MAKING MODERN LIVING POSSIBLE

Fitters Notes

Hints and tips for the installer

REFRIGERATION &
AIR CONDITIONING DIVISION

Manual

This Fitters Notes, gives practical hints about **Danfoss commercial refrigeration controls** (mechanical) and **Danfoss compressors**.

If you need further information about the Danfoss product range please contact your dealer or local Danfoss agency. You can also find some very useful information on our web site:

www.danfoss.com

We hope that this book will help you in your daily work.

Danfoss A/S

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Introduction

A thermostatic expansion valve is built up around a thermostatic element (1) separated from the valve body by a diaphragm.

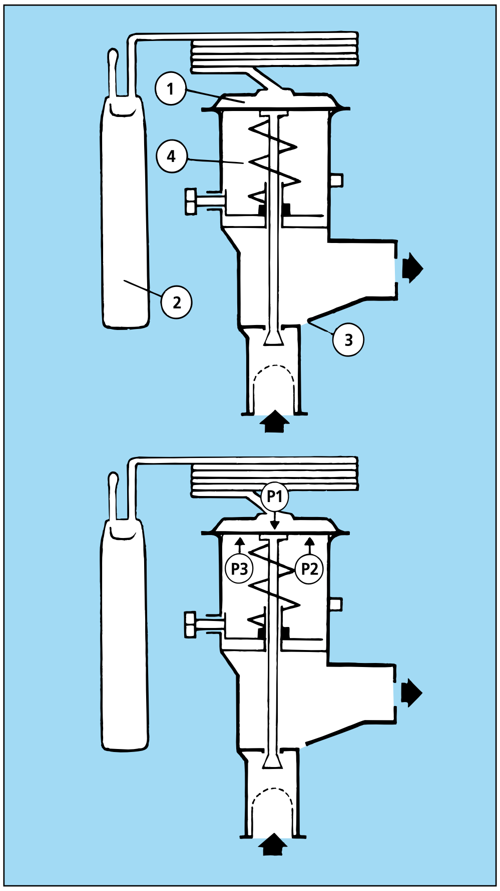
A capillary tube connects the element to a bulb (2) and a valve body with valve seat (3) and a spring (4).

A thermostatic expansion valve works like this:
The function of a thermostatic expansion valve is determined by three fundamental pressures:

P1: Bulb pressure which acts on the upper surface of the diaphragm, in the valve opening direction.
P2: Evaporating pressure which acts on the underside of the diaphragm, in the valve closing direction.
P3: Spring pressure which also acts on the underside of the diaphragm, in the valve closing direction.

When the expansion valve regulates, balance is created between bulb pressure on one side of the diaphragm and evaporating pressure plus spring force on the other side.

The spring is used to set superheat.

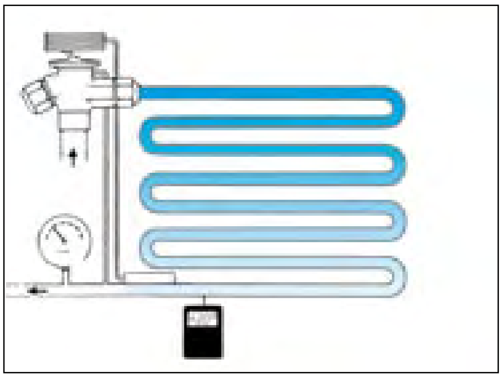


Ad0-0001

Superheat

Superheat is measured at the point where the bulb is located on the suction line and is the difference between the temperature at the bulb and the evaporating pressure/evaporating temperature at the same point.

Superheat is measured in Kelvin (K) and is used as a signal to regulate liquid injection through the expansion valve.



Ad0-0012

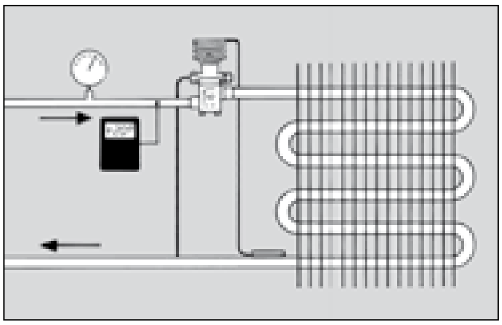
Subcooling

Subcooling is defined as the difference between condensing pressure/temperature and liquid temperature at the expansion valve inlet.

Subcooling is measured in Kelvin (K).
Subcooling of the refrigerant is necessary to avoid vapour bubbles in the refrigerant ahead of the expansion valve.

Vapour bubbles in the refrigerant reduce capacity in the expansion valve and thereby reduce liquid supply to the evaporator.

Subcooling of 4-5K is adequate in most cases.



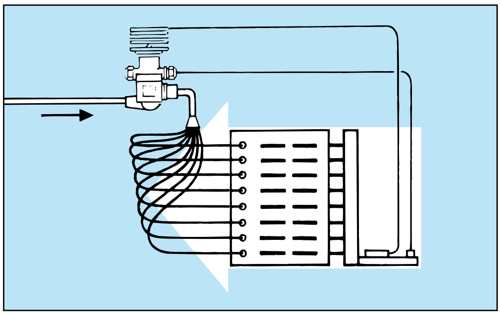
Ad0-0015

External pressure equalization

Expansion valves with external pressure equalization must always be used if liquid distributors are installed.

Typically, the use of distributors gives a pressure drop of 1 bar across distributor and distribution tubes.

Expansion valves with external pressure equalization should always be used in refrigeration systems with heavy evaporators or plate exchangers, where normally the pressure drop will be greater than pressure corresponding to 2K.



Ad0-0016

Charges

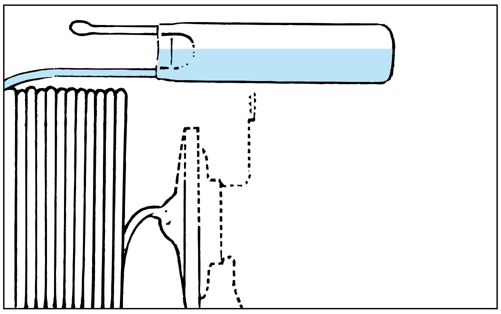
Thermostatic expansion valves can contain one of three different types of charge:

1. Universal charge
2. MOP charge
3. MOP charge with ballast, standard for Danfoss expansion valves with MOP.

Universal charge

Expansion valves with **Universal charge** are used in most refrigeration systems where there is no pressure limitation requirement and where the bulb can be located warmer than the element or at high evaporating temperature/evaporating pressure.

Universal charge means that there is liquid charge in the bulb. The amount of charge is so large that charge remains in the bulb irrespective of whether the element is colder or warmer than the bulb.



Ad0-0017

MOP charge

Expansion valves with **MOP charge** are typically used on factory-made units where suction pressure limitation on starting is required, e.g. in the transport sector and in air conditioning systems.

All expansion valves with MOP have a very small charge in the bulb.

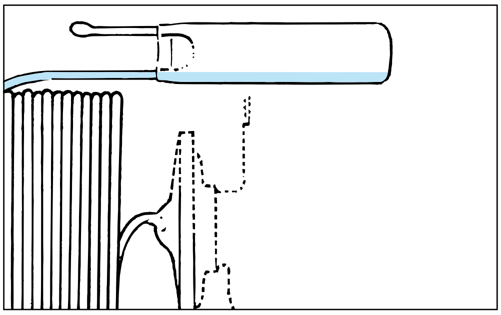
This means that the valve or the element must be located warmer than the bulb. If it is not, charge can migrate from the bulb to the element and prevent the expansion valve from functioning.

MOP charge means limited liquid charge in the bulb.

"MOP" stands for Maximum Operating Pressure and is the highest suction pressure/ evaporating pressure permissible in the evaporator/suction line.

The charge will have evaporated when the temperature reaches the MOP point. Gradually, as the suction pressure rises, the expansion valve begins to close at approx. 0.3/0.4 bar below the MOP point. It becomes completely closed when the suction pressure is the same as the MOP point.

MOP is often called "Motor Overload Protection".



Ad0-0018

MOP ballast charge

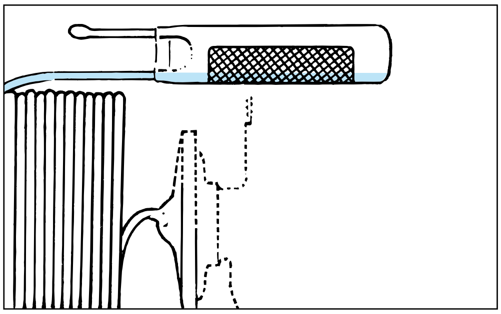
Expansion valves with **MOP ballast charges** are used mainly in refrigeration systems with "high-dynamic" evaporators, e.g. in air conditioning systems and plate heat exchangers with high heat transfer.

With MOP ballast charge, up to 2 - 4 K less superheat can be obtained than with other types of charge.

The bulb in a thermostatic expansion valve contains a material of high porosity and large surface area in relation to weight.

MOP charge with ballast has a damping effect on expansion valve regulation.

The valve opens slowly as bulb temperature rises and closes quickly as bulb temperature fails.



Ad0-0021

Thermostatic expansion valve selection

The thermostatic expansion valve can be selected when the following are known:

- Refrigerant
- Evaporator capacity
- Evaporating pressure
- Condensing pressure
- Subcooling
- Pressure drop across valve
- Internal or external pressure equalization

Identification

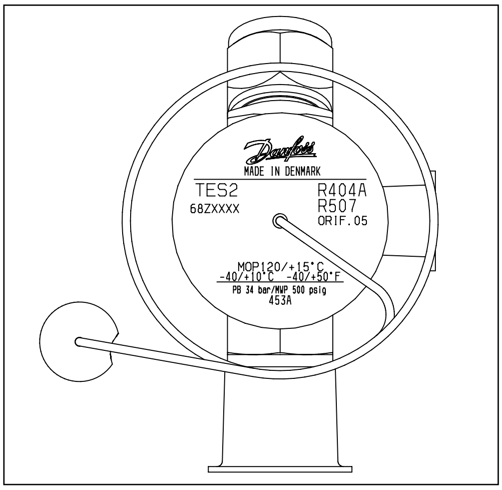
The thermostatic element is fitted with a laser engraving on top of the diaphragm.

The code refers to the refrigerant for which the valve is designed:

L = R410A
N = R134a
S = R404A/ R507
X = R22
Z = R407C

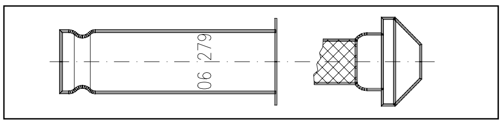
This engraving gives valve type (with code number), evaporating temperature range, MOP point, refrigerant, and max. working pressure, PS/MWP.

With TE 20 and TE 55 the rated capacity is stamped on a band label fastened to the valve.



Ad0-0019

The orifice assembly for T2 and TE2 is marked with the orifice size (e.g. 06) and week stamp + last number in the year (e.g. 279).
The orifice assembly number is also given on the lid of its plastic container.

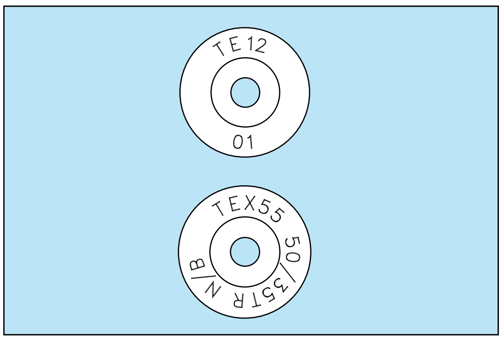


Ad0-0023

On TE 5 and TE 12 the upper stamp (TE 12) indicates for which valve type the orifice can be used. The lower stamp (01) is the orifice size.

On TE 20 and TE 55 the lower stamp (50/35 TR N/B) indicates the rated capacity in the two evaporating temperature ranges N and B, and the refrigerant. (50/35 TR = 175 kW in range N and 123 kW in range B).

The upper stamp (TEX 55) refers to the valve type for which the assembly can be used.

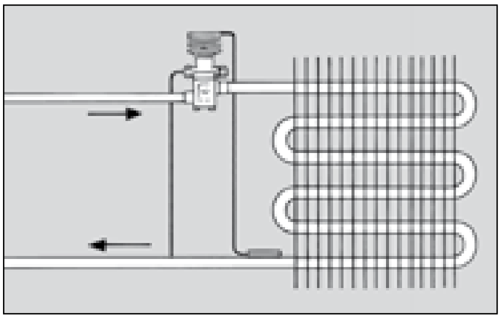


Ad0-0020

Installation

The expansion valve must be installed in the liquid line, ahead of the evaporator, with its bulb fastened to the suction line as close to the evaporator as possible.

If there is external pressure equalization, the equalizing line must be connected to the suction line immediately after the bulb.

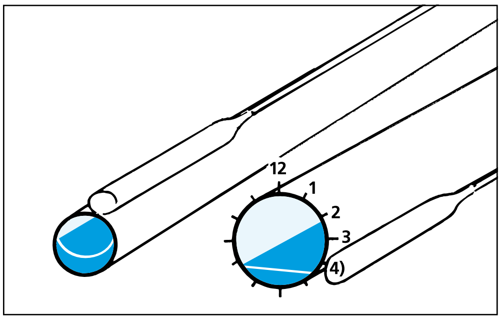


Ad0-0002

The bulb is best mounted on a horizontal suction line tube and in a position corresponding to between 1 o'clock and 4 o'clock.

Location depends on the outside diameter of the tube.

Note:
The bulb must never be located at the bottom of the suction line due to the possibility of oil laying in the bottom of the pipe causing false signals.

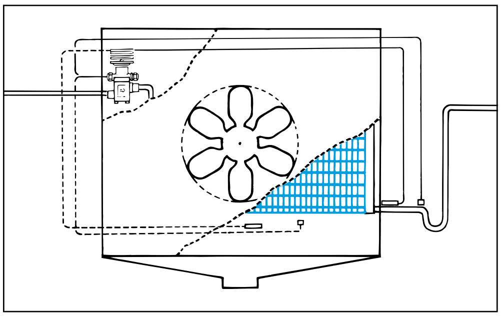


Ad0-0003

The bulb must be able to sense the temperature of the superheated suction vapour and must therefore not be located in a position that will expose it to extraneous heat/cold.

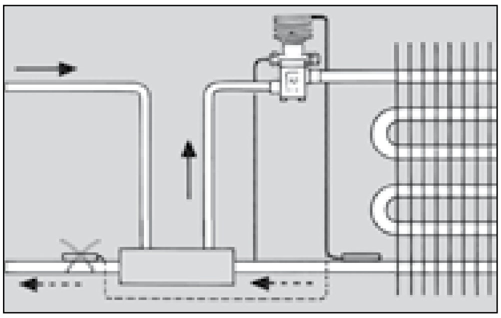
If the bulb is exposed to a warm air current, insulation of the bulb is recommended.

The Danfoss bulb strap allows a tight and secure fitting of the bulb to the tube, thereby securing that the bulb has ultimate thermal contact to the suction tube. The TORX design of the screw makes it easy for the fitter to transfer the torque from the tool to the screw without having to press the tool into the screw slot. Furthermore, with the TORX slot design, there is no risk of damaging the screw slot.



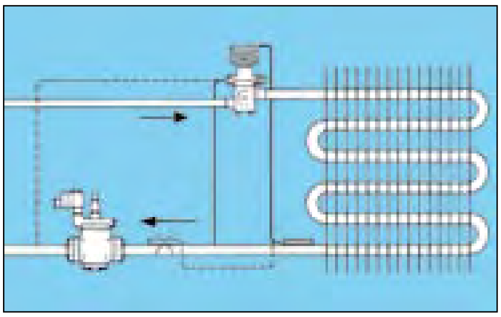
Ad0-0004

The bulb must not be installed after a heat exchanger because in this position it will give false signals to the expansion valve.



Ad0-0005

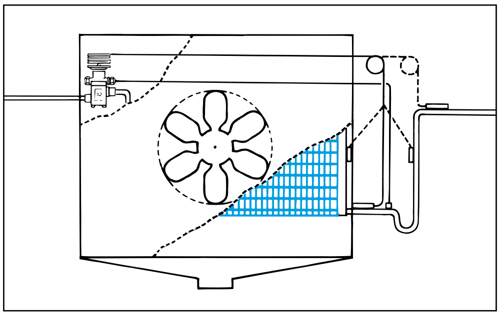
The bulb must not be installed close to components of large mass as this also will give rise to false signals to the expansion valve



Ad0-0006

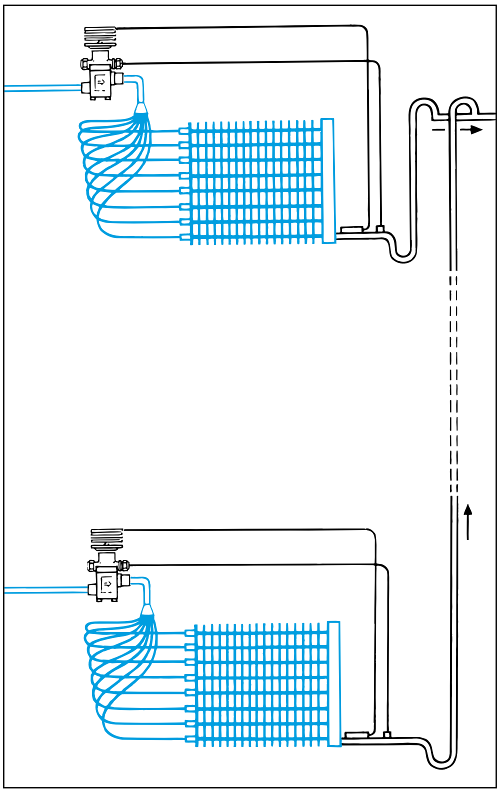
Installation *(cont.)*

As previously mentioned, the bulb must be installed to the horizontal part of the suction line immediately after the evaporator. It must not be installed to a collection tube or a riser after an oil pocket.



Ad0-0007

The expansion valve bulb must always be installed ahead of any liquid lock.



Ad0-0008

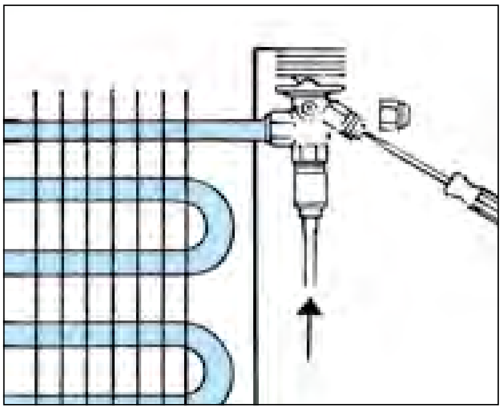
Setting

The expansion valve is supplied with a factory setting suitable for most applications.

If necessary, readjustment can be made using the setting spindle on the valve.

Turning the spindle clockwise increases the expansion valve superheat and turning it counterclock-wise reduces it.

For T /TE 2, one turn of the spindle produces a change of approx. 4K in the superheat at 0°C evaporating temperature.

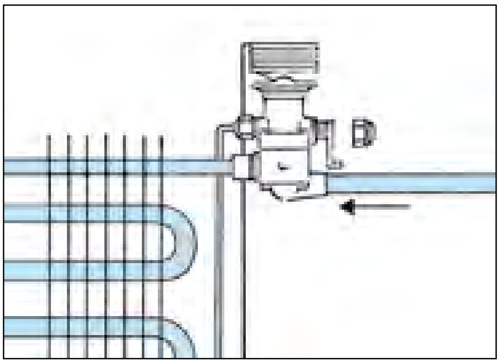


Ad0-0009

Setting *(cont.)*

For TE 5 and following sizes, one turn of the spindle produces a change of approx. 0.5K in the superheat at 0°C evaporating temperature.

For TUA and TUB, one turn of the spindle produces a change of approx. 3K in the superheat at 0°C evaporating temperature.

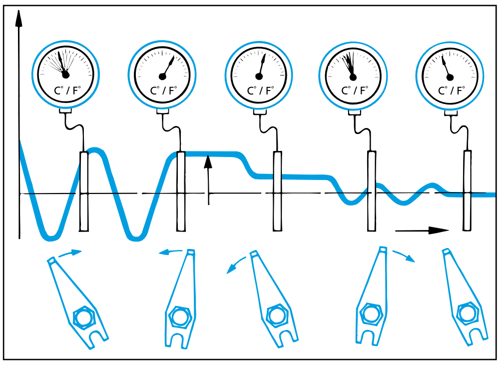


Ad0-0010

Hunting in the evaporator can be eliminated by the following procedure:
Increase the superheat by turning the expansion valve setting spindle well to the right (clockwise) so that hunting stops. Then turn the setting spindle in counter-clockwise steps so that hunting again occurs.

From this position, turn the spindle about once clockwise (but only 1/4 turn for T /TE 2 valves).

On this setting the refrigeration system will not hunt and the evaporator is fully utilized.
A variation of 1 K in superheat is not regarded as hunting.

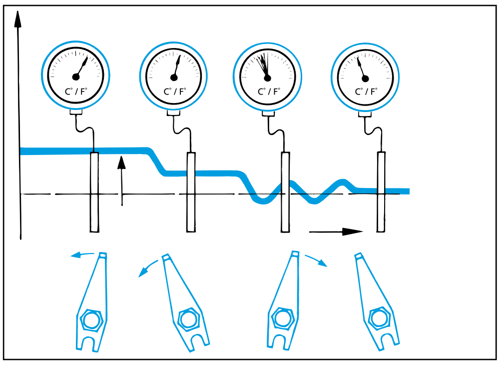


Ad0-0011

If the superheat in the evaporator is too high, the reason might be an inadequate supply of liquid refrigerant.

The superheat can be reduced by turning the expansion valve setting spindle counterclockwise in steps until hunting is observed.

From this setting, the spindle must be turned about once clockwise (but only 1/4 turn for T/TE 2). This setting fully utilizes the evaporator.
A variation of 1 K in superheat is not regarded as hunting.



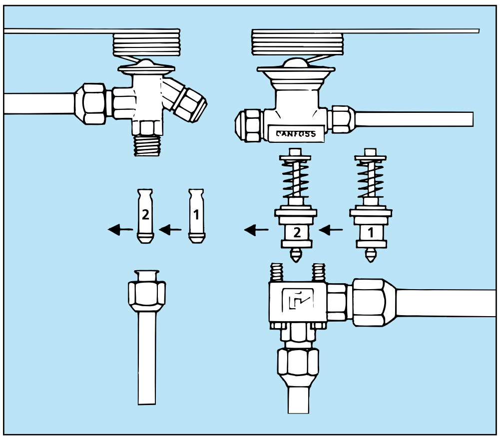
Ad0-0013

Orifice assembly replacement

If the evaporator continues to hunt, regardless of the superheat setting, the valve capacity might be too high and the orifice assembly, or the valve, needs replacing with a smaller one.

If the evaporator superheat is too high the valve capacity is too low and the orifice assembly must be replaced with a larger one.

TE, T2, TUA, TCAE valves are supplied with an interchangeable orifice.



Ad0-0014

Danfoss product range Thermostatic expansion valves

Danfoss offers a comprehensive range of thermostatic expansion valves with capacities from 0.4 to 1083 kW (R134a).

T/TE 2 valves have a brass housing and flare/flare or solder/flare connections.
Rated capacity: 0.4 - 10.5 kW (R134a).

TUA, TUB, TUC valves have a stainless steel housing and stainless steel/copper bimetal solder connections.

Rated capacity: 0.5 - 12 kW (R134a).

The valves can be supplied with or without external pressure equalization.

- TUA has an interchangeable orifice assembly and adjustable superheat.
- TUB has a fixed orifice and adjustable superheat.
- TUC has a fixed orifice and factory set superheat.

