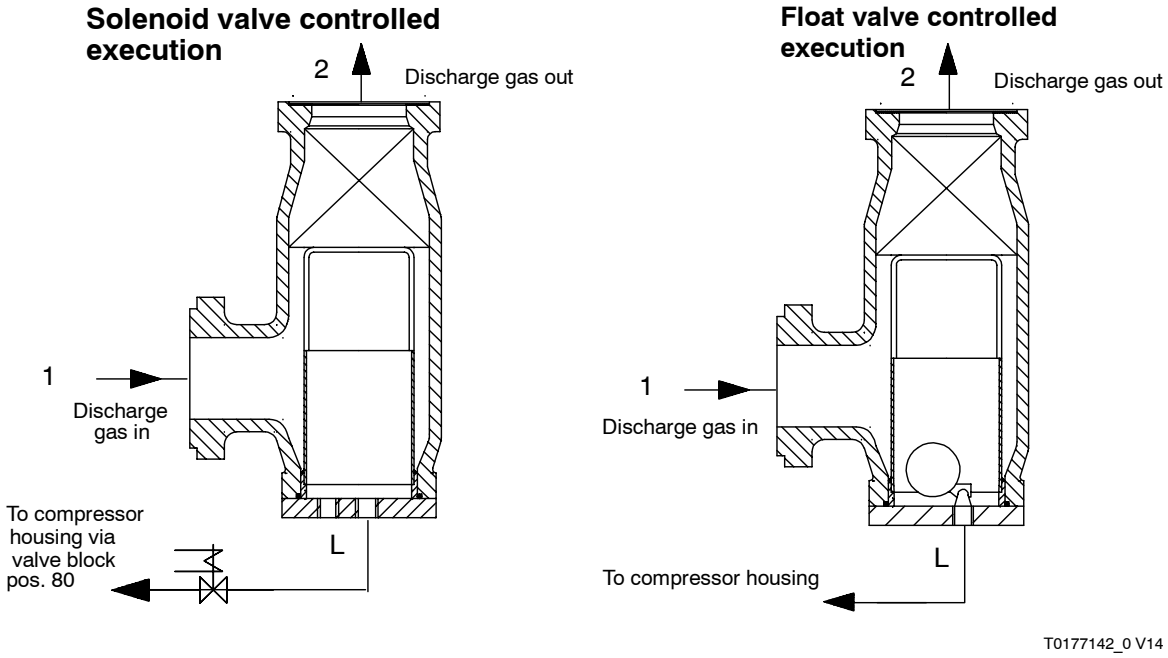


Fig. 3

R717 CMO

Normal standard oil separator

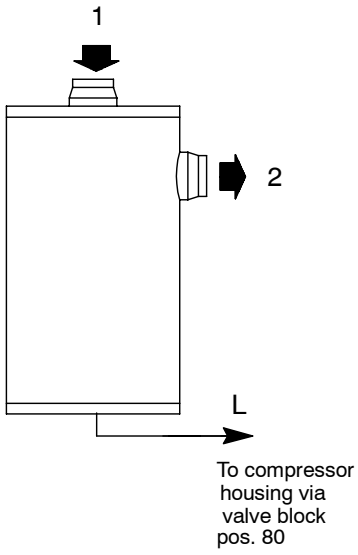
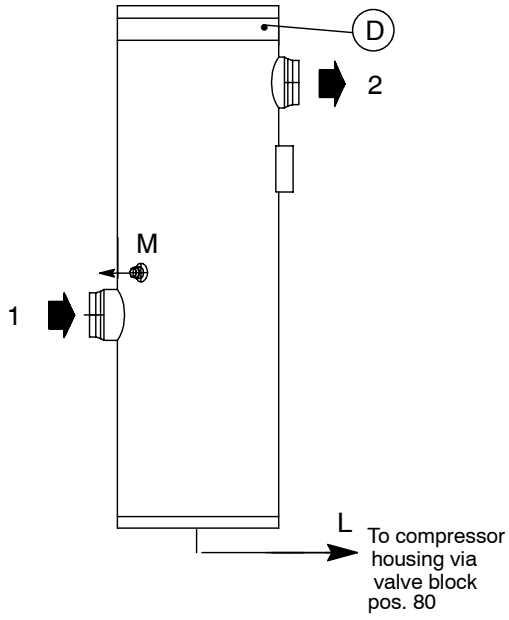


Fig. 4

R717 CMO

Fine filter oil separator



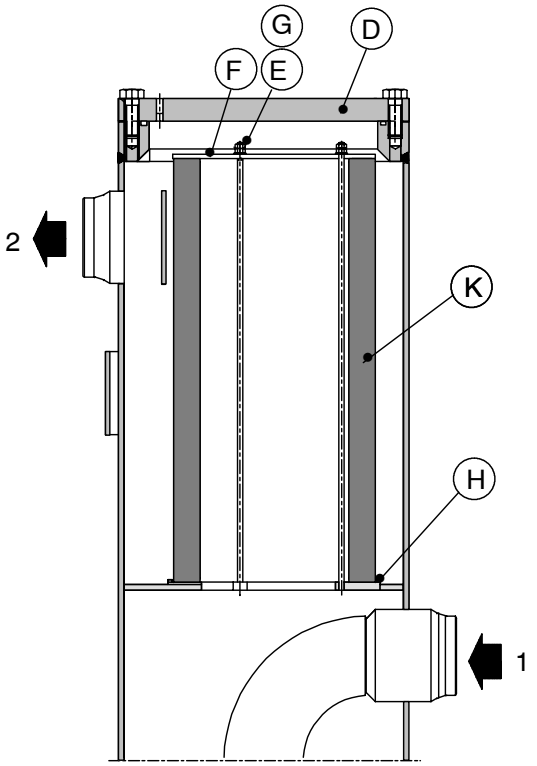
Function

The discharge gas from the compressor flows through the oil separator from pos. 1 to 2 and passes through filters in which the oil is separated from the discharge gas. In **the oil separators fig. 1, 2 and 3** the oil is separated in a number of rustproof wire-mesh filters which normally need no cleaning and consequently cannot be removed from the oil separator.

In **the oil separator fig. 4** the oil is separated, partly in above rustproof wire-mesh filters, partly in a **fine filter pos. K**, positioned in the upper part of the oil separator. This fine filter may, as shown in fig. 5, be taken out of the oil separator through the flanged joint pos. D. On mounting of the fine filter the nuts pos. E must be tightened **evenly** against the plate pos. F and secured with counter nuts pos. G.

Also make sure that the fine filter is fitted correctly against the intermediate plate pos. H.

Fig. 5



t4241347_1

Oil return to the compressor

The separated oil leaves the oil separator through the connecting branches pos. L and in case of the fine filter oil separator fig. 4 also through branch pos. M. This means that two oil return systems are used for the fine filter oil separator.

The oil flow from the connecting branches pos. L and M can be regulated by the following systems:

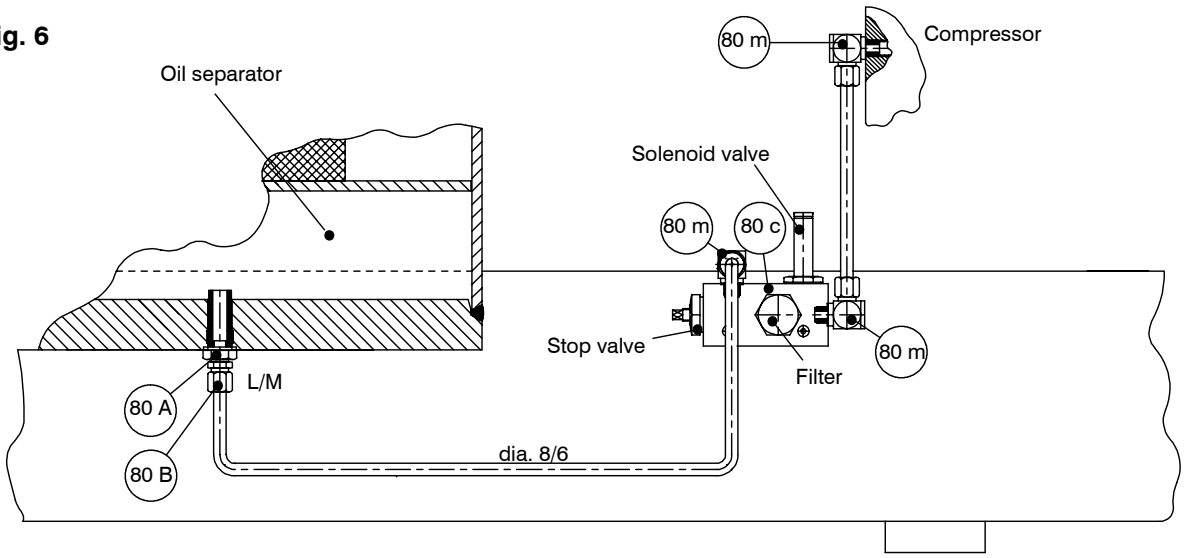
- Solenoid valve controlled oil return
- Float valve controlled oil return

a: Solenoid valve controlled oil return

As illustrated in fig. 6 the oil is conveyed from the oil separator through the screwed connections pos. 80A and 80B. Fig. 6 pos. also shows that pos. 80A is of such a length that it pierces the base plate by approx. 10mm.

In this way any dirt particles may be collected on the bottom of the oil separator instead of being returned with the oil to the compressor.

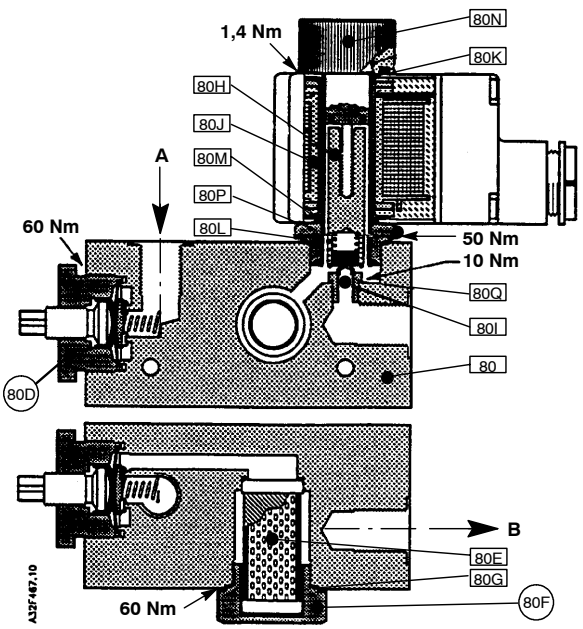
Fig. 6



Valve block pos. 80C, shown in fig. 7, consists of a stop valve pos. 80D, which is closed and opened by turning of the spindle. This valve may be dismantled by unscrewing the big union nut from the valve block.
On refitting the nut, tighten it with 60 Nm.
From the stop valve the oil passes filter pos. 80E, which can be removed by dismounting cover pos. 80F. The filter can be cleaned in a cleansing fluid and blown clean with compressed air.

On remounting tighten the cover with a torque of 60 Nm. **Remember gasket pos. 80G.**

Fig. 7



After the oil has been cleaned, it flows to the solenoid valve pos. 80H, **which is always closed at compressor standstill**.

During start-up of the compressor, the solenoid valve can be kept closed for **20 to 30 mins.** by means of a time relay, available as an additional equipment. This prevents any refrigerant from entering the compressor.

The seat of the solenoid valve **pos. 80I** also acts as a nozzle that regulates the oil flow back to the compressor.

Select the nozzle size on the basis of table 8. We recommend **not to use a bigger nozzle size** than prescribed. In order to replace the nozzle the compressor must first be depressurized. Next, dismantle coil pos. **80J** and armature tube **pos. 80P**.
The nozzle is screwed into the valve block and, on remounting, use gasket **pos. 80Q** for the nozzle and gasket **pos. 80L** for the armature tube. Tighten with the prescribed moments of 10 and 50 Nm – see fig. 7.

On mounting the coil keep it in place by using hand screw **pos. 80N** and O-ring **pos. 80K** and **80M**.

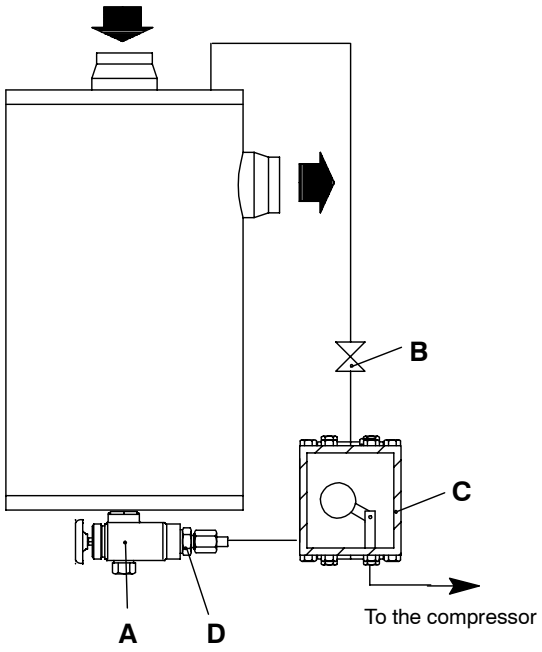
Fig. 8

R717		One stage compr.			Booster compr.			Two stage compressor					
								TCMO Mk 2		TSMC 100		TSMC 180	
		CMO Mk 2	SMC 100	SMC 180	CMO Mk 2	SMC 100	SMC 180	LP	HP	LP	HP	LP	HP
Number of cylinders	4	0.6	0.6	0.6	0.6	0.6	0.8						
	6	0.6	0.6	0.6	0.6	0.6	0.8						
	8	0.6	0.6	0.6	0.6	0.6	0.8		0.6	0.8	0.6	1.0	0.6
	12		0.6			0.8							
	16		0.6			0.8				0.8	0.6		

HFC/ HCFC		One stage compr.			Booster ompr.			Two stage compressor					
								TCMO Mk 2		TSMC 100		TSMC 180	
		CMO Mk 2	SMC 100	SMC 180	CMO Mk 2	SMC 100	SMC 180	LP	HP	LP	HP	LP	HP
Number of cylinders	4	0.6	0.6	0.8	0.6	0.8	1.0						
	6	0.6	0.6	0.8	0.6	0.8	1.0						
	8	0.6	0.6	0.8	0.6	0.8	1.0		0.6		0.6		0.8
	12		0.8			1.0							
	16		0.8			1.0					0.6		

b: Float valve controlled oil return

Fig. 9

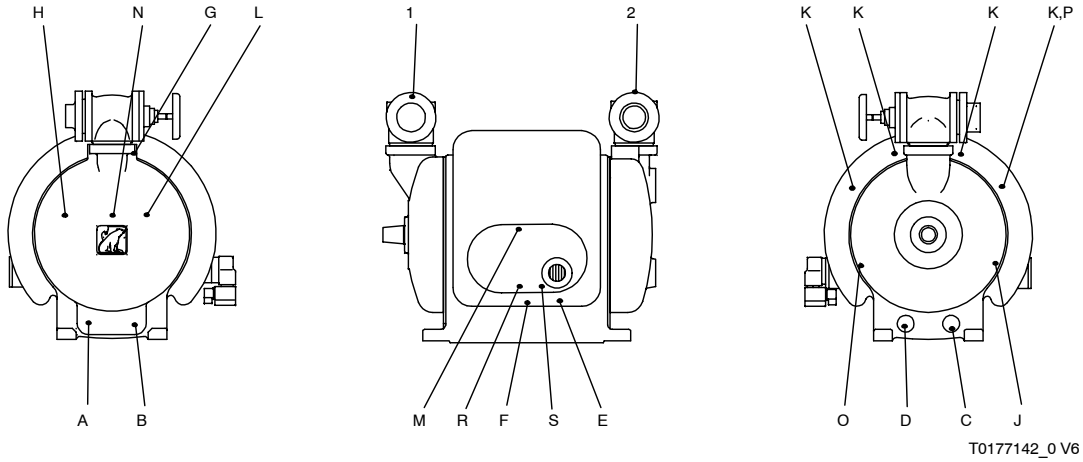


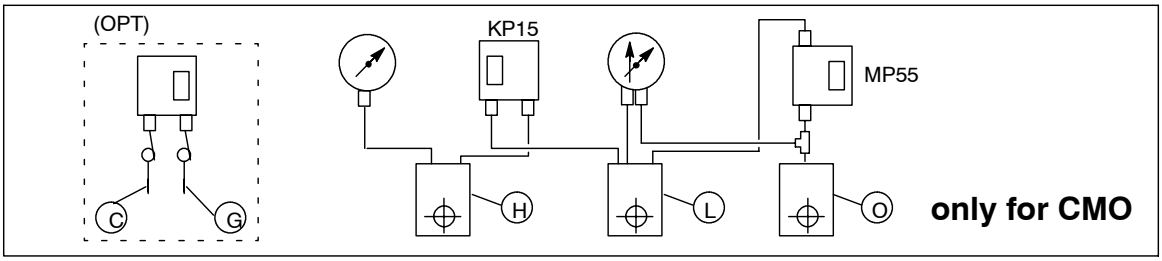
For the oil separators shown in fig. 1 and 2 the float valve is built into the oil separator. After the oil separator has been depressurized, this valve can be removed by dismantling of the bottom cover.

As to the oil separator types as shown in fig. 3, drain the separated oil from the float valve pos. C, as outlined in fig. 9, once the valves pos. A and B are open. At a rising oil level the float valve will open and lead the oil back to the compressor crankcase.

The filter pos. D and the float valve can be cleaned by dismantling the threaded nipple on the stop valve housing and removing the cover on the float housing after the valves pos. A and B are closed and the pressure in the compressor equalized to atmospheric.

Connections on CMO/HPO 24-26-28





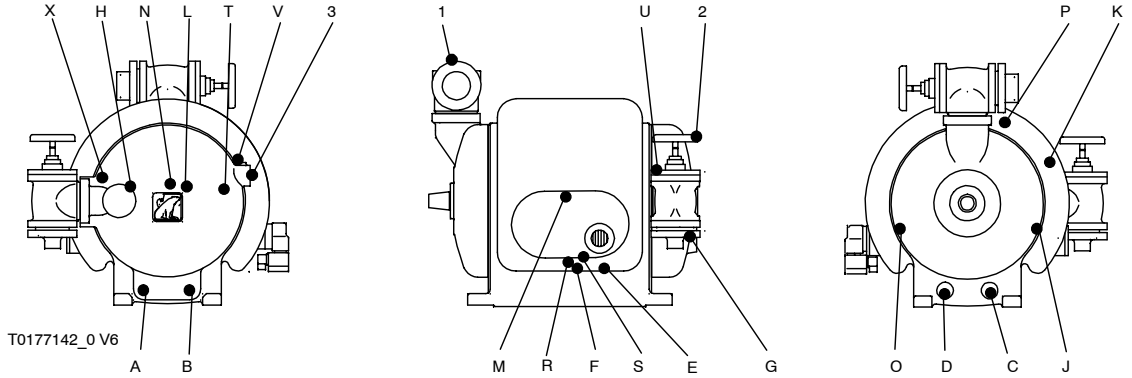
93.11

0171-339-EN

Pos.	Thread RG (INCH)	Pressure frame/ cover	Pressure connect. max.	Air-cooled/ water-cooled	Air-cooled with built-in oil-cooler	Booster with oil-cooler	Thermo-pump	Normal appilication
A	$1^1/_4$	Suction	Suction	+	+	+	+	Heating rod
B	$^3/_4$	Suction	Suction	+	+	+	+	Oil charging valve
C	$^1/_2$	Suction	Suction	Plugged	Plugged	Plugged	Plugged	Applicable for thermostat KP 98 oil temp.
D	$^1/_2$	Suction	Suction	Plugged	+	+	Plugged	Thermostat KP 77
E	$^3/_4$ - $^3/_8$	Suction	H-pressure	Plugged	+	+	Plugged	Inlet to built in oil cooler
F	$^3/_4$ - $^3/_8$	Suction	H-pressure	Plugged	+	+	Plugged	Outlet from built in oil cooler
G	$^1/_2$	H-pressure	H-pressure	Plugged	Plugged	Plugged	Plugged	Applicable for KP 98
H	$^1/_4$	H-pressure	H-pressure	+	+	+	+	Equalizing pressure for pressure gauge and pressure switch
J	$^3/_8$	Suction	H-pressure	Plugged	+	Plugged	+	Return from oil cooler/equalizing from Thermopump
K	$^1/_4$	H-pressure	H-pressure	-	-	-	+	Injection from Thermopump
L	$^1/_4$	Suction	Suction	+	+	+	+	Suction pressure to pressure gauge and pressure switch
M	$^3/_8$	Suction	-	Plugged	Plugged	Plugged	-	Available
N	$^1/_4$	Suction	-	+	+	+	+	Oil return from oil separator
O	$^1/_4$	Oil	Oil	+	+	+	+	Oil pressure to pressure gauge and pressure switch
P	$^1/_4$	L-pressure	H-pressure	-	-	+	+	Return from oil cooler (Booster)
R	$^1/_4$	H-pressure	H-pressure	-	-	-	+	Liquid supply to Thermopump
S	$^1/_4$	H-pressure	H-pressure	-	-	-	+	Equalizing to suction side from Thermo-pump

1	LP-suction stop valve	+	Is present on compressor block unit and used for
2	LP-discharge stop valve	-	Not present on compressor block

Connections on TCMO 28



Pos.	Thread RG (INCH)	Pressure in frame/ cover	Pressure connect. max.	Air-cooled/ water-cooled	Air-cooled with built-in oil cooler	Thermo-pump	Normal application
A	$1^1/_4$	Suction	Suction	+	+	+	Heating rod
B	$^3/_4$	Suction	Suction	+	+	+	Oil charging valve
C	$^1/_2$	Suction	Suction	Plugged	Plugged	Plugged	Applicable for thermostat KP 98 oil temp.
D	$^1/_2$	Suction	Suction	Plugged	+	Plugged	Thermostat KP 77
E	$^3/_4$ - $^3/_8$	Suction	H-pressure	Plugged	+	Plugged	Inlet to built-in oil cooler
F	$^3/_4$ - $^3/_8$	Suction	H-pressure	Plugged	+	Plugged	Outlet from built-in oil cooler
G	$^1/_2$	H-pressure	H-pressure	Plugged	Plugged	Plugged	Applicable for thermostat KP 98
H	$^1/_4$	H-pressure	H-pressure	+	+	+	Equilizing pressure for pressure gauge and pressure switch
J	$^3/_8$	Suction	-				Available
K	$^1/_4$	H-pressure	H-pressure	-	-	+	Injection from Thermopump
L	$^1/_4$	Suction	Suction	+	+	+	Suction pressure to pressure gauge and pressure control switch
M	$^3/_8$	Suction	-	Plugged	Plugged	-	Available
N	$^1/_4$	Suction	-	+	+	+	Oil return from oil separator
O	$^1/_4$	Oil	Oil	+	+	+	Oil pressure to pressure gauge and pressure switch
P	$^1/_4$	I-pressure	H-pressure	-	+	+	Return from oil cooler/equalizing from Thermopump
R	$^1/_4$	H-pressure	H-pressure	-	-	+	Liquid supply toThermopump
S	$^1/_4$	H-pressure	H-pressure	-	-	+	Pressure equalizing from Thermopump
T	$^1/_4$	I-pressure	I-pressure	+	+	+	Intermediate pressure to pressure gauge
U	$^3/_8$	H-pressure	H-pressure	+	+	+	By-pass outlet
V	$^3/_8$	I-pressure	H-pressure	+	+	+	By-pass inlet
X	$^1/_2$	H-pressure	H-pressure	+	+	+	TEAT injection valve

1	LP-suction stop valve	+	Is present on compressor block unit and used for
2	LP-discharge stop valve	-	Not present on compressor block
3	I-pressure stop valve		

Water cooling of the reciprocating compressor CMO 24 - 26 - 28 and TCMO 28 HPO 24 - 26 - 28

The piston compressor can be cooled with water on the top and side covers, the cooling requirement being dependent on the operating conditions and the refrigerant on which the compressor operates.