TUB and TUC are primarily for OEM customers. All TUB and TUC valves can be replaced by TUA valves.

TCAE, TCBE, TCCE valves have a stainless steel housing and stainless steel/copper bimetal solder connections.

Rated capacity: 12 - 18 kW (R134a).

The valves are designed as the TU valves but with a higher capacity.

The valves are supplied with external pressure equalization.

TRE valves have a brass housing and stainless steel/copper bimetal connections.

Rated capacity: 18 - 196 kW (R134a).

The valves are supplied with a fixed orifice and adjustable superheat.

TDE valves have a brass housing and copper solder connections.

Rated capacity: 10.5 - 140 kW (R407C)

The valves are supplied with a fixed orifice and adjustable superheat.

TE 5 - TE 55 valves have a brass housing. The valves are supplied as a part programme consisting of valve housing, orifice and thermostatic element.

The valve housing is available in a straightway or angleway version with solder, flare and flange connections.

Rated capacity: 12.9 - 220 kW (R134a).

The valves are supplied with external pressure equalization.

PHT 85 - 300 valves are supplied as a part programme consisting of valve housing, flanges, orifice and thermostatic element.

Rated capacity: 55 - 1083 kW (R134a).

For further information consult the internet or the catalogue material.

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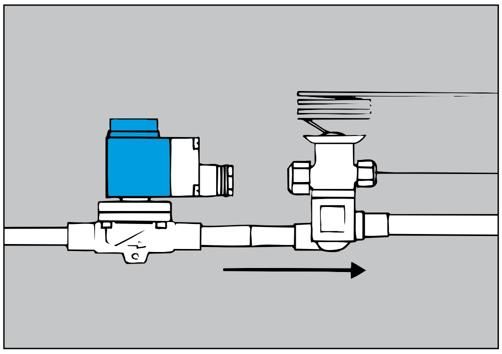
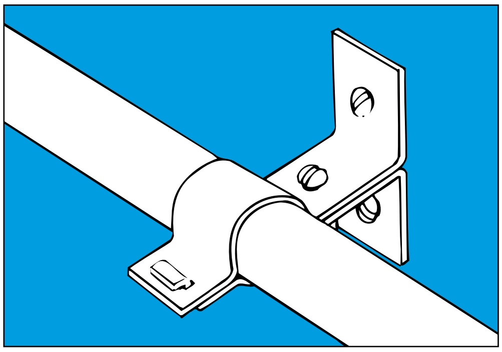
All EVR/EVRA, and EVH types solenoid valves operate only when installed correctly in the direction of flow, i.e. in the direction indicated by the arrow.

Normally, solenoid valves installed ahead of a thermostatic expansion valve must be close to that valve.

This avoids liquid hammer when the solenoid valve opens.


Af0_0001

Ensure that pipes around the valve are properly installed so that no fracture can occur.

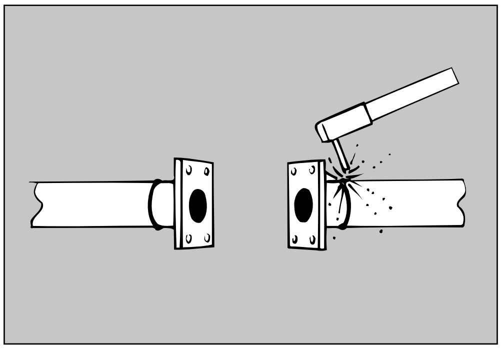

Af0_0003

Brazing/welding EVR/EVRA and EVH solenoid valves does not normally necessitate dismantling, provided steps are taken to avoid heating the valve.

Note! Always protect the armature tube against weld spatter.

EVRA 32 & 40 precautions

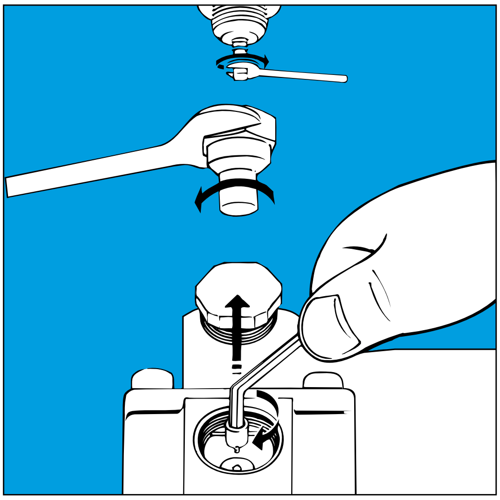
After tacking the valve to the pipe, remove the valve body to protect O-rings and gaskets against heat. In installations with welded steel pipe, a FA type strainer or similar mounted ahead of the solenoid valve is recommended. (On new plant, flushing out before starting up is recommended).


Af0_0004

When pressure testing

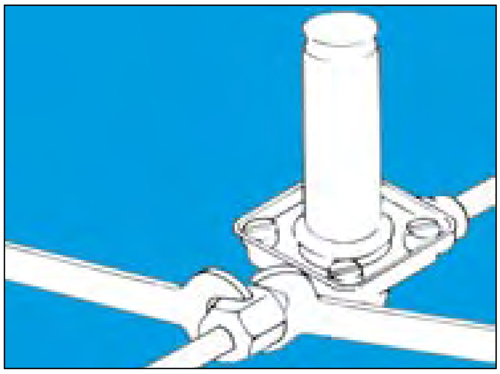
All solenoid valves in the system must be open, either by applying voltage to the coils or by opening the valves manually (provided a manual operation spindle is fitted).

Remember to screw the spindle back before starting up, otherwise the valve will be unable to close.



Af0_0005

Always use counter force when finally tightening the solenoid valve on pipes, i.e. two spanners on the same side of the valve.



Af0_0006

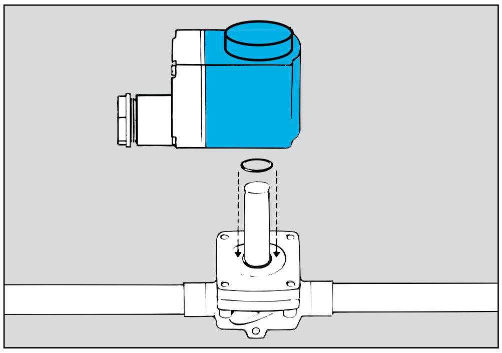
The coil

When fitting the coil, it has merely to be pressed down over the armature tube until a click is heard. This means that the coil has been correctly fitted.

Note: Remember to fit an O-ring between valve body and coil.

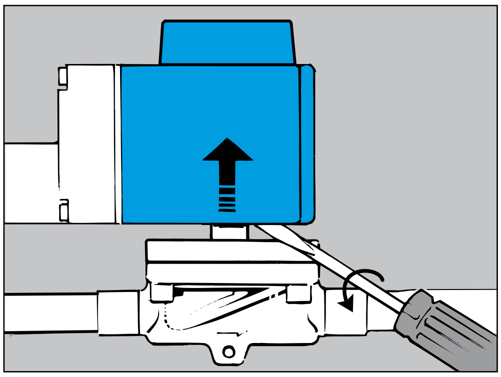
Be sure that the O-ring is smooth, not damaged and that the surface is free from paint or any other material.

Note: The O-ring must be changed at service.



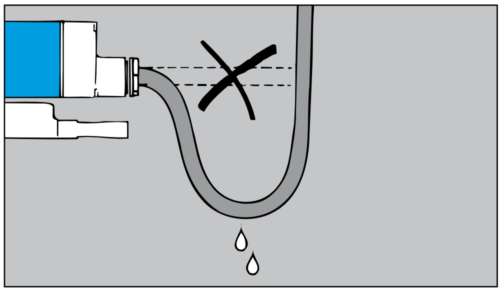
Af0_0018

The coil can be removed by inserting a screwdriver between valve body and coil. The screwdriver can then be used as a lever to loosen the coil.



Af0_0019

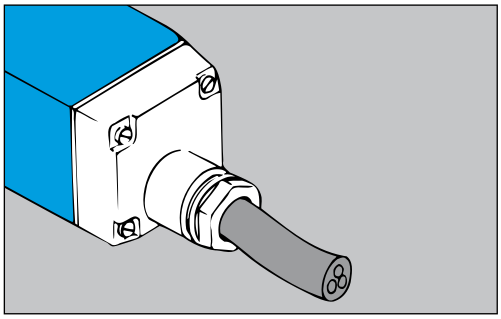
Be careful with cable entries. It must not be possible for water to enter the terminal box. The cable must be led out via a drip loop.



Af0_0009

The entire cable circumference must be retained by the cable entry.

Therefore, always use round cable (which is the only type of cable that can be sealed effectively).

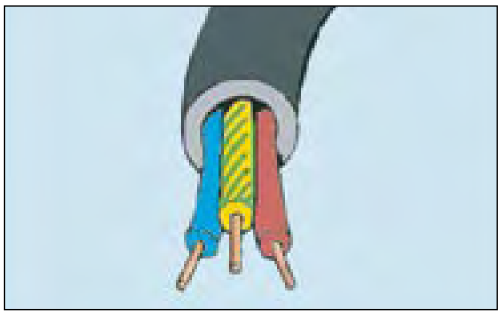


Af0_0010

Be aware of the colour of leads in the cable.

Yellow/green is always earth.

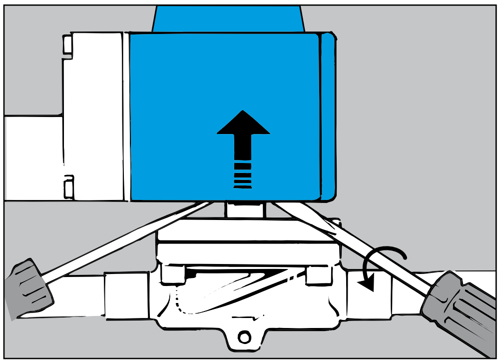
Leads of one colour are either phase or neutral.



Af0_0011

The coil (cont.)

When removing a coil it might be necessary to use hand tools, e.g. two screwdrivers.



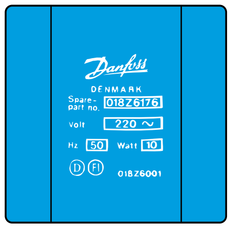
Af0_0012

The correct product
(The "old" coil type)

Make sure that coil data (voltage and frequency) and supply voltage correspond. If they do not, the coil might burn out. Always ensure that valve and coil match each other.

When replacing a coil in an EVR 20 NC
(NC = normally closed) note:
- A valve body using an a.c. coil has a square armature.
- A valve body using a d.c. coil has a round armature.

Fitting the wrong coil results in a lower MOPD. See data on the top nut. As far as possible, always choose single-frequency coils. These give off less heat than double-frequency coils.
Use NC (normally closed) solenoid valves for systems in which the valve must remain closed (de-energised) for most of the operating time.
Use NO (normally open) solenoid valves for systems in which the valve must remain open (de-energised) for most of the operating time.
Never replace an NO (normally open) solenoid valve with an NC (normally closed) valve - or vice versa.



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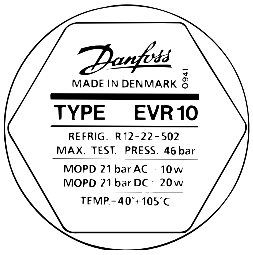
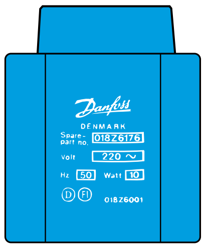


Af0_0014

(The new "clip-on" coil type)

Two labels are supplied with each clip-on coil (see illustration).

The adhesive label is for attaching to the side of the coil, while the other, perforated label should be placed over the armature tube before the coil is clicked into position.



Af0_0015

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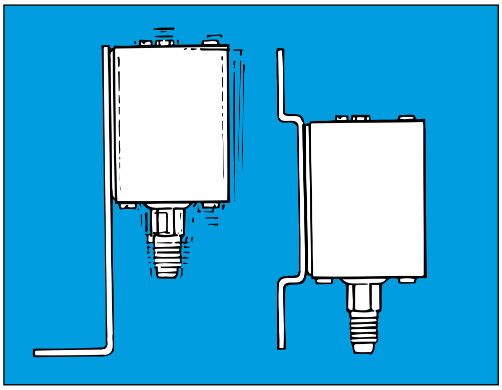
Mount the KP pressure control on a bracket or on a completely flat surface.

The pressure control can also be mounted on the compressor itself.

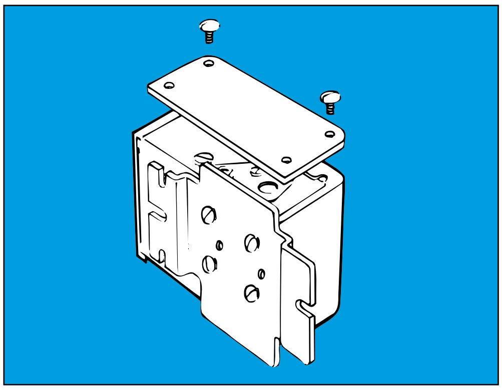
In unfavourable conditions, an angle bracket could amplify vibration in the mounting plane. Therefore, always use a wall bracket where strong vibration occurs.



AI0_0001

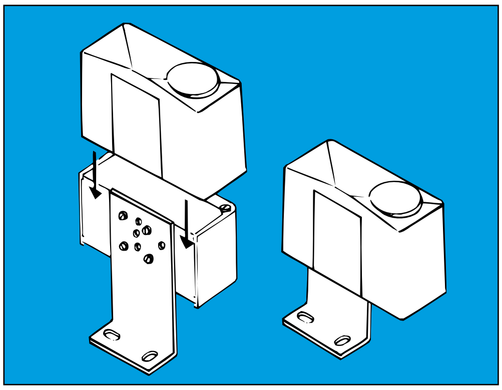
If the risk of water droplets or water spray is present, the accompanying top plate should be used. The plate increases the grade of enclosure to IP 44 and is suitable for all KP pressure controls. To obtain IP 44, the holes in the backplate of the control must be covered by mounting on either an angle bracket (060-105666) or a wall plate (060-105566).

The top plate is supplied with all units incorporating automatic reset. It can also be used on units with manual reset, but in that case must be purchased separately (code no.: for single unit, 060-109766; for dual unit, 060-109866).



AI0_0007

If the unit is to be used in dirty conditions or where it might be exposed to heavy spray - from above or from the side - it should be fitted with a protective cap. The cap can be used together with either an angle bracket or a wall bracket.



AI0_0008

If the unit risk being exposed to heavy water influence a better grade of enclosure can be achieved when mounting the product in a special IP 55 enclosure.

The IP 55 enclosure is available for both single unit (060-033066) and dual unit (060-035066).

Ak0_0020

Pressure controls

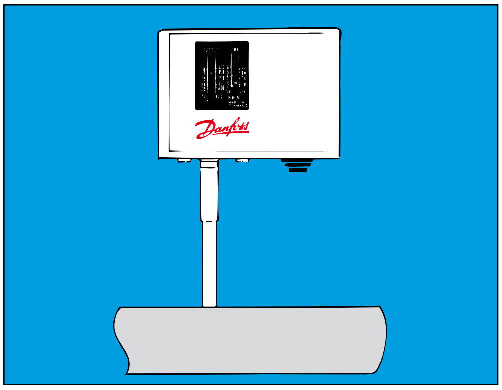
Installation *(cont.)*

The pressure connection of the control must always be fitted to the pipe in such a way that liquid cannot collect in the bellows. This risk is present especially when:

- the unit is located in a low ambient condition, e.g. in an air current,
- the connection is made on the underside of the pipe.

Such liquid could damage the high-pressure control.

Consequently, compressor pulsation would not be damped and might give rise to contact chatter.



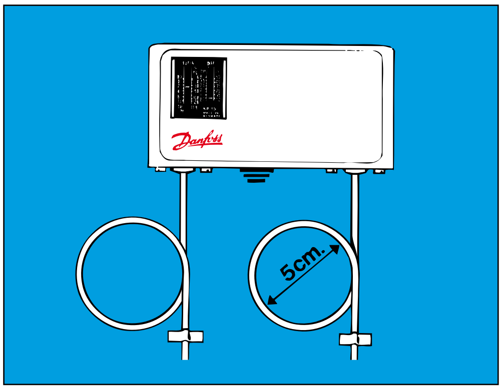
AI0_0009

Placing of surplus capillary tube

Surplus capillary tube can fracture if vibration occurs and might lead to complete loss of system charge. It is therefore very important that the following rules are observed:

- When mounting direct on compressor:
  Secure the capillary tube so that the compressor/control installation vibrates as a whole. Surplus capillary tube must be coiled and bound.

Note:
According to EN rules it is not allowed to use capillary tube for connecting safety pressure controles. In such case a 1/4 inch tube is prescribed.

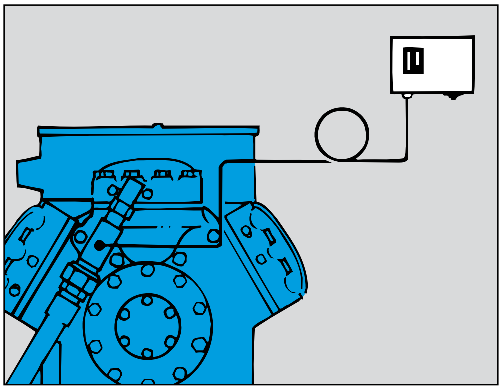


AI0_0010

- Other types of mounting:
  Coil surplus capillary tube into a loose loop. Secure the length of capillary tube between compressor and loop to the compressor.

  Secure the length of capillary tube between loop and pressure control to the base on which the pressure control is mounted.

In case of very strong vibrations, Danfoss steel capillary tubes with flare connection are recommended:
Code no. 0.5 m = 060-016666
Code no. 1.0 m = 060-016766
Code no. 1.5 m = 060-016866



AI0_0011

Setting

KP pressure controls can be preset using a compressed air cylinder. Ensure that the change-over contacts are correctly connected for the required function.

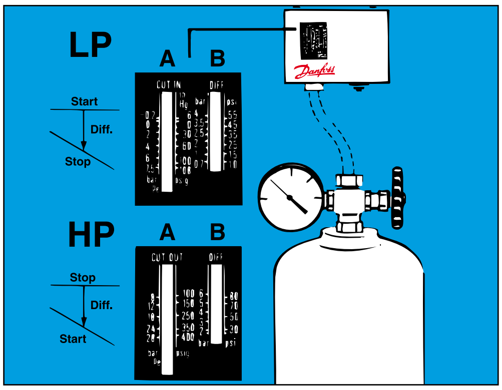
Low-pressure control

Set the start pressure (CUT IN) on the range scale (A). Then set the differential on the differential scale (B).
Stop pressure = CUT IN minus DIFF.

High-pressure control

Set the stop pressure (CUTOUT) on the range scale (A). The set the differential on the differential scale (B).
Start pressure = CUT OUT minus DIFF.

Remember: The scales are indicative only.



AI0_0012

Example with four compressors in parallel (R404A)

Medium: ice cream at −25°C,
$t_0 \approx -37°C$,
$p_0 \approx -0.5$ bar,
Δp suction line corresponding to 0.1 bar.

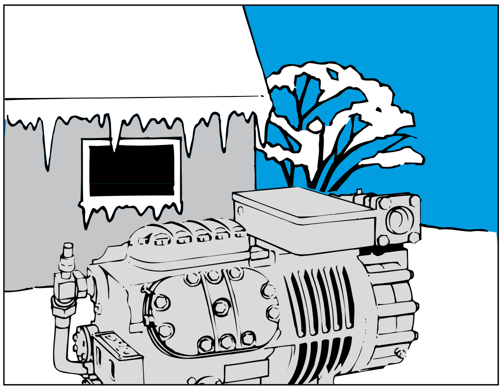
Each pressure control (e.g. KP 2) must be set individually in accordance with the following table.

Compressor	CUT OUT	CUT IN
1	−0.05 bar	0.35 bar
2	0.1 bar	0.5 bar
3	0.2 bar	0.6 bar
4	0.35 bar	0.75 bar
The pressure control must be mounted in such a way that liquid cannot collect in the bellows.		

Setting LP for outdoor location

If the compressor, condenser and receiver are situated outdoors, KP low pressure must be set to a "CUT IN" setting lower than the lowest occurring pressure (temperature around compressor) during winter operation. In this case, after longer standstill periods the pressure in the receiver determines the suction pressure.

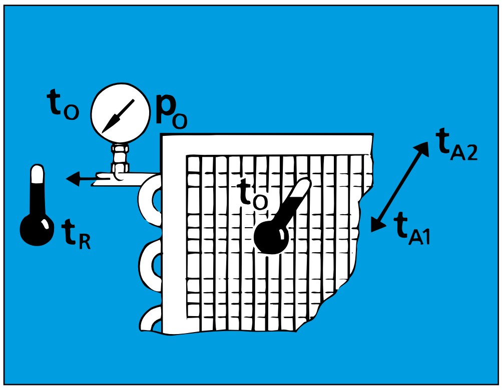
Example:
Lowest occurring temperature around the compressor −20°C means, for R404A, a pressure of 1 bar. CUT IN must be set at −24°C (corresponding to 1.6 bar).



AI0_0013

Indicative evaporating pressures (p_e) for different types of systems

Room temp. (t_r)	System type	Difference between t_e and t_{media} (air)	Evaporating pressure (p_e)	RH [%]	Setting of KP2/KP1 (cut in - cut out) D = Operating press. cont. S = Safety press. cont.
+0.5°/+2°C	Fan-cooled meat cold room	10K	1.0 - 1.1 bar (R134a)	85	0.9 - 2.1 bar (D)
+0.5°/+2°C	Meat cold room with natural air circulation	12K	0.8 - 0.9 bar (R134a)	85	0.7 - 2.1 bar (D)
−1°/0°C	Refrigeration meat counter (open)	14K	0.6 bar (R134a)	85	0.5 - 1.8 bar (D)
+2°/+6°C	Milk cold room	14K	1.0 bar (R134a)	85	0.7 - 2.1 bar (D)
0°/+2°C	Fruit cold room Vegetable chiller	6K	1.3 - 1.5 bar (R134a)	90	1.2 - 2.1 bar (D)
−24°C	Freezer	10K	1.6 bar (R404A)	90	0.7 - 2.2 bar (S)
−30°C	Ventilated deep freeze room	10K	1 bar (R404A)	90	0.3 - 2.7 bar (S)
−26°C	Ice cream freezer	10K	1.4 bar (R404A)	90	0.5 - 2.0 bar (S)



AI0_0015

Test of contact function

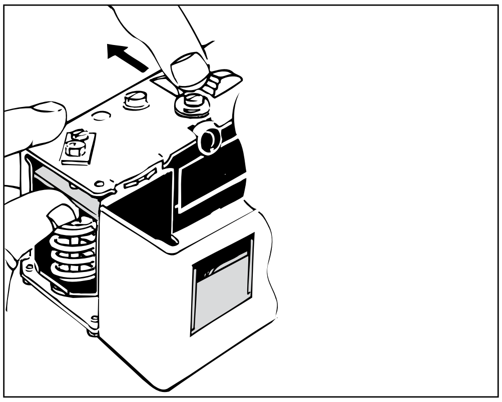
When the electrical leads are connected and the system is under normal operating pressure, the contact function can be tested manually.

Depending on the bellows pressure and setting, the test device must be pressed up or down.

Any reset mechanism becomes inoperative during the test.

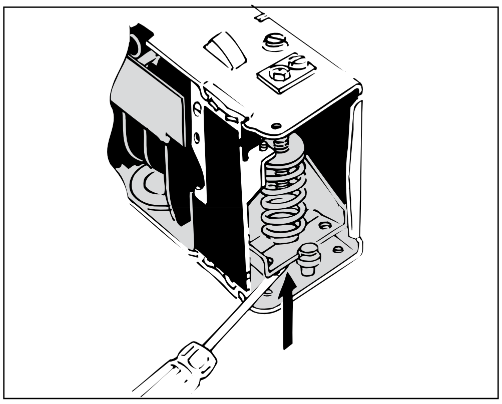
On single units:
Use the test device at top left.