See page 1 for details.

Water cooling is obtained by mounting an extra cover (water cover) Pos. 2K/3K on the outside of top and side covers with the intervening gaskets Pos. 2L and 3L and 2P/3P in between.

Tighten top and water covers with the bolts Pos. 2C, which are longer than the bolts for the air-cooled version.
See the *Spare-parts list* at the end of this instruction manual for details.

For water cooling of the side covers, only a special finned side cover Pos. 3A is used together with a water cover Pos. 3K and a gaskets Pos. 3L and 3P. These are also listed in the spare-parts list.

The water cover, together with the cover on which it is mounted, forms a ducting system in which the water is channelled back and forth and effectively cools the top or side cover. By virtue of their large surface area, the cooling fins on the interior of the side cover Pos. 3A provide excellent cooling of the oil in the crankcase.

When dismantling top or side covers with water covers, it is a good idea first to dismantle the topmost covers on the compressor. In addition, you should ensure that the two covers are kept tight against the intervening gasket. This will prevent water flowing into the compressor block.

Fitting cooling water hoses

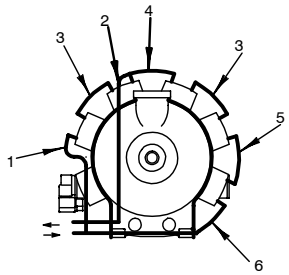
When supplied, the compressor is not fitted with cooling water hoses or appurtenant assembling parts. These are provided loose. This avoids damage to the parts in transit. Fit the cooling water hoses as shown in the following drawing, corresponding to the specification enclosed with the delivery.

Please note:

- The direction of water throughflow is shown by arrows on the drawing.
- The hose length is indicated opposite the respective Pos. nos. on the drawing.
- The hoses must not be in contact with the frame, covers, discharge pipe or similar components.

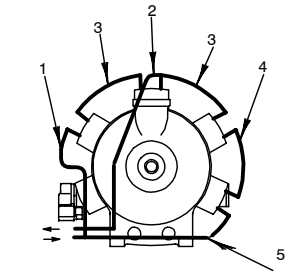
*In the supply pipe to the water system a solenoid valve must be fitted which **shuts off the water flow** in the refrigeration system at compressor standstill.*
However, we do recommend to continue the water cooling for approx. 10 mins after the compressor has been stopped as this protects the cooling water hoses against excessive temperatures

97.03
0171-333-EN



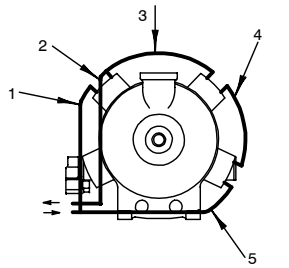
CMO 28 & TCMO 28
HPO 28

Pos.	A mm
1	365
2	610
3	150
4	205
5	230
6	590



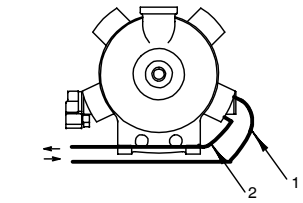
CMO 26
HPO 26

Pos.	A mm
1	370
2	705
3	275
4	190
5	575



CMO 24
HPO 24

Pos.	A mm
1	465
2	520
3	410
4	260
5	550



CMO 24-26-28

Pos.	A mm
1	710
2	590

T0177142_0 V7

Mounting of hoses for cooling water

The flow direction of the water is indicated by arrows on the sketch. The length of the hose is indicated by A-measures in the table. The hoses must not touch frame, discharge pipes or similar.

Max. permissible inlet temperature:
+40 °C

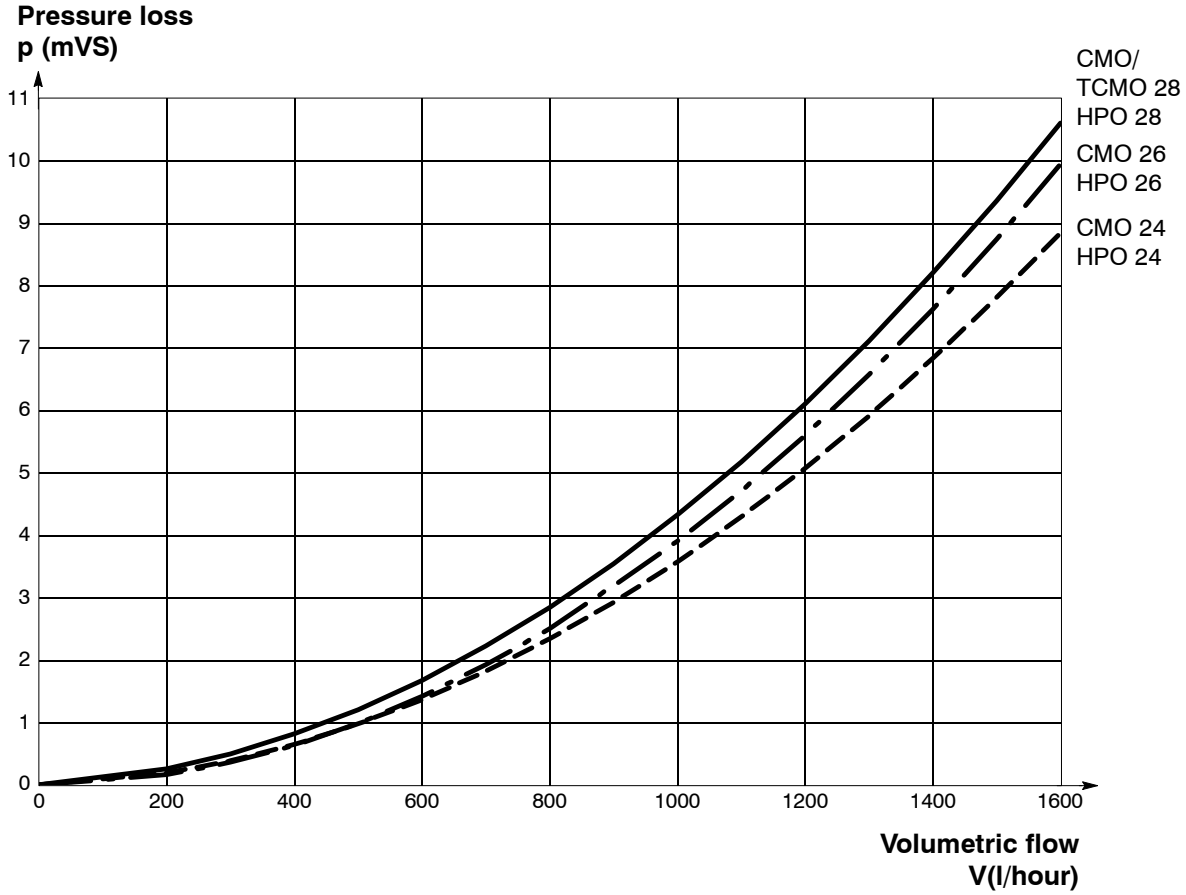
Min. permissible inlet temperature:
+10 °C

Max. permissible outlet temperature:
+55°C

Max. permissible temperature rise from inlet to outlet on the compressor: 15°C

Minimum water consumption is 5.5 litres per kW motor power.

Pressure loss in water cooling system on CMO/TCMO & HPO compressors



Reciprocating compressors used for air conditioning CMO 24-26-28 and SMC 104-106-108

When the CMO or SMC compressor is used for air conditioning, you can choose to control the compressor capacity by means of one or two KP1 pressure cut-outs.

CMO compressors are all controlled by three solenoid valves. When these are to be controlled with pressure cut-outs, cut-out **A** must be connected in parallel with solenoid valves nos. 1 and 2. Cut-out **B** must be connected with solenoid valve no. 3.

The SMC 108 must be connected in the same way as CMO.

The SMC 106 is controlled by two solenoid valves, where pressure cut-out **A** must be connected to solenoid valve no. 1 and cut-out **B** to solenoid valve no. 2.

The SMC 104 is controlled by a solenoid valve to be connected to pressure cut-out **A.** Only one cut-out is to be used for the SMC 104.

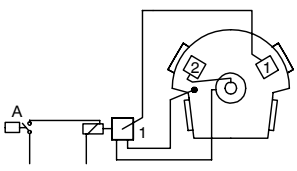
If the compressor features a solenoid valve for totally unloaded start, this must not be connected to any of the above pressure cut-outs.

Pressure cut-out **A** must be set to a close at a pressure approx. 0.5 bar higher than the setpoint for cut-out **B.**

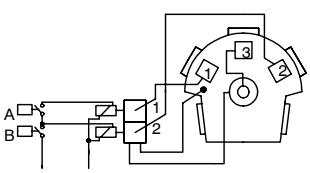
A third cut-out, the low-pressure cut-out, must be set to break at a pressure equal to the lowest evaporator temperature that can occur, however, never lower than started in section *Pressure and temperature settings*. At this temperature, the compressor must stop. This control form provides the following capacity stages:

	Capacity in %		
Capacity stage	**1**	**2**	**3**
CMO 24	100	50	25
CMO 26	100	50	35
CMO 28	100	50	25
SMC 104	100	50	–
SMC 106	100	66	33
SMC 108	100	50	25

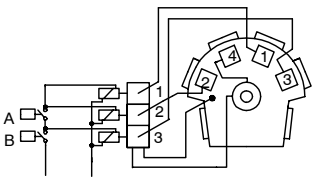
SMC 104



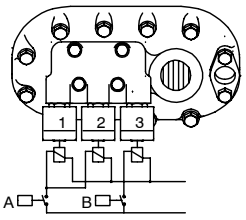
SMC 106



SMC 108



CMO



91.06
0171-348-EN

Cooling of the intermediate gas on TCMO and TSMC 100 and 180

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

Common for these intermediate cooling systems is the fact that they must cool the intermediate pressure gas sufficiently and, at the same time, ensure that no liquid is admitted into the HP stage, as liquid can produce liquid stroke in the HP cylinders and result in wear to the moving parts. It is important, therefore, to check the systems as indicated below.

Intermediate cooling system with intermediate cooler type DVEA, R717

The two-stage R717 plant may consist of two compressors, one low pressure compressor (LP) and one high pressure compressor (HP) as illustrated in fig. 1. The plant may also consist of two-stage compressors as shown in fig. 2.

In both cases the compressors are connected to an intermediate cooler in which the warm gas from the LP-stage is cooled down before it flows on to the HP-stage.

Fig. 1

CMO, SMC 100/180 compressor

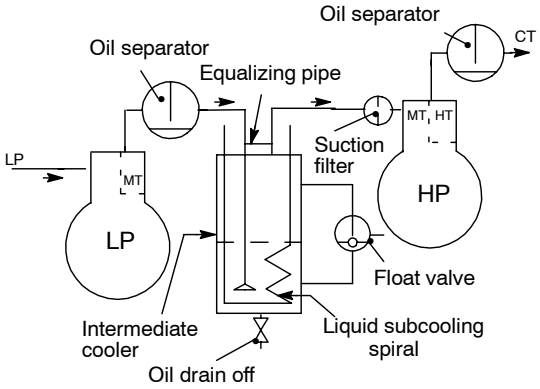
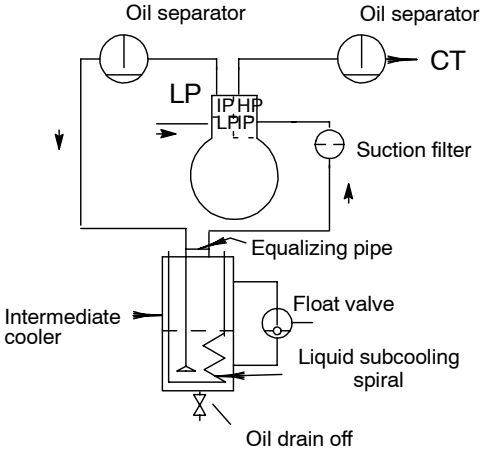


Fig. 2

TCMO, TSMC 100/180 compressor



In the intermediate cooler, the liquid level of R717 is regulated by the float valve and the discharge gas from the LP stage is cooled by bubbling up through the refrigerant from the distributor at the bottom of the intermediate cooler.

97.03
0171-359-EN

In the liquid subcooling spiral, the refrigerant flowing from the receiver to the evaporator side of the refrigeration plant is cooled. The intermediate cooler is dimensioned so that the cooled gas is free of liquid refrigerant before leaving the top of the intermediate cooler. It is important to check that the float valve is functioning correctly and keeping the liquid level constant. Frosting of the liquid level pipe on the intermediate cooler indicates the liquid level.

In order to avoid violent foaming of the liquid in the intermediate cooler, the compressor should run for a few minutes after start-up at the lowest capacity stage to stabilize plant pressures. Capacity can then be increased stage by stage at suitable time intervals.

Make sure that the equalizing pipe on the intermediate cooler has been connected. The equalizing pipe safeguards against backflow of liquid from the intermediate cooler to the LP stage of the compressor, when the compressor is not working.

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

Intermediate cooling system with liquid injection into the intermediate discharge gas, R22 and R717

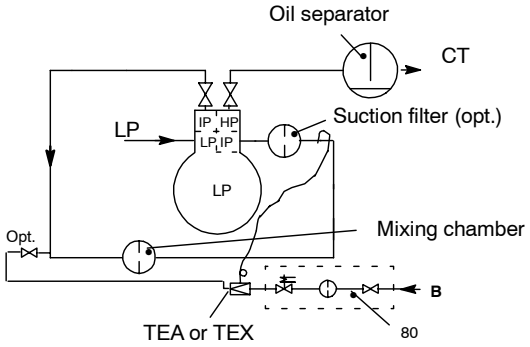
Two-stage compressors can be equipped with a pipe connection from the LP stage outlet branch to the HP stage suction branch as shown in fig. 3.

In the pipe connection the hot discharge gas from the LP stage is cooled by injection of liquid refrigerant into the intermediate pipe. This is achieved with the following systems 1 and 2:

1: Intermediate cooling with thermostatic expansion valve type:
TEA (R717) or TEX (R22)
TCMO and TSMC 100/180

Fig. 3

TCMO and TSMC



In the system in fig. 3 the liquid refrigerant conveyed to the intermediate pipe is regulated by a **thermostatic expansion valve type TEA (R717) or TEX (R22)** with a sensor placed on the intermediate pipe close to the HP stage.

A valve block pos. 80 is built into the liquid system.

Connection, **pos. B**, pipe dimension OD 10 mm, emerges from receiver or priority vessel and is conveyed to valve block pos. 80 which is the same type as the one described in section entitled: *Solenoid controlled oil return* of this instruction manual.

Please note:
that nozzle size pos. 80I must be 3.3 mm.

It is essential to make sure that the intermediate cooling system functions correctly in order to prevent too much liquid refrigerant from being injected into the IP gas.

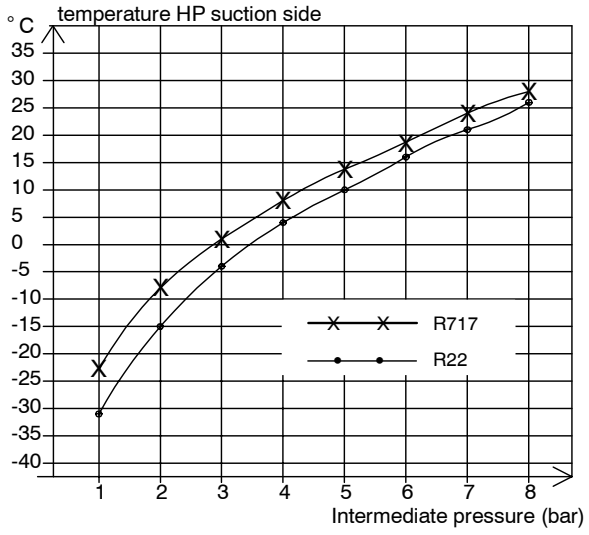
Too much liquid refrigerant may impede the evaporation of the liquid before the IP gas is sucked into the HP stage of the compressor. This may result in liquid hammer and wear and tear on moveable parts.

The expansion valve must be adjusted to superheat the intermediate gas at a temperature not below 10 K.

This is done by measuring the pressure and the temperature of the intermediate gas before it enters the compressor to the HP stage. (For this purpose SABROE has mounted an empty sensor pocket. To ensure an exact measurement the pocket can be filled with oil before the thermometer is introduced).

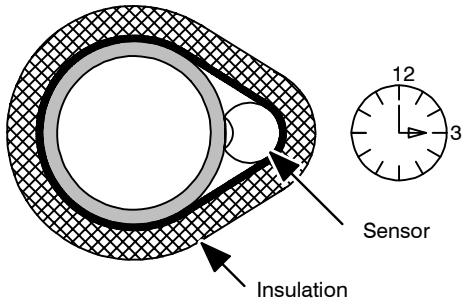
Compare the measured values with the curves in fig. 4. For any given intermediate pressure the temperature must be close to the curve, ***but never below.***

Fig. 4



Position the sensor of the expansion valve on the intermediate pressure pipe immediately before the HP-stage suction filter. The sensor must be fitted on the side of the pipe and insulated as shown in fig. 5

Fig. 5



Note:

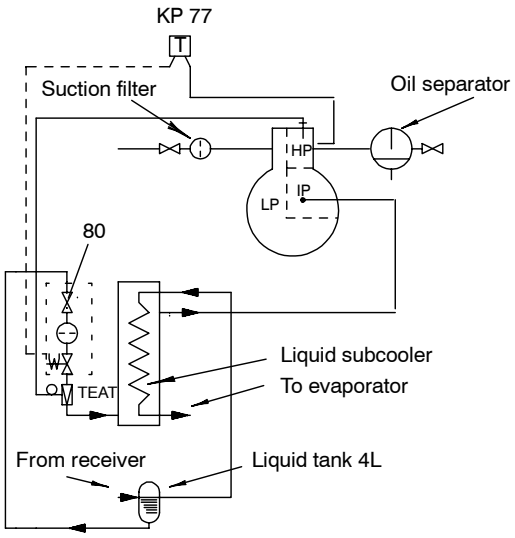
- The necessary superheat of 10 K is included in the curve, fig. 4.
- An exact measurement of the temperature cannot be read until after a stabilisation period which is not under 5 minutes for R22 and not under 15 minutes for R717.
- Before the initial adjustment of the valve it must be adjusted to its highest level to make sure that the superheat is above 10 K. Do this by turning the spindle 20 turns **clockwise** for R717 and 2.5 turns for R22. The superheat can now be regulated on the basis of measurements and the curves in fig. 4.
- The valve for R717 changes the superheat 0.5 K per rotation of the adjusting screw. The valve for R22 changes the superheat 4 K per rotation.
  By turning the adjusting screw **clockwise** the superheat is increased. By turning the screw **anti-clockwise** the superheat is reduced.
- SABROE has adjusted the valve to 10 K superheat.

2: Intermediate cooling with thermostatic injection valve type:
TEAT (R22)
TCMO and TSMC 100/180

Different systems are applied for TCMO and TSMC 100/180 as described below in **sections A and B**.

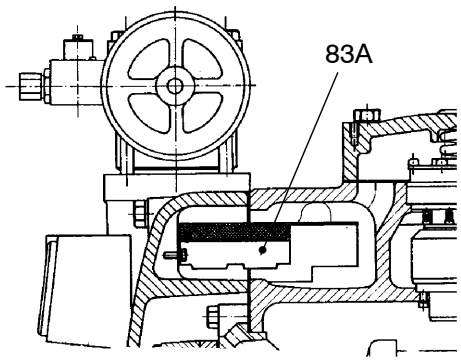
A: TCMO

Fig. 6



As illustrated in fig. 6 the intermediate gas is cooled by injecting refrigerant into the **low pressure stage pressure chamber** in the compressor. The liquid is thoroughly mixed with the hot discharge gas by means of the distributor pos. 83A as may be seen from fig. 7.

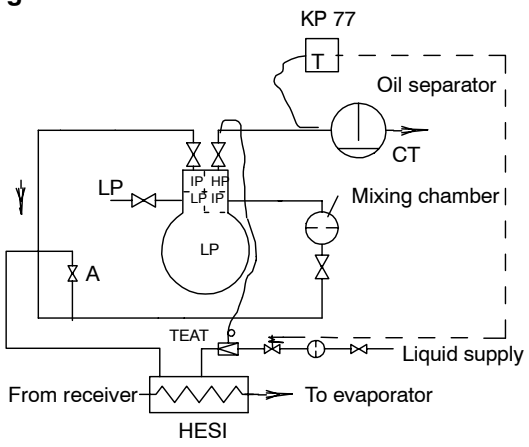
Fig. 7



For sub-cooling of liquid to the evaporators the injected liquid first passes a **liquid sub-cooler**, mounted on the compressor. The liquid injection is controlled by a TEAT valve.