On dual units:
Use the test device on the left for low-pressure testing and the one at bottom right for high-pressure testing.



AI0_0018

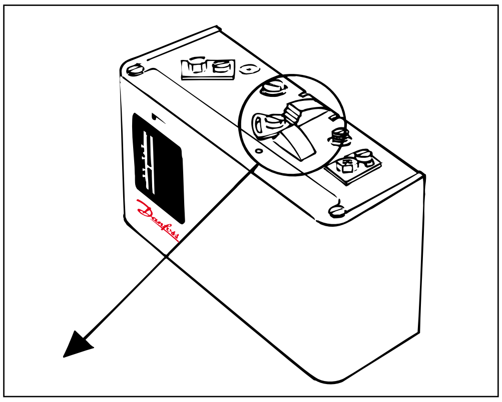
Warning!
The contact function on a KP Pressure Control must never be tested by activating the device at top right. If this warning is ignored, the control may go out of adjustment. In the worst case function can be impaired.



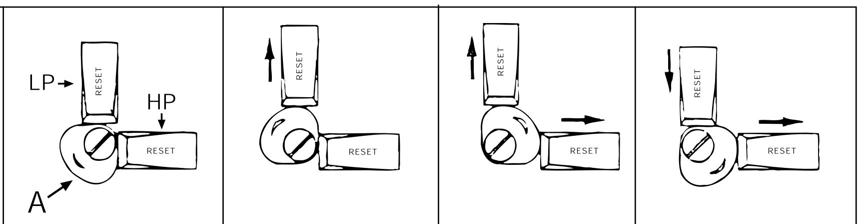
AI0_0019

On the KP 15 dual pressure control with optional automatic or manual reset on low-pressure and high-pressure side, automatic reset must be set when servicing is being carried out. The pressure control can then automatically restart. Remember, the original reset function must be set after servicing.

The pressure control can be protected against being set on automatic reset: Simply remove the washer controlling the reset function!
If the unit is to be protected against tampering, the washer can be sealed with red lacquer.



AI0_0020



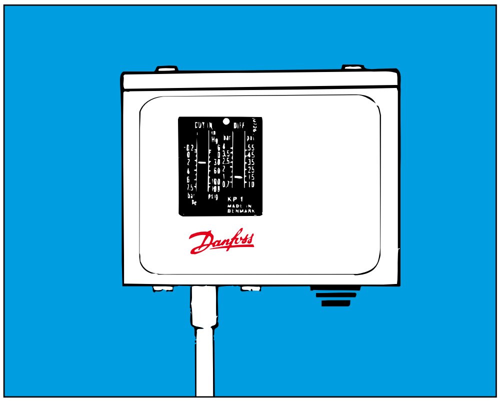
Low pressure	Manual reset *)	Automatic reset	Automatic reset	Manual reset
High pressure	Manual reset *)	Manual reset	Automatic reset	Automatic reset

*) Factory setting

AI0_0021

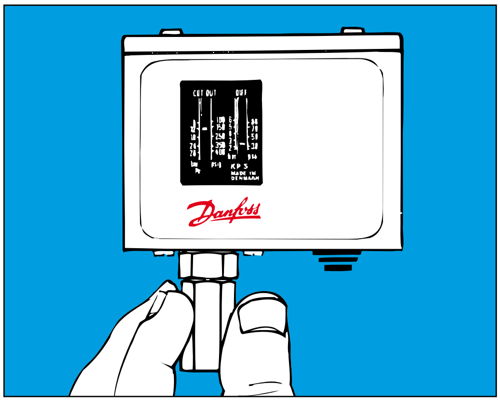
The correct pressure control for your system

KP with solder connections can be used instead of flare connections on hermetic systems.



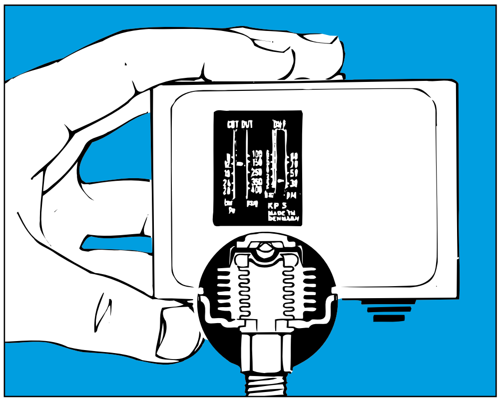
AI0_0006

In ammonia plant where KP pressure controls are used, they must be type KP-A.
A connector with M10 × 0.75 – $^{1}/_{4}$ - 18 NPT (code no. 060- 014166).



AI0_0002

For refrigerating systems containing a large quantity of charge medium and where extra safety is desired/demanded (Fail-safe): Use KP 7/17 with double bellows. The system will stop if one of the bellows ruptures - without loss of charge.



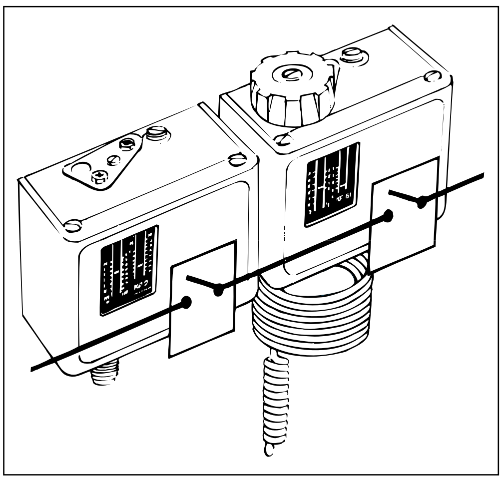
AI0_0003

For systems operating with low pressure on the evaporator side, and where the pressure control must regulate (not just monitor): Use KP 2 with a small differential.
An example where pressure control and thermostat are in series:

KP 61 regulates the temperature via compressor stop/start.
KP 2 stops the compressor when suction pressure becomes too low.

KP 61:
CUT IN = 5°C (2.6 bar)
CUT OUT = 1°C (2.2 bar)

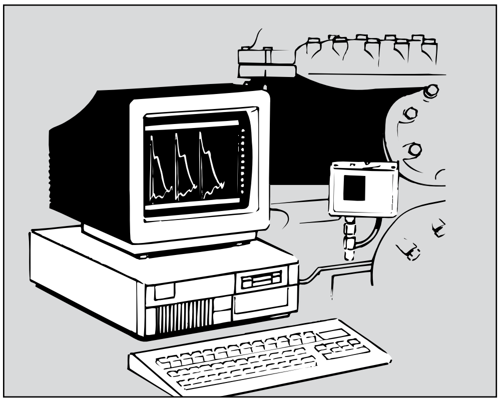
KP 2 low pressure:
CUT IN = 2.3 bar
CUT OUT = 1.8 bar



AI0_0004

The correct pressure control for your system *(cont.)*

For systems where KP is activated occasionally (alarm) and for systems where KP is the signal source for PLC, etc.: Use KP with gold contacts; these give good contact at low voltages.



AI0_0005

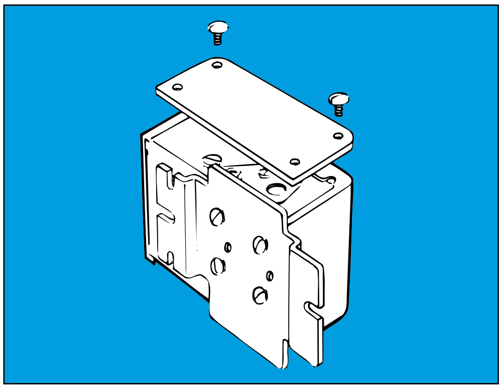
Contents

Notes

Installation

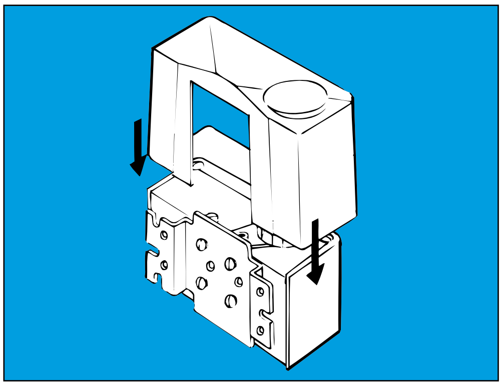
If the risk of water droplets or water spray is present, fit a top plate. The plate increases the grade of enclosure to IP 44 and is suitable for all KP thermostats. The top plate must be purchased separately (Code no.: for single unit, 060-109766; for dual unit, 060-109866).

To obtain IP 44, cover all holes in the backplate of the thermostat.



Aj0_0001

If the unit is to be used in dirty conditions or where it might be exposed to heavy spray it should be fitted with a protective cap. The cap can be used together with either an angle bracket (060-105666) or a wall bracket (060-105566).



Aj0_0002

If the unit risk being exposed to heavy water influence a better grade of enclosure can be achieved when mounting the product in a special IP 55 enclosure
The IP 55 enclosure is available for both single unit (060-033066) and dual unit (060-035066).

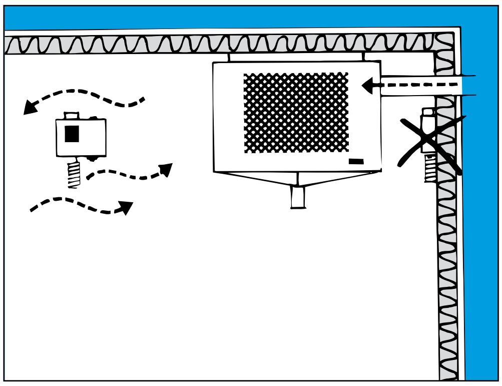
Ak0_0020

KP thermostat with air sensor

Remember that the differential is affected by air circulation around the sensor. Insufficient air circulation can increase the differential by 2-3°C.

Place the room thermostat so that air is able to flow freely around the sensor. At the same time, ensure that the sensor is not exposed to draughts from doors or radiation from the evaporator surface.

Never place the thermostat directly on a cold wall; this increases the differential. Instead, mount the unit on an insulating plate.



Aj0_0003

KP thermostat with air sensor (cont.)

When placing the sensor: Remember that air must be able to circulate freely around the sensor. With control from, for example, return air temperature, the sensor must not touch the evaporator.

Ah0_0006

KP thermostat with cylindrical sensor
There are three ways of securing the sensor:
1) The pipe.
2) Between evaporator fins.
3) In a pocket.

When using a pocket: Always use heat-conductive compound (code no. 041E0110) to ensure good contact between sensor and medium.

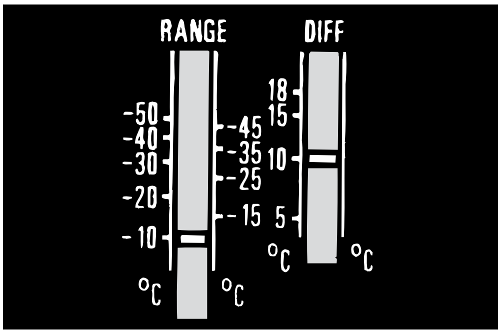
Setting

Thermostats with automatic reset

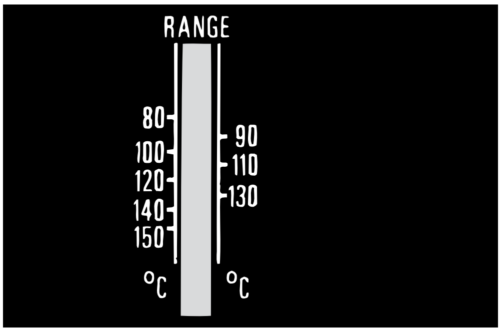
Always set the highest temperature on the range scale. Then set the differential on the DIFF scale.

The temperature setting on the range scale then corresponds to the temperature at which a refrigeration compressor will be started on rising temperature. The compressor will stop when the temperature corresponds to the value set on the DIFF scale.

For pre-setting of vapour charged thermostats, the graph curves stated in the customer instruction sheet should be used.
If the compressor will not stop when it is set for low stop temperatures: Check to see whether the differential has been set at too high a value.



Aj0_0004



Aj0_0005

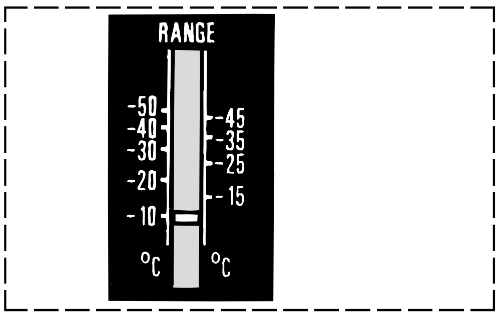
Thermostats with maximum reset

Set the highest temperature = stop temperature on range scale.

The differential setting is fixed. When the temperature on the thermostat sensor corresponds to the differential setting, the system can be restarted by pressing the "Reset" button.

Thermostats with minimum reset

Set the lowest temperature = stop temperature on range scale.
The differential setting is fixed.
When the temperature around the thermostat sensor has risen to the differential setting, the compressor can be restarted by pressing the “Reset” button.



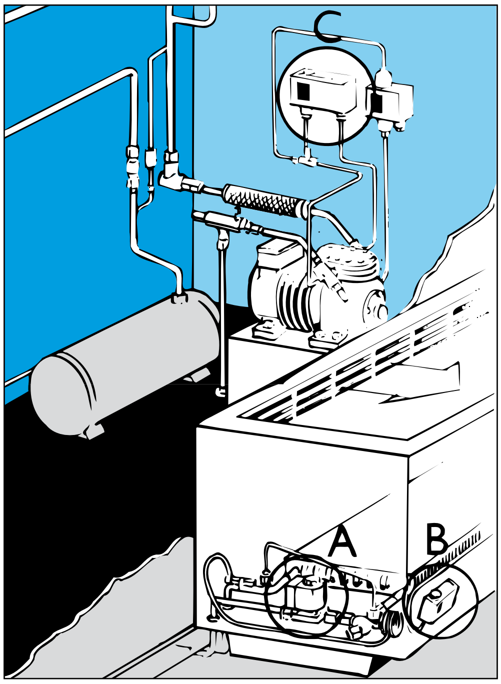
Aj0_0006

Setting example

The temperature in a deep freeze room is to be controlled by a thermostat that closes a solenoid valve. The system is of the pump-down type and is stopped via a low-pressure control.
Here, the pressure control must not be set to cut out at a pressure lower than necessary.
At the same time, it must cut in at a pressure corresponding to the cut-in temperature of the thermostat.

Example:

Deep freeze room with	R404A
Room temperature:	–20°C
Thermostat cut out temperature:	–20°C
Thermostat cut in temperature:	–18°C
Pressure control cut out pressure:	0.9 bar (–32°C)
Pressure control cut in pressure:	2.2 bar (–18°C)

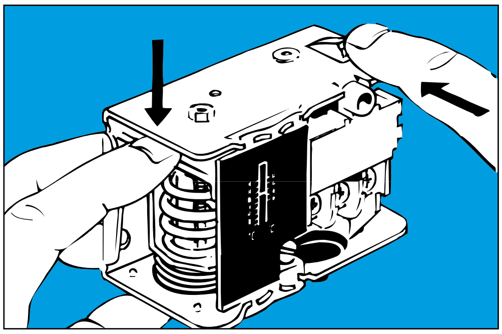


Aj0_0007

Test of contact function

When the electrical leads are connected, the contact function can be tested manually. Depending on the sensor temperature and the thermostat setting, the test device must be pressed up or down. Any reset mechanism becomes inoperative during the test.

Use the test device at top left.

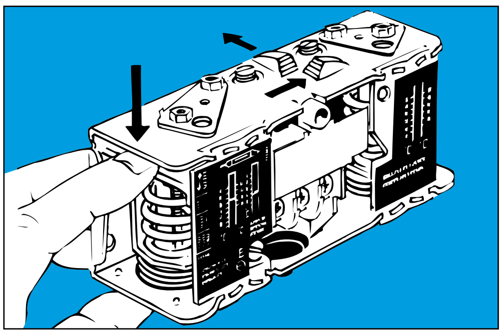


Aj0_0009

Warning!
The contact function on a KP single thermostat must never be tested by activating the device on the righthand side. If this warning is ignored, the thermostat might go out of adjustment. In the worst case, function can be impaired.

KP 98 dual thermostat

Use the test device on the lefthand side to test function on rising oil temperature and the test device at bottom right to test function on rising pressure gas temperature.



Aj0_0010

The correct thermostat for your refrigeration system

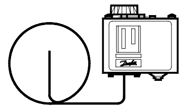
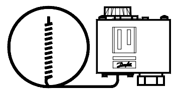
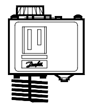
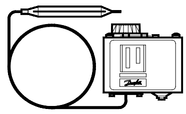
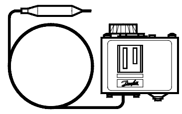
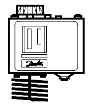
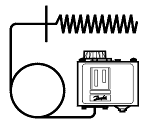
A thermostat must contain the correct charge, as described below.

Vapour charge

Low temperatures, coldest bellows, not enclosure-sensitive.
Thermostat with air coil: On gradual temperature rise and fall (less than 0.2K/min), e.g. in large, sluggish cold rooms containing many items, KP 62 with vapour charge is recommended.

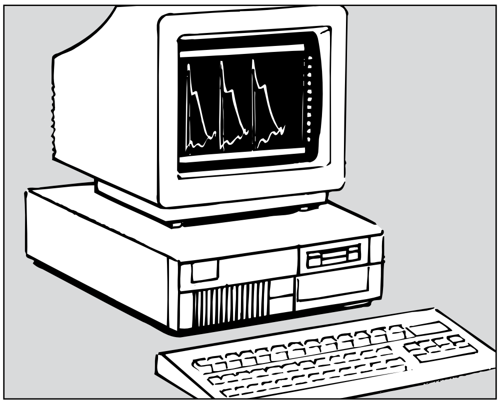
Absorption charge

High temperatures, enclosure-sensitive. Bellows colder or warmer.
Thermostat with air coil: On fast changes in temperature (more than 0.2K/ min), e.g. in smaller cold rooms where the produce turnover rate is high, KP 62 with absorption charge is recommended.

Vapour charge	 60I8012	Straight capillary tube
	 60I8032	Remote air coil
	 60I8013	Air coil (integral with thermostat)
Absorption charge	 60I8017	Double contact remote bulb
	 60I8008	Cylindric remote bulb
	 60I8013	Air coil (integral with thermostat)
	 60I8018	Remote air coil (for duct mounting)

Low voltage

For systems where KP is activated occasionally (alarm) and for systems where KP is the signal source for PLC, etc. (low voltage): Use KP with gold contacts; these give good contact at low voltages.

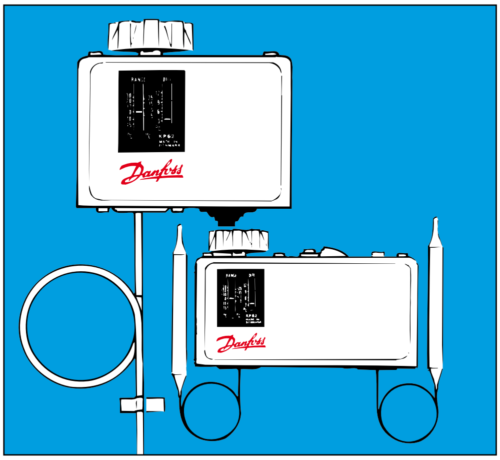


Aj0_0012

Placing of surplus capillary tube

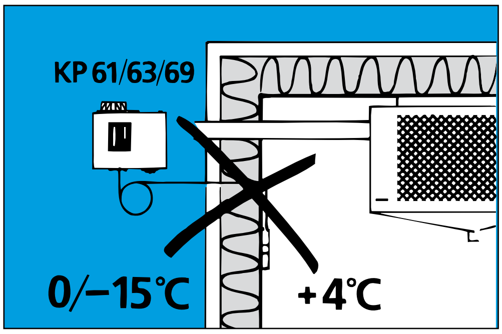
Dual thermostat KP 98:
Surplus capillary tube can fracture if vibration occurs and might lead to loss of thermostat charge. It is therefore very important that the following rules be observed:

- When mounting direct on compressor: Secure the capillary tube so that the compressor/thermostat installation vibrates as a whole. Surplus capillary tube must be coiled and bound.
- Other types of mounting: Coil surplus capillary tube into a loose loop. Secure the length of capillary tube between compressor and loop to the compressor.
  Secure the length of capillary tube between loop and thermostat to the base on which the thermostat is mounted.


Aj0_0017

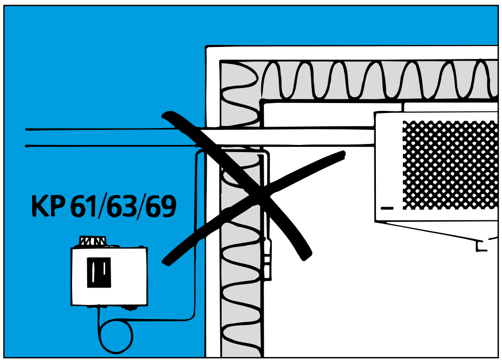
Thermostats with vapour charge

Never locate a KP thermostat with vapour charge in a room where the temperature is or can be lower than that in the cold room.



Aj0_0014

Never allow the capillary tube from a KP thermostat to run alongside of a suction line in a wall entry.



Aj0_0015

Contents

Notes

Application

Type KV pressure regulators will control the low and high pressure sides of the system under varying load conditions:

KVP is used as an evaporating pressure regulator.
KVR is used as a condensing pressure regulator.
KVL is used as a crankcase pressure regulator.
KVC is used as a capacity regulator.
NRD is used as a differential pressure regulator and as a receiver pressure regulator.
KVD is used as a receiver pressure regulator.
CPCE is used as a capacity regulator.

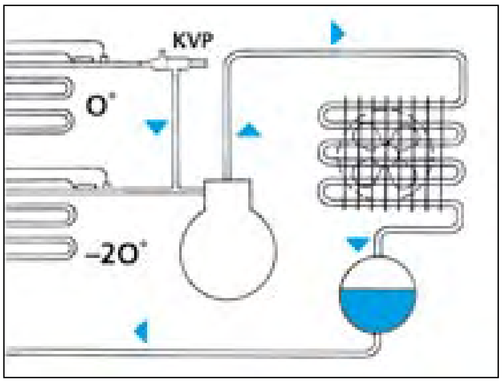
Ak0_0031

KVP evaporating pressure regulator

The evaporating pressure regulator is installed in the suction line after the evaporator to regulate the evaporating pressure in refrigeration systems with one or more evaporators and one compressor.

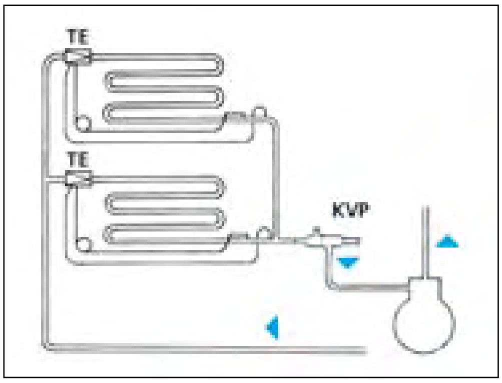
In such refrigeration systems (operating on different evaporating pressures) KVP is installed after the evaporator with the highest evaporating pressure.

Each evaporator is activated by a solenoid valve in the liquid line. The compressor is contolled by a pressure switch in a pump down function. The maximum pressure on the suction side corresponds to the lowest room temperature.