B: TSMC 100/180

Fig. 8



On TSMC 100 and 180 plants, the intermediate cooling system can be designed as illustrated in fig. 8, in which the intermediate cooling is carried out by a thermostatic injection valve of the TEAT type, and in which the sub-cooling takes place in a HESI heat exchanger.

Adjusting the TEAT valve:

For both systems, A and B, the following applies:
The sensor of the TEAT valve is placed in a sensor pocket at the discharge branch of the compressor, and a proper thermal contact is obtained by means of the heat conducting compound.

The solenoid valve is opened by the KP77 thermostat whenever the temperature of the pressure pipe is above 55°C.

It is important to make sure that the intermediate cooling system functions correctly and thus prevent too much refrigerant from being injected into the intermediate pressure gas.

Excess refrigerant may lead to the liquid being unable to evaporate before the intermediate pressure gas is sucked into the HP stage of the compressor and may thus cause liquid strokes and wear to the moving parts.

When supplied, the TEAT valve is **factory set** to the following regulating temperatures:

Refrigerant	Regulating temp.
R22	75 °C
R717	75 °C

Before using the valve, the **regulating temperature** must be changed to the same value as the discharge gas temperature indicated in the table *Anticipated discharge gas temperatures* in this instruction manual.

Adjustments are made by rotating the regulating spindle clockwise, 5 turns for every 10K of temperature increase.

Example:

Refrigerant R22

Regulating temperature
factory setting 75°C

Estimated discharge
gas temperature
IT = –10°C
CT = 35°C 96°C
Superheat = 20°C

Adjustment

$$96 - 75 \times \frac{5}{10} = \underline{10.5 \text{ revolutions}}$$

Under all circumstances, the regulating temperature of the valve must be raised **at least** 10K, corresponding to 5 revolutions (clockwise).

When the plant has stabilized and the compressor is working at 100% capacity, the valve must be readjusted to the same value as the discharge temperature with the *Anticipated discharge gas temperature* in the table, within -5K to +10K. (In the example, 91°C < 96°C < 106°C)

At reduced compressor capacity, the discharge gas temperature may rise somewhat; under these circumstances it should be checked that the discharge gas temperature does not exceed the **Set point** for the KP98.

Ordering Spare Parts

When placing an order for spare parts, please state the following:

1. Shop No.

All compressors are fitted with an identification plate, which states the type and shop no. of the compressor and indicates what refrigerant is to be used.

2. Part No.

Spare parts drawings and parts lists inserted in an instruction manual identify spare parts with the following:

a) Spare part no. – which is a reference number to facilitate finding a part in the drawing and cross-referencing in the parts list or vice versa.
b) Designation of the part.
c) Part no. – a 7-digit number which refers to SABROE's stores.

When you order spare parts, please always advise at least the designation and part number. If you are in any doubt, add the spare part no. too.

3. Forwarding instructions

When ordering spares, please advise the forwarding address, and the address to which the invoice should be sent. If appropriate, please state the name of your local bank, the way in which you want the goods transported and required delivery date.

4. Classification certificate

If you require a certificate from a Classification authority, please mark the order appropriately, as the inspection and issuing procedures take extra time and incur extra expenses.

5. Quotation No.

If a quotation no. has been given during earlier correspondence, please refer to this when placing your order – it will help us to identify and execute your order quickly.

0171-466-EN 94.05

Spare parts sets for compressors and units CMO/TCMO - SMC/TSMC 100 - SMC/TSMC 180

On servicing compressor and unit it is always an advantage if you, as our customer, have some of the most commonly used spare parts at your disposal. This enables you or a summoned SABROE service engineer to carry out the necessary service work without having to spend extra time on procuring the spare parts needed.

Spare parts are obtainable in sets as mentioned in the following.
By contacting **SABROE's local representative** it is possible to receive a list of the spare part sets recommended by SABROE.

Compressor block

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

Spare part set for Basic Unit

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

97.03
0171-941-EN

Spare parts for CMO 24-26-28 & TCMO 28

	CMO 2	TCMO 2
Drawings for the compressor	0662-213	0662-214/217
Cylinder liner	0662-212	

Pos.	Designation	Weight each in kg	Number each compressor CMO 24	CMO 26	CMO 28	TCMO 28	Part no.
	Compressor frame						
1A-1	Frame CMO 24		1				3111-076
1A-2	Frame CMO 26			1			3111-077
1A-3	Frame CMO 28				1		3111-078
1A-4	Frame TCMO 28, int. IP connection					1	3111-079
1A-4	Frame TCMO 28, ext. IP connection					1	3111-088
1B-1	Non return valve	0.400	1	1	1	1	2415-031
1C-1	Hexagon plug G 3/4” with collar	0.065	1	1	1	1	2314-027
1D-1	Gasket for plug dia. 34/27 x 1,5	0.002	1	1	1	1	2356-140
1E-1	Hexagon plug with collar G 1/2”	0.128	1	1	1	1	2314-026
1F-1	Gasket for plug dia. 27/21 x 1,5	0.008	1	1	1	1	2356-133
	Top cover - air cooled						
2A-1	Top cover	2.960	2	3	4	4	3113-198
2B-1	Gasket for top cover	0.012	2	3	4	4	2353-101
2C-1	Hexagon head M12 x 70	0.080	24	36	48	48	1424-060
2D-1	Washer dia. 24/13 x 2,5	0.006	24	36	48	48	1436-075
	Top cover - water cooled (see sketch below)						
2A-1	Top cover		2	3	4	4	3113-198
2B-1	Gasket for top cover	0.012	2	3	4	4	2353-101
2C-3	Hexagon head screw M12 x 90	0.092	24	36	48	48	1424-064
2D-3	Washer dia. 24/13 x 2,5	0.006	24	36	48	48	1436-075
2K-3	Water cover		2	3	4	4	3113-166
2L-3	Gasket for water cover	0.012	2	3	4	4	2353-172
2M-3	Hexagon head screw M8 x 30	0.014	4	6	8	8	1424-169
2N-3	Chamfered washer dia. 17/8,4 x 1,6	0.002	4	6	8	8	1436-034
2P-3	Rubber cord dia. 10 x 220	0.015	2	3	4	4	1323-077

Pos.	Designation	Weight each in kg	Number each compressor CMO 24	CMO 26	CMO 28	TCMO 28	Part no.
	Side cover with oil level glass						
3A-1	Side cover - air cooled	6.830	1	1	1	1	3113-099
3B-1	Gasket for side cover	0.012	1	1	1	1	2353-101
3C-1	Hexagon head screw M12 x 65	0.070	12	12	12	12	1424-059
3D-1	Washer dia. 24/13 x 2,5	0.006	12	12	12	12	1436-075
3G-1	Oil level glass	0.220	1	1	1	1	1226-015
3H-1	O-ring dia. 52,07 x 2,62	0.002	1	1	1	1	1331-140
3J-1	Hexagon head screw M6 x 18	0.004	4	4	4	4	1424-148
	Side cover - water cooled						
3A-2	Side cover		1	1	1	1	3113-167
3B-2	Gasket for side cover	0.012	1	1	1	1	2353-172
3C-2	Hexagon head screw M12 x 50	0.052	12	12	12	12	1424-219
3D-2	Washer for dia. 24/13 x 2,5	0.006	12	12	12	12	1436-075
3K-2	Water cover		1	1	1	1	3113-166
3L-2	Gasket for water cover		1	1	1	1	2353-172
3M-2	Hexagon head screw M8 x 25	0.014	2	2	2	2	1424-168
3N-2	Washer for M8	0.002	2	2	2	2	1436-034
3P-2	Rubber cord dia. 10 x 220	0.015	1	1	1	1	1323-077
	End cover at pump						
4A-1	End cover at pump - CMO	34.500	1	1	1		3113-006
4A-2	End cover at pump - TCMO int. IP	34.500				1	3113-112
4A-2	End cover at pump - TCMO ext. IP	34.500				1	3113-214
4B-1	Gasket for end cover - CMO	0.050	1	1	1		2353-105
4B-2	Gasket for end cover - TCMO int. IP	0.056				1	2353-142
4B-2	Gasket for end cover - TCMO ext. IP	0.056				1	2353-182
4C-1	Hexagon head screw M14 x 110	0.148	14	14	14	14	1424-087
4D-1	Hexagon head screw M14 x 120	0.160	2	2	2	2	1424-090
4E-1	Washer dia. 28/16 x 3	0.008	18	18	18	18	1436-076
	Bearing cover at pump						
5A-1	Bearing cover		1	1	1	1	3113-168
5B-1	Gasket 0,3 mm	0.007	1	1	1	1	2353-166
5B-2	Gasket 0,5 mm	0.010	1	1	1	1	2353-167
5B-3	Gasket 0,8 mm	0.016	1	1	1	1	2353-168
5B-4	Gasket 1,0 mm	0.020	1	1	1	1	2353-169
5C-1	Hexagon head screw M10 x 40	0.032	8	8	8	8	1424-194
5E-1	Main bearing bushing		1	1	1	1	2132-086
5E-2	Main bearing bushing for repair - 0,5 mm undersize		1	1	1	1	2132-088

Pos.	Designation	Weight each in kg	Number each compressor				Part no.
			CMO 24	CMO 26	CMO 28	TCMO 28	
	Bearing cover at shaft end						
6A-1	Bearing cover at shaft end		1	1	1	1	3113-169
6B-1	Gasket 0,5 mm	0.010	1	1	1	1	2353-167
6C-1	Hexagon head screw M10 x 35	0.030	7	7	7	7	1424-193
6D-1	Hexagon head screw M10 x 50		1	1	1	1	1424-196
6E-1	Main bushing		1	1	1	1	2132-086
6E-2	Main bushing for repair - 0,5 mm undersize		1	1	1	1	2132-088
	End cover at shaft end						
7A-1	End cover		1	1	1	1	3113-172
7B-1	Gasket for end cover	0.022	1	1	1	1	2353-104
7C-1	O-ring dia. 132,7 x 7	0.024	1	1	1	1	1331-050
7D-1	Hexagon head screw M14 x 90	0.126	14	14	14	14	1424-083
7E-1	Hexagon head screw M14 x 160	0.208	2	2	2	2	1424-095
7F-1	Washer dia. 28/15 x 3	0.008	16	16	16	16	1436-076
7G-1	Dust strainer	0.818	1	1	1	1	3425-057
7H-1	Gasket for dust strainer dia. 326 x 8	0.074	1	1	1	1	2353-118
7J-1	Hexagon head screw M5 x 10	0.002	8	8	8	8	1424-140
7K-1	Lock washer dia. 10,5/5,3 x 0,6	0.002	8	8	8	8	1437-061
	Delivery oil pipe - internal						
9A-1	Oil pipe CMO 24	0.294	1				3141-148
9A-2	Oil pipe CMO 26	0.300		1			3141-149
9A-3	Oil pipe CMO/TCMO 28	0.310			1	1	3141-150
9B-1	O-ring dia. 18,5 x 2,62	0.003	4	4	4	4	1331-017
9C-1	Thrust ring	0.004	2	2	2	2	2351-020

Pos.	Designation	Weight each in kg	Number each compressor CMO 24	CMO 26	CMO 28	TCMO 28	Part no.
	Shaft seal type SB CMO						
	Spare parts kit:		1	1	1	1	3126-165
	Consist of:						
10A-1	Slide ring, steel		1	1	1		3126-162
10B-1	Slide ring, carbon		1	1	1	1	3126-158
10C-1	O-ring dia. 53,57 x 3,53	0.002	1	1	1	1	1331-068
10D-1	O-ring dia. 63,09 x 3,53	0.004	1	1	1	1	1331-071
8B-1	O-ring dia. 98,02 x 3,53		1	1	1	1	1331-081
10G-1	Hex. socket screw M5 x 16	0.004	4	4	4	4	1413-329
	Allen key NV - 4 x 90 x 90		1	1	1	1	1612-392
	Mounting instruction						*0171-949*
	Shaft seal complete for CMO/TCMO		1	1	1	1	3126-180
	Consist of:						
8A-1	Cover for shaft seal		1	1	1	1	3113-170
8B-1	O-ring dia. 98,02 x 3,53		1	1	1	1	1331-081
8C-1	Hex. head screw M8 x 30		5	5	5	5	1424-169
8D-1	Spring washer dia. 14,2 /8,2 x 2		5	5	5	5	1437-023
8E-1	Locking ring		1	1	1	1	3126-164
8H-1	Cylindrical pin		1	1	1	1	1446-081
10A-1	Slide ring, steel		1	1	1	1	3126-162
10B-1	Slide ring, carbon		1	1	1	1	3126-158
10C-1	O-ring dia. 53,57 x 3,53		1	1	1	1	1331-068
10D-1	O-ring dia. 63,09 x 3,53		1	1	1	1	1331-071
10F-1	Retaining flange		1	1	1	1	3126-161
10G-1	Hex. socket screw M5 x 16		4	4	4	4	1413-329
10H-1	Locking ring		1	1	1	1	3126-163
10K-1	Spring - DC 5 x 32 x dia. 1		8	8	8	8	2142-058
	Oil pump						
11 - 1	Oil pump complete *)		1	1	1	1	3141-154
11A-1	Gasket pump housing/cover		1	1	1	1	2353-170
11B-1	Socket cap screw M8 x 60	0.018	4	4	4	4	1413-364
11C-1	Pump housing		1	1	1	1	
11D-1	Cover for pump		1	1	1	1	
11E-1	O-ring dia. 75,8 x 3,5	0.004	1	1	1	1	1331-075
11F-1	Socket cap screw M6 x 16	0.006	4	4	4	4	1413-340
11G-1	Cylindrical pin dia. 6 x 36		2	2	2	2	1445-061
11J-1	Gear wheel		1	1	1	1	

Pos.	Designation	Weight each in kg	Number each compressor				Part no.
			CMO 24	CMO 26	CMO 28	TCMO 28	
11K-1	Gear wheel		1	1	1	1	
11L-1	Grooved pin dia. 6 x 24 DIN 1475		1	1	1	1	1446-032
11M-1	Dog clutch		1	1	1	1	2125-298
11N-1	Bushing for dog clutch - nylon		2	2	2	2	2132-087
	Unloading mechanism						
12 - 1	Unloading mechanism complete		4	4	8	4	3135-172
12A-1	Socket cap screw M5 x 20	0.004	8	12	16	8	1413-332
12B-1	Spring washer	0.002	8	12	16	8	1437-061
12C-1	Bottom part		4	6	8	4	3135-168
12D-1	Unloading piston		4	6	8	4	3135-169
12E-1	Unloading cylinder		4	6	8	4	3135-170
12F-1	Spring		64	84	128	64	2142-052
12G-1	Sealing ring		4	6	8	4	1332-113
12H-1	Sealing ring		4	6	8	4	1332-114
12J-1	Locking ring		4	6	8	4	3135-171

*) If the oil pump is faulty, the entire pump must be replaced

Pos.	Designation	Weight each in kg	Number each compressor CMO 24	CMO 26	CMO 28	TCMO 28	Part no.
	Crank shaft						
16 - 1	Crank shaft CMO 24 complete		1				3121-195
16 - 2	Crank shaft CMO 26 complete			1			3121-196
16 - 3	Crank shaft CMO/TCMO 28				1	1	3121-197
16C-1	Key 14 x 9 x 40	0.034	1	1	1	1	2123-003
16D-1	Plain washer	0.245	1	1	1	1	2125-040
16E-1	Hexagon head screw M12 x 40	0.070	1	1	1	1	1424-217
16F-1	Spring washer dia. 21/12.2 x 2.5	0.006	1	1	1	1	1437-081
16G-1	Spray ring	0.004	1	1	1	1	1437-255
16H-1	Plug	0.002	3	3	3	3	1413-250
16J-1	Grooved pin DIN 1474	0.015	2	2	2	2	1446-031
	Connecting rod - for CMO and TCMO LP						
17 - 1	Connecting rod complete with bolts		4	6	8	6	3123-076
17 - 2	Connecting rod complete undersize		4	6	8	6	3123-078
17C-1	Bolt for connecting rod	0.030	8	12	16	12	2111-004
17H-1	Self locking nut UNF 5/16”	0.006	8	12	16	12	1433-115
17J-1	Chamfered washer dia. 17/8,4 x 1,6	0.008	8	12	16	12	1436-034
	Connecting rod - for TCMO HP needle bearing						
17 - 3	Connecting rod complete with bolts					2	3123-077
17 - 4	Connecting rod complete undersize					2	3123-079
17C-1	Bolts for connection rod	0.030				4	2111-004
17H-1	Self locking nut UNF 5/16”	0.006				4	1433-115
17J-1	Chamfered washer dia. 17/8,4 x 1,6	0.008				4	1436-034
17K-1	Needle bearing					2	1511-272
	Piston						
18	Piston with pin and rings		4	6	8	8	3124-062
18A-1	Piston pin		4	6	8	8	3125-122
18C-1	Piston ring		4	6	8	8	3125-129
18D-1	Oil scraper ring		4	6	8	8	3125-124
18E-1	Circlip for bore dia. 22		8	12	16	16	1437-138

Pos.	Designation	Weight each in kg	Number each compressor CMO 24	CMO 26	CMO 28	TCMO 28	Part no.
	Cylinder liner with suction valve - See drawing 0662-212						
19 - 1	Cylinder liner complete - CMO and TCMO LP - R717 for capacity regulation		4	6	8	6	3112-077
19 - 2	Cylinder liner complete - TCMO LP/HP - R717 without capacity regulation					2	3112-079
19 - 4	Cylinder liner complete - CMO and TCMO LP - HFC for capacity regulation		4	6	8	6	3112-076
19 - 5	Cylinder liner complete - TCMO LP/HP - HFC/HCFC without capacity regulation					2	3112-078
19A-1	Cylinder liners LP/HP - R717/HFC/HCFC		4	6	8	8	3112-075
19B-1	Unloading pin		24	36	48	36	2122-023
19C-1	Spring for unloading pin		24	36	48	36	2142-034
19F-1	Ring plate for suction valve		4	6	8	8	3131-072
19G-1	Valve spring		16	24	32	32	2141-047
19H-1	Suction valve retaining plate R717		4	6	8	8	3132-075
19H-2	Suction valve retaining plate HFC		4	6	8	8	3132-073
19J-1	Socket cap screw M5 x 25		24	36	48	48	1413-333
19K-1	Gasket 0,5 mm		4	6	8	8	2356-288
19K-2	Gasket 0,8 mm		4	6	8	8	2356-289
19M-1	O-ring dia. 72,69 x 2,62					2	1331-147
	Discharge valve						
20 - 1	Discharge valve complete R717		4	6	8	8	3136-080
20 - 2	Discharge valve complete HFC/HCFC		4	6	8	8	3136-079
20A-1	Valve seat		4	6	8	8	3133-008
20B-1	Valve retaining plate R717		4	6	8	8	3132-074
20B-2	Valve retaining plate HFC/HCFC		4	6	8	8	3132-072
20C-1	Ring plate for discharge valve		4	6	8	8	3131-006
20D-1	Counter sunk screw M8 x 40		4	6	8	8	1413-106
20E-1	Nut M8		8	12	16	16	1432-063
20F-1	Spring guide		4	6	8	8	2145-011
20H-1	Valve spring		24	36	48	48	2141-047
20J-1	Spring washer		4	6	8	8	1437-054

Pos.	Designation	Weight each in kg	Number each compressor CMO 24	CMO 26	CMO 28	TCMO 28	Part no.
	Spring for safety head						
21	Spring		4	5	8	8	2142-059
	Oil pressure valve						
21 - 1	Oil pressure valve - complete	0.450	1	1	1	1	3142-150
22A-1	Gasket	0.001	1	1	1	1	2354-075
	Oil charging valve for HFC/HCFC refrigerant						
23 - 1	Oil charging valve	0.300	1	1	1	1	1374-132
23A-1	Union nut 3/4" flare	0.005	1	1	1	1	1376-012
23B-1	Seal cap 1/2"	0.002	1	1	1	1	1376-042
23C-1	Bushing G 3/4" x G 3/8"	0.140	1	1	1	1	2312-007
23D-1	Gasket dia. 34/27 x 1,5	0.001	1	1	1	1	2356-140
	for R717 refrigerant						
23A-2	Oil charging valve - complete	0.300	1	1	1	1	2412-585
23B-2	Threaded reducing nipple	0.155	1	1	1	1	2311-059
23C-2	Socket	0.075	1	1	1	1	2313-035
23D-2	Gasket	0.001	1	1	1	1	2356-123
23E-2	Gasket	0.001	1	1	1	1	2356-140
23F-2	Gasket	0.001	1	1	1	1	2356-283
23G-2	Nut	0.060	1	1	1	1	2313-027
	By-pass valve						
24 - 1	By-pass valve dia. 20 24 bar	2.400	1	1	1		3137-011
24 - 2	By-pass valve dia. 20 22 bar	2.400	1	1	1		3137-012
24 - 3	By-pass valve dia. 10 24 bar	0.850				1	3137-013
24 - 4	By-pass valve dia. 10 22 bar	0.850				1	3137-034
24C-1	O-ring for cylinder dia. 44,05 x 3,5	0.006	1	1	1		1331-065
24C-4	O-ring for cylinder dia. 25,07 x 2,5	0.004				1	1331-131
24E-1	O-ring for cover dia. 56,75 x 3,5	0.006	1	1	1		1331-069
24E-4	O-ring for cover dia. 32,99 x 2,6	0.004				1	1331-133
24G-1	Hexagon head screw M6 x 25	0.006	5	5	5		1424-153
24G-4	Hexagon head screw M4 x 16	0.002				5	1424-135
24H-1	Spring washer dia. 11,1/6,1 x 1,6	0.002	5	5	5		1437-022
24H-4	Spring washer dia. 7,1/4,1 x 0,9	0.001				5	1437-020

Pos.	Designation	Valve dim. dia.	Weight each in kg	Number each valve	Part no.
	Stop valve				
25 - 1	Complete valve - discharge	40		1	2414-066
25 - 2	complete valve - suction	50		1	2414-067
25A-1	Valve housing	40		1	2432-156
25A-2	Valve housing	50		1	2432-157
25B-1	Valve bonnet	40-50	1.760	1	2433-028
25C-1	Front part for cone	40-50	0.098	1	2444-090
25D-1	Rear part for cone	40-50	0.180	1	2444-091
25E-1	Screw for cone	40-50	0.054	1	2444-017
25F-1	Gasket for screw	40-50	0.002	1	2356-138
25G-1	Threaded connection	40-50	0.180	1	2445-053
25H-1	Sealing ring dia. 62/45 x 3	40-50	0.010	1	2354-003
25J-1	O-ring for bonnet dia. 72,4 x 5,3	40-50	0.010	1	1331-154
25K-1	Spindle	40-50	0.234	1	2442-023
25L-1	Lock washer	40-50	0.010	1	2445-019
25M-1	Packing gland complete with o-rings	40-50	0.152	1	2452-073
25N-1	Guide pin dia. 5 x 10	40-50	0.002	1	1446-085
25P-1	O-ring dia. 21,8 x 3,5	40-50	0.002	1	1331-020
25Q-1	Nylon washer dia. 39,5/28 x 1,5	40-50	0.002	1	2354-018
25R-1	O-ring dia. 17,12 x 3,5	40-50	0.002	2	1331-016
25S-1	Hand wheel dia. 120	40-50	0.164	1	1365-036
25T-1	Screw for hand wheel	40-50	0.002	1	1424-140
25U-1	Washer for hand wheel	40-50	0.004	1	1436-024
25Y-1	Gasket for welding nipple	40-50	0.008	1	2356-087
25Z-1	Screw valve/compressor M12 x 130	40	0.116	4	1424-072
25Z-2	Screw valve/compressor M14 x 130	50	0.160	4	1424-091
25AC-1	Counter flange	40-50	1.162	1	2344-091
25AD-1	Welding nipple dia. 40		0.992	1	2322-100
25AD-2	Welding nipple dia. 50		0.856	1	2322-102
25AD-3	Welding nipple dia. 65		0.838	1	2322-103
25AG-1	Gasket valve/compressor	40	0.014	1	2356-212
25AG-2	Gasket valve/compressor	50	0.018	1	2356-213
25AJ-1	Screw bonnet/valve M10 x 25	40-50	0.024	8	1424-191
25AK-1	Screw for counter flange M10 x 40	40-50	0.032	6	1424-194

Pos.	Designation	Weight each in kg	Number each compressor CMO 24	CMO 26	CMO 28	TCMO 28	Part no.
	Suction and oil pressure gauge						
30 - 1	R12/R22 bar and °C	0.700	1	1	1	1	1541-251
30 - 2	R502 bar and °C	0.700	1	1	1	1	1541-365
30 - 3	R717 bar and °C	0.700	1	1	1	1	1541-109
30 - 4	R134a/R404A bar and °C	0.700	1	1	1	1	1541-071
	Discharge pressure gauge						
31 - 1	R12/R22 bar and °C HP	0.700	1	1	1		1541-191
31 - 2	R12/R22 bar and °C IP-HP	0.700				1	1541-278
31 - 3	R502 bar and °C HP	0.700	1	1	1		1541-364
31 - 4	R502 bar and °C IP-HP	0.700				1	1541-366
31 - 5	R717 bar and °C HP	0.700	1	1	1		1541-050
31 - 6	R717 bar and °C IP-HP	0.700				1	1541-103
31 - 7	R134a/R404A bar and °C HP	0.700	1	1	1		1541-072
31 - 8	R134a/R404A bar and °C IP-HP	0.700				1	1541-073
	Bracket for gauge						
39 - 1	Bracket	1.000	1	1	1	1	3146-015
39A-1	Hexagon head screw M5 x 6	0.002	4	4	4	4	1424-140
39B-1	Spring washer	0.002	4	4	4	4	1437-061
	Cooling water connections						
40A-1	Set of hoses for cooling water 4 cyl.		1				3185-226
40A-2	Set of hoses for cooling water 6 cyl.			1			3185-227
40A-3	Set of hoses for cooling water 8 cyl.				1	1	3185-228
40A-4	Set of hoses SIDE COVER only						3185-229
	Parts for instruments						
41A-1	Gasket dia. 19/14 x 1,5	0.001	6	6	6	8	2356-124
41B-1	Connecting piece - 2 pipes	0.025	2	2	2	2	2333-012
41C-1	Plug for connecting piece	0.040	3	3	3	4	2314-048
41D-1	Union nut - R12 - R22 - R502	0.003	5	5	5	6	1376-010
41E-1	Union nut M10 x 0,75 - R717	0.010	5	5	5	6	1349-011
41F-1	Gasket dia. 9/3 x 1 - R717	0.001	5	5	5	6	2356-117
41H-1	Gasket dia. 14,5/6 x 1,5	0.001	2	2	2	2	2356-120
41J-1	Connecting piece - 1 pipe	0.015				1	2333-014
41Q-1	Pipe holder	0.004	1	1	1	1	1377-096
41R-1	Cylinder head screw M4 x 6	0.002	1	1	1	1	1412-200
41T-1	Pipe section with flare	0.006	7	7	7	7	2333-016
41U-1	Connecting piece - 3 pipes	0.017	1	1	1	1	2333-013
	Purge valve						
42A-1	Purge valve complete	0.300	1	1	1	1	2412-585

Pos.	Designation	Weight each in kg	Number each compressor CMO 24	CMO 26	CMO 28	TCMO 28	Part no.
42B-1	Threaded nipple						
42C-1	Cutting ring	0.135	1	1	1	1	1349-062
42D-1	Nut						
42E-1	Nut	0.070	1	1	1	1	2313-045
42F-1	Connection pipe with collar	0.025	1	1	1	1	2334-027
42G-1	Gasket	0.001	2	2	2	2	2356-123
42H-1	Nut	0.060	1	1	1	1	2313-027
	Parts for mounting pressure control						
44A-1	Bracket for pressure controls		1	1	1	1	2213-409
44B-1	Counter sunk screw M6 x 12	0.020	2	2	2	2	1413-090
44C-1	Bracket for KP77 or KP1		1	1	1	1	2213-411
44D-1	Bracket for KP98		1	1	1	1	2213-410
44E-1	Socket cap screw M6 x 12	0.004	4	4	4	4	1413-339
44F-1	Spring washer	0.006	4	4	4	4	1437-022
44G-1	Cylinder head screw M4 x 6	0.002	8	8	8	8	1412-200
44H-1	Spring washer dia. 7,1/4 x 1	0.002	8	8	8	8	1437-020
	Pressure controls for HFC/HCFC						
45A-1	Pressure control KP15 A	0.532	1	1	1	1	1373-135
45B-1	Differential pressure control MP55	0.864	1	1	1	1	1373-159
	for R717						
45A-2	Pressure control KP15 A	0.754	1	1	1	1	1373-142
45B-2	Differential pressure control MP55 A	0.978	1	1	1	1	1373-162
	Temperature controls						
46A-1	Temperature control KP77	0.466	1	1	1	1	1373-044
46B-1	Temperature control KP98	0.674	1	1	1	1	1373-043
46C-1	Phil pocket for temperature control	0.162	3	3	3	3	1377-171
46D	Gasket for phil pocket dia. 27/21 x 1,5	0.008	3	3	3	3	2356-133
	Coupling						
48A-1	Disc pack	0.282	2	2	2	2	1524-155
48B-1	Bolt	0.054	16	16	16	16	1524-163
48C-1	Level washer	0.004	16	16	16	16	1524-179
48D-1	Lock nut	0.006	16	16	16	16	1524-171
	Crankcase heater						
57A-4	Crankcase heater 270W, 115V, G 1 1/4		1	1	1	1	3181-034
57A-5	Crankcase heater 270W, 230V, G 1 1/4		1	1	1	1	3181-035

Pos.	Designation	Weight each in kg	Number each compressor CMO 24	CMO 26	CMO 28	TCMO 28	Part no.
57A-6	Crankcase heater 270W, 250V, G 1 1/4		1	1	1	1	3181-036
57B-2	Sealing ring dia. 42/49 x 6,5	0.022	1	1	1	1	1349-213
	Bracket for oil filter						
59A-1	Bracket for oil filter		1	1	1	1	3421-081
59B-1	Socket screw M8 x 35	0.018	2	2	2	2	1413-359
59C-1	Gasket for bracket		1	1	1	1	2353-171
59D-1	Plug		1	1	1	1	1413-265
	Oil filter Complete 4524-052						
60A	Filter element		1	1	1	1	1517-124
60B	Gasket for filter		1	1	1	1	1334-025
60H	Washer dia. 19/8,2 x 6		1	1	1	1	2114-036
60J	Iron ring		3	3	3	3	2114-038
60K	Magnets		3	3	3	3	1517-022
60L	Rod for magnets		1	1	1	1	2112-156
60M	Rubber ring		1	1	1	1	1334-012
60N	Washer		1	1	1	1	1436-034
60P	Locking nut		1	1	1	1	1433-073
	Oil pipes for unloading mechanism						
	CMO 24						
62A-1	Pipe set	0.200	1				3143-292
	CMO 26						
62A-2	Pipe set	0.114		1			3143-291
	CMO 28						
62A-3	Pipe set	0.108			1		3143-290
	TCMO 28						
62A-4	Pipe set	0.108				1	3143-293
	Joint for oil pipes						
62F	Spirolox-ring RS 50	0.002	4	4	4	4	1437-275
62G	O-ring dia. 9,25 x 1,78	0.001	4	4	4	4	1331-010
62H	O-ring 7,65 x 1,78	0.001	4	6	8	4	1331-009
	Oil separator CMO 2 - HFC/HCFC						
65 - 1	Oil separator - complete		1	1	1		4241-208
65A-1	Housing		1	1	1		4241-207
65B-1	Demister		1	1	1		1375-288
65C-1	End cover		1	1	1		3422-114
65D-1	O-ring for 65C		1	1	1		1331-089
65E-1	Hexagon head screw M16 x 45		4	4	4		1424-102

Pos.	Designation	Weight each in kg	Number each compressor CMO 24	CMO 26	CMO 28	TCMO 28	Part no.
65F-1	Spring washer		4	4	4		1437-057
65G-1	Gasket against compr. dia. 100/62 x 1,5		1	1	1		2356-212
65H-1	Hexagon head screw M12 x 40		4	4	4		1424-217
65J-1	Stop valve complete		1	1	1		2414-066
65K-1	Gasket for stop valve dia. 100/62 x 1,5		1	1	1		2356-212
65L-1	Hexagon head screw M12 x 120		4	4	4		1424-069
	Oil separator CMO 2 - R717						
65 - 2	Oil separator - complete		1	1	1		4241-230
65G-2	Gasket against compr. dia. 100/62 x 1,5		1	1	1		2356-212
65H-2	Hexagon head screw M12 x 40		4	4	4		1424-217
65J-2	Stop valve SCV 40D 111		1	1	1		2411-840
	Oil separator TCMO 2 - R717 - HFC/HCFC						
65 - 3	Oil separator - complete					1	4241-233
65A-3	Housing					1	4241-232
65B-3	Demister					1	1375-295
65C-3	End cover					1	3254-315
65D-3	O-ring dia. 91,97 x 3,5	0.004				1	1331-080
65E-3	Hexagon head screw M12 x 35	0.042				4	1424-216
65F-3	Spring washer	0.004				4	1437-081
65G-3	Gasket against compr. dia. 100/62 x 1,5					1	2356-212
65H-3	Hexagon head screw M12 x 40	0.046				1	1424-217
65J-3	Stop valve complete					1	2414-066
65K-3	Gasket for stop valve dia. 100/62 x 1,5	0.014				1	2356-212
65L-3	Hexagon head screw M12 x 120	0.116				1	1424-069
	Extra suction filter - only delivered on demand						
66 - 1	Extra suction filter complete		1	1	1	1	4521-030
66A-1	Filter housing		1	1	1	1	3421-063
66B-1	End cover	2.310	1	1	1	1	3422-103
66C-1	O-ring dia. 91,67 x 3,53	0.004	1	1	1	1	1331-080
66D-1	Hexagon head screw M12 x 40	0.046	4	4	4	4	1424-217
66E-1	Spring washer dia. 20,2/12,2 x 2,5	0.004	4	4	4	4	1437-081
66F-1	Strainer filter	0.374	1	1	1	1	3425-082
66G-1	Filter bag	0.028	1	1	1	1	3425-083
66H-1	Insert for filter bag	0.032	1	1	1	1	3424-058

Pos.	Designation	Weight	Number each compressor				Part no.
		each in kg	CMO 24	CMO 26	CMO 28	TCMO 28	
66J-1	O-ring dia. 75,56 x 5,33	0.004	1	1	1	1	1331-042
66K-1	Hexagon head screw M14 x 45	0.070	4	4	4	1	1424-242
66L-1	Gasket against compr. dia. 112/70 x 1,5	0.018	1	1	1	1	2356-213
	Oil cooler R717						
76A-1	Angle swivel screw-joint dia. 3/8”/12	0.180	1	1	1	1	1349-091
76B-1	Bushing G 3/4” x G 3/8”		2	2	2	2	2312-022
76C-1	Gasket dia. 32/27 x 1,5	0.008	2	2	2	2	2356-139
76D-1	Straight swivel-in joint	0.070	2	2	2	2	1349-053
76E-1	Angle swivel screw-in joint	0.170	1	1	1	1	1349-091
76F-1	Straight screw-in joint	0.058	1	1	1	1	1349-054

Pos.	Designation	Weight each in kg	Number each compressor CMO 24	CMO 26	CMO 28	TCMO 28	Part no.
	Oil cooler HFC/HCFC						
76A-2	Angle swivel screw-joint dia. 3/8"/10	0.178	1	1	1	1	1349-090
76B-2	Bushing G 3/4" x G 3/8"		2	2	2	2	2312-022
76C-2	Gasket dia. 32/27 x 1,5	0.008	2	2	2	2	2356-139
76D-2	Straight screw-in joint	0.070	2	2	2	2	1349-053
76E-2	Angle swivel screw-in joint	0.170	1	1	1	1	1349-091
76F-2	Angle swivel screw-in joint	0.170	1	1	1	1	1349-091
80	Solenoide valve blok, complete with 0,6 mm orifice for oil return. excl. coil	2.040	1	1	1	1 or 2	1372-179
	Strainer kit consist of:		1	1	1	1 or 2	1372-089
80E	Strainer						
80G	Al-gasket						
	Service kit consist of:		1	1	1	1 or 2	1372-086
80P	Armature tube						
80H	Armature						
80K	O-ring						
80M	O-ring						
80L	Al-gasket						
80N	Snap fastener						
	Seal kit consist of:		1	1	1	1 or 2	1372-091
80G	Al-gasket						
80K	O-ring						
80M	O-ring						
80L	Al-gasket						
80Q	Al-gasket						
	Orifice kit 0,6 mm consist of:		1	1	1	1 or 2	1371-034
80L	Al-gasket						
80Q	Al-gasket						
80I	Orifice 0,6 mm						
	Orifice kit 0,8 mm consist of:		1	1	1	1 or 2	1371-035
80L	Al-gasket						
80Q	Al-gasket						
80I	Orifice 0,8 mm						
	Orifice kit 1,0 mm consist of:		1	1	1	1 or 2	1371-036
80L	Al-gasket						
80Q	Al-gasket						
80I	Orifice 1,0 mm						

Pos.	Designation	Weight each in kg	Number each compressor CMO 24	CMO 26	CMO 28	TCMO 28	Part no.
	Orifice kit 3,3 mm (for thermopump only) **consist of:**		1	1	1	1 or 2	1371-037
80L	Al-gasket						
80Q	Al-gasket						
80I	Orifice 3,3 mm						
80J-1	Coil 220/230V, 50/60 Hz, 10 W	0.285					1372-537
80J-2	Coil 110 V, 50/60 Hz, 10 W	0.285					1372-538
80J-3	Coil 240 V, 50 Hz, 10 W	0.285					1372-539
80J-4	Coil 24 V, 50 Hz, 10 W	0.285					1372-541
	Injection system for TCMO						
	Only for TCMO with int. IP system						
83A-1	Guard	0.968				1	3116-048
83B-1	Nipple	0.156				1	3116-041
83C-1	O-ring dia. 25 x 3,5 for 83B	0.012				1	1331-022
83D-1	O-ring dia. 20,2 x 3,5 for 83B	0.009				1	1331-019
83E-1	Socket cap screw M6 x 16	0.006				2	1413-340
83F-1	Spring washer 11,1/6,1 x 1,6	0.004				2	1437-022
83G-1	Stop valve DN 20 with oval flange	1.800				1	2412-016
83H-1	Gasket for stop valve dia. 44/33 x 1,5	0.002				1	2356-039
83J-1	Hexagon head screw M12 x 40	0.045				2	1424-217
83K-1	Stop valve SG 6	0.540				1	2413-010
83L-1	Gasket for valve dia. 18/10 x 1,5	0.006				2	2356-123
83M-1	Filter complete					1	4522-002
83M-2	Insert for filter					1	3425-097
83N-1	Solenoid valve without coil	0.688				1	1372-423
83S-1	Coil 220/230V, 50/60Hz, 10W	0.260					1372-537
83S-2	Coil 110V, 50/60Hz, 10W	0.260					1372-538
83S-3	Coil 240V, 50Hz, 10W	0.260					1372-539
83P-1	Injection valve TEAT 20-5 - R22	2.460				1	1371-242
83P-2	Injection valve TEAT 20-5 - R717	2.460				1	1371-240
	Spec. spring for 83P-2	0.018				1	1523-070
83Q-1	Solenoid valve for by-pass, without coil	0.822				1	1372-423
83T-1	Coil 220/230V, 50/60Hz, 10W	0.260					1372-537
83T-2	Coil 110V, 50/60Hz, 10W	0.260					1372-538
83T-3	Coil 240V, 50Hz, 10W	0.260					1372-539
83R-1	Non-return valve for discharge pipe	2.958				1	1372-249

Pos.	Designation	Weight each in kg	Number each compressor CMO 24	CMO 26	CMO 28	TCMO 28	Part no.
	Side cover with solenoid valves for capacity control						
86A-1	Side cover with oil level glass	10.760	1	1	1	1	3113-134
86B-1	Gasket for side cover	0.014	1	1	1	1	2353-102
86C-1	Hexagon head screw M12 x 65	0.070	10	10	10	10	1424-059
86D-1	Hexagon head screw M12 x 75	0.078	2	2	2	2	1424-061
86E-1	Oil level glass	0.230	1	1	1	1	1226-015
86F-1	O-ring for oil level glass, dia. 52,07 x 2,62	0.002	1	1	1	1	1331-140
86G-1	Hexagon head screw M6 x 18	0.006	4	4	4	4	1424-148
86H-1	Valve body with 3 solenoid valves, without coils	3.690	1	1	1	1	3143-413
86X-1	Coil 220/230V, 50/60Hz, 10W	0.260					1372-537
86X-2	Coil 110V, 50/60Hz, 10W	0.260					1372-538
86X-3	Coil 240V, 50Hz, 10W	0.260					1372-539
86Y	Solenoid valve - Service kit for one solenoid valve	3.690					1372-424
86J-1	Gasket for valve body	0.010	1	1	1	1	2353-185
86J-2	Gasket for valve body for ex-exelution	0.010	1	1	1	1	2353-188
86K-1	Hexagon head screw M8 x 70	0.030	4	4	4	4	1424-042
86N-1	Washer dia. 24/13 x 2,5	0.006	12	12	12	12	1436-036
86P-1	Plug connector for coils		3	3	3	3	1372-545
86Q-1	Valve for prelubrication		1	1	1	1	2412-585
86R-1	Nut		1	1	1	1	2313-045
86s-1	Special joint		1	1	1	1	2334-027
86T-1	Cap		1	1	1	1	2313-027
86U-1	Joint 3/8”		1	1	1	1	1349-053
86V-1	Alu-gasket		1	1	1	1	2356-123
	Side cover for unloading start						
86A-1	Side cover with oil level glas	10.760	1	1	1	1	3113-134
86B-1	Gasket for side cover	0.014	1	1	1	1	2356-102
86C-1	Hexagon head screw M12 x 6	0.070	10	10	10	10	1424-059
86D-1	Hexagon head screw M12 x 75	0.078	2	2	2	2	1424-061
86E-1	Oil level glas	0.230	1	1	1	1	1226-015
86F-1	O-ring dia. 52,07 x 2,62	0.002	1	1	1	1	1331-140
86G-1	Hexagon head screw M6 x 18	0.006	4	4	4	4	1424-149
87K-1	Cover for unloading start	0.805	1	1	1	1	3143-187
87L-1	Gasket for cover	0.008	1	1	1	1	2353-149
87M-1	Hexagon head screw M8 x 35	0.016	4	4	4	4	1424-170