Ak0_0025

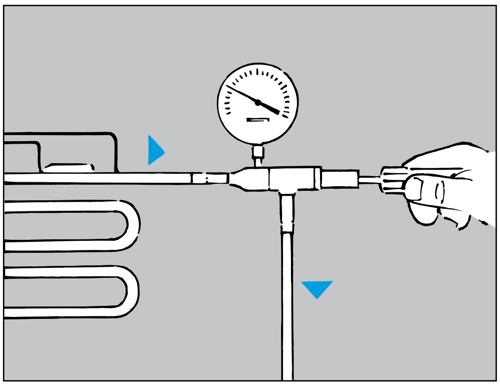
In refrigeration systems with parallel coupled evaporators and common compressors, and where the same evaporating pressure is required, KVP must be installed in the common suction line.



Ak0_0019

The KVP evaporating pressure regulator has a pressure gauge connection for use when setting the evaporating pressure. KVP maintains constant pressure in the evaporator.

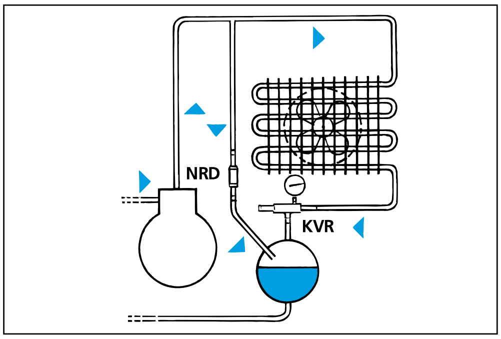
KVP opens on rising inlet pressure (evaporating pressure).


Ak0_0023

KVR condensing pressure regulator

KVR is normally installed between the air-cooled condenser and the receiver. KVR maintains constant pressure in air-cooled condensers.
It opens on rising inlet pressure (condensing pressure).

KVR together with a KVD or an NRD ensures a sufficiently high liquid pressure in the receiver during varying operating conditions.
The KVR condensing pressure regulator has a pressure gauge connection for use when setting the condensing pressure.

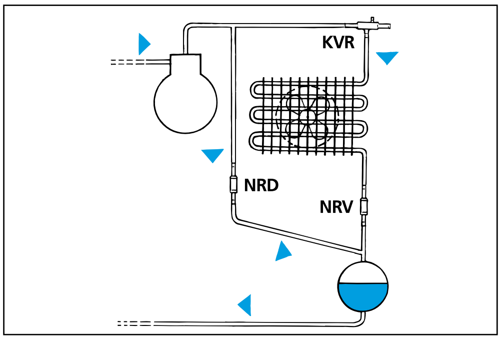


Ak0_0026

In situations where both the air-cooled condenser and the receiver are located outdoors in very cold surroundings it can be difficult to start the refrigeration system after a long standstill period.

In such conditions, KVR is installed ahead of the air-cooled condenser, with an NRD in a bypass line around the condenser.

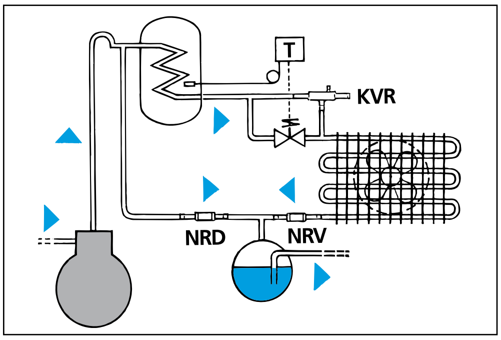
NRV prevent back flow during start up process.



Ak0_0027

KVR is also used in heat recovery. In this application, KVR is installed between the heat recovery vessel and condenser.

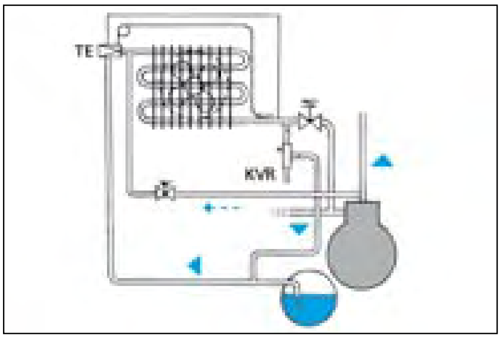
It is necessary to install an NRV between condenser and receiver in order to prevent back-condensation of the liquid in the condenser.



Ak0_0028

KVR can be used as a relief valve in refrigeration systems with automatic defrosting. Here, KVR is installed between the outlet tube from evaporator and receiver.

Note!
KVR must **<u>never</u>** be used as a safety valve.



Ak0_0029

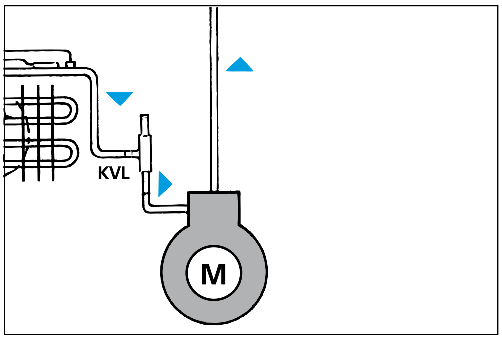
KVL crankcase pressure regulator

KVL crankcase pressure regulator limits compressor operation and start-up if the suction pressure becomes too high.

It is installed in the refrigeration system suction line immediately ahead of the compressor.

KVL is often used in refrigeration systems with hermetic or semihermetic compressors designed for low-temperature ranges.

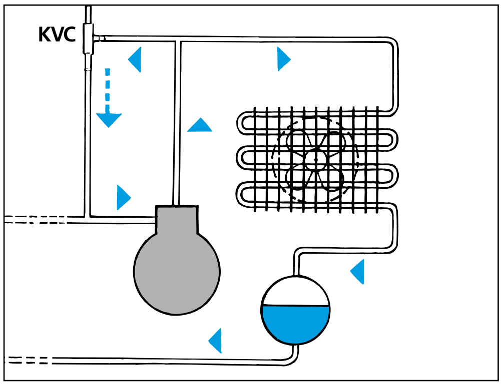
KVL opens on falling outlet pressure (suction pressure).



Ak0_0024

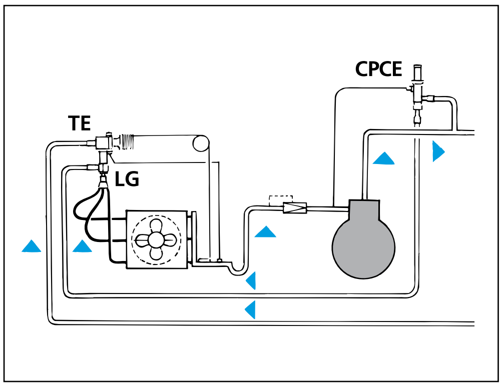
KVC capacity regulator

KVC is used for capacity regulation in refrigeration systems where low-load situations occur and where it is necessary to avoid low suction pressure and "compressor cycling".
Too low a suction pressure will also cause vacuum in the refrigeration system and thus create the risk of moisture ingress in refrigeration systems with open compressor. KVC is normally installed in a bypass line between compressor discharge tube and suction tube. KVC opens on falling outlet pressure (suction pressure).



Ak0_0030

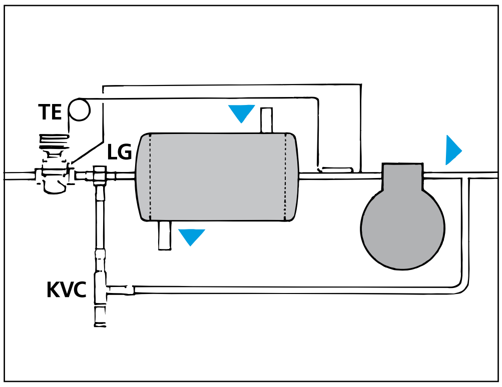
A CPCE capacity regulator can be used as an alternative to KVC if the requirement is greater accuracy in the regulation, low suction pressure or if higher pressure drop is given between CPCE outlet and the suction pressure.



Ak0_0002

KVC can also be installed in a bypass line from the compressor discharge pipe, with valve outlet led to a point between expansion valve and evaporator.

This arrangement can be used on a liquid cooler with several parallelcoupled compressors and where no liquid distributor is used.



Ak0_0003

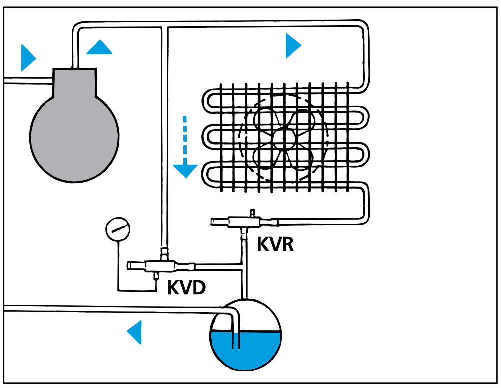
KVD receiver pressure regulator

KVD is used to maintain sufficiently high receiver pressure in refrigeration systems with or without heat recovery.

KVD is used together with a KVR condensing pressure regulator.

The KVD receiver pressure regulator has a pressure gauge connection for use when setting receiver pressure.

KVD opens on falling outlet pressure (receiver pressure).



Ak0_0004

Identification

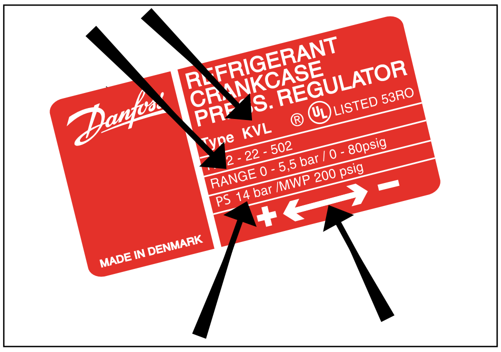
All KV pressure regulators carry a label giving the valve function and type, e.g. CRANKCASE PRESS. REGULATOR type KVL.

The label also gives the operating range of the valve and its max. permissible working pressure (PS/MWP).

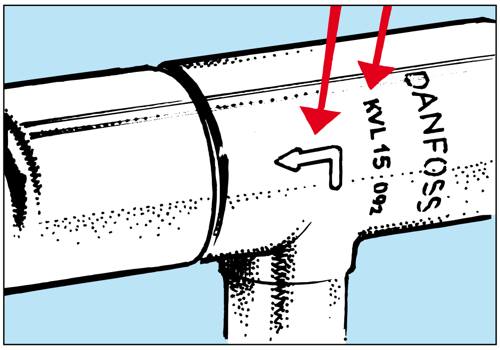
A double-ended arrow (“+” and “-“) is printed on the bottom of the label. Direction “+” (plus) means higher pressure and “–“ (minus) means lower pressure.

KV pressure regulators can be used with all existing refrigerants except ammonia (NH_3), provided valve pressure ranges are respected.

The valve body is stamped with the valve size, e.g. KVP 15, with an arrow to indicate valve flow direction.



Ak0_0032



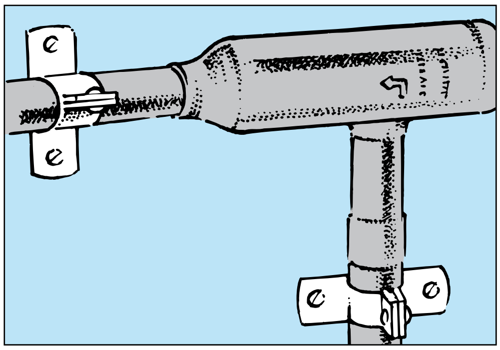
Ak0_0005

Installation

Ensure that piping around KV valves is clean and well-secured. This will protect valves against vibration.

All KV pressure regulators must always be installed so that flow is in the direction of the arrow.

KV pressure regulators can otherwise be installed in any position, but they must never be able to create an oil or liquid lock.

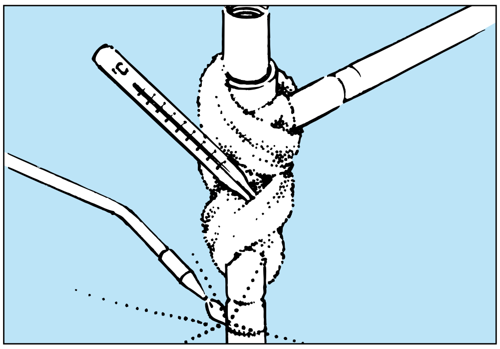

Ak0_0006

Soldering/brazing

During soldering, it is important to wrap a wet cloth around the valve.

Always point the gas flame away from the valve so that the valve is never subjected to direct heat. When soldering, be careful not to leave soldering material in the valve as this can impair function.

Before soldering a KV valve, be sure that any pressure gauge insert has been removed. Always use inert gas when soldering KV valves.


Ak0_0007

Warning!
Alloys in soldering materials and flux give off smoke which can be hazardous to health. Please read suppliers’ instructions and follow their safety precautions. Keep the head away from the smoke during soldering. Use good ventilation and/or an extract at the flame and do not inhale smoke and gases. It is a good idea to use safety goggles. Soldering while refrigerant is present in the system is not recommended.

Aggressive gases might be created which can, for example, break down the bellows in KV valves or other parts in the refrigeration system.

Pressure testing

KV pressure regulators can be pressure-tested after they have been installed, provided the test pressure does not exceed the maximum permissible pressure on the valves.

The maximum test pressure for KV valves is shown in the table.

Type	Test pressure, bar
KVP 12 - 15 - 22	28
KVP 28 - 35	25
KVL 12 - 15 - 22	28
KVL 28 - 35	25
KVR 12 - 15 - 22	31
KVR 28 - 35	31
KVD 12 - 15	31
KVC 12 - 15 - 22	31

Evacuation

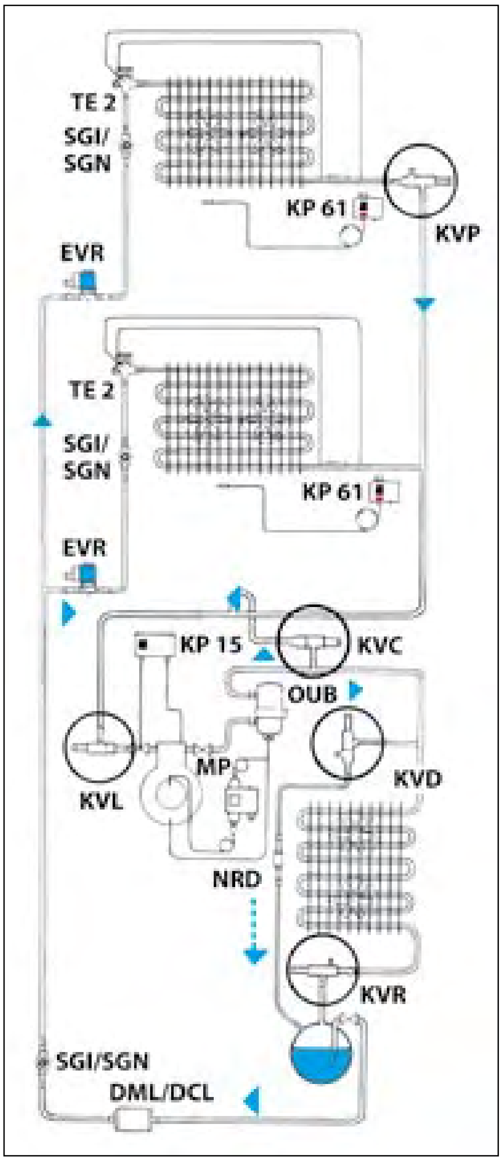
During evacuation of the refrigeration system, all KV valves must be open.

Factory-set KV valves will have the following positions when supplied:
KVP, closed
KVR, closed
KVL, open
KVC, open
KVD, open

It is therefore necessary to screw the setting spindle of KVP and KVR right back counter-clockwise during system evacuation.

In individual cases it can be necessary to evacuate from both discharge side and low-pressure side in the refrigeration system.

Evacuation through the pressure gauge connections of KVP, KVR and KVD is not advisable because the orifice in these ports are very small.



Ak0_0009

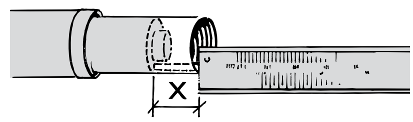
Setting

When setting KV pressure regulators in refrigeration systems it can be a good idea to use the factory setting as the starting-out point.

The factory setting for individual pressure regulators can be found again by measuring from the top of the valve to the top of the setting screw.

The table shows the factory setting, the distance "x" and the pressure change per revolution of the setting screw for all KV types.

Type	Factory setting	X mm	bar/rev.
KVP 12 - 15 - 22	2 bar	13	0.45
KVP 28 - 35	2 bar	19	0.30
KVL 12 - 15 - 22	2 bar	22	0.45
KVL 28 - 35	2 bar	32	0.30
KVR 12 - 15 -22	10 bar	13	2.5
KVR 28 - 35	10 bar	15	1.5
KVD 12 - 15	10 bar	21	2.5
KVC 12 - 15 - 22	2 bar	13	0.45



Ak0_0010

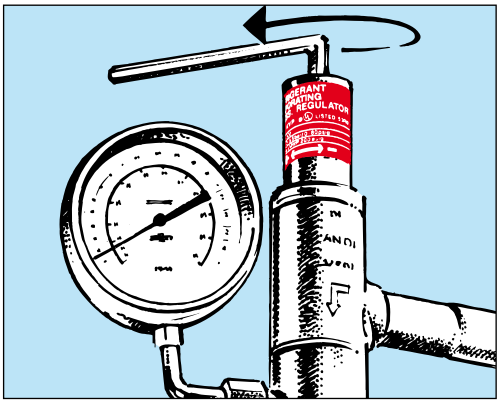
KVP evaporating pressure regulators

KVP evaporating pressure regulators are always supplied with a factory setting of 2 bar. Turning clockwise gives higher pressure and turning counterclockwise gives lower pressure.

After the system has been in normal operation for a time, fine adjustment is necessary. Always use a pressure gauge when making fine adjustments.

If KVP is used for frost protection, fine adjustment must be made when the system is operating under minimum load.

Remember to always replace the protective cap on the setting screw after final setting.



Ak0_0011

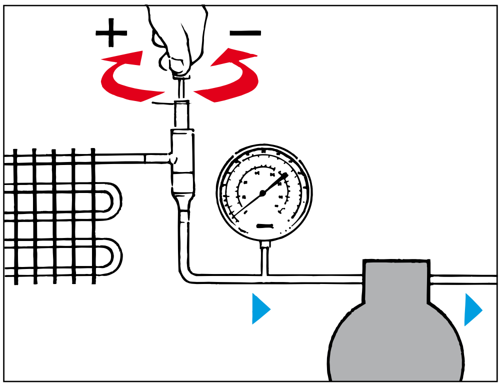
KVL crankcase pressure regulators

KVL crankcase pressure regulators are always supplied with a factory setting of 2 bar.

Turning clockwise gives higher pressure and turning counterclockwise gives lower pressure.

The factory setting is the point at which KVL begins to open or where it just closes. Since the compressor must be protected, the KVL setting is the max. permissible suction pressure of the compressor.

The setting must be made using the compressor suction pressure gauge.



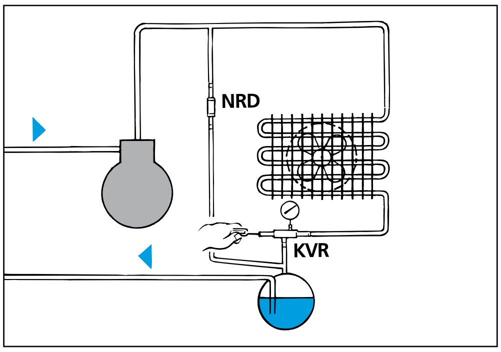
Ak0_0012

KVR + NRD condensing pressure regulators

In refrigeration systems with KVR + NRD, the setting of KVR must give a suitable receiver pressure.

Pressure in the condenser of between 1.4 and 3.0 bar (pressure drop across NRD) higher than the pressure in the receiver should be acceptable. If it cannot be accepted, an arrangement with KVR + KVD must be used.

This setting is best made during operating in a winter period.



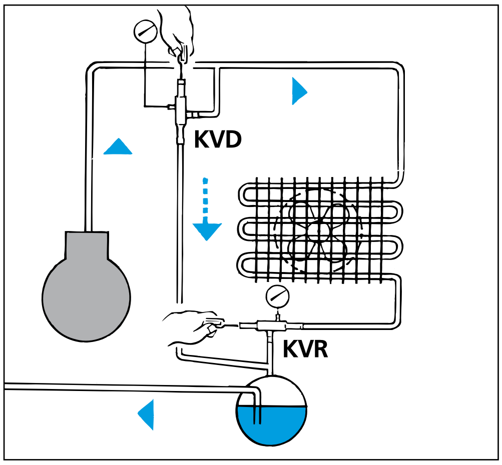
Ak0_0013

KVR + KVD condensing pressure regulators

In refrigeration systems with KVR + KVD, the condensing pressure must first be set with KVR while KVD is closed (setting screw turned back fully counterclockwise).

Then, KVD must be set to a receiver pressure, e.g. about 1 bar lower than condensing pressure. A pressure gauge must be used for this setting which is best made during operation in a winter period.

If the condensing pressure is set during summer operation, one of two procedures can be used:
1) In a newly-installed refrigeration system with a KVR/KVD setting of 10 bar as the starting out point, the system can be set by counting the number of turns on the setting screw.
2) In an existing refrigeration system, where the KVR/KVD setting is not known, the starting-out point must first be established. The number of turns on the setting screw can then be counted.



Ak0_0014

Danfoss pressure regulators

Product	Used as	Opens	Pressure range
KVP	Evaporating pressure regulator	on a rise in pressure on the inlet side	0 - 5.5 bar
KVR	Condensing pressure regulator	on a rise in pressure on the inlet side	5 - 17.5 bar
KVL	Crankcase pressure regulator	at a fall in pressure on the outlet side	0.2 - 6 bar
KVC	Capacity regulator	at a fall in pressure on the outlet side	0.2 - 6 bar
CPCE	Capacity regulator	at a fall in pressure on the outlet side	0 - 6 bar
NRD	Differential pressure regulator	Begins to open when the pressure drop in the valve is 1.4 bar, and is fully open when the pressure drop is 3 bar.	3 - 20 bar
KVD	Receiver pressure regulator	at a fall in pressure on the outlet side	3 - 20 bar

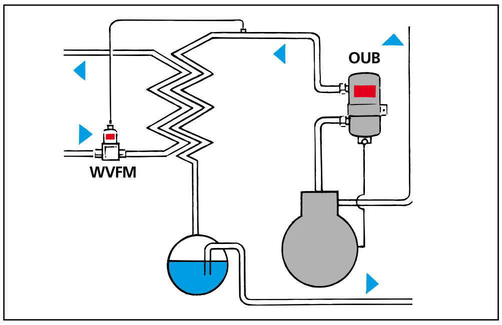
Contents

Notes

Application

WV pressure-operated water valves are used in refrigeration systems with water-cooled condensers to maintain constant condensing pressure under varying loads.

The water valves can be used for common refrigerants provided the operating range of the valves is not exceeded. The WVS can be used for R717 (ammonia)

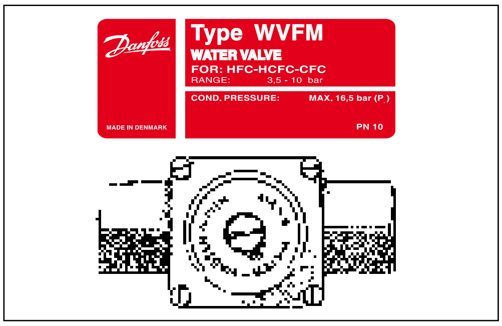


Ag0_0001

Identification

Danfoss water valve type WVFM consists of a valve body and bellows housing. The bellows housing carries a label giving valve type, operating range and max. permissible working pressure.