Pos.	Designation	Weight each in kg	Number each compressor				Part no.
			CMO 24	CMO 26	CMO 28	TCMO 28	
86N-1	Washer dia. 24/13 x 2,5	0.006	12	12	12	12	1436-036
86Q-1	Valve for prelubrication		1	1	1	1	2412-585
86R-1	Nut		1	1	1	1	2313-045
86S-1	Special joint		1	1	1	1	2334-027
86T-1	Cap		1	1	1	1	2313-027
86U-1	Joint 3/8”		1	1	1	1	1349-053
86V-1	Alu-gasket		1	1	1	1	2356-123
	Intermediate pressure connection						
	Only for TCMO with ex. system						
90A-1	IP champer R22					1	3114-100
90A-2	IP champer R717					1	3114-101
90B-1	IP pipe					1	3114-102
90C-1	Filter strainer					1	2464-232
90D-1	O-ring					2	1331-019
90E-1	Flange for cover					1	
90F-1	Insert for cover					1	
90H-1	O-ring					1	1331-024
90H-1	Screw					4	1424-191
90J-1	Gasket					1	2353-180
90K-1	Screw					4	1424-194
90L-1	Nut					4	1432-064
90M-1	Washer					8	1436-035
	Oil return with solenoid valve						
	Only for CMO with HFC/HCFC						
94A-1	Cover against oil separator		1	1	1		4241-229
94B-1	O-ring dia. 82,15 x 3,5	0.004	1	1	1		1331-077
94C-1	Hexagon head screw M8 x 18	0.012	8	8	8		1424-164
94D-1	Spring washer	0.006	8	8	8		1437-054
94E-1	Straight screw-in joint GE 6-SR 1/4”	0.054	1	1	1		1349-124
94F-1	Stop valve BML 6	0.280	1	1	1		1374-050
94G-1	Straight screw-in joint GE 10-LR 1/4”	0.048	1	1	1		1349-051
94H-1	Filter	0.054	1	1	1		4522-002
94J-1	Straight screw-in joint GE 8-LR 1/4”	0.044	1	1	1		1349-050
94K-1	Welding nipple	0.018	1	1	1		2322-032
94L-1	Gasket	0.006	2	2	2		2356-123
94M-1	Nozzle 0,6 mm	0.002	1	1	1		3142-035
94N-1	Union nut	0.080	1	1	1		2313-006
94P-1	Bushing G 1/4” x G 1/2”	0.072	1	1	1		2312-013

Pos.	Designation	Weight each in kg	Number each compressor CMO 24	CMO 26	CMO 28	TCMO 28	Part no.
94Q-1	Angle swivel screw-in joint 1/4” NPT	0.120	2	2	2		1349-089
94R-1	Straight screw-in joint GE 8-LR 1/4”	0.020	1	1	1		1349-106
94S-1	Solenoid valve without coil	0.624	1	1	1		1372-422
94U-1	Coil 220/230V, 50/60Hz, 10W	0.260					1372-537
94U-2	Coil 110V, 50/60Hz, 10W	0.260					1372-538
94U-3	Coil 240V, 50Hz, 10W	0.260					1372-539
94T-1	Screw-in joint 1/4” NPT for dia. 10	0.046	1	1	1		1349-060
	Oil return with solenoid valve						
	Only for CMO with R717						
94A-2	Cover against oil separator		1	1	1		3254-066
94B-2	Gasket for cover	0.020	1	1	1		2355-105
94C-2	Hexagon head screw M12 x 30	0.042	6	6	6		1424-215
94D-2	Straight screw-in joint	0.102	1	1	1		1349-089
94E-2	Nipple	0.044	1	1	1		2334-024
94F-2	Union nut	0.080	2	2	2		2313-006
94G-2	Gasket for nipple/valve	0.006	4	4	4		2356-123
94H-2	Stop valve		1	1	1		2413-010
94J-2	Welding nipple	0.018	1	1	1		2322-032
94K-2	Angle swivel screw-in joint G 1/4”	0.098	2	2	2		1349-087
94L-2	Filter complete		1	1	1		4522-002
94M-2	Nozzle 0,5 mm	0.002	1	1	1		3142-034
94P-2	Nipple G 1/4” x G 1/2”	0.082	1	1	1		2311-040
94Q-2	Straight screw-in joint 1/4” NPT	0.042	1	1	1		1349-056
94S-2	Solenoid valve without coil	0.624	1	1	1		1372-422
94U-1	Coil 220/230V, 50/60Hz, 10W	0.260					1372-537
94U-2	Coil 110V, 50/60Hz, 10W	0.260					1372-538
94U-3	Coil 240V, 50Hz, 10W	0.260					1372-539
	Oil return with solenoid valve						
	Only for TCMO with R717 and HFC/HCFC						
94A-3	Cover against oil separator					1	
94B-3	O-ring dia. 91,67 x 3,53	0.004				1	1331-080
94C-3	Hexagon head screw M12 x 40	0.046				4	1424-217
94D-3	Spring washer 20,2/12,2 x 2,5	0.004				4	1437-081
94E-3	Angle swivel screw-joint	0.102				1	1349-087
94F-3	Nipple	0.044				1	2334-024
94G-3	Union	0.080				3	2313-006
94H-3	Gasket for nipple/valve	0.006				4	2356-123
94J-3	Welding nipple	0.018				2	2322-032

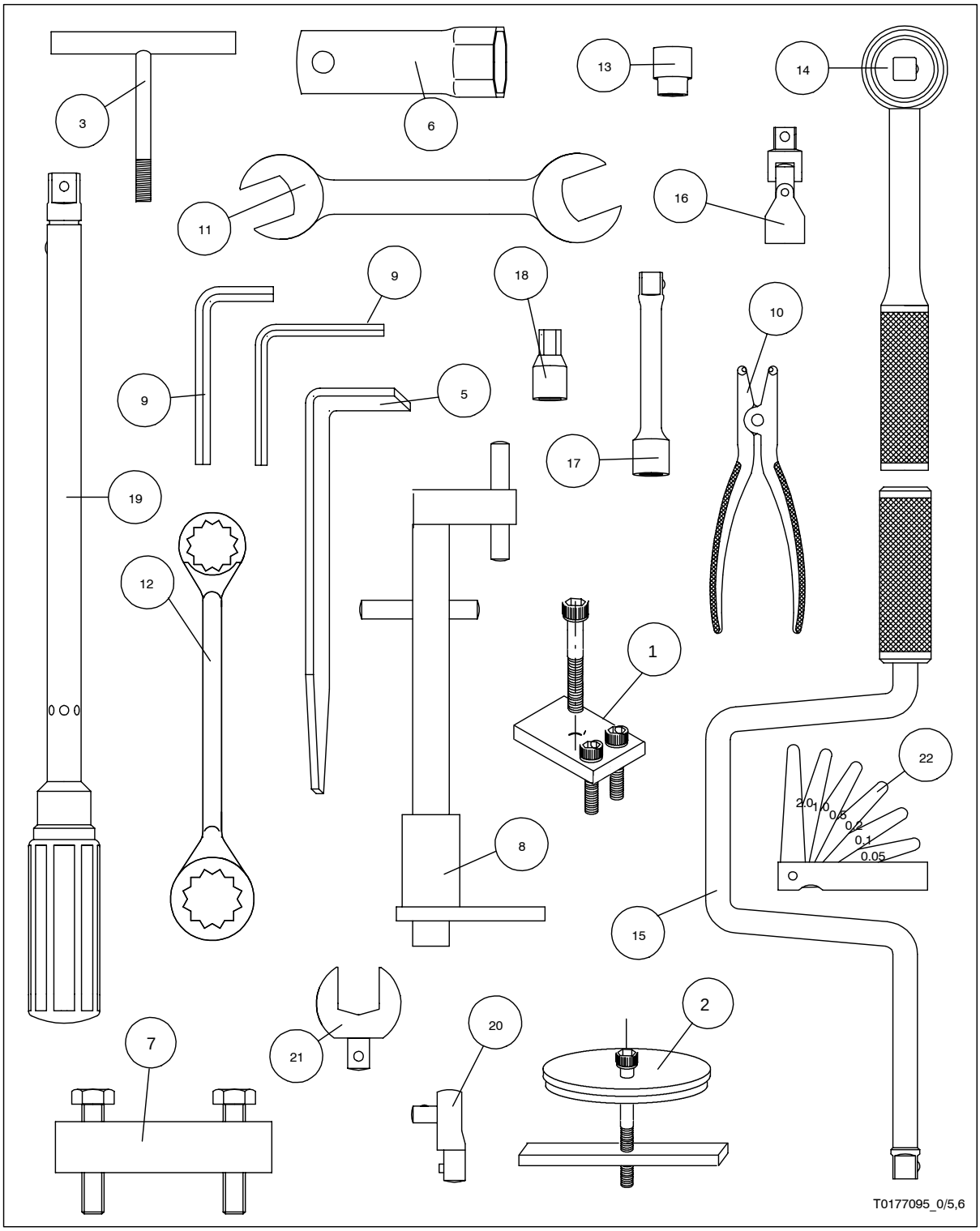
Pos.	Designation	Weight each in kg	Number each compressor CMO 24	CMO 26	CMO 28	TCMO 28	Part no.
94K-3	Angle swivel screw-in joint G 1/4”	0.098				2	1349-087
94L-3	Filter complete					1	4522-002
94M-3	Nipple G 1/4” x G 1/2”	0.082				1	2311-040
94N-3	Gasket dia. 19/14 x 1,5	0.004				2	2356-124
94P-3	Nozzle 0,4 mm - only for R717	0.002				1	3142-033
94P-3	Nozzle 0,5 mm - only for HFC/HCFC	0.002				1	1342-034
94Q-3	Straight screw-in joint 1/4” NPT	0.042				2	1349-056
94S-3	Solenoid valve without coil	0.624				1	1372-422
94U-1	Coil 220/230V, 50/60Hz, 10W	0.260					1372-537
94U-2	Coil 110V, 50/60Hz, 10W	0.260					1372-538
94U-3	Coil 240V, 50Hz, 10W	0.260					1372-539
94	Stop valve					1	2413-010
	Oil return with float valve						
	Only for CMO with HFC/HCFC						
95A-1	Cover against oil separator	0.626	1	1	1		3411-007
95B-1	O-ring dia. 82,15 x 3,5 for 95A	0.004	1	1	1		1331-077
95C-1	Hexagon head screw M8 x 18	0.012	8	8	8		1424-164
95D-1	Sprig washer	0.006	8	8	8		1437-054
95E-1	Float valve complete	0.200	1	1	1		1374-505
95F-1	Distance ring dia. 10/8 x 8	0.002	1	1	1		2212-036
95G-1	Hexagon head screw M5 x 35	0.006	2	2	2		1413-334
95H-1	Angle swivel G 1/4” for dia. 6		1	1	1		1349-092
	Oil return with float valve						
	Only for CMO with R717						
95A-2	Cover against oil separator		1	1	1		4512-003
95B-2	Gasket for cover		1	1	1		2355-108
95C-2	Filter		1	1	1		3425-077
95D-2	Hexagon head screw M12 x 30		6	6	6		1424-215
95E-2	Angle swivel screw-in joint		2	2	2		1349-092
	Oil return with float valve						
	Only for TCMO with R717 and HFC/HCFC						
95A-3	Cover with float valve					1	4512-004
95B-3	O-ring dia. 91,67 x 3,53	0.004				1	1331-080
95C-3	Hexagon head screw M12 x 40	0.046				4	1424-217
95D-3	Spring washer dia. 20,2/12,2 x 2,5	0.004				4	1437-081
95E-3	Angle swivel screw-in joint					2	1349-092

Pos.	Designation	Weight each in kg	Number each compressor CMO 24	CMO 26	CMO 28	TCMO 28	Part no.
	Thermopump						
98A-1	Side cover for thermopump		1	1	1	1	3113-133
98B-1	Monitor box		1	1	1	1	1553-215
	Allen screw		2	2	2	2	1412-204
	Spring washer		4	4	4	4	1437-020
98C-1	Level indicator		2	2	2	2	3185-038
98D-1	Outer part for level indicator		2	2	2	2	3185-034
98E-1	Washer dia. 20/13 x 1,5 Al		3	3	3	3	2356-125
98F-1	Rubber cap		2	2	2	2	1554-194
98G-1	Solenoid valve without coil		1	1	1	1	1372-422
98H-1	Solenoid valve without coil		1	1	1	1	1372-423
98AB-1	Coil 220/230V, 50/60Hz, 10W	0.260					1372-537
98AB-2	Coil 110V, 50/60Hz, 10W	0.260					1372-538
98AB-3	Coil 240V, 50Hz, 10W	0.260					1372-539
98K-1	Check valve		2	2	2	2	1364-008
98M-1	VA-joint with nozzle 0,6 mm					1	2314-100
	Plug connector for coils		1	1	1	1	1372-490
98M-2	VA-joint with nozzle 1,2 mm		2	3	4		2314-097
	Bracket for stop valve		1	1	1	1	2213-085
	Allen screw M4 x 12		2	2	2	2	1412-203
	Cable binder		1	1	1	1	1554-053
	Straight joint 10 mm		1	1	1	1	1349-051
	T-joint 10 mm		2	3	4	1	1349-041
	Straight joint 6 mm		3	3	3	3	1349-006
	Socket 10 mm NPT		1	1	1	1	1349-101
	Angle swivel joint 10 mm BSP		1	1	2	1	1349-177
	Angle joint 10 mm		2	2	2	2	1349-089
	Angle swivel joint 6 mm					1	1349-092
	Angle joint 10 mm		1	1	2	1	1349-033
	Reducing socket 3/8” - 1/4”		1	1	1		1349-076
	Straight joint 10 mm NPT		2	2			1349-060
	Angle socket 10 mm		1				1349-112
	Washer 18/10 x 1,5 Al		2	2	2		2356-123
	Washer 25/17 x 1,5 Al		1	1	1		2356-130
	Washer 19/14 x 1,5 Al		2	2	2	2	2356-124
	Spring washer for M12		1	1	1		1437-026
	Plug			1	1		2314-048
	Pipe for pressure equalizing		1	1	1		3185-033

Pos.	Designation	Weight	Number each compressor				Part no.
		each in kg	CMO 24	CMO 26	CMO 28	TCMO 28	
98N-1	Filter		1	1	1	1	4522-002
98P-1	Stop valve		1	1	1	1	2412-277
98Q-1	Cooling cover		1	1	1	1	3113-171
98R-1	Washer dia. 29/21 x 1,5 Al		2	2	2	2	2356-136
98S-1	Gasket for side cover		1	1	1	1	2353-101
98T-1	Hexagon head screw M12 x 75		14	14	14	14	1424-061
	Socket 1/4”		1	1	1	1	1349-101
98U	Solenoid valve without coil						1372-423
98V	Solenoid valve without coil		1	1	1		1372-423
98AB-1	Coil 220/230V, 50/60Hz, 10W	0.260	1	1	1	1	1372-537
98AB-2	Coil 110V, 50/60Hz, 10W	0.260					1372-538
98AB-3	Coil 240V, 50Hz, 10W	0.260					1372-539
98X	PT100 sensor		1	1	1	1	1373-253
98Y	Stop valve		1	1	1	1	2412-277
98Z	Non-return valve		1	1	1	1	1364-022
98AA	Screw joint		1	1	1	1	2314-105
	UNISAB						
99A-1	Support for UNISAB		1	1	1	1	2213-500
99B-1	Distance washers		4	4	4	4	2212-130
99C-1	Screw for support M10 x 20		2	2	2	2	1424-190
99D-1	Screw for UNISAB M6 x 20		4	4	4	4	1424-152
99E-1	Washers dia. 22/7		4	4	4	4	1436-025

98.02

Tools for compressor
CMO 24-26-28 Mk2 & TCMO 24-26-28 Mk2



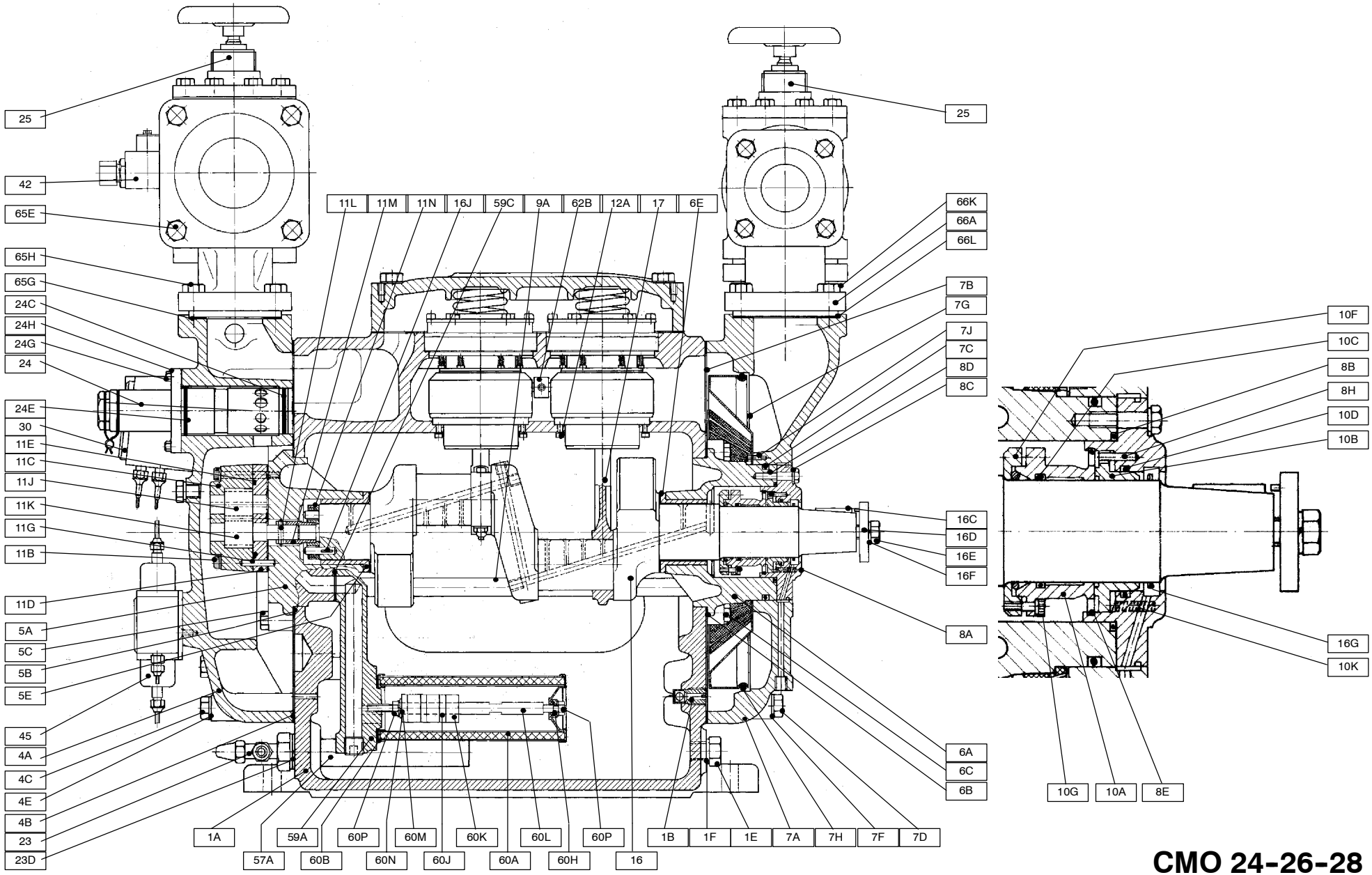
Tools for compressor
CMO and TCMO

Line no. A600 = Normal set
Line no. A601 = Extended set
Line no. A602 = Tools for coupling AMR
Line no. A603 = Tools for alignment of flexible coupling

Pos no	Designation	Dim	Part no	Line no A600	Line no A601	Line no A602	Line no A603
1	Clamp with screw		3183-141	4	4		
2	Tools for shaft seal		3183-139	1	1		
3	Tommy screws for cyl. liners		3183-041	2	2		
5	Supporting plate for pistons		3181-114	8	8		
6	Spanner for heating cartridge	JV55	3183-060	1	1		
7	Puller for coupling or belt pulley		3183-058	1	1		
8	Adjustment jig for couping		3183-104				1
9-1	Wrench for socket cap screw	JV2			1		
9-2	Wrench for socket cap screw	JV3			1		
9-3	Wrench for socket cap screw	JV4			1		
9-4	Wrench for socket cap screw	JV5			1		
9-5	Special wrench for shaft seal		1612-392		1		
10	Retaining ring pliers	J21			1		
11-1	Ring and open spanner	JV10	1612-392		1		
11-2	Ring and open spanner	JV13			1		
11-3	Ring and open spanner	JV17			1		
11-4	Ring and open spanner	JV27			1		
12-1	Ring spanner	JV6X7			1		
12-2	Ring spanner	JV8X9			1		
13-1	Socket wrench	JV10			1		
13-2	Socket wrench	JV13			1		
13-3	Socket wrench	JV17			1		
13-4	Socket wrench	JV19			1		
13-5	Sockte wrench	JV22			1		
13-6	Socket wrench	JV24			1		
13-7	Socket wrench	JV1/2			1	1	
14	Ratchet handle				1		
15	Speed handle				1		
16	Universal joint for socket wrench				1		

Pos no	Designation	Dim	Part no	Line no A600	Line no A601	Line no A602	Line no A603
17-1	Extension rod for socket wrench				1		
17-2	Extension rod for socket wrench				1		
18	Screw driver socket				1		
19-1	Torque wrench 15-90 Nm				1	1	
19-2	Torque wrench 40-200 Nm				1		
20	Coupler for torque wrench				1	1	
21	Open spanner for torque wrench	JV1/2			1	1	
22	Feeler gauge						1

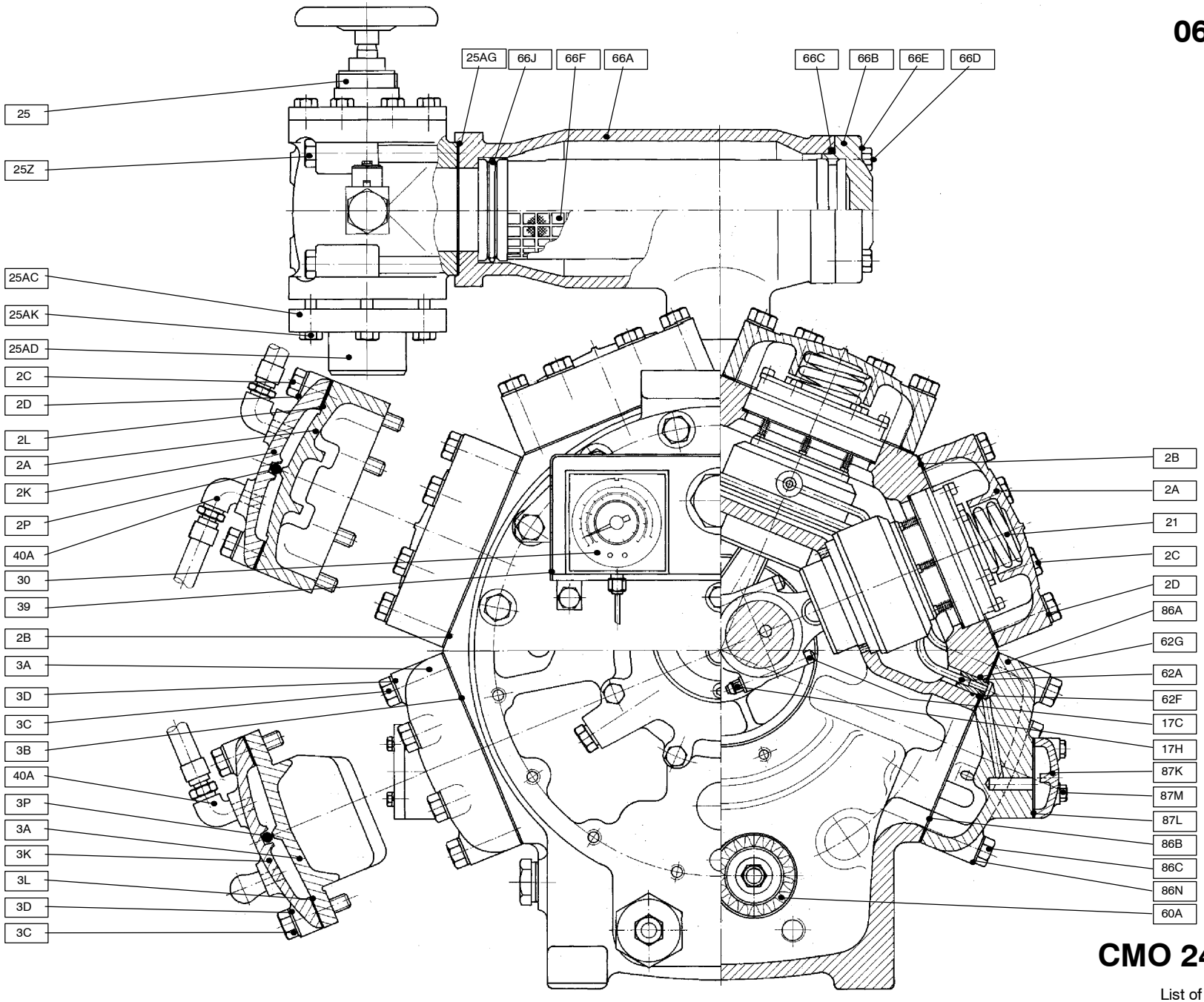
0662-213



CMO 24-26-28

List of parts 0662-215

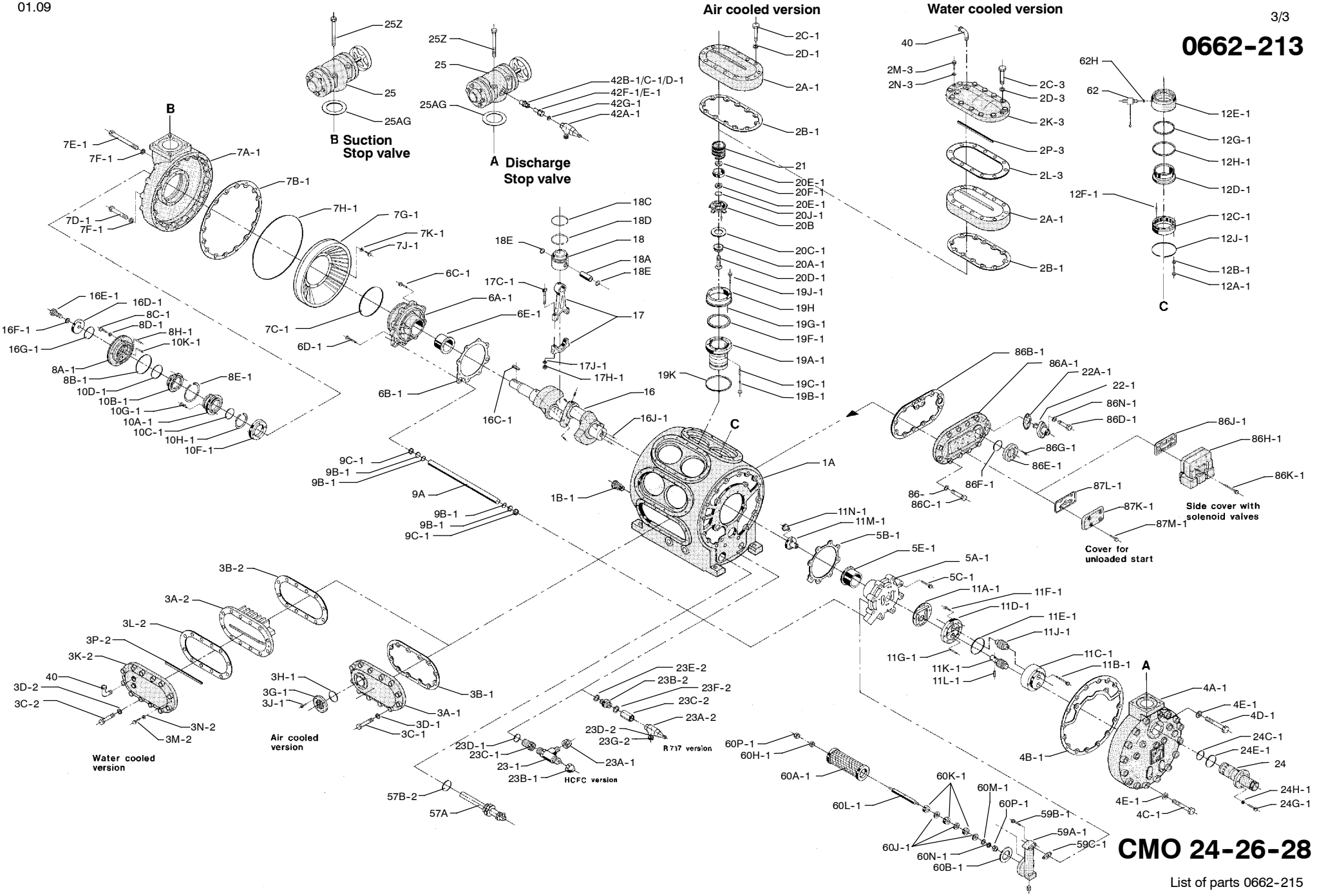
0662-213



CMO 24-26-28

List of parts 0662-215

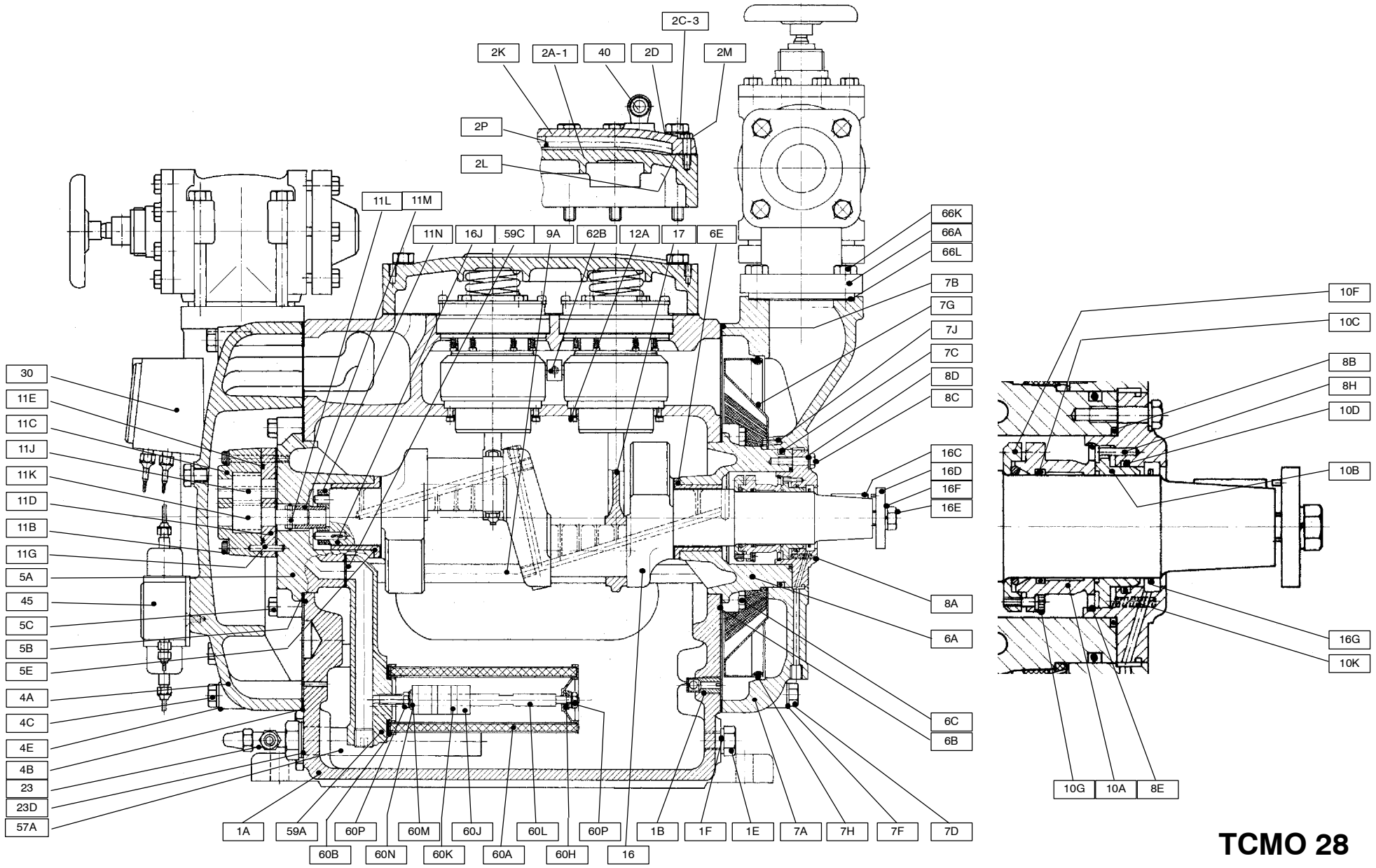
0662-213



CMO 24-26-28

List of parts 0662-215

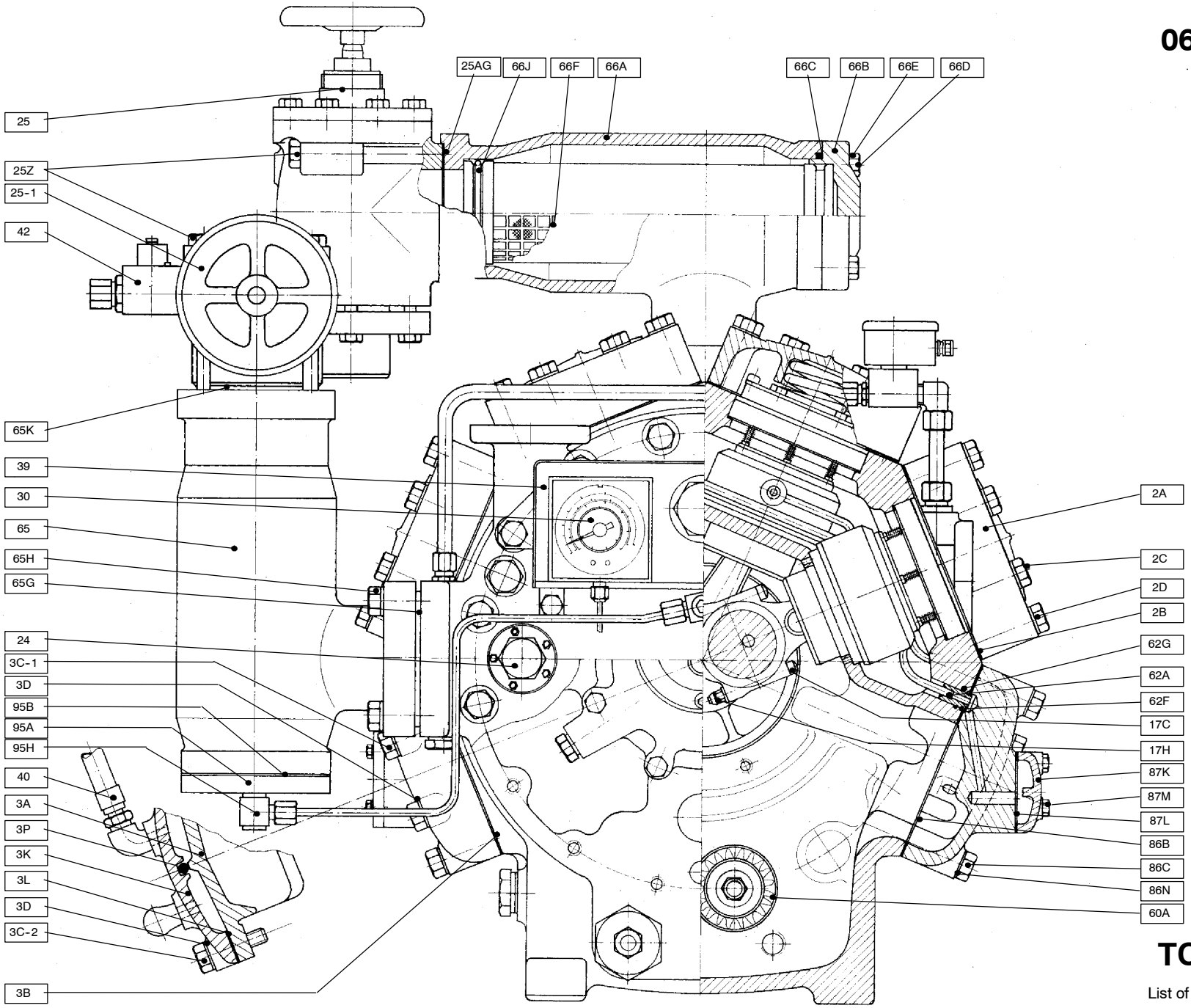
0662-217



TCMO 28

List of parts 0662-215

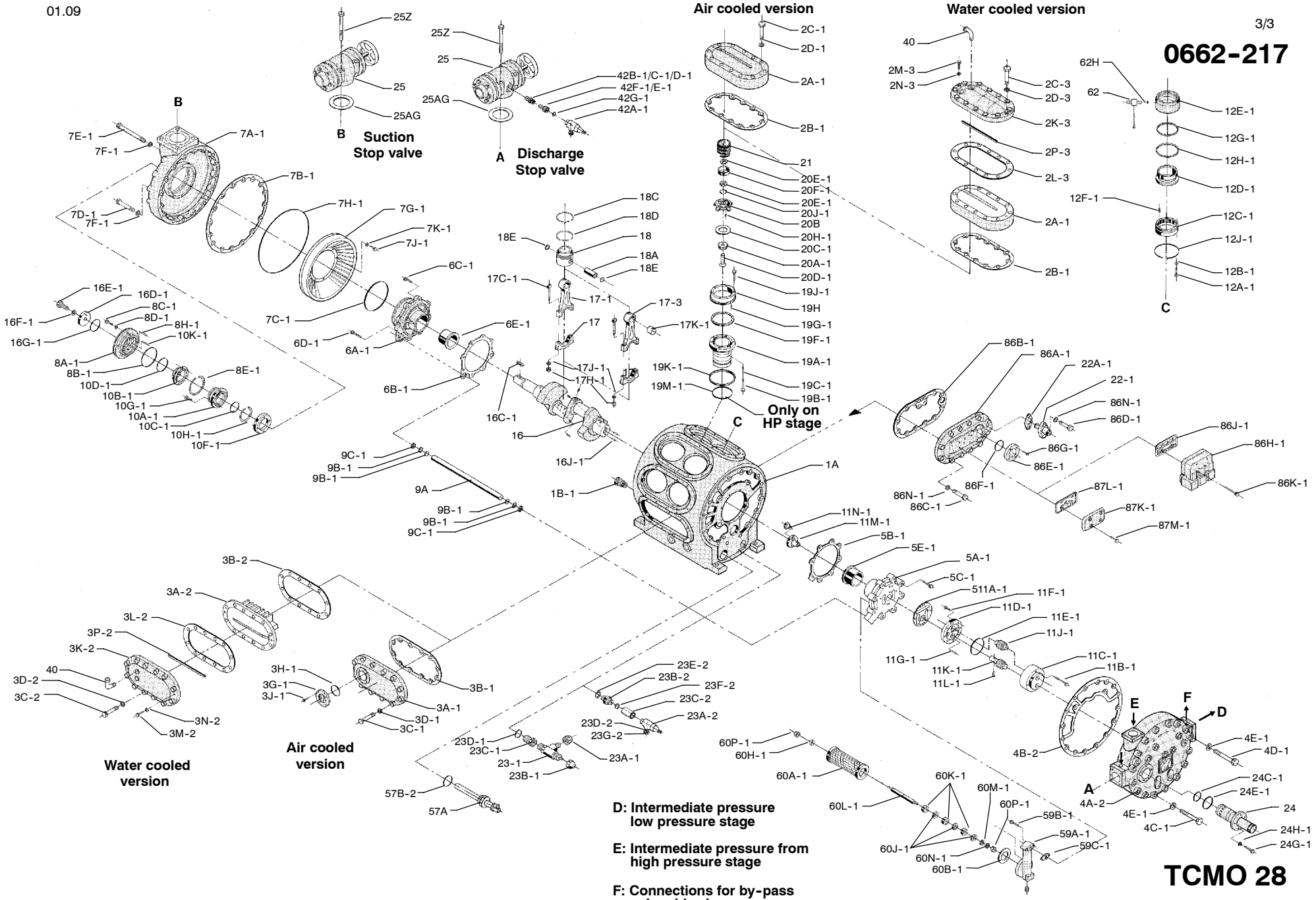
0662-217



TCMO 28

List of parts 0662-215

0662-217



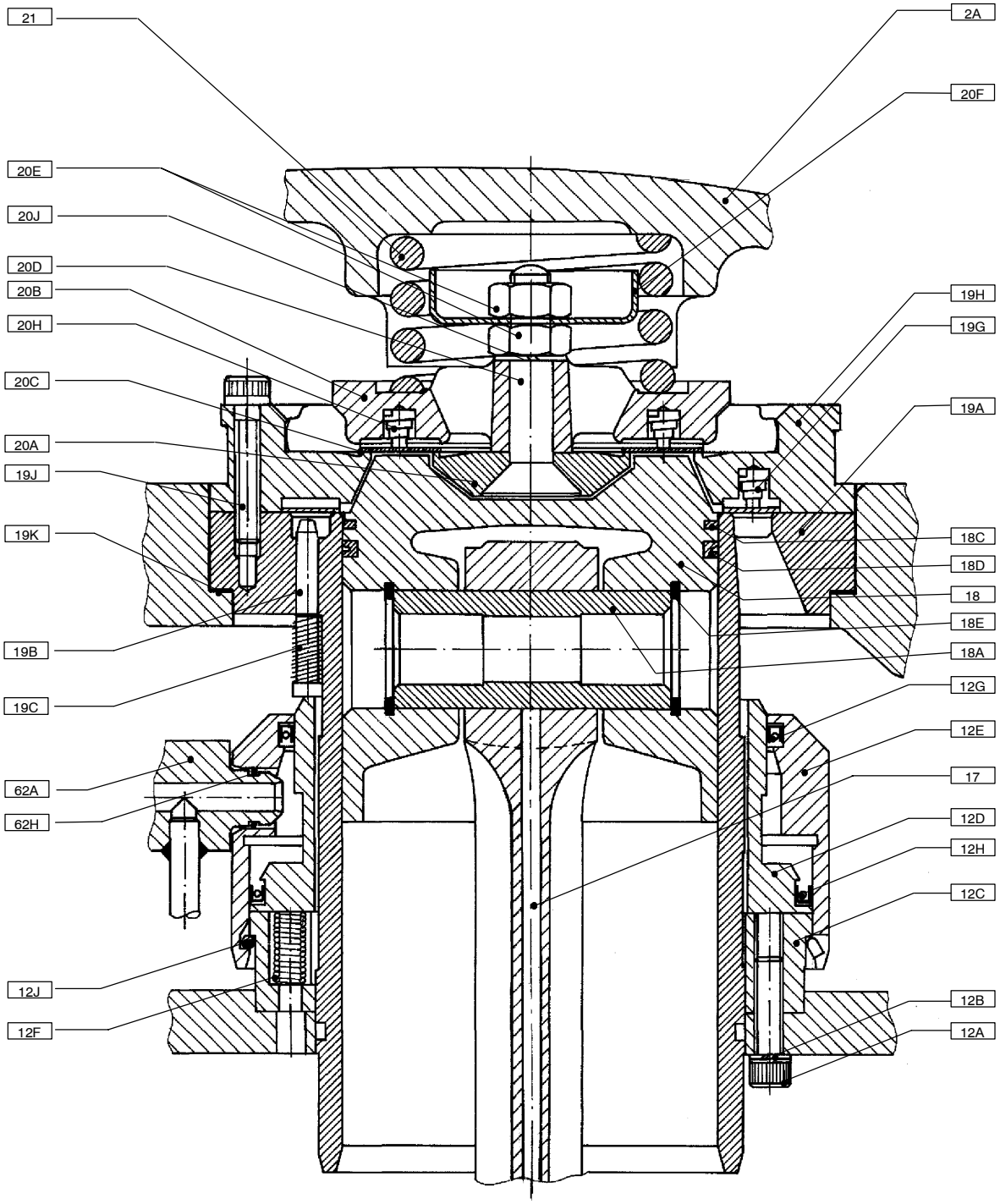
TCMO 28

List of parts 0662-215

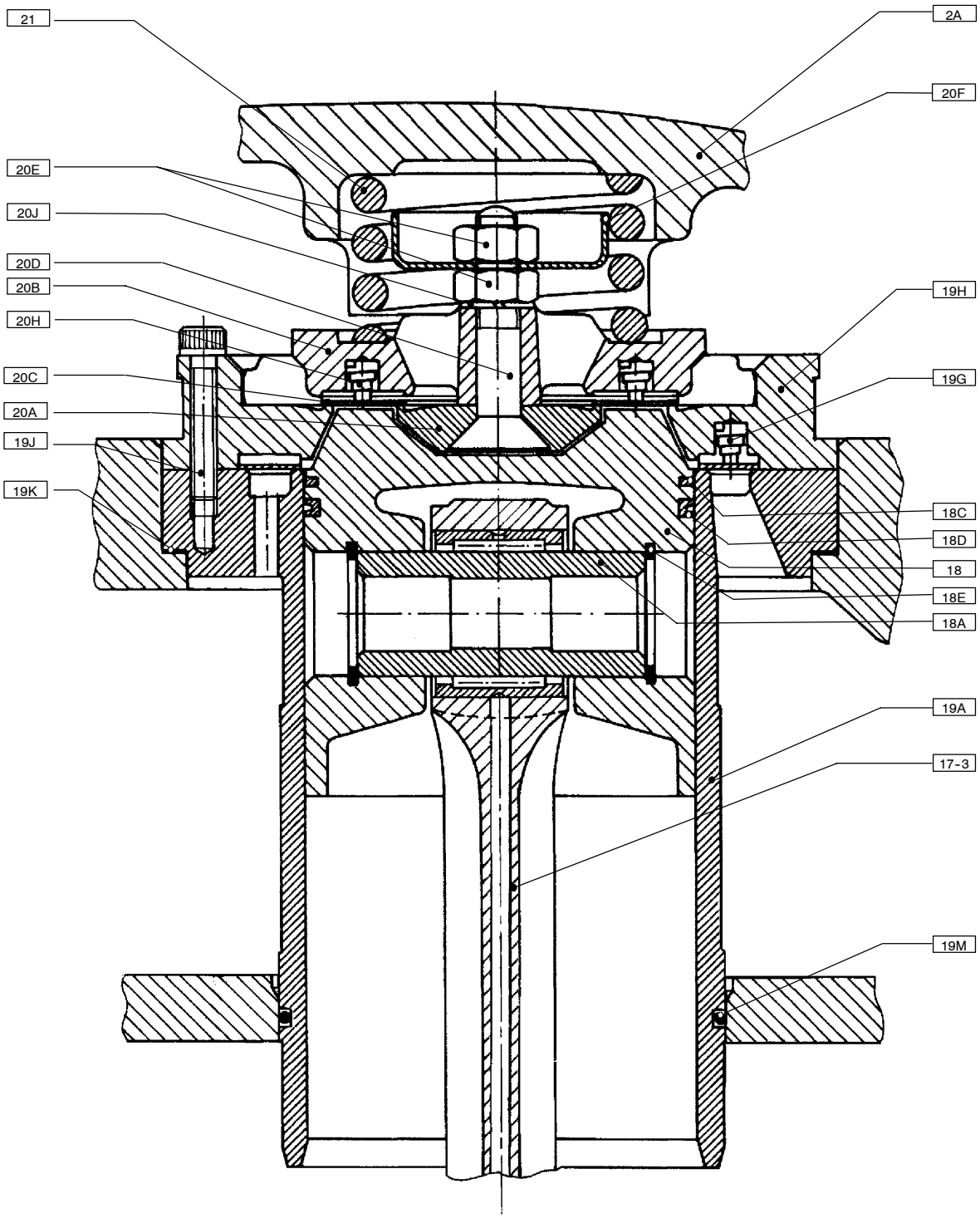
0662-212

TCMO 28
CMO 24-26-28

List of parts 0662-215

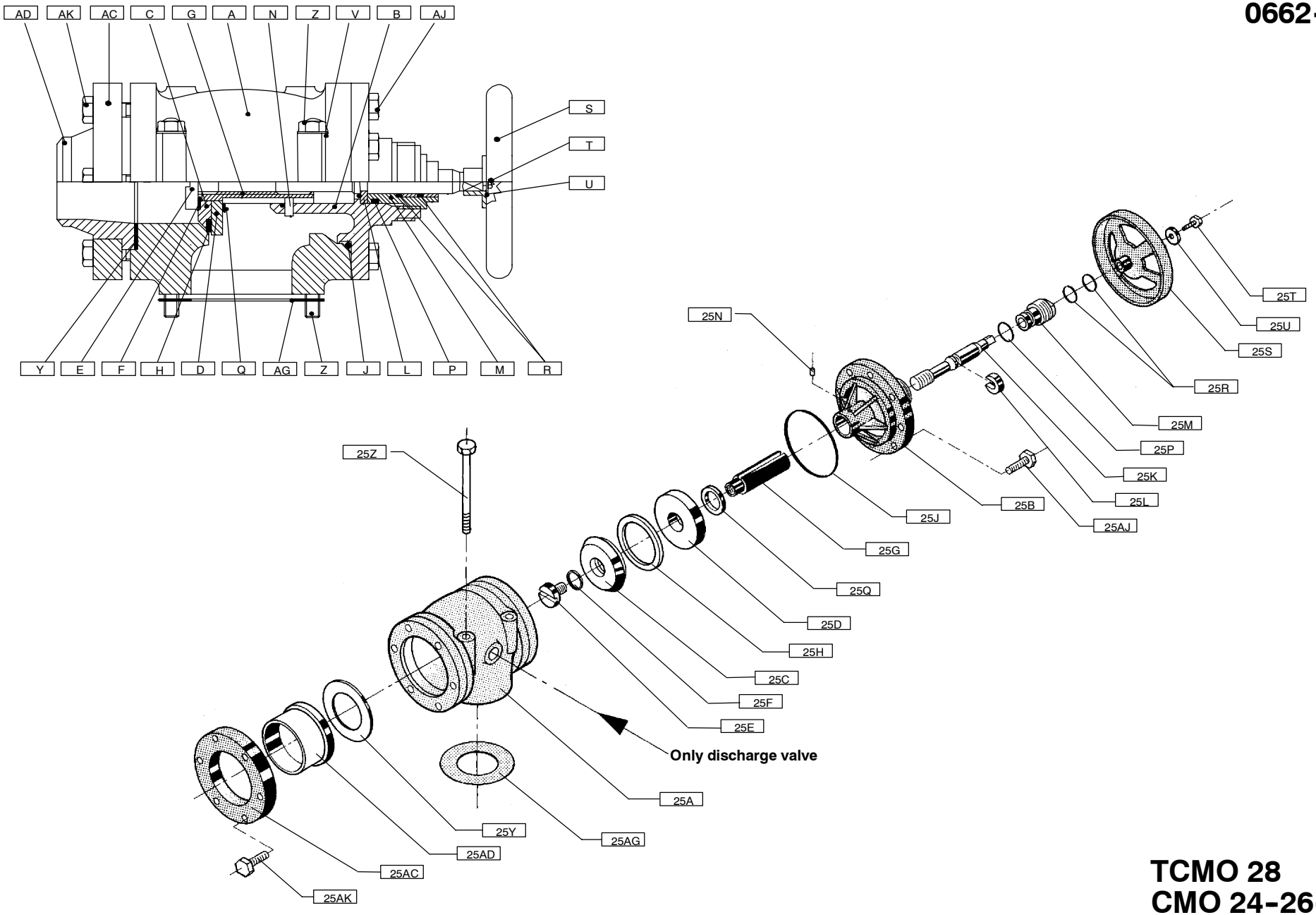


Cylinder Liner
CMO + TCMO (LP)



Cylinder Liner
TCMO (HP)

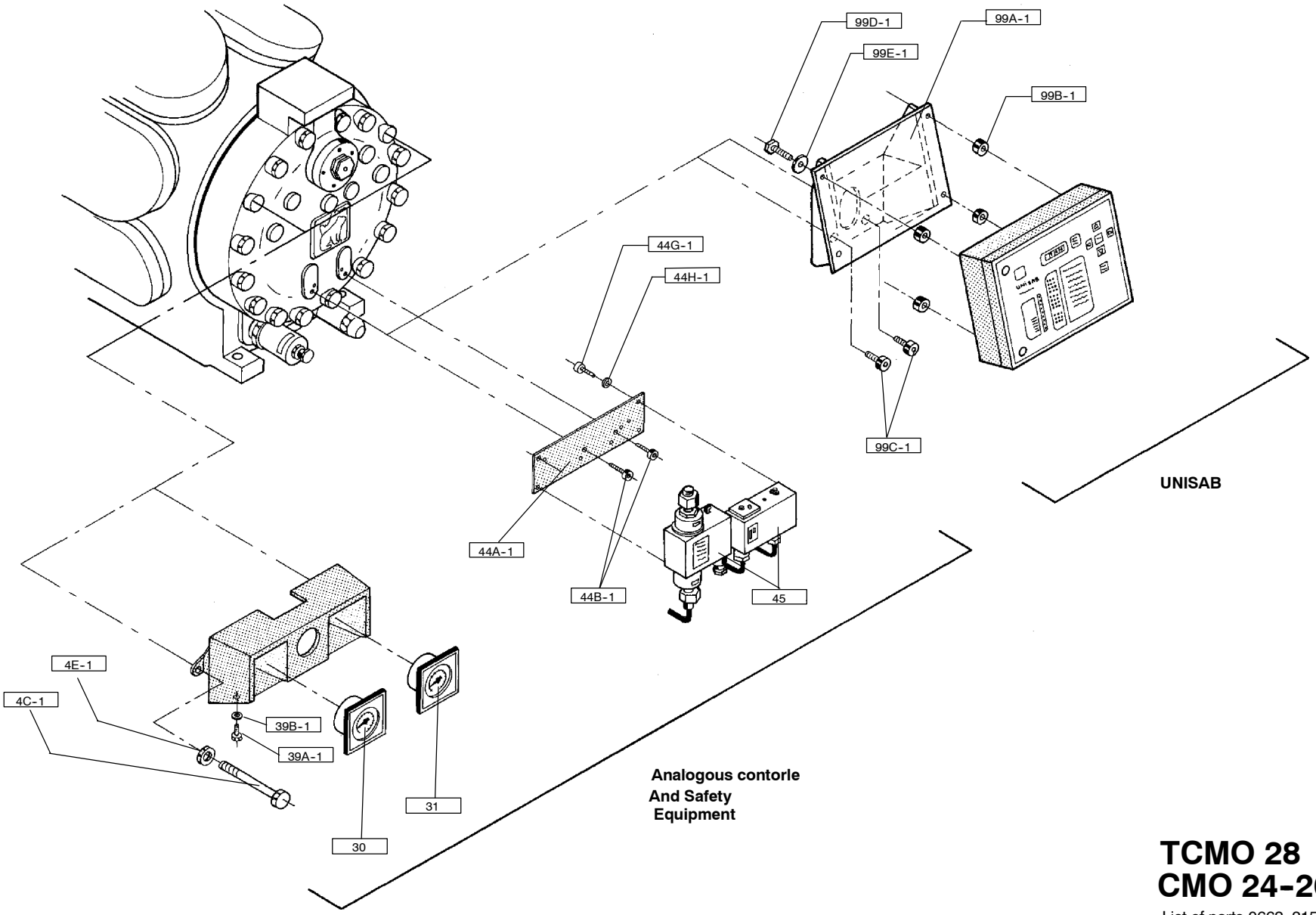
0662-212



TCMO 28
CMO 24-26-28

List of parts 0662-215

0662-212



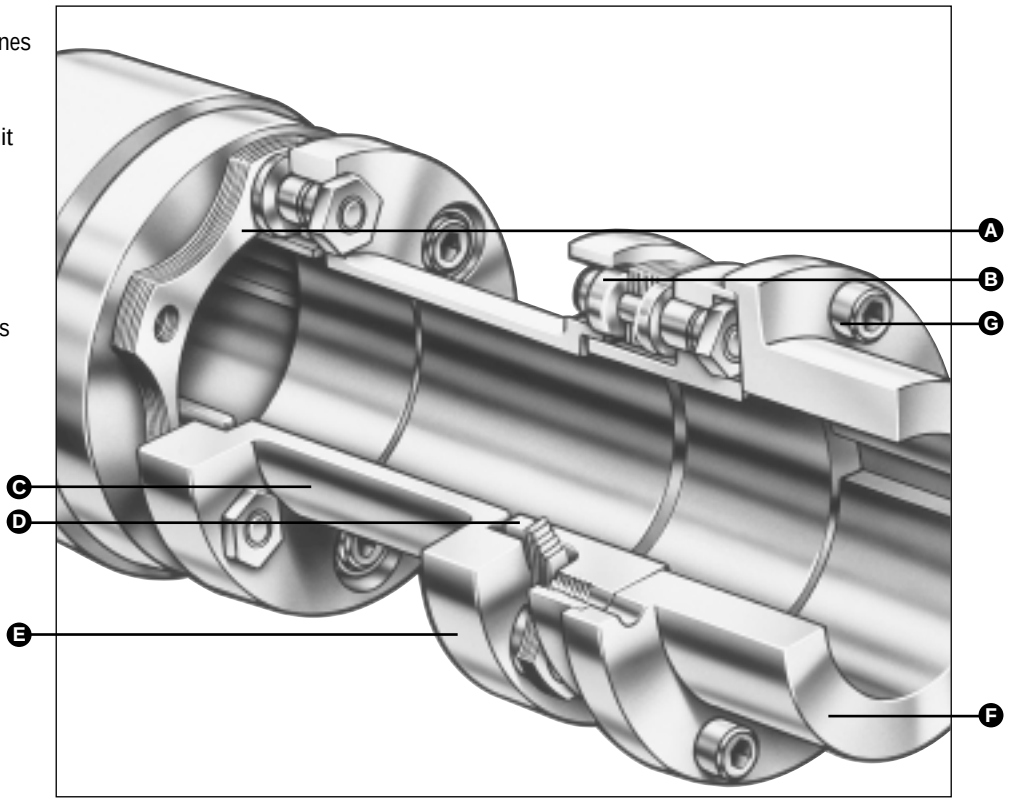
TCMO 28
CMO 24-26-28

List of parts 0662-215

TSK

METASTREAM® T Series Couplings

A – Stainless Steel Flexible Membranes
B – Overload Collars
C – Cartridge Transmission Unit
D – Anti-Fly Feature
E – Anti-Corrosion Treatment
F – Hubs with Puller Holes
G – Robust Hub Bolts



Product Description

Metastream® T Series Couplings, pioneered by John Crane Flexibox®, incorporate a scalloped, stainless steel, flexible membrane design. This design gives the most flexible solution for high torque and misalignment.

- Easy to fit.
- Meets API 610 8th edition. Can be supplied to meet API 671.
- Intrinsic balance meets AGMA class 9.
- Ideally suited for electric motors and turbine drives in critical process industry, marine, and power generation applications.

Design Features

- Excellent power-to-weight ratio.
- High misalignment capability.
- Low imposed forces on machinery leading to:
  - Reduced machinery vibration
  - Maximized bearing life
- Stainless steel flexible membranes for maximum life.
- Cartridge transmission unit eases assembly and gives repeatable balance.
- Overload collars are fitted to protect the flexible membranes in case of a more severe torsional overload.
- Anti-fly retention of the spacer in the unlikely event of membrane failure.
- Jacking bolt feature for easy installation and removal of spacer assembly available.
- Puller holes incorporated into hubs as standard.

TSK

METASTREAM® T Series Couplings

TSK Technical Data

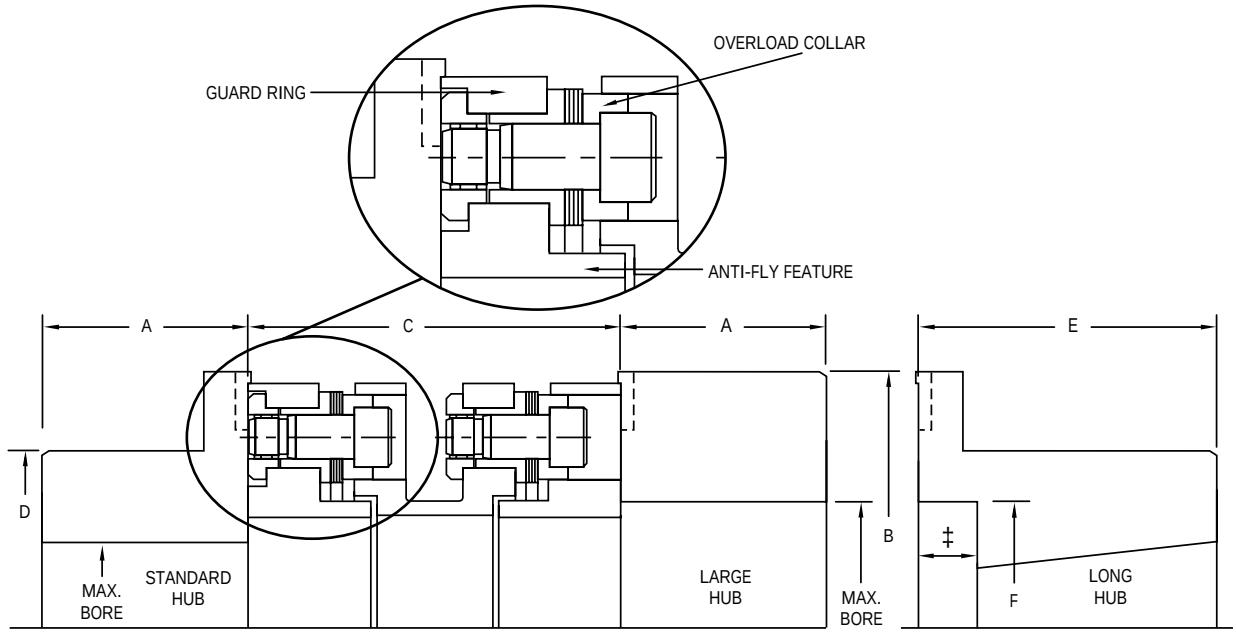
Coupling Size	Rating kW/ 1000 rpm	Max. Continuous Torque Nm	Peak Overload Torque Nm	Max. rpm	Weight - Transmission Unit Minimum DBSE - Kg	Weight - Transmission Unit Extra DBSE Kg/m	Weight Unbored Hubs - Kg Standard	Large	Long
0013	13	124	310	25,500	1.4	3.2	0.9	1.8	-
0033	33	315	790	20,000	2.7	5.3	1.6	3.1	-
0075	75	716	1,790	16,500	5.1	6.8	3.4	5.7	3.7
0135	135	1,289	3,220	14,400	8.9	11.0	5.6	8.8	6.7