The label also indicates the max. permissible working pressure on the water side, given as PN 10 in accordance with IEC 534-4.
The direction in which the setting spindle must be turned for greater or lesser water quantity is given at the bottom of the valve.

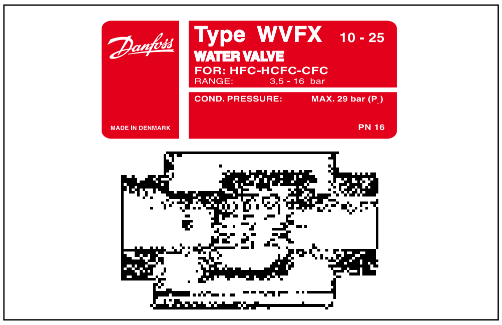


Ag0_0002

Water valve type WVFX consists of a valve body with setting unit on one side and a bellows housing on the other.

The bellows housing carries a label giving valve type, operating range and permissible working pressure.

All pressures given apply to the condenser side. Moulded in on one side of the valve body are PN 16 (nom. pressure) and, for example, DN 15 (nom. diameter), together with k_{vs} 1.9 (valve capacity in m^3/h at a pressure drop of 1 bar).

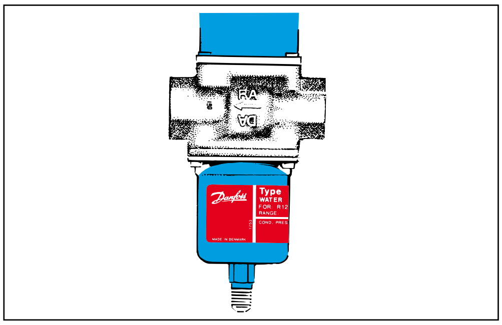


Ag0_0003

RA and DA are moulded in on the opposite side of the valve body.

RA means "reverse acting" and DA means "direct acting".

When WVFX is used as a condensing pressure valve the bellows housing must always be mounted nearest the DA marking.



Ag0_0004

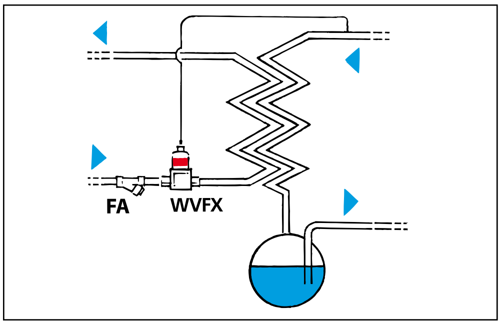
Installation

WVFM and WVFX are installed in the water line, normally ahead of the condenser, with flow in the direction of the arrow.

It is a good idea to always install an FV filter ahead of the water valve to exclude dirt from the moving parts of the valve.

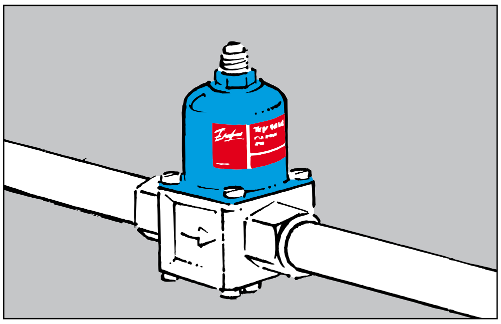
To prevent vibrations from being transmitted to the bellows housing the housing must be connected to the discharge line after the oil separator, via a capillary tube.

The capillary tube must be connected to the top side of the discharge line to prevent the back-flow of oil and perhaps dirt.



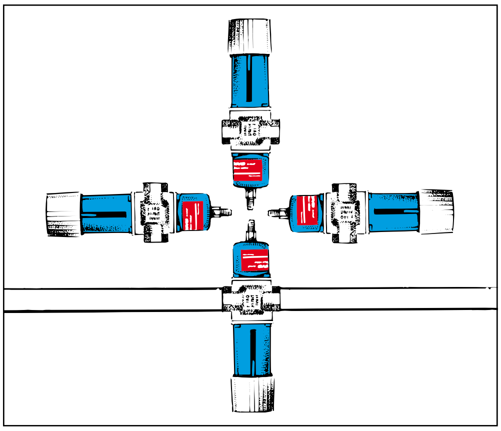
Ag0_0005

WVFM and WVFX 32-40 water valves are normally installed with bellows housing upwards.



Ag0_0006

WVFX 10-25 water valves can be installed in any position.



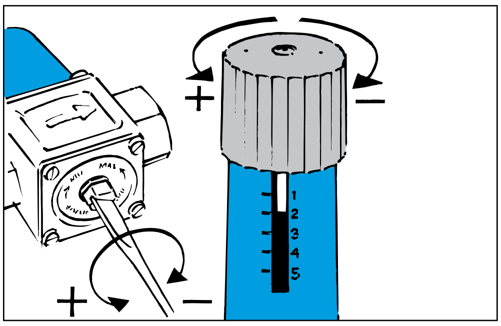
Ag0_0007

Setting

WVFM and WVFX water valves must be set to obtain the required condensing pressure. Turning the setting spindle clockwise gives lower pressure, turning it counterclockwise gives higher pressure.

The scale marks 1 - 5 can be used for coarse setting. Scale mark 1 corresponds to about 2 bar, and scale mark 5 corresponds to about 17 bar.

Note that the valve setting range is given for when the valve begins to open.
The condensing pressure must increase by 3 bar to fully open the valve.

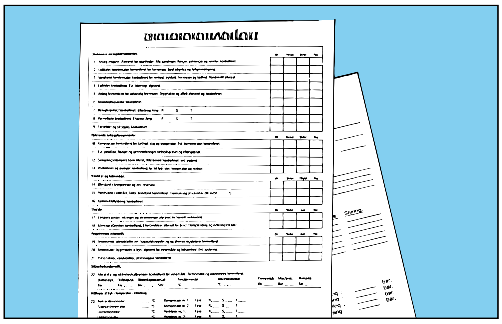


Ag0_0008

Maintenance

It is a good idea to include water valves in preventive maintenance because dirt (sludge) can collect around the moving parts of the valves.

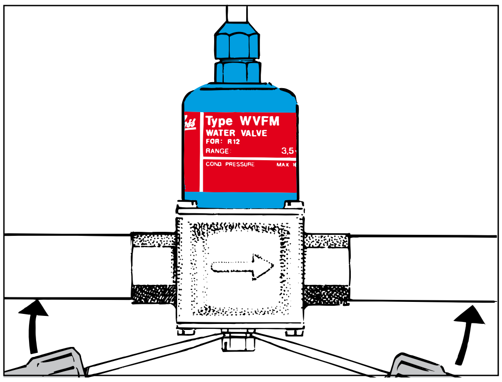
The maintenance routine can include flushing the water valves, partly to wash out impurities and partly to be able to “sense” whether the reaction of valves has become slower.



Ag0_0009

Flushing a WVFM water valve is easiest to perform if two screwdrivers are inserted under the setting screw.

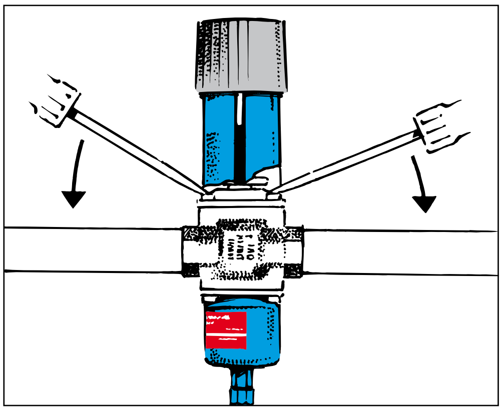
The screw can then be levered up to give greater water flow.



Ag0_0010

WVFX valves can be flushed similarly using two screwdrivers inserted in the slots on each side of the setting unit (spring housing) and under the spring cup.

Levering the screwdrivers down towards the piping gives greater water flow.

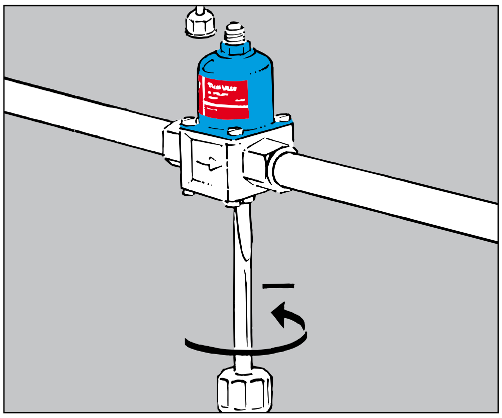


Ag0_0011

If operating irregularities appear in a water valve, or if leakage occurs across the valve seat, dismantle the valve and clean it.

Before dismantling a valve, the pressure must always be relieved from the bellows housing, i.e. it must be disconnected from the refrigeration system condenser.

Before dismantling, screw the setting spring fully clockwise towards the lowest pressure setting. The O-ring and remaining seals must always be replaced after dismantling.



Ag0_0012

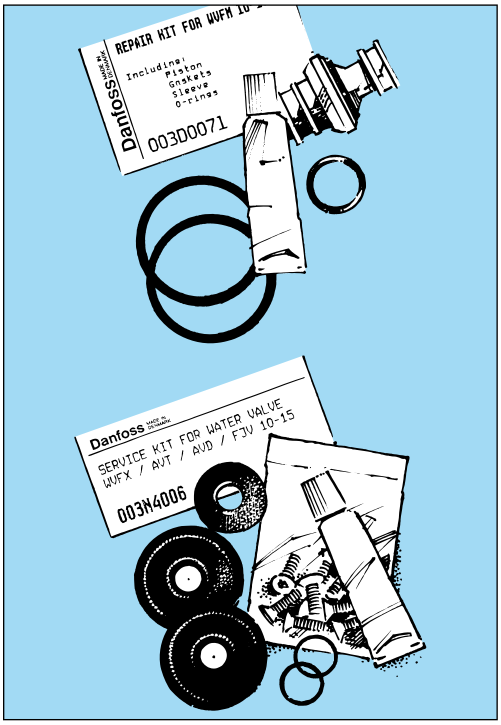
Water valves

Spare parts

Spare parts for WVFM and WVFX water valves can be obtained from Danfoss:

- one bellows housing.
- one service kit (containing spare parts, gaskets and grease for the water side of the valve).
- A gasket set is also supplied as a spare part for type WVFM.

The code numbers of spare parts and gasket sets are given in the spare parts catalogue*.



Ag0_0013

*) Find spare part documentation on http://www.danfoss.com

Contents

Notes

Function

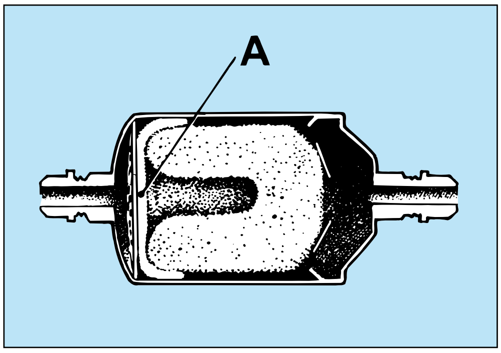
To ensure optimum function the refrigeration system must be internally clean and dry.

Before starting the system, moisture must be removed by evacuation at a max. pressure of 0.05 mbar abs.

During operation, dirt and moisture must be collected and removed. This is performed by a filter drier containing a solid core consisting of:

- Molecular Sieves
- Silica gel (low effectiveness - not used in Danfoss driers)
- Activated aluminium oxide and a polyester mesh A inserted in the filter outlet.

DML: 100% Molecular Sieves
DCL: 80% Molecular Sieves
20% Activated aluminium



Ah0_0001

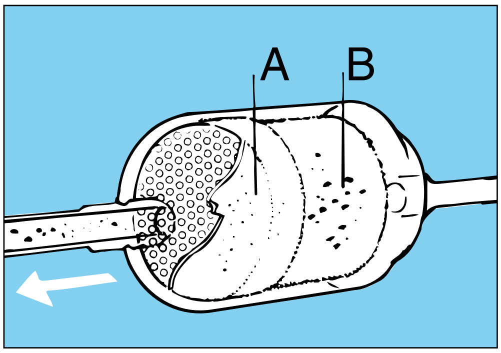
The solid core can be compared to a sponge's ability to soak up water and retain it.

Molecular Sieves retain water, whereas activated aluminium oxide retains water and acids.

The solid core B together with the polyester mat A also acts as a dirt filter.

The solid core retains large dirt particles and the polyester mat small ones.

The filter drier is thus able to collect all dirt particles larger than 25 micron.



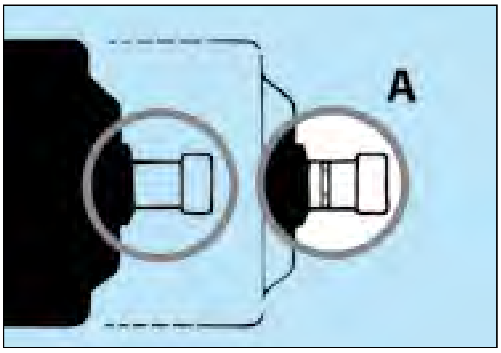
Ah0_0011

Filter drier selection

The filter drier must be selected to suit the connections and the capacity of the refrigeration system.

If a filter drier with solder connections is required, a Danfoss type DCL/DML filter drier can be used to advantage. It has an extra-high drying capacity which prolongs the interval between replacements.

A collar on the connector A indicates that the connection is a mm size. If the connector A is plain, i.e. no collar, the connector is an inch size. Type DCL can be used for CFC/HCFC refrigerants. Type DML can be used for HFC refrigerants. See page 60 for more details.

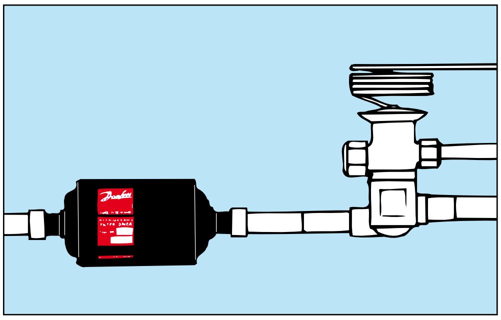


Ah0_0018

Location in refrigeration system

The filter drier is normally installed in the liquid line where its primary function is to protect the expansion valve.

The velocity of the refrigerant in the liquid line is low and therefore contact between the refrigerant and the solid core in the filter drier is good. At the same time, the pressure drop across the filter drier is low.



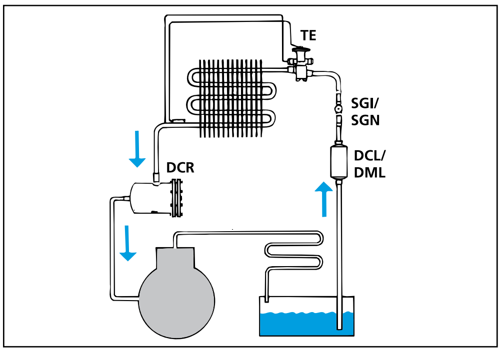
Ah0_0019

A filter drier can also be installed in the suction line where its task is to protect the compressor against dirt and dry the refrigerant.

Suction filters, so-called "burn-out" filters, are used to remove acids after motor damage. To ensure low pressure drop, a suction filter must normally be larger than a liquid line filter.

A suction filter must be replaced before the pressure drop exceeds the following values:

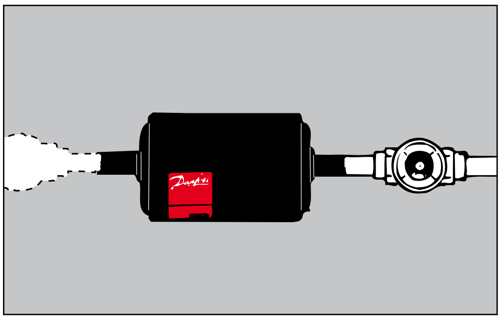
- A/C systems: 0.50 bar
- Refrigeration systems: 0.25 bar
- Freezing systems: 0.15 bar



Ah0_0020

A sight glass with moisture indicator is normally installed after the filter drier, where the sight glass indication means:
Green: No dangerous moisture in the refrigerant.
Yellow: Moisture content too high in the refrigerant ahead of the expansion valve.

Bubbles:
1) Pressure drop across the filter drier too high.
2) No subcooling.
3) Insufficient refrigerant in whole system.



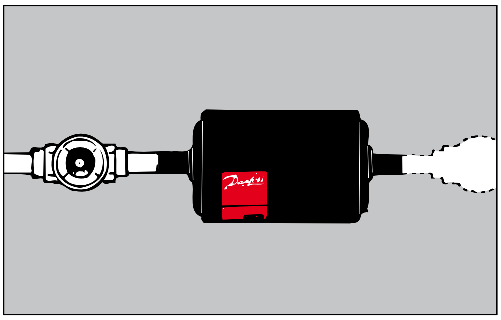
Ah0_0032

If the sight glass is installed ahead of the filter drier the indication is:
Green: No dangerous moisture in the refrigerant.
Yellow: Moisture content in the whole refrigeration system too high.

The changeover point from green to yellow in the sight glass indicator is determined by the water solubility of the refrigerant.

Note:
The changeover points in Danfoss sight glasses are very small. This ensures that a switch to green in the indicator only occurs when the refrigerant is dry.

Bubbles:
1) No subcooling.
2) Insufficient refrigerant in whole system.



Ah0_0031

Note!
Do not replenish refrigerant solely because of bubbles in the sight glass.
First find out the cause of the bubbles!

Ah0_0006

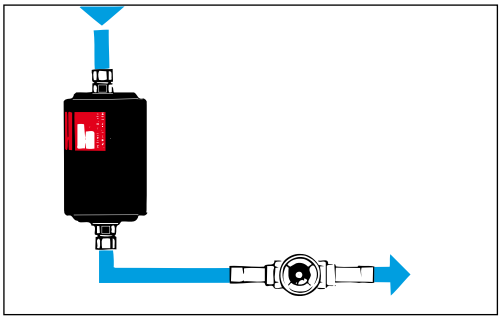
Installation

The filter drier must be installed with flow in the direction of the arrow on the filter drier label.

The filter drier can have any orientation, but the following must be remembered:

Vertical mounting with downward flow means rapid evacuation/emptying of the refrigeration system.

With vertical mounting and upward flow, evacuation/emptying takes longer because refrigerant must be evaporated out of the filter drier.

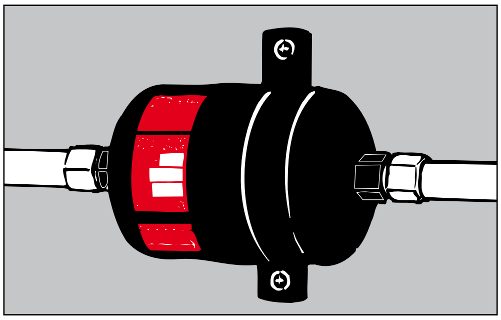


Ah0_0022

The filter core is firmly fixed in the filter housing. Danfoss filter driers are therefore able to resist vibration up to 10 g*).

Find out whether the tubing will support the filter drier and resist vibration. If not, the filter drier must be installed using a clamping band or similar secured to a rigid part of the system.

*) 10 g = Ten times the gravitational force of the earth.

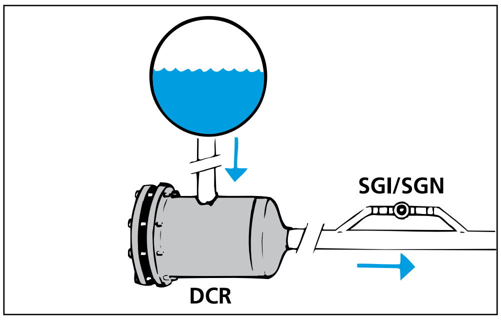


Ah0_0028

For DCR: Install with the inlet connector upwards or horizontal.

This avoids collected dirt running out into the tubing when the core is replaced.

When installing a new DCR, remember that there must always be sufficient space for core replacement.

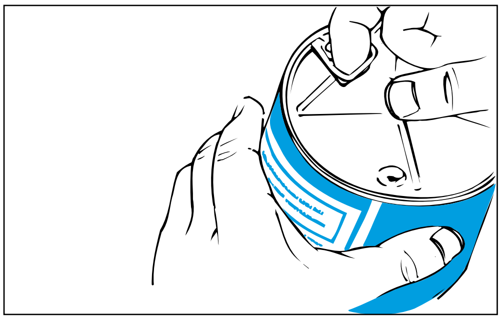


Ah0_0002

Do not unpack filter driers or cores until immediately before installation. This will safe-guard the items in the best possible way.

There is neither vacuum nor overpressure in filters or cans.

Plastic union nuts, capsolutes and the hermetically sealed can guarantee completely "fresh" desiccants.

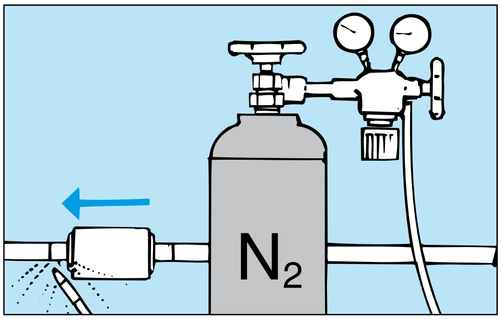


Ah0_0003

Soldering

Protective gas, e.g. N_2, should be used when soldering the filter drier.

Ensure that the protective gas flows in the direction of filter flow. This avoids heat from soldering being damaging the polyester mesh.



Ah0_0004

Soldering alloys and flux give off fumes that can be hazardous. Read supplier instructions and observe their safety stipulations. Keep your head away from the fumes during soldering.

Use strong ventilation and/or extraction at the flame so that you do not inhale fumes and gases.
Use protective goggles.
Use wet cloth around filter driers with pure copper connectors.

Operation

Moisture enters the system:
1) When the refrigeration system is being built up.
2) When the refrigeration system is opened for servicing.
3) If leakage occurs on the suction side, if it is under vacuum.
4) When the system is filled with oil or refrigerant containing moisture.
5) If leakage occurs in a water-cooled condenser.

Moisture in the refrigeration system can cause:
a) Blockage of the expansion device because of ice formation.
b) Corrosion of metal parts.
c) Chemical damage to the insulation in hermetic and semihermetic compressors.
d) Oil breakdown (acid formation).

The filter drier removes moisture that remains after evacuation or that subsequently enters the refrigeration system.

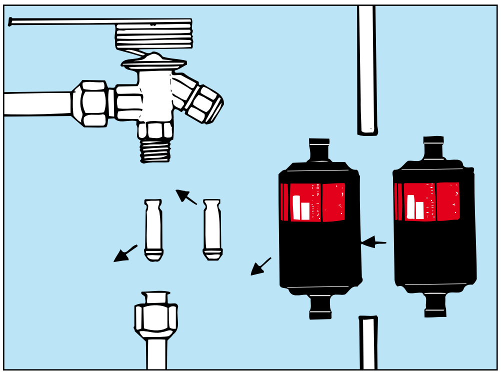

Ah0_0005

Warning!
Never use "antifreeze liquids" like methyl alcohol together with a filter drier. Such liquid can damage the filter so that it is unable to absorb water and acid.

Replace the filter drier when

1. The sight glass indicates that the moisture content is too high (yellow).
2. Pressure drop across the filter is too high (bubbles in sight glass during normal operation).
3. A main component in the refrigerant system has been replaced, e.g. the compressor.
4. Each time the refrigeration system is otherwise opened, e.g. if the orifice assembly in an expansion valve is replaced.

Never re-use a used filter drier. It will give off moisture if it is used in a refrigeration system with low moisture content, or if it becomes heated.