0230	230	2,196	5,490	12,000	12.8	13.1	8.8	13.9	11.1
0350	350	3,342	8,360	10,500	16.0	12.5	15.7	-	18.8
0500	500	4,775	11,940	9,500	20.1	15.7	20.6	-	26.2
0740	740	7,066	17,670	8,000	25.4	19.8	29.4	-	37.2
0930	930	8,881	22,200	7,000	32.6	23.4	37.9	-	50.3
1400	1,400	13,369	33,400	6,000	46.2	31.4	51.8	-	72.5

Note that for the complete coupling, weights of two appropriate hubs plus a transmission unit are required.

The standard parallel bore machining tolerance is Grade 7, to give a light interference on the shaft.

TSK keyways will be cut to BS 4235 Pt.1(metric) or BS 46 Pt.1(inch).

TSK Typical Arrangement



‡To Suit Specific Applications

TSK Dimensional Data (mm)

Coupling Size	A	B	Distance Between Shaft Ends C Min.	C-Preferred* in.		in.		in.			D	E	F	MAXIMUM BORES Standard Hub**	Large Hub**	Long Hub***
0013	40	86	66	3.5	100	5.0	140	7.0	180	-	54	-	-	36	51	-
0033	45	105	79	3.5	100	5.0	140	7.0	180	-	69	-	-	46	70	-
0075	55	130	99	-	-	5.0	140	7.0	180	250	90	62	82	65	90	65
0135	62	152	121	-	-	-	140	7.0	180	250	112	77	104	80	102	80
0230	70	179	130	-	-	-	140	7.0	180	250	131	91	123	90	121	90
0350	90	197	131	-	-	-	-	-	180	250	163	106	116	115	-	115
0500	95	222	133	-	-	-	-	-	180	250	181	121	132	127	-	127
0740	107	247	138	-	-	-	-	-	180	250	206	135	151	140	-	140
0930	115	272	148	-	-	-	-	-	180	250	223	153	166	155	-	155
1400	130	297	171	-	-	-	-	-	180	250	248	183	180	172	-	172

All dimensions in mm unless otherwise stated, and should not be used for construction. Certified dimensions furnished upon request.

NOTES: * These Distance Between Shaft End (DBSE) sizes are more readily available. Other lengths to suit specific shaft separations are available.

** Maximum bores shown are based on standard ISO/BS rectangular keys.

*** Based on typical taper shafts. Consult John Crane.

TSK

METASTREAM® T Series Couplings

Selection Procedure

1. Select appropriate service factor SF.
2. Calculate coupling rating R from
   $R = \frac{kW \times 1000 \times SF}{N}$
   where:
   kW = driver rated power
   N = speed (rev./min.)
3. Select a coupling with the same or higher rating.
4. Check that the hub bore capacity is suitable.
5. Check peak torque capability is suitable for application.
6. Check speed capability.
7. Check whether additional dynamic balancing is required.
8. Specify Distance Between Shaft Ends (DBSE).

Example: 150 kW electric motor to centrifugal pump at 2960 rpm

$R = \frac{150 \times 1000 \times 1}{2960}$

R = 50.7 kW per 1000 rpm

Selection: TSK - 0075

Standard hub bore up to 65 mm.
Large hub bore up to 90 mm.
Peak torque capability - 1790 Nm

Additional dynamic balancing should not be required.

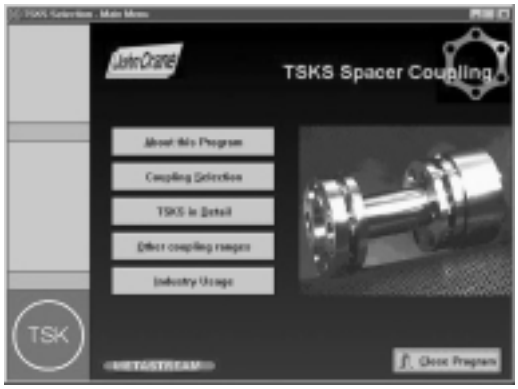
Service Factor SF

Suggested service factors for electric motor, steam turbine, and gas turbine drivers are given below.