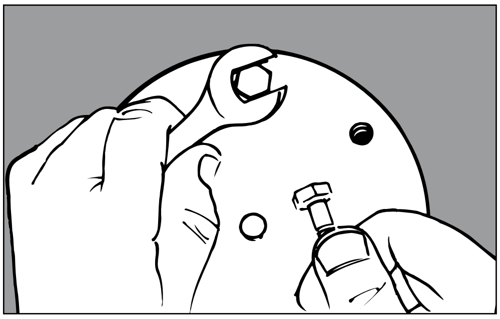

Ah0_0008

DCR

Note, there can be overpressure in the filter. Therefore be careful when opening the filter.

Never re-use the flange gasket in the DCR filter.

Fit a new gasket and smear it with a little refrigeration machine oil before tightening.



Ah0_0009

Using gaskets

- Only use undamaged gaskets.
- Flange surfaces that are to form the seal must be faultless, clean and dry before mounting.
- Do not use adhesive filler, rust remover or similar chemicals when mounting or dismantling.
- Use sufficient oil for lubricating bolts and screws during mounting.
- Do not use bolts which are dry, corroded or defective in any other way (defective bolts can give incorrect tightening which may result in leaking flange joints).

Mounting gaskets

1. Moisten gasket surfaces with a drop of refrigerant oil.
2. Put gasket in place.
3. Mount bolts and tighten slightly until all bolts have made good contact.
4. Cross-tighten bolts.

Tighten bolts in at least 3-4 steps, e.g. as follows:

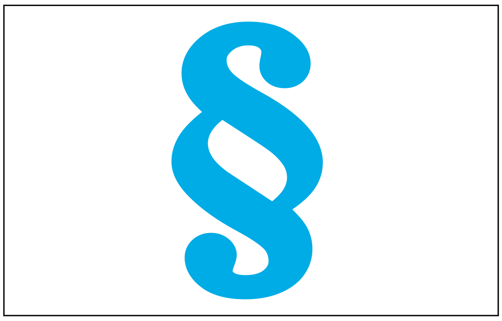
Step 1: to approx. 10% of required torque.
Step 2: to approx. 30% of required torque.
Step 3: to approx. 60% of required torque.
Step 4: to 100% of required torque.

Finally, check that the torque is correct in the same order as used when tightening.

Disposal

Always seal used filter driers. They contain small amounts of refrigerant and oil residue.

Observe authority requirements when scrapping used filter driers.



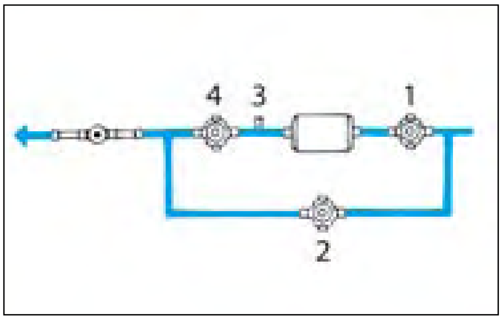
Ah0_0023

Filter drier replacement

- Close valve no. 1.
- Suck the filter empty.
- Close valve no. 4.
- Close valve no. 2.

The system will now operate, bypassing the filter.

- Replace filter or filter core.
- Evacuate the filter drier via a schrader valve (no. 3).
- Restart the system by opening/closing the valves in the reverse order.
- Remove any levers/handwheels from the valves.



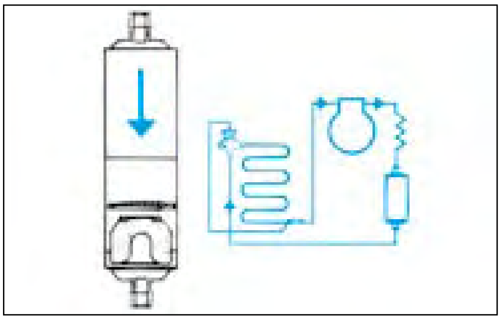
Ah0_0014

Special filters from Danfoss
Combidriers type DCC and DMC

Combidriers type DCC and DMC are used in smaller systems with expansion valve where the condenser cannot contain the entire quantity of refrigerant.

The receiver in the combidrier increases liquid subcooling and creates the possibility of automatic defrost on pumpdown. The receiver takes up varying refrigerant volume (from varying condensing temperature) and must be able to contain the whole refrigerant quantity during service and repair.

In the interests of safety, the volume of the receiver must be at least 15% greater than the refrigerant volume.



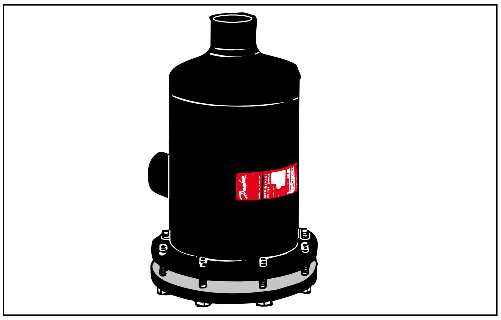
Ah0_0012

Burn-out filter, type 48-DA

Burn-out filter, type 48-DA, is for use after a hermetic or semihermetic compressor has suffered damage.

Compressor damage that gives rise to acid formation will be revealed by oil odour and perhaps discolouration. Damage can occur because of:

- moisture, dirt or air
- defective starter
- refrigerant failure because of too small a refrigerant charge,
- hot gas temperature higher than 175°C

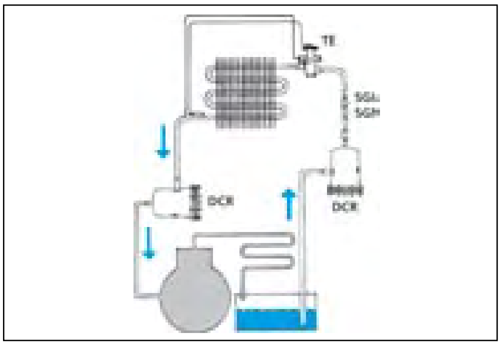


Ah0_0013

After replacing the compressor and cleaning the remainder of the system, two burn-out filters are installed; one in the liquid line and one in the suction line.

The acid content is then checked regularly and the filters replaced as necessary.

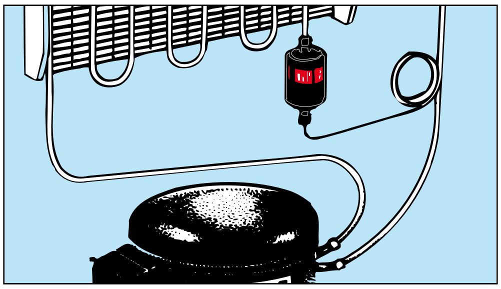
When an oil check shows that the system no longer contains acid, the burn-out filter in the liquid line can be replaced by an ordinary filter drier. The burn-out filter core in the suction line can be removed.



Ah0_0010

Special application
DCL/DML filter driers

Type DCL/DML 032s, DCL/DML 032.5s and DCL/DML 033s are manufactured specially for capillary tube systems and are therefore used in refrigeration systems where expansion is through a capillary tube.

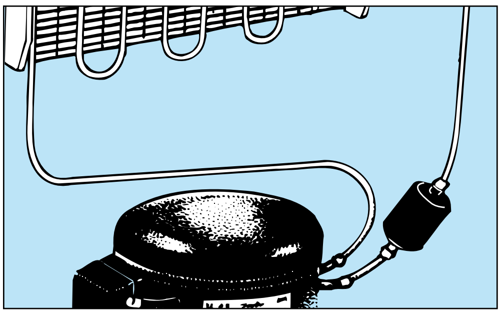


Ah0_0017

DCL/DML filter driers can also be used when reparing refrigerators and freezers, etc. Both time and money can be saved by installing a DCL/DML filter drier in the suction line.

The advantage of doing so can best be illustrated by comparing the normal repair procedure for a defective compressor with a method that exploits the good characteristics of the DCL/DML filter in retaining moisture, acid and dirt.

NOTE: The „DCL/DML method" can only be used when the oil is not discoloured and when the pencil filter is not clogged.



Ah0_0015

Special application
DCL/DML filter driers (cont.)

The advantages gained by installing a DCL/DML filter in the suction line are:
1. Faster repair.
2. Increased drying and acid capacity.
3. Protection of the compressor against impurities of every kind.
4. Better quality of repair.
5. Cleaner working environment.

The acid and moisture bound in the old oil will be absorbed by the DCL/DML filter.

Therefore it is not necessary to remove remaining oil from the refrigeration system.

Procedure with pencil filter	Procedure with DCL/DML filter
Recover refrigerant and evaluate for re-use	Recover refrigerant and evaluate for re-use
Remove compressor + pencil filter	Remove compressor
Remove oil residue in system	Nothing
Dry system with nitrogen	Nothing
Connect new compressor and fit new pencil filter	Connect new compressor and fit DCL/DML filter in suction line
Evaluate and change refrigerant	Evaluate and change refrigerant

A DCL/DML in the suction line retains impurities from condenser, evaporator, tubing, etc. and thereby prolongs the life of the new compressor.

DCL/DML filters having the same connections as the compressor can be used. The Danfoss range of hermetic compressors can also be recommended.

Example:

Compressor type	Suction tube [mm]	Filter type
TL	Ø6.2	DCL/DML 032s
NL 6-7	Ø6.2	DCL/DML 032s

Dimensioning

When choosing filter driers from catalogues there are several expressions each of which can form the basis of selection.

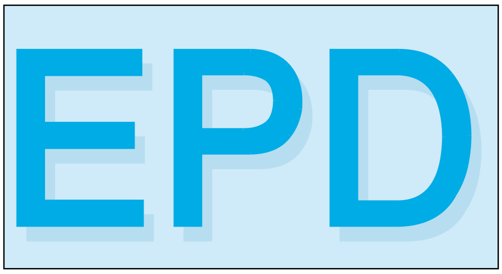
EPD (Equilibrium Point Dryness)

Defines the least possible water content in a refrigerant in its liquid phase, after it has been in contact with a filter drier.

EPD for R22	=	60 ppmW *)
EPD for R410A	=	50 ppmW *)
EPD for R134a	=	50 ppmW *)
EPD for R404A / R507 / R407C	=	50 ppmW *)

As stipulated by ARI 710, in ppmW ($mg_{water}/kg_{refrigerant}$)

*) ARI: Air-conditioning and Refrigeration Institute, Virginia, USA



Ah0_0025

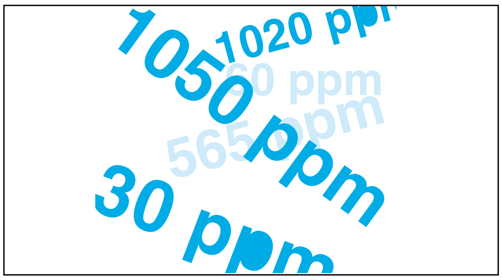
Drying capacity (water capacity)

The quantity of water the filter drier is able to absorb at 24°C and 52°C liquid temperature, as stipulated by the ARI 710* standard.

The drying capacity is given in grams of water, drops of water or kg refrigerant on drying out.

R22:	1050 ppmW to 60 ppmW
R410A:	1050 ppmW to 50 ppmW
R134a:	1050 ppmW to 50 ppmW
R404A / R507 / R407C:	1020 ppmW to 50 ppmW

1000 ppmW = 1 g water in 1 kg refrigerant 1 g water = 20 drops.



Ah0_0016

Liquid capacity (ARI 710)*

Gives the quantity of liquid able to flow through a filter with a pressure drop of 0.07 bar at t_c = +30°C, t_e = -15°C.

The liquid capacity is stated in l/min or in kW.

Conversion from kW to litres/minute:

R22 / R410A	1kW	=	0.32 l/min
R134a	1kW	=	0.35 l/min
R404A / R507 / R407C	1kW	=	0.52 l/min

*) ARI: Air-conditioning and Refrigeration Institute, Virginia, USA

Ah0_0024

Recommended system capacity

Stated in kW for different types of refrigeration systems on the basis of a liquid capacity of Δp = 0.14 bar and typical operating conditions.

Operating conditions:

Refrigeration and freezing systems	t_e = -15°C, t_c = +30°C
A/C systems	t_e = -5°C, t_c = +45°C
A/C units	t_e = +5°C, t_c = +45°C

t_e = evaporating temperature
t_c = condensing temperature

Warning:
With the same system capacity in kW for A/C units and for refrigeration/freezing systems, smaller filter driers can be installed in A/C units because of higher evaporating temperature (t_e) and the assumption that factory produced units contain less moisture than systems built up „on site".

Filter driers from Danfoss

Product type	Function	Refrigerant	Core	Oil type
DML	Standard filter drier	HFC, compatible with R22	100% molecular sieves	Polyolester (POE) Polyalkyl (PAG)
DCL	Standard filter drier	CFC/HCFC	80% molecular sieves 20% activated alumina	Mineral oil (MO) Alkyl benzene (BE)
DMB	Bi-flow filter drier	HFC, compatible with R22	100% molecular sieves	Polyolester (POE) Polyalkyl (PAG)
DCB	Bi-flow filter drier	CFC/HCFC	80% molecular sieves 20% activated alumina	Mineral oil (MO) Alkyl benzene (BE)
DMC	Combi filter drier	HFC, compatible with R22	100% molecular sieves	Polyolester (POE) Polyalkyl (PAG)
DCC	Combi filter drier	CFC/HCFC	80% molecular sieves 20% activated alumina	Mineral oil (MO) Alkyl benzene (BE)
DAS	Burn-out filter drier	R22, R134a, R404A, R507	30% molecular sieves 70% activated alumina	
DCR	Filter drier with exchangeable core	See core description below	48-DU/DM, 48-DN DC, 48-DA, 48-F	-
48-DU/DM for DCR	Exchangeable core for DCR: std. filter drier	HFC, compatible with R22	100% molecular sieves	Polyolester (POE) Polyalkyl (PAG)
48-DN/DC for DCR	Exchangeable core for DCR: std. filter drier	CFC/HCFC	80% molecular sieves 20% activated alumina	Mineral oil (MO) Alkyl benzene (BE)
48-DA for DCR	Exchangeable core for DCR: std. filter drier	R22, R134a, R404A, R507		
48-F for DCR	Exchangeable core for DCR with exchangeable filter insert	All	-	All

This chapter is divided into four sections:

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Contents

Notes

1.0 General

When a compressor has to be installed in new appliances normally sufficient time is available to choose the right compressor type from datasheets and make sufficient testing. Contrary when a faulty compressor has to be replaced it can in many cases be impossible to get the same compressor type as the original. In such cases it is necessary to compare relevant compressor catalogue data.

Long lifetime for a compressor can be expected if the service work is done in the right way and cleanness and dryness of the components are taken into consideration.

The service technician has to observe the following when choosing a compressor. Type of refrigerant, voltage and frequency, application range, compressor displacement/capacity, starting con-ditions and cooling conditions.

If possible use the same refrigerant type as in the faulty system.

2.0 Compressor

The programme of Danfoss compressors consists of the basic types P, T, N, F, SC and SC Twin.

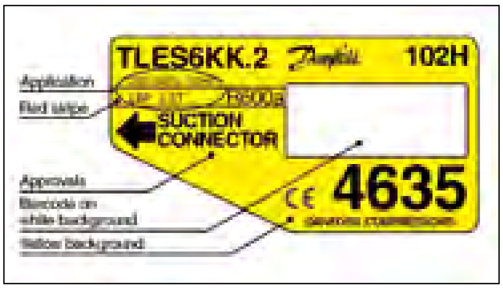
Danfoss 220 V compressors have a yellow label with information of the type designation, voltage and frequency, application, starting conditions, refrigerant and code number.

The 115 V compressors have a green label.

LST/HST mentioned both means that the starting characteristics are depending on the electrical equipment.

Am0_0024

If the type label has been destroyed, the compressor type and the code number can be found in the stamping on the side of the compressor. See first pages in collection of datasheets for the compressor.



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2.1 Denomination

Example of compressor denomination

T L E S 4 F K

- Basic design (P, T, N, F, S)
- L, R, C = int. motor protection; T, F = ext. motor protection; LV = variable speed
- E = energy optimization; Y = High energy optimization
- S = semi direct suction
- Nominal displacement in cm³

A	= LBP / (MBP)	R12
AT	= LBP (tropical)	R12
B	= LBP / MBP / HBP	R12
BM	= LBP (240 V)	R22
C	= LBP	R502 / (R22)
CL	= LBP	R404A/ R507
CM	= LBP	R22 / R502
CN	= LBP	R290
D	= HBP	R22
DL	= HBP	R404A/ R507
F	= LBP	R134a
FT	= LBP (tropical)	R134a
G	= LBP/MBP/HBP	R134a
GH	= Heat pumps	R134a
GHH	= Heat pumps (optimized)	R134a
H	= Heat pumps	R12
HH	= Heat pumps (optimized)	R12
K	= LBP/(MBP)	R600a
KT	= LBP (tropical)	R600a
MF	= MBP	R134a
ML	= MBP	R404A/R507

empty = LST / HST
K = Capillary tube (LST)
X = Expansion valve (HST)

Danfoss compressors

2.1
Denomination (cont.)

The first letter of the denomination (P, T, N, F or S) indicates compressor series whereas the second letter indicates motor protection placing.

E, Y and X mean different energy optimization steps. S means semi direct suction. V means variable speed compressors. On all these mentioned types the indicated suction connector has to be used. Using the wrong connector as suction connector will lead to reduced capacity and efficiency.

A number indicates the displacement in cm^3, but for PL compressors the number indicates the nominal capacity.

The letter after the displacement indicates which refrigerant must be used as well as the field of application for the compressor. (See example) LBP (Low Back Pressure) indicates the range of low evaporating temperatures, typically -10°C down to -35°C or even -45°C,for use in freezers and refrigerators with freezer compartments.

MBP (Medium Back Pressure) indicates the range of medium evaporating temperatures, typically -20°C up to 0°C, such as in cold cabinets, milk coolers, ice machines and water coolers.

HBP (High Back Pressure) indicates high evaporating temperatures, typically -5°C up to +15°C, such as in dehumidifiers and some liquid coolers.

T as extra character indicates a compressor intended for tropical application. This means high ambient temperatures and capability of working with more unstable power supply.

The final letter in the compressor denomination provides information on the starting torque. If, as principal rule, the compressor is intended for LST (Low Starting Torque) and HST (High Starting Torque), the place is left empty. The starting characteristics are depending on the electrical equipment chosen.

K indicates LST (capillary tube and pressure equalization during standstill) and X indicates HST (expansion valve or no pressure equalization).

2.2
Low and High starting torque

Description of the different electrical equipments shown can be found in the datasheets for the compressors. See also section 6.0.

Low starting torque (LST) compressors must only be used in refrigerating systems having capillary tube throttling device where pressure equalization is obtained between suction and discharge sides during each standstill period.

A PTC starting device (LST) requires that the standstill time is at least 5 minutes, since this is the time necessary for cooling the PTC.

The HST starting device, which gives the compressor a high starting torque, must always be used in refrigeration systems with expansion valve, and for capillary tube systems without full pressure equalization before each start.

High stating torque (HST) compressors are normally using a relay and starting capacitor as starting device.

The starting capacitors are designed for short time cut-in.

“1.7% ED”, which is stamped onto the starting capacitor, means for instance max. 10 cut-ins per hour each with a duration of 6 seconds.

2.3
Motor protector and winding temperature

Most of the Danfoss compressors are equipped with a built-in motor protector (winding protector) in the motor windings. See also section 2.1.

At peak load the winding temperature must not exceed 135°C and at stable conditions the winding temperature must not exceed 125°C. Specific information on some special types can be found in the collection of data sheets.

2.4
Rubber grommets

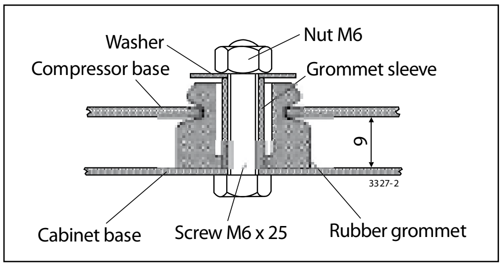
Stand the compressor on the base plate until it is fitted.

This reduces the risk of oil coatings inside the connectors and associated brazing problems.

Place the compressor on its side with the connectors pointing upwards and then fit the rubber grommets and grommet sleeves on the base plate of the compressor.

Do not turn the compressor upside down.

Mount the compressor on the baseplate of the appliance.



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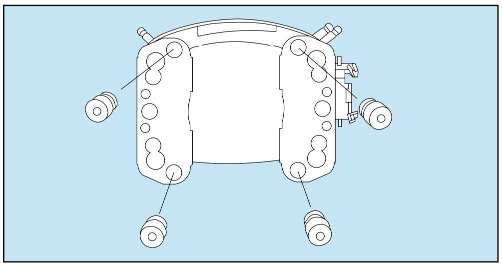
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2.5
Minimum ambient temperature

Allow the compressor to reach a temperature above 10°C before starting the first time to avoid starting problems.

3.0
Fault finding

If the compressor does not operate, it could have many reasons. Before replacing the compressor, it should be made sure, that it is defect.

For easy failure location, please see the section "Trouble shooting".

3.1
Winding protector cut-out

If the winding protector cuts out while the compressor is cold, it can take approx 5 minutes for the protector to reset.

If the winding protector cuts out while the compressor is warm (compressor housing above 80°C) the resetting time is increased. Up to approx 45 minutes may pass before reset.

3.2
PTC and protector interaction

The PTC starting unit requires a cooling time of 5 minutes before it can restart the compressor with full starting torque.

Short time power supply cut offs, not long enough to allow the PTC to cool down, can result in start failure for up to 1 hour.

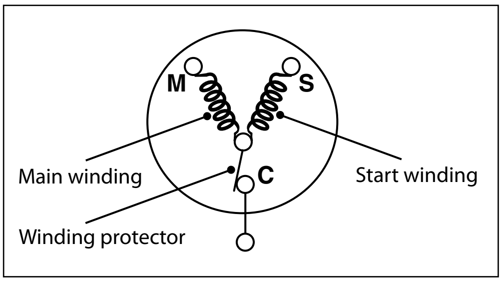
The PTC will not be able to provide full action during the first protector resets, as they typically do not allow pressure equalization also. Thus the protector trips until the reset time is long enough.

This mismatch condition can be solved by unplugging the appliance for 5 to 10 minutes typically.

3.3
Check of winding protector and resistance

In the event of compressor failure a check is made by means of resistance measurement directly on the current lead-in to see whether the defect is due to motor damage or simply a temporarily cut out of the winding protector.

If tests with resistance measurement reveal a connection through the motor windings from point M to S of the current lead-in, but broken circuit between point M and C and S and C this indicates that the winding protector is cut out. Therefore, wait for resetting.



Am0_0028

4.0
Opening the refrigerating system

Never open a refrigerating system before all components for the repair are available.

Compressor, drier and other system components must be sealed off until a continuous assembly can occur.

Opening a defect system must be done in different ways depending on the refrigerant used.

Fit a service valve to the system and collect the refrigerant in the right way.

If the refrigerant is flammable it can be released outside in the open air through a hose if the amount is very limited.

Then flush the system with dry nitrogen.

Danfoss compressors

4.1
Flammable refrigerants

R600a and R290 are hydrocarbons. These refrigerants are flammable and are only allowed for use in appliances which fulfil the requirements laid down in the latest revision of EN/IEC 60335-2-24. (To cover potential risk originated from the use of flammable refrigerants).

Consequently, R600a and R290 are only allowed to be used in household appliances designed for this refrigerant and fulfil the above-mentioned standard. R600a and R290 are heavier than air and the concentration will always be highest at the floor. The flammability limits are approx. as follows:

Refrigerant	R600a	R290
Lower limit	1.5% by vol. (38 g/m^3)	2.1% by vol. (39 g/m^3)
Upper limit	8.5% by vol. (203 g/m^3)	9.5% by vol. (177 g/m^3)
Ignition temperature	460°C	470°C

In order to carry out service and repair on R600a and R290 systems the service personnel must be properly trained to be able to handle flammable refrigerants.

This includes knowledge on tools, transportation of compressor and refrigerant, and the relevant regulations and safety precautions when carrying out service and repair.

Do not use open fire when working with refrigerants R600a and R290!

Danfoss compressors for the flammable refrigerants R600a and R290 are equipped with a yellow warning label as shown.

The smaller R290 compressors, types T and N, are LST types. These often need a timer to ensure sufficient pressure equalization time.

For further information, please see the section "Practical Application of Refrigerant R290 Propane in Small Hermetic Systems".

Am0_0029

Am0_0030

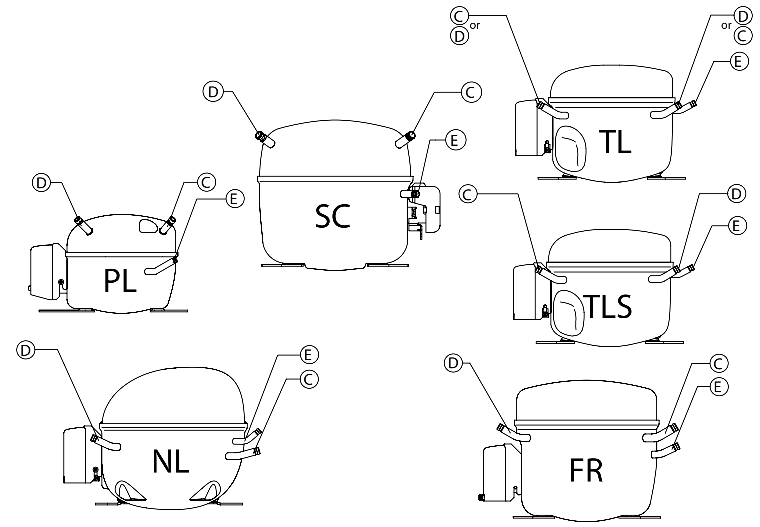
5.0
Mounting

Soldering problems caused by oil in the connectors can be avoided by placing the compressor on its base plate some time before soldering it into the system.

The compressor must never be placed upside down. The system should be closed within 15 minutes to avoid moisture and dirt penetration.

5.1
Connectors

The positions of connectors are found in the sketches. "C" means suction and must always be connected to the suction line. "E" means discharge and must be connected to the discharge line. "D" means process and is used for processing the system.



Am0_0031

5.1
Connectors (cont.)

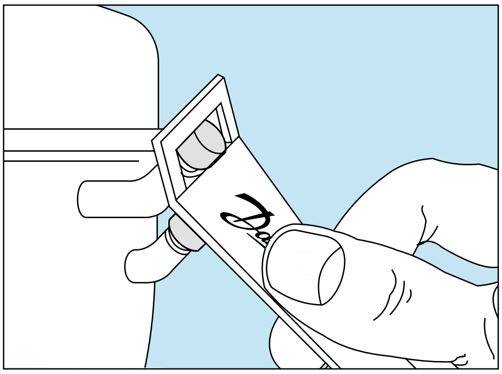
Most Danfoss compressors are equipped with tube connectors of thick-walled, copper-plated steel tube which have a solderability which comes up to that of conventional copper connectors.

The connectors are welded into the compressor housing and weldings cannot be damaged by overheating during soldering.

The connectors have an aluminium cap sealing (capsolut) which gives a tight sealing. The sealing secures that the compressors have not been opened after leaving Danfoss' production lines. In addition to that, the sealing makes a protecting charge of nitrogen superfluous.

The capsoluts are easily removed with an ordinary pair of pliers or a special tool as shown. The capsolut cannot be remounted. When the seals on the compressor connectors are removed the compressor must be mounted in the system within 15 minutes to avoid moisture and dirt penetration.

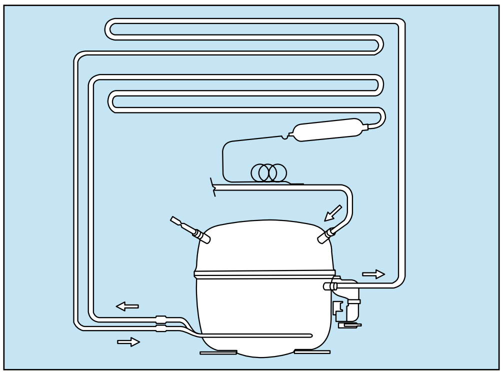
Capsolut seals on connectors must never be left in the assembled system.



Am0_0032

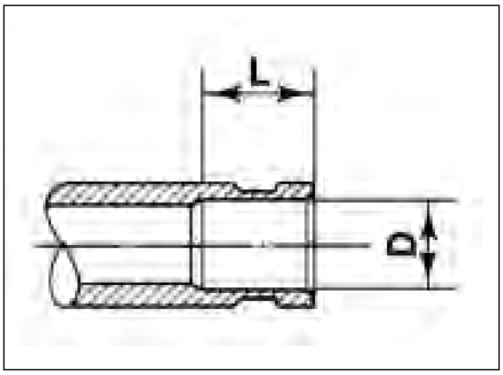
Oil coolers, if mounted (compressors from 7 cm^3 displacement), are made of copper tube and the tube connectors are sealed with rubber plugs. An oil-cooling coil must be connected in the middle of the condenser circuit.

SC Twin compressors must have a non-return valve in the discharge line to compressor no. 2. If a change in the starting sequence between compressor no.1 and no. 2 is wanted a non-return valve has to be placed in both discharge lines.



Am0_0033

In order to have optimum conditions for soldering and to minimize the consumption of soldering material, all tube connectors on Danfoss compressors have shoulders, as shown.



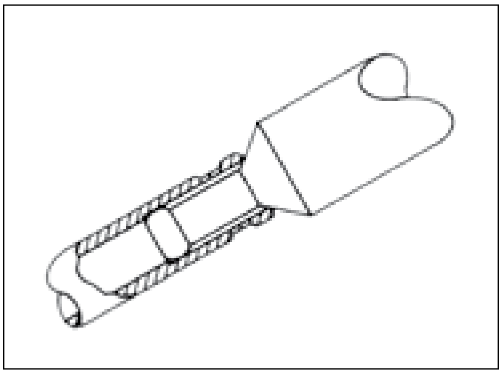
Am0_0034

5.2
Drifting out connectors

It is possible to drift out the connectors having inside diameters from 6.2 mm to 6.5 mm which suit 1⁄4" (6.35 mm) tube, but we advise against drifting out the connectors by more than 0.3 mm.

During drifting it is necessary to have a suitable counterforce on the connectors so that they don't break off.

A different solution to this problem would be to reduce the diameter of the end of the connector tube with special pliers.

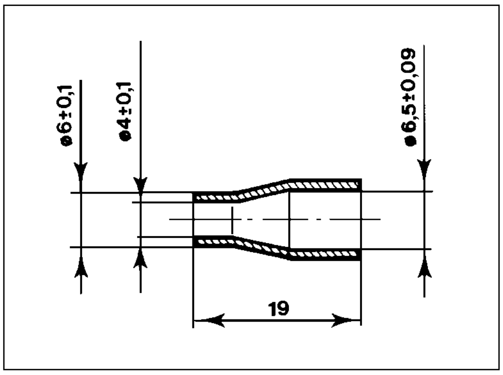


Am0_0035

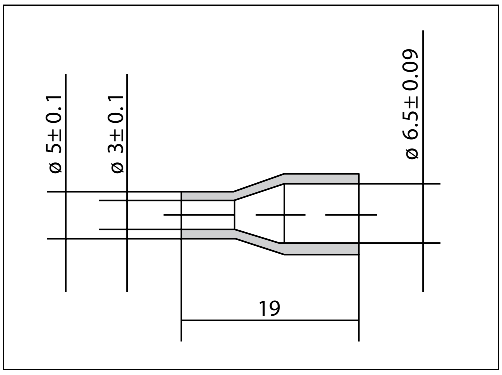
5.3
Tube adapters

Instead of drifting out the connectors or reducing the diameter of the connection tube, copper adapter tubes can be used for service.
A 6/6.5 mm adapter tube can be used where a compressor with millimetre connectors (6.2 mm) is to be connected to a refrigerating system with 1⁄4" (6.35 mm) tubes.

A 5/6.5 mm adapter tube can be used where a compressor with a 5 mm discharge connector is to be connected to a 1⁄4" (6.35 mm) tube.



Am0_0036



Am0_0037

5.4
Solders

For soldering the connectors and copper tubes solders having a silver content as low as 2% can be used. This means that the so-called phosphor solders can also be used when the connecting tube is made of copper.

If the connecting tube is made of steel, a solder with high silver content which does not contain phosphor and which has a liquidus temperature below 740°C is required. For this also a flux is needed.

5.5
Soldering

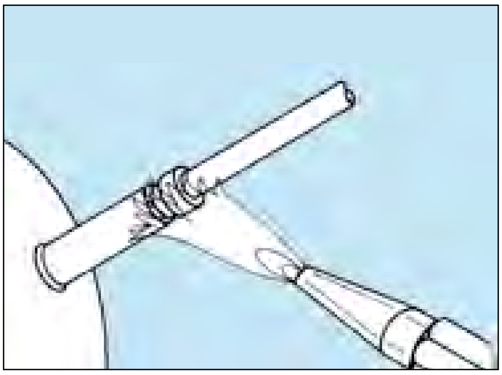
The following are guidelines for soldering of steel connectors different from soldering copper connectors.

During heating, the temperature should be kept as close to the melting point of the solder as possible.

Overheating will lead to surface damage, so decreasing the chances of good soldering.

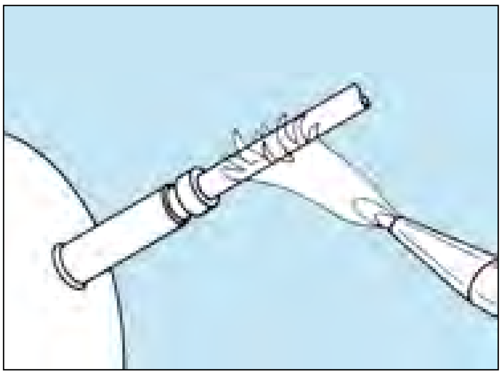
Use the "soft" heat in the torch flame when heating the joint.

Distribute the flame so at least 90% of the heat concentrates around the connector and approx. 10% around the connecting tube.



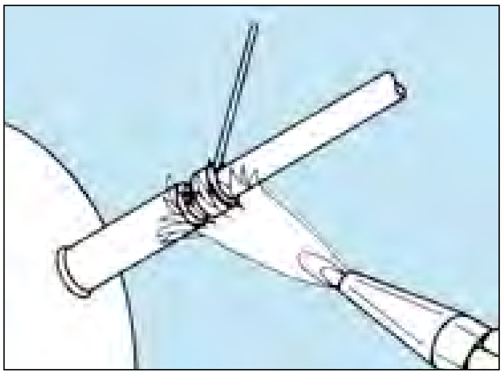
Am0_0038

When the connector is cherry-red (approx. 600°C) apply the flame to the connecting tube for a few seconds.



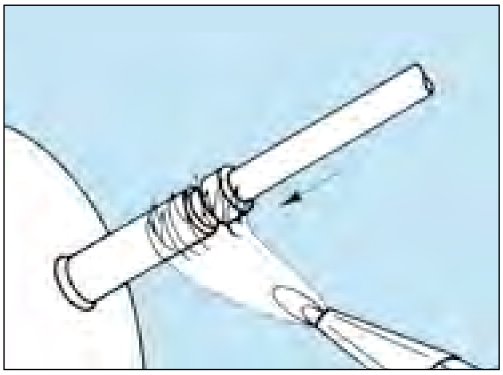
Am0_0039

Continue heating the joint with the "soft" flame and apply solder.



Am0_0040

Draw the solder down into the solder gap by slowly moving the flame towards the compressor; then completely remove the flame.



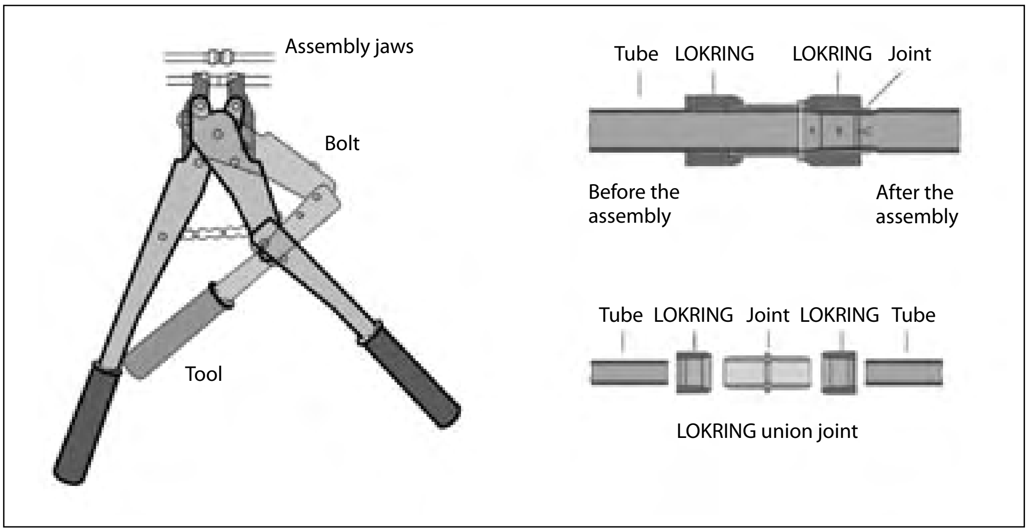
Am0_0041

5.6
Lokring connections

System containing the flammable refrigerants R600a or R290 must not be soldered. In such cases a Lokring connection as shown can be used.

Newly made systems can be soldered as usual, as long as they have not been charged with flammable refrigerant.

Charged systems are never to be opened by use of the flame. Compressors from systems with flammable refrigerant have to be evacuated to remove the refrigerant residues from the oil.



Am0_0042

5.7
Driers

Danfoss compressors are expected used in well-dimensioned refrigerant systems including a drier containing an adequate amount and type of desiccant and with a suitable quality.

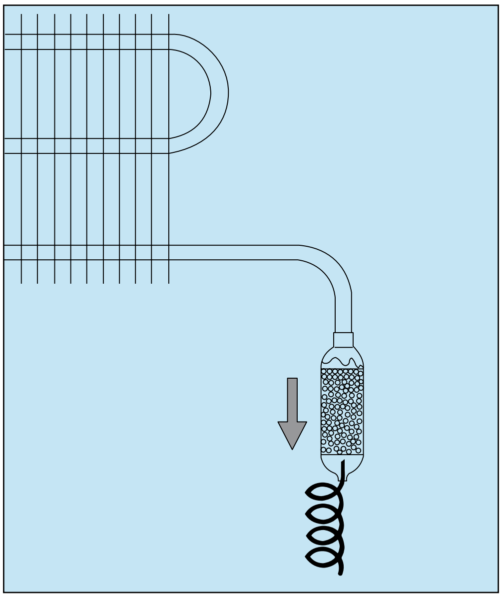
The refrigerating systems are expected to have a dryness corresponding to 10 ppm. As a max limit 20 ppm is accepted.

The drier must be placed in a way ensuring that the direction of flow of the refrigerant follows gravitation.

Thus the MS beads are prevented from moving among themselves and in this way making dust and possible blockage at the inlet of the capillary tube. At capillary tube systems this also ensures a minimal pressure equalizing time.

Especially pencil driers should be chosen carefully to ensure proper quality. In transportable systems only driers approved for mobile application are to be used.

A new drier must always be installed when a refrigeration system has been opened.



Am0_0043

5.8
Driers and refrigerants

Water has a molecular size of 2.8 Ångström. Accordingly, Molecular Sieves with a pore size of 3 Ångström will be suitable for normally used refrigerants.

MS with a pore size of 3 Ångström can be supplied by the following,

UOP Molecular Sieve Division (former Union Carbide) 25 East Algonquin Road, Des Plaines Illinois 60017-5017, USA	4A-XH6	4A-XH7	4A-XH9
R12, R22, R502	×	×	×
R134a		×	×
HFC/HCFC blends			×
R290, R600a		×	×

Grace Davison Chemical W.R.Grace & Co, P.O.Box 2117, Baltimore Maryland 212203 USA		"574"	"594"
R12, R22, R502		×	×
R134a		×	×
HFC/HCFC blends			×
R290, R600a			×

CECA S.A La Defense 2, Cedex 54, 92062 Paris-La Defense France		NL30R	Siliporite H3R
R12, R22, R502		×	×
R134a		×	×
HFC/HCFC blends			×
R290, R600a			×

Driers with the following amount of desiccants are recommended.

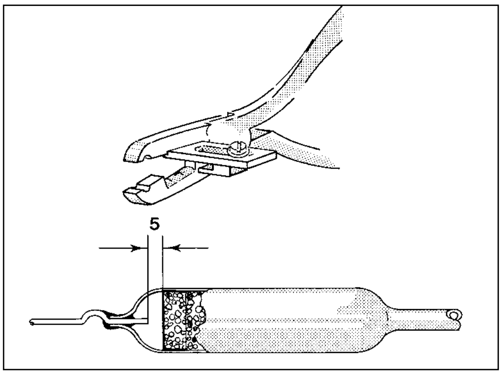
Compressor	Drier
PL and TL	6 gram or more
FR and NL	10 gram or more
SC	15 gram or more

In commercial systems larger solid core driers are often used. These are to be used for the refrigerants according to the manufacturers instructions. If a burn-out filter is needed in a repair case, please contact the supplier for detail information.

5.9
Capillary tube in drier

Special care should be taken when soldering the capillary tube. When mounting the capillary tube it should not be pushed too far into the drier, thus touching the gaze or filter disc, causing a blockage or restriction. If, on the other hand, the tube is only partly inserted into the drier, blockage could occur during the soldering.

This problem can be avoided by making a "stop" on the capillary tube with a pair of special pliers as shown.



Am0_0044

Danfoss compressors

6.0 Electrical equipment

For information on the right starting devices, please see Datasheets for the compressor. Never use a starting device of and old compressor, because this may cause a compressor failure.

No attempt must be made to start the compressor without the complete starting equipment. For safety reasons the compressor must always be earthed or otherwise additionally protected. Keep away inflammable material from the electrical equipment.

The compressor must not be started under vacuum.

6.1 LST starting device

Compressors with internal motor protector.
The below drawings show three types of devices with PTC starters.

Mount the starting device on the current lead-in of the compressor.

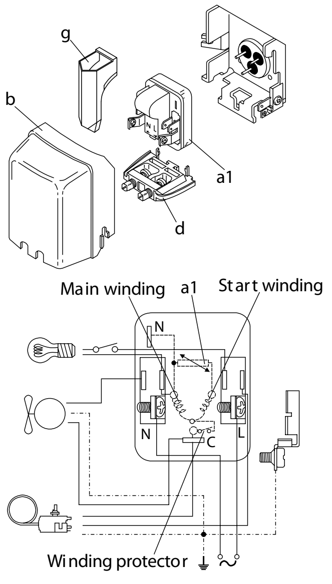
Pressure must be applied to the centre of the starting device so that the clips are not deformed.

Mount the cord relief on the bracket under the starting device.

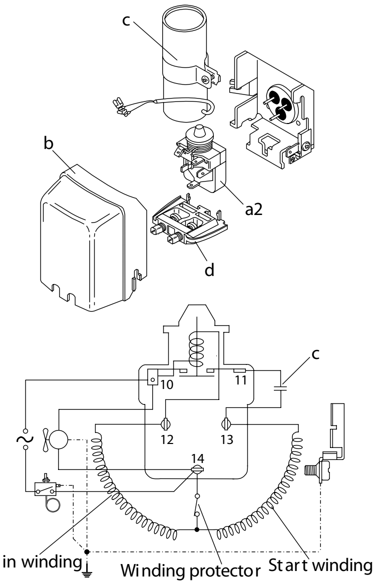
On some energy optimized compressors a run capacitor is connected across the terminals N and S for lower power consumption.

Pressure must be applied to the centre of the starting device when dismantling so that the clips are not deformed.

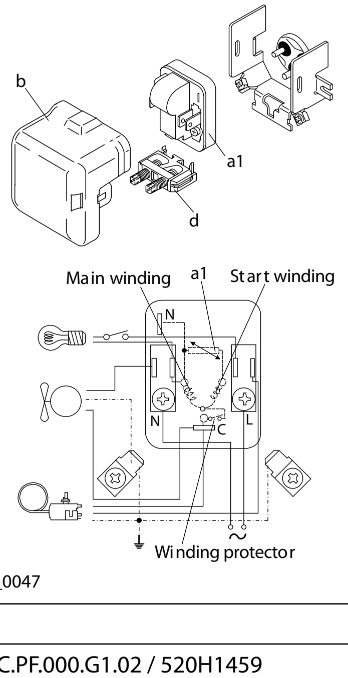
Place the cover over the starting device and screw it to the bracket.



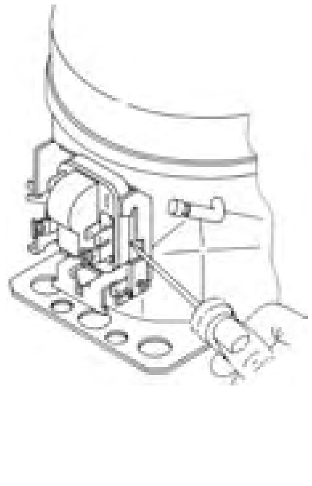
Am0_0045



Am0_0046



Am0_0047

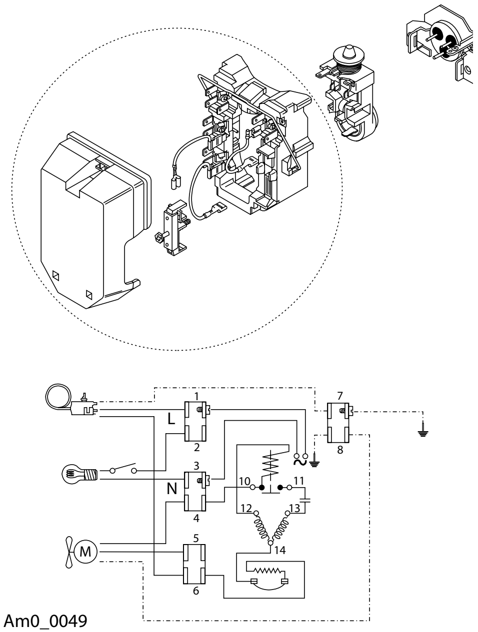


Am0_0048

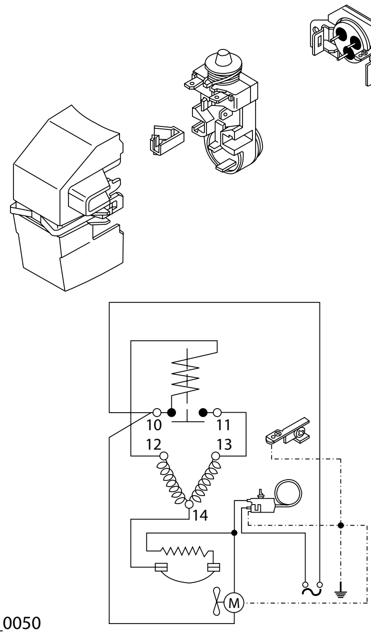
6.1
LST starting device (cont.)

Compressors with external motor protector.
The below drawings show equipment with relay and motor protector.

Mounting of the relay is also done by applying pressure on the center of the relay.
The cover is fixed with a clamp.