Torque Variation		Service Factor
Constant Torque	Centrifugal Pump Centrifugal Compressor Axial Compressor Centrifugal Blower	1.0*
Slight Torque Fluctuation	Screw Compressor Gear, Lobe and Vane Pumps Forced Draft Fan Medium Duty Mixer Lobe Blower	1.5
Substantial Torque Fluctuations	Reciprocating Pumps Heavy Duty Mixers Induced Draft Fans	2.0

*Use a minimum service factor of 1.25 on electric motor drives through a gearbox.

The examples given are for typical machines and are empirically based guidelines. Knowledge of actual torque characteristics may indicate a different service factor. For example, variable-speed electric motors may exhibit a fluctuating torque characteristic. Consult John Crane for advice.



A Windows® based computer selection program for the TSK is available. This selection program provides all necessary technical data, inertias, torsional stiffness, etc. Contact John Crane.

Available Options

- Spark-resistant couplings for hazardous zone operation.
- Special materials for low temperature applications and/or higher corrosion resistance.
- Electrical insulation.
- Torque limiting and shear pin designs.

Consult John Crane for any other special requirements. Metastream couplings can be adapted to suit virtually all power transmission coupling needs.

TSK

METASTREAM® T Series Couplings

Coupling Alignment

Correct installation and alignment of couplings is essential for reliable machinery performance.

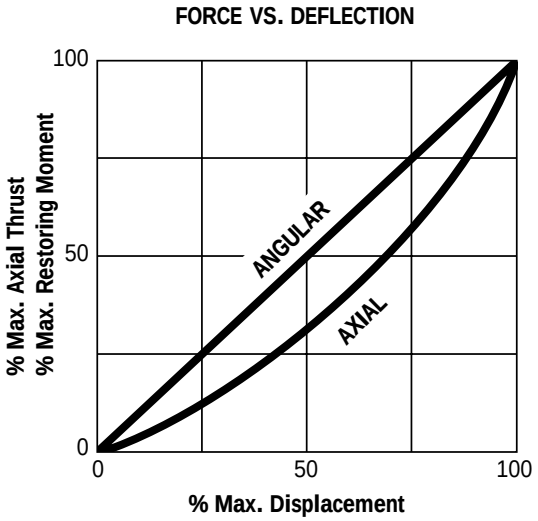
John Crane supplies a variety of shaft alignment equipment and offers alignment training courses.

TSK MISALIGNMENT				
	Max. Axial Misalignment*		Max. Parallel Misalignment**	
Coupling Size	+/– mm.	Equivalent Thrust kN	mm.	Restoring Moment Nm
0013	1.00	210	0.30	4.1
0033	1.25	280	0.36	6.1
0075	1.50	360	0.45	8.8
0135	2.00	560	0.55	11.8
0230	2.50	740	0.60	14.7
0350	2.75	780	0.64	34.3
0500	3.25	1080	0.65	40.7
0740	3.75	1270	0.68	47.6
0930	4.25	1470	0.72	53.9
1400	5.00	2700	0.83	61.3

NOTES: * Meets NEMA end float specification without modification.

** Values based on angular deflection of 1/2° per end and minimum DBSE. Greater misalignment accommodation is possible by increasing dimension C.

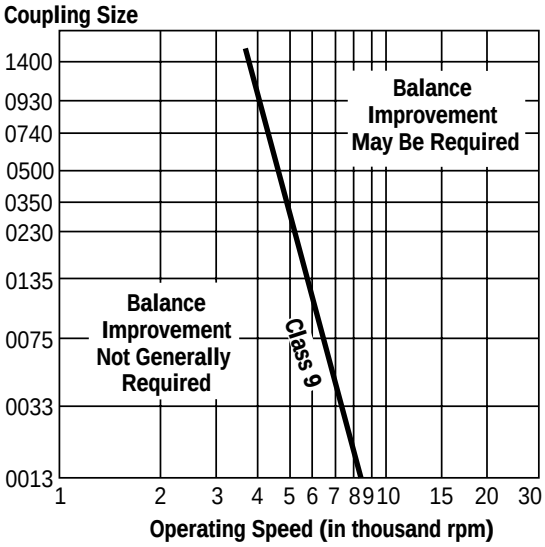
The angular and axial restoring forces in the table below left are given at maximum deflections. The chart can be used to determine forces across the full deflection range. The nonlinear characteristics can detune a system to prevent high amplitude axial vibration.



Balance Recommendations

The inherent balance of the TSK range meets AGMA standard 9000-C90 class 9. The adjacent chart relates the TSK sizes to operating speeds on the basis of this AGMA class 9 characteristic to provide a general guide to determine if dynamic balance improvement is necessary.

When balancing improvement is requested, John Crane will dynamically balance the transmission unit. Hubs may also be dynamically balanced, and this will usually be carried out after machining the bore but before cutting single keyways.



John Crane

North and Latin Americas
Morton Grove, Illinois USA

Tel: 1-847-967-2400
Fax: 1-847-967-3915
1-800-SEALING

Europe, Middle East, Africa
Slough, UK

Tel: 44-1753-224000
Fax: 44-1753-224224

Asia Pacific
Singapore

Tel: 65-222-9161
Fax: 65-223-5035

TI Group
Global Specialised Engineering

For your nearest John Crane facility, please contact one of the locations above.

FITTING, OPERATING & MAINTENANCE INSTRUCTIONS for METASTREAM™ TSK, TSP, & TLK[1] including TSA & TSC DESIGNS

T -SERIES FLEXIBLE ELEMENT SPACER COUPLINGS

DESCRIPTION

The ranges of Flexibox METASTREAM™ couplings covered by this data sheet are designed to transmit torque between the rotating shafts of a driving and driven machine, whilst accommodating the inevitable lateral, angular and axial misalignment, which will exist between two coupled machines.

The usual extent of supply comprises :-

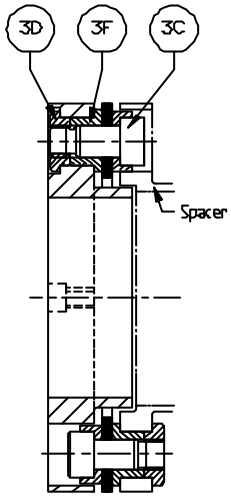
- a hub for the DRIVING machine (motor) shaft
- a hub for the DRIVEN machine shaft
- a factory assembled transmission unit, comprising two packs of flexible metallic discs, each bolted to a "guard ring" and to a common spacer (distance piece), which separates the two disc packs. The overall length of the transmission unit is sized to suit the shaft end separation of the coupled machines.
- a set of fasteners to assemble the transmission unit to the two hub flanges.

[1] Pre-2001 type using TSK components.

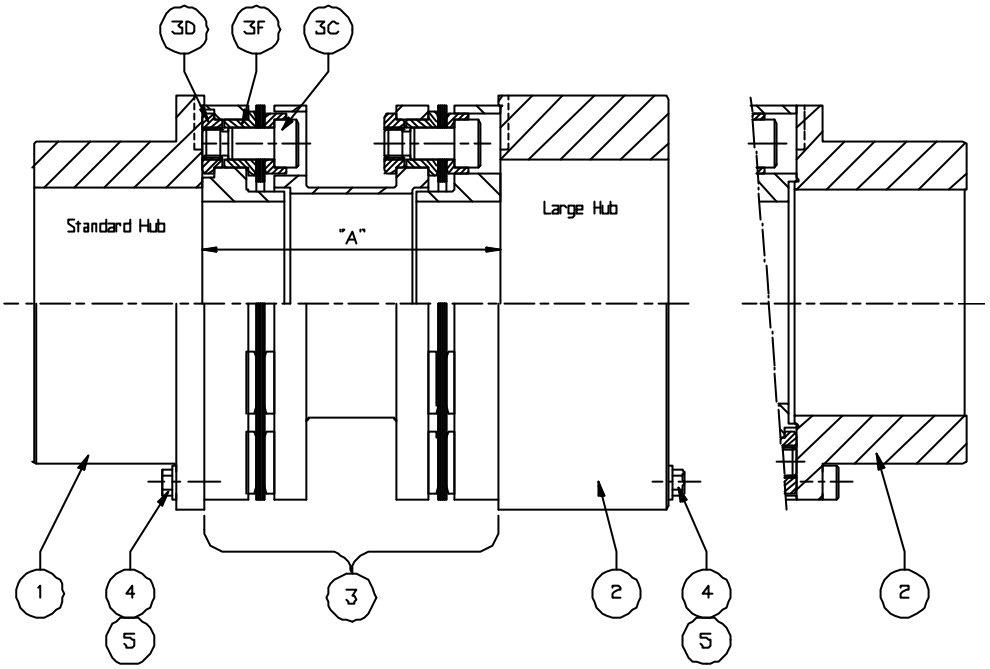
DRAWINGS

These instructions are written for standard catalogue products, generally designed in accordance with the following outline drawings.

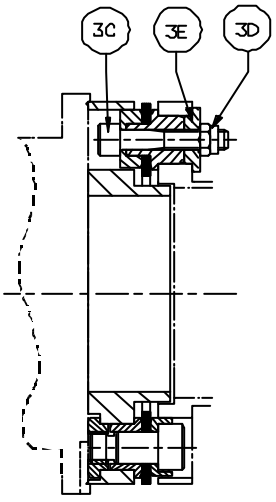
- **METASTREAM TSK, TSC, TLK DESIGNS**



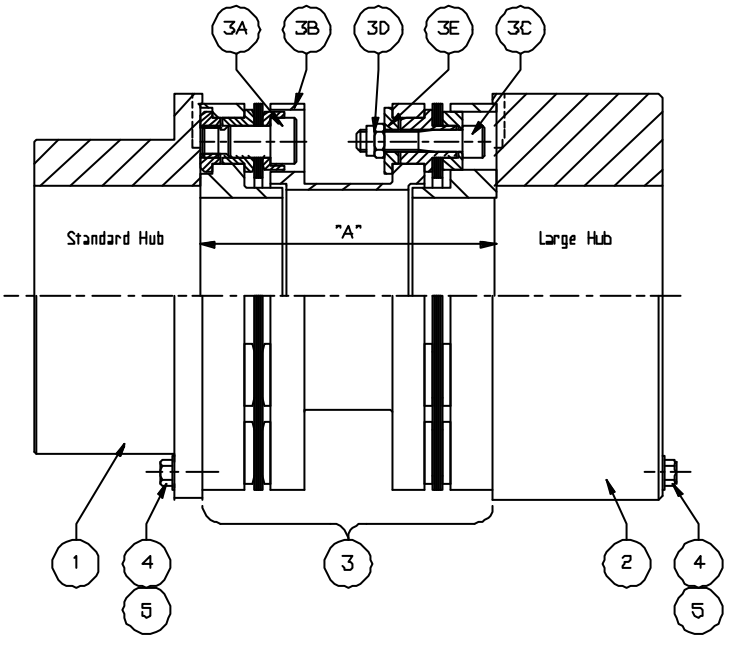
REPLACEMENT MEMBRANE PACK



- **METASTREAM TSP AND TSA DESIGNS**



REPLACEMENT MEMBRANE PACK



IMPORTANT - These instructions should be read in conjunction with any application specific general arrangement drawing which may be supplied with the coupling.

SELECTION VERIFICATION

Although a coupling may be correctly specified at the time of order placement, the duty conditions can sometimes change prior to the coupling being put into service. Information is available from FLEXIBOX to advise on the selection and limitations of their power transmission products, but the USER is ultimately responsible for verifying the suitability of the selection for the actual service conditions.

The coupling and its manner of use must conform to any legal or licensing requirements, and, where appropriate, meet local health and safety requirements.

IMPORTANT If the conditions of operation are changed without approval from FLEXIBOX, then we would decline responsibility for any consequent damage and the USER would assume all risks.

UNPACKING AND STORAGE

The coupling should be unpacked and examined for any signs of transit damage. Particular attention should be paid to hub bores and spigot/recess location diameters.

If the coupling is not to be used immediately, it should be re-packed and stored in a dry building away from direct heat.

Documentation supplied with the coupling should be retained for future reference.

INSTALLATION

DANGER ***PRIOR TO INSTALLING THE COUPLING, ENSURE THAT THE MACHINERY IS MADE SAFE***

- Remove the coupling from its packaging and carefully inspect for signs of damage. Particular attention should be paid to the hub bores and the spigot/recess location features, which should be free from burrs and other damage.

- Fit the DRIVER (1) and DRIVEN (2) hubs to the corresponding machine shafts. Normally, FLEXIBOX supply parallel bored and keywayed hubs, individually machined to give a light interference fit with the associated shaft. If it is necessary to apply some heating to the hub to assist fitting, then a warm oil bath will usually be adequate.

DANGER ***HUBS MUST BE ADEQUATELY SUPPORTED DURING INSTALLATION TO AVOID ACCIDENTAL DAMAGE SHOULD THEY SLIP***

It is usual to install the hub such that the hub face and shaft end are flush, but consult the arrangement drawing, or other particular instructions, to check the configuration for individual designs.

- Align the centre lines of the DRIVING and DRIVEN machine shafts as follows:-

i) With one machine firmly bolted down, set the distance between shaft ends (DBSE) according to drawing or catalogue dimension 'A'.

IMPORTANT - DBSE is usually measured between the inner face of the hubs and should not be taken as the length of the transmission unit at its outer periphery.

ii) Align the shaft centre lines both horizontally and vertically by aligning the hub flanges. The Flexibox METASTREAM™ coupling alignment kit and reverse periphery procedure allows rapid and accurate alignment of shafts.

IMPORTANT - The misalignment tolerances quoted in literature and on drawings allow for dynamic conditions and variations. For the best service from the coupling, FLEXIBOX recommend that installed misalignment is no more than 10% of the maximum allowable misalignment, allowance being made for any anticipated movements which will occur during operation (eg. thermal movements on hot pumps).

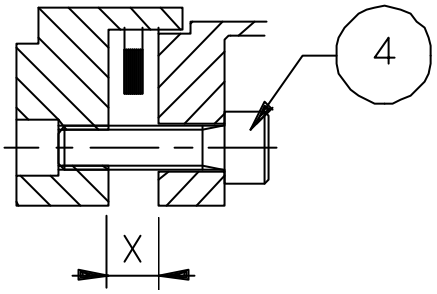
- Check spigot and recess locations on the hubs and transmission unit for burrs or other signs of damage and then fit the transmission unit (3) between the hubs.

DANGER - ***THE TRANSMISSION UNIT MUST BE ADEQUATELY SUPPORTED DURING INSTALLATION TO AVOID ACCIDENTAL DAMAGE SHOULD IT SLIP***

It may be necessary to compress the transmission unit whilst sliding it between the hubs, and facilities are provided to make this easier:-

i) on smaller units, lever slots are provided in the hub flanges

ii) on larger units, including the TLK, the spacer flanges are drilled so that the hub bolts (4) may be used to compress the transmission unit sufficiently to clear the spigot location (see sketch).



Maximum compression of the gap 'X' should not exceed 0.8 times the COUPLING maximum axial misalignment value, unless indicated otherwise on the general arrangement drawing.

IMPORTANT - always remove the compression bolts as soon as the transmission unit is in position and before fully tightening the hub bolts.

- Fit the hub bolts (4) (and locking washers (5) if supplied) and tighten these evenly to locate the transmission unit, ensuring that the spigots enter their recesses squarely. Bolts should be tightened in a "diametrically opposite" sequence to the values quoted in Table 1. If a general arrangement drawing is supplied with the coupling, then torque values quoted on that drawing take precedence.

COUPLING SIZES	BOLT TIGHTENING TORQUES							
	HUB BOLTS (4)			SPACER BOLTS (3C/3D) - FOR REFURBISHMENT				
	TSK TSP	TSC TSA	TLK	TSK	TSP	TSC	TSA	TLK
	N-m	lb-ft	N-m	N-m	N-m	lb-ft	lb-ft	N-m
0011, 0013	13	7	-	11	-	8	-	-
0027, 0033	25	14	-	23	9	17	7	-
0060, 0075	25	14	-	47	17	35	14	-
0110, 0135	25	14	-	75	31	55	26	-
0180, 0230	50	26	-	130	31	95	26	-
0260, 0350	25	14	-	150	58	110	41	-
0400, 0500	50	26	-	205	58	150	41	-
0560, 0740	50	26	-	285	145	210	125	-
0750, 0930	86	63	-	380	145	280	125	-
1120	86	63	-	490	277	360	220	-
1400	86	63	86	490	-	360	-	380
1850	-	-	86	-	-	-	-	490

TABLE 1 - STANDARD COUPLING BOLT TIGHTENING TORQUES

[Data given on general arrangement drawings takes precedence]

- Rotate the machinery two or three times slowly to ensure it moves freely.

The coupling is now ready for continuous and trouble free service.

OPERATION

ATTENTION: ***BEFORE STARTING THE MACHINERY, ENSURE THAT ALL NECESSARY SAFETY PROCEDURES ARE BEING OBSERVED***

When operated within the duty conditions for which they were designed, Flexibox METASTREAM™ flexible disc couplings will give long and trouble free service. Routine examination should include a periodic check on the tightness of fasteners and visual inspection of transmission components for signs of fatigue or wear.

If the coupled machinery is disturbed at any time, then shaft alignment should be re-checked as a matter of routine. Alignment checking is also recommended if a deterioration of installation alignment during service is suspected.

INSPECTION AND MAINTENANCE

DANGER - ***MAINTENANCE WORK MUST ONLY BE CARRIED OUT BY SUITABLY QUALIFIED PERSONNEL WHEN THE EQUIPMENT IS STATIONARY AND HAS BEEN MADE SAFE***

Flexibox METASTREAM™ flexible power transmission couplings are designed to give long and trouble free service if operated within the conditions for which they were specified. Failures are rare and can generally be attributed to:-

- excessive misalignment
- severe torsional overload

In all cases of coupling failure, the cause should be identified and corrected before replacing the coupling.

The usual mode of failure of flexible disc couplings is rupture of the flexing membranes. In such circumstances, it is possible to repair the coupling by fitting a replacement disc pack assembly.

ATTENTION: ***WHEN REPAIRING Flexibox METASTREAM™ FLEXIBLE DISC COUPLINGS, ONLY FLEXIBOX APPROVED PARTS SHOULD BE USED***

- To replace the transmission unit (3), first remove the hub bolts (4) and then withdraw the transmission unit using the lever slots in the hubs or compression bolt feature in the spacer as appropriate.

DANGER - ***TRANSMISSION UNIT MUST BE ADEQUATELY SUPPORTED DURING REMOVAL TO AVOID ACCIDENTAL DAMAGE SHOULD IT SLIP***

- Identify the bolts which connect the disc packs to the spacer piece. Slacken and remove these drive bolts (3C) and nuts (3D) and carefully dismantle the disc pack assemblies from the spacer piece. Do not attempt to dismantle the disc pack assemblies any further; replacement disc packs are always supplied complete with a new guard ring.

- Subsequent refurbishment is dependent on the type of coupling involved and the precise configuration of the replacement membrane pack. It is recommended that BOTH membrane packs be replaced, as failure of one inevitably results in some damage to the other.

- **TSP (TSA) REPLACEMENT PACK**

- Complete the removal of the old disc pack assemblies by pressing the washers (3E) out of the holes in each spacer flange.

- Identify the fasteners which attach the disc packs to the spacer. Disassemble the loosely assembled nuts (3D) and separate the bolts (3C) and washers (3E).

- Fit new washers (3E) into the spacer.

- Carefully press the protruding sleeves in each disc pack into the holes in the spacer flange, taking care not to over-strain the flexible discs. Insert the drive bolts (3C) from the guard ring side and secure using the locknuts (3D). Tighten the locknuts evenly to the correct SPACER BOLT tightening torque value given in Table 1.

- Complete the refurbishment of the transmission unit by replacing the second disc pack assembly.

- **TSK [TSC] AND TLK REPLACEMENT PACK**

- Complete the disassembly of the old disc packs by pressing the sleeves (3F) out of the holes in each spacer flange.

- Identify the fasteners which attach the disc packs to the spacer flanges. Disassemble the loosely assembled nuts (3D).

- With the bolts (3C) in position, carefully press on the bolt heads to push the new sleeves into the holes in the spacer flange. Take care not to over-strain the flexible discs.
- Place a small amount of threadlocking compound (e.g. Loctite 242) on the protruding bolt threads and then assemble the nuts (3D). Tighten these nuts evenly to the correct spacer bolt tightening torque value given in Table 1.

- Complete the refurbishment of the transmission unit by replacing the second disc pack assembly.

- Having rebuilt the transmission unit, it is recommended that the shaft alignment be checked prior to re-installation.

- The refurbished transmission unit should be installed in accordance with the instructions for fitting a new coupling.

IMPORTANT - Hub bolts should be replaced every time the coupling is dismounted.

ATTENTION - ***REPLACEMENT OF THE DISC PACK ASSEMBLIES INEVITABLY CHANGES THE INHERENT BALANCE OF THE TRANSMISSION UNIT. HENCE, IF A BALANCED COUPLING NEEDS REFURBISHING, IT IS RECOMMENDED THAT A FACTORY ASSEMBLED AND BALANCED TRANSMISSION UNIT BE FITTED TO ENSURE FUTURE, VIBRATION FREE OPERATION. IF REPLACEMENT DISC PACK ASSEMBLIES ARE FITTED TO A BALANCED TRANSMISSION UNIT, THEN CONSIDERATION MUST BE GIVEN TO REBALANCING OF THE REFURBISHED TRANSMISSION UNIT OR IN-SITU BALANCING OF THE COUPLING.***

WARNING

All reasonable care has been taken in the design and manufacture of this coupling to ensure that it will be safe when properly used. However, these instructions are of a general nature, and it is assumed that the USER is aware of the statutory requirements of his plant.

FLEXIBOX will provide advice on the use of this coupling, but the following matters are the sole responsibility of the USER:-

- Compliance with statutory plant requirements
- Compliance with other safety requirements
- Final choice of a coupling for a particular duty.

NOTES ON THESE INSTRUCTIONS

These instructions should be available to everybody who has need of them at the place where the coupling is used.

In accordance with European agreement, certain words or symbols have particular meanings, when used within these Territories or when applied to actual coupling parts. They are used as follows:-

'IMPORTANT' is used for items of particular concern when using the coupling

'ATTENTION' where there is an obligation or prohibition concerning the avoidance of risk

'DANGER' (OR '!' printed in a triangle) - where there is an obligation or prohibition concerning harm to people or damage to the equipment.