Am0_0049

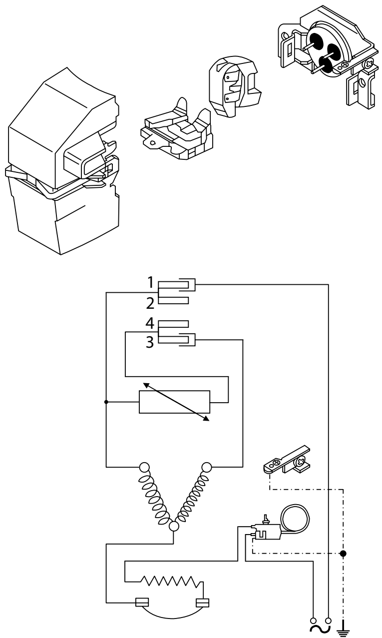


Am0_0050

The below drawing shows equipment with PTC and external protector.

The protector is placed on the bottom terminal pin and the PTC on the 2 on the top.

The cover is fixed with a clamp. No cord relief is available for this equipment.



Am0_0051

6.2
HST starting equipment

The next drawings show five types of devices with relays and starting capacitor.

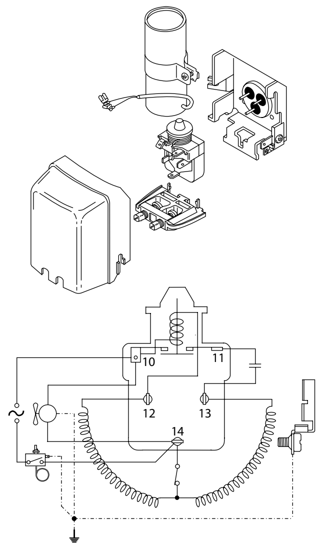
Mount the starting relay on the current lead-in on the compressor. Apply pressure to the centre of the starting relay to avoid deforming the clips. Fasten the starting capacitor to the bracket on the compressor.

Mount the cord relief in the bracket under the starting relay. (Fig. A and B only).

Place the cover over the starting relay and screw it to the bracket or lock it in position with the locking clamp, or the integrated hooks.

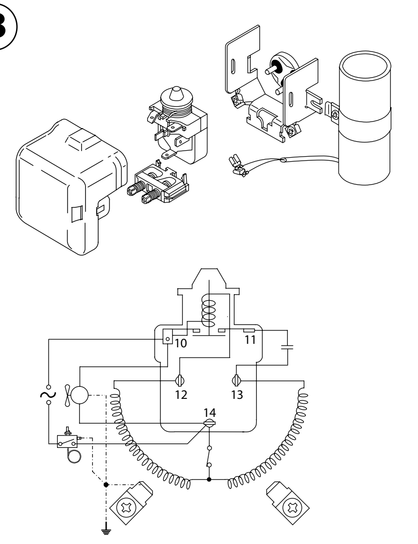
6.2
HST starting equipment (cont.)

A



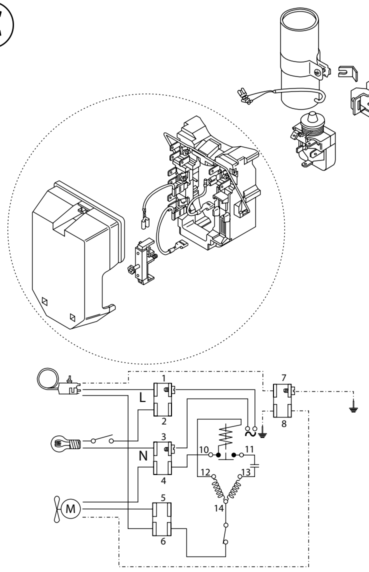
Am0_0052

B



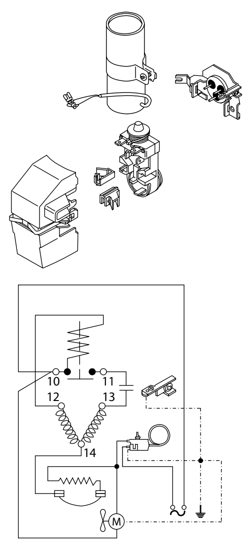
Am0_0053

C



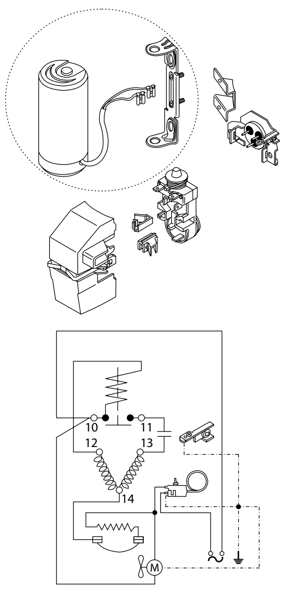
Am0_0054

D



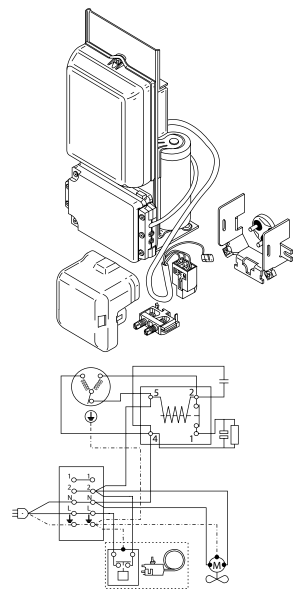
Am0_0055

E



Am0_0056

F



Am0_0057

6.3
HST CSR starting equipment

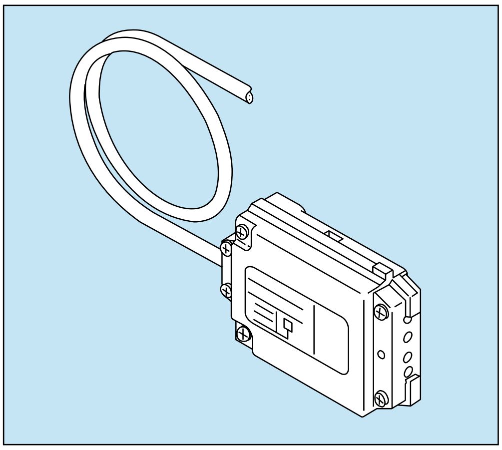
Mount the terminal box on the current lead-in. Note that the leads must face upwards. Mount the cord relief in the bracket under terminal box. Place the cover. (See fig. F).

6.4
Equipment for SC twin compressors

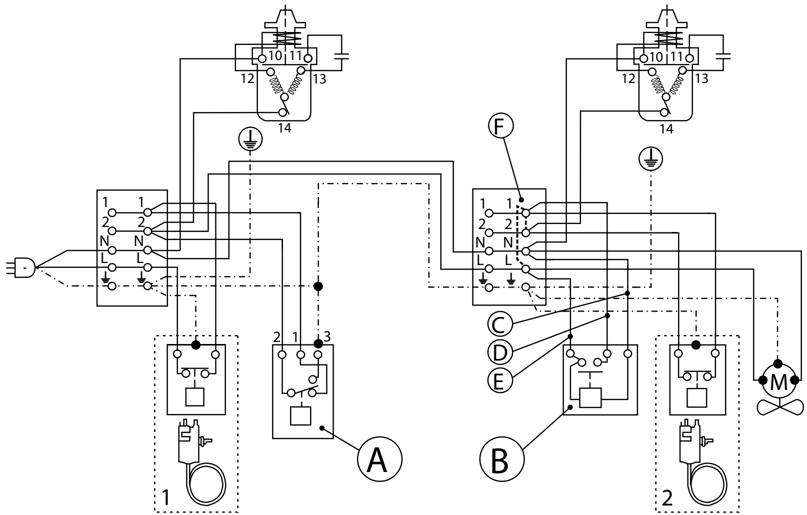
The use of a time delay (e.g. Danfoss 117N0001) is recommended for starting the second section (15 seconds time delay).

If time delay is used, the connection on the terminal board between L and 1 must be removed from the compressor no. 2 connection box.

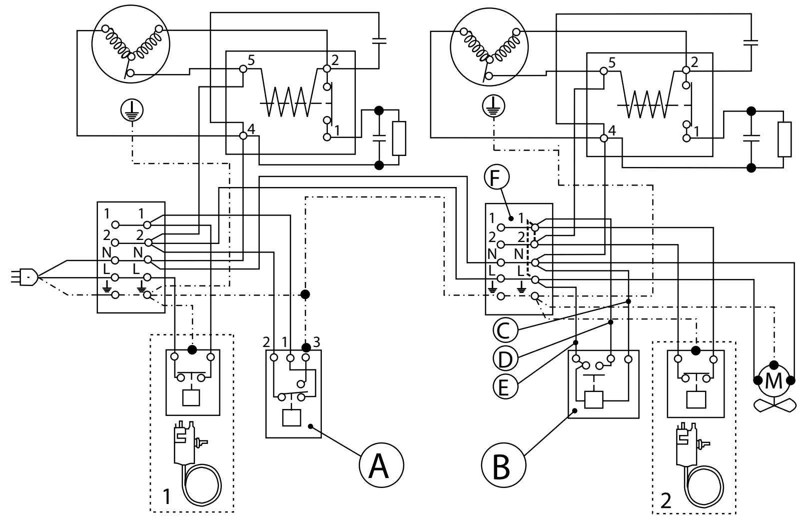
If thermostat for capacity control is used, the connection on the terminal board between 1 and 2 must be removed.



Am0_0058



Am0_0059



Am0_0060

A: Safety pressure control
B: Time delay relay
C: Blue
D: Black
E: Brown
F: Remove wire L-1 if time delay is used
Remove wire 1-2 if thermostat 2 is used

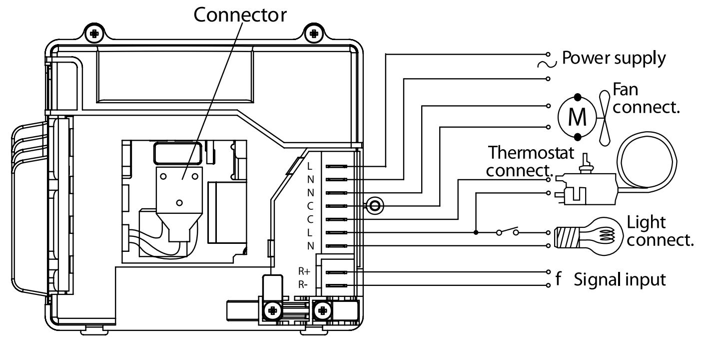
6.5
Electronic unit for variable speed compressors

The electronic unit provides the TLV and NLV compressors with a high starting torque (HST) which means that a pressure-equalization of the system before each start is not necessary.

The variable speed compressor motor is electronically controlled. The electronic unit has built-in overload protection as well as thermal protection. In case of activation of the protection the electronic unit will protect the compressor motor as well as itself. When the protection has been activated, the electronic unit automatically will restart the compressor after a certain time.

The compressors are equipped with permanent magnet rotors (PM motor) and 3 identical stator windings. The electronic unit is mounted directly on the compressor and controls the PM motor.

Connecting the motor directly to AC mains, by fault, will damage the magnets and lead to drastically reduced efficiency, or even no functioning.



Am0_0061

7.0
Evacuation

After brazing, evacuation of the refrigeration system is started.

When a vacuum below 1 mbar is obtained the system is pressure equalized before the final evacuation and charging of refrigerant.

If a pressure test has been performed directly before evacuation, the evacuation process is to be started smoothly, with low pumping volume, to avoid oil loss from the compressor.

Many opinions exist how evacuation can be carried out in the best way.

Dependent on the volume conditions of the suction and the discharge side in the refrigeration system, it might be necessary to choose one of the following procedures for evacuation.

One-sided evacuation with continuous evacuation until a sufficiently low pressure in the condenser has been obtained. One or more short evacuation cycles with pressure equalization in between is necessary.

Two-sided evacuation with continuous evacuation until a sufficiently low pressure has been obtained.

These procedures naturally require a good uniform quality (dryness) of the components used.

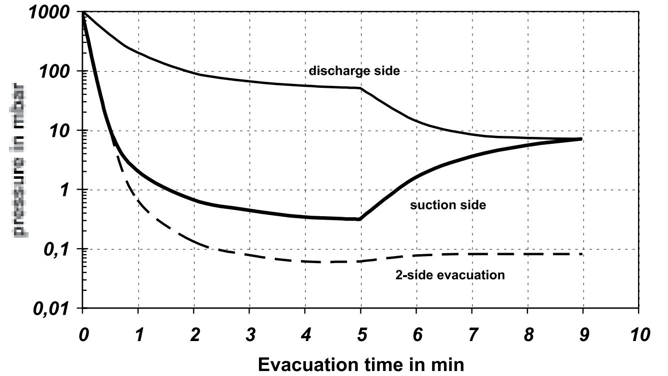
The below drawing shows a typical course of a one-sided evacuation from the process tube of the compressor. It also shows a pressure difference measured in the condenser. This can be remedied by increasing the numbers of pressure equalizations.

The dotted line shows a procedure where two sides are evacuated simultaneously.

When the time is limited, the final vacuum to be obtained is only dependent on the capacity of the vacuum pump and the content of non condensable elements or refrigerant residues in the oil charge.

The advantage of a two-sided evacuation is that it is possible to obtain a considerably lower pressure in the system within a reasonable process time.

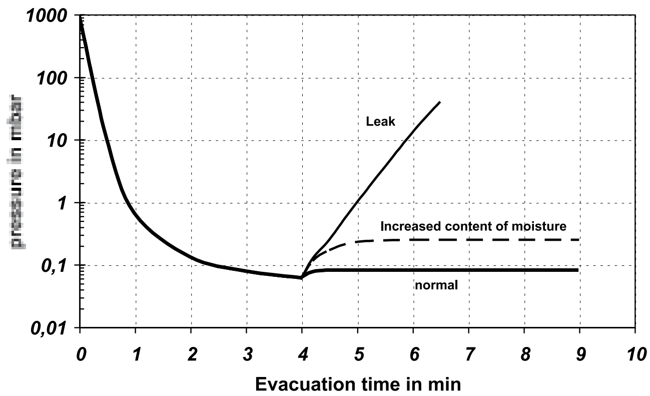
This implies that it will be possible to build a leak check into the process in order to sort out leaks before charging the refrigerant.



Am0_0062

7.0
Evacuation *(cont.)*

The below drawing is an example of a pre-evacuation process with built-in leak test. The level of vacuum obtained depends on the process chosen. Two-sided evacuation is recommended.



Am0_0062

7.1
Vacuum pumps

An explosion-safe vacuum pump must be used for systems with the flammable refrigerants R600a and R290.

The same vacuum pump can be used for all refrigerants if it is charged with Ester oil.

8.0
Charging of refrigerant

Always charge the system with type and amount of refrigerant recommended by the manufacturer. In most cases the refrigerant charge is indicated on the type label of the appliance.

Charging can be done according to volume or by weight. Use a charging glass for charging by volume. Flammable refrigerants must be charged by weight.

8.1
Maximum refrigerant charge

If the max refrigerant charge is exceeded the oil in the compressor may foam after a cold start and the valve system could be demaged.

The refrigerant charge must never be too large to be contained on the condenser side of the refrigeration system. Only the refrigerant amount necessary for the system to function must be charged.

Compressor	Maximum refrigerant charge			
	R134a	R600a	R290	R404A
P	300 g	150 g		
T	400 g*	150 g	150 g	400 g
N	400 g*	150 g	150 g	400 g
F	900 g	150 g		850 g
SC	1300 g		150 g	1300 g
SC-Twin	2200 g			

*) Single types with higher limits available, see data sheets.

8.2
Closing the process tube

For the refrigerants R600a and R290 the closing of the process tube can be done by means of a Lokring connection.

Soldering is not allowed on systems with flammable refrigerants.

9.0 Testing

Hermetic refrigerating systems must be tight. If a household appliance shall function over a reasonable lifetime, it is necessary to have leak rates below 1 gram per year. So leak test equipment of a high quality is required.

All connections must be tested for leaks with a leak testing equipment. This can be done with an electronic leak testing equipment.

The discharge side of the system (from discharge connector to the condenser and to the drier) must be tested with the compressor running.

The evaporator, the suction line and the compressor must be tested during standstill and equalized pressure.

If refrigerant R600a is used, leak test should be done with other means than the refrigerant, e.g. helium, as the equalizing pressure is low, so often below ambient air pressure. Thus leaks would not be detectable.

9.1 Testing of the appliance

Before leaving a system it must be checked that cooling down of the evaporator is possible and that the compressor operates satisfactory on the thermostat.

For systems with capillary tube as throttling device it is important to check that the system is able to pressure equalize during standstill periods and that the low starting torque compressor is able to start the system without causing trips on the motor protector.

Contents

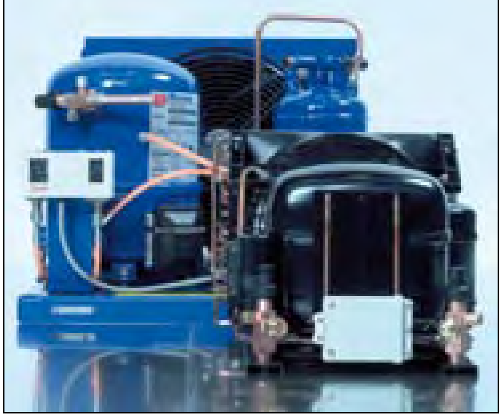
Notes

General information on operating Danfoss condensing units

In the following you will find general information and practical tips for using Danfoss condensing units. Danfoss condensing units represent an integrated range of units with Danfoss reciprocating piston compressors. The versions and configurations of this series correspond to the requirements of the market. To give an overview of the program, the individual subsections are generally divided into the various hermetic compressors mounted on the condensing units.

- Condensing units with 1-cylinder compressors (types TL, FR, NL, SC and SC-TWIN).
- Condensing units with hermetic 1 -2 and 4 cylinder Maneurop® reciprocating piston compressors MTZ, NTZ and MPZ.

Programme:



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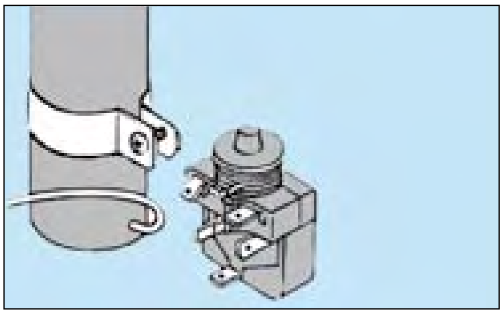
Equipment configuration

Danfoss condensing units are delivered with a compressor and condenser mounted on rails or a base plate. Terminal boxes are prewired. In addition, stop valves, solder adaptors, collectors, dual pressure switches and power cables with 3-pin grounded plugs complete the delivery kit. Please consult the corresponding Danfoss documentation or the current price list for details and ordering numbers. The Danfoss sales company responsible for your area will be glad to help you make your selection.

Power supply and electrical equipment

- Condensing units with 1-cylinder compressors (types TL, FR, NL,SC and SC-TWIN)
  These condensing units are equipped with hermetic compressors and fans for 230 V 1-, 50 Hz power supply.
  The compressors are equipped with an HST starting device consisting of a starting relay and a starting capacitor. The components can also be delivered as spare parts.
  The starting capacitor is designed for short activation cycles (1.7 % ED). In practice, this means that the compressors can perform up to 10 starts per hour with an activation duration of 6 seconds.



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- Condensing units with hermetic 1 -2 and 4 cylinder Maneurop® reciprocating piston compressors MTZ and NTZ.

  These condensing units are equipped with hermetic compressors and fan(s) for different voltage supplies:
  - 400V-3ph-50 Hz for compressor and for fan(s).
  - 400V-3ph-50Hz for compressor and 230V-1ph-50Hz for fan(s) (the capacitor(s) of the fans are included inside the electrical box).
  - 230V-3ph-50Hz for compressor and 230V-1ph-50Hz for fan(s) (the capacitor(s) of the fans are included inside the electrical box).
  - 230V-1ph-50Hz for compressor (the starting device (capcitors, relay) is included into the electrical box) and 230V-1ph-50Hz for fan(s)

The starting current of the Maneurop® three-phase compressor can be reduced through the use of a soft starter. CI-tronic™ soft start, type MCI-C is recommended for use with this type of compressor. The starting current can be reduced up to 40 % depending on the compressor model and the model of soft start used. The mechanical load that occurs at start-up is also reduced, which increases the lifespan of the internal components.

For details on the CI-tronic™ MCI-C soft start, please contact your local Danfoss dealer.
The number of compressor starts is limited to 12 per hour in normal conditions. Pressure equalisation is recommended when MCI-C is used.

Hermetic compressors

The fully hermetically sealed compressor types TL, FR, NL, SC and SC TWIN have a built-in winding protector. When the protector is activated, a switch-off time of up to 45 minutes can occur as the result of heat storage in the motor.

The single-phase Maneurop® compressors MTZ and NTZ are internally protected by a temperature/current sensing bimetallic protector, which senses the main and start winding currents and also the winding temperature.

The three-phase Maneurop® reciprocating piston compressors MTZ and NTZ are equipped against over-current and over-temperature by internal motor protection. The motor protection is located in the star point of the windings and opens all 3 phases simultaneously via a bimetallic disk. After the compressor has switched off via the bi-metallic disc, reactivation can take up to 3 hours.

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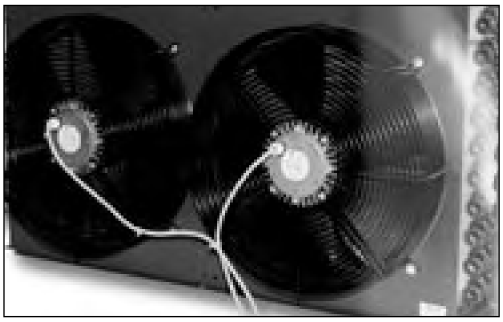
If the motor does not work, you can determine by means of resistance measurement whether the cause is a switched off winding protection switch or a possible broken winding.

Condensers and fans

Highly effective condensers allow a broader range of usage at higher ambient temperatures. One or two fan motors are used per condensing unit depending on the output value.

In addition, the fans can be equipped, e.g. with a Danfoss Saginomiya fan speed regulator, type RGE. This allows good condensing pressure control and reduces the noise level. The fans are provided with self-lubricating bearings, which ensures many years of maintenance-free operation.



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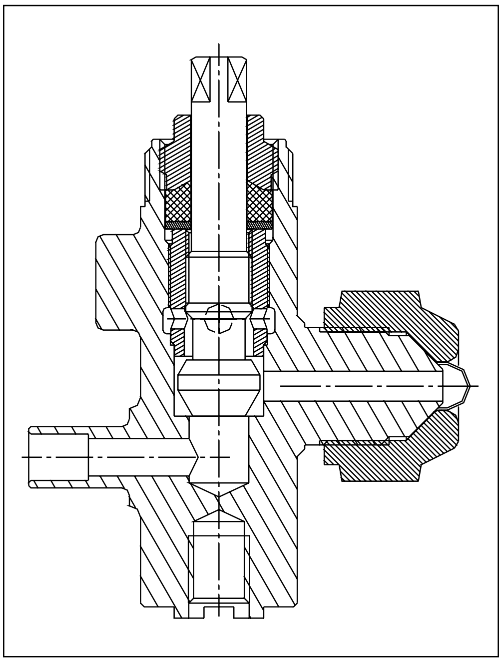
Stop valves

Danfoss condensing units are provided with stop valves on the suction and liquid side.

The stop valves of the condensing units with the 1-cylinder compressors (types TL, FR, NL, SC and SC TWIN) are closed by turning the spindle clockwise to the soldered piece. This opens the flow between the pressure gauge connection and the flare connection. If you turn the spindle counter-clockwise to the rear stop, the pressure gauge connection is closed. The flow between the soldered and the flare connection is free. In the centre position, the flow through the three connections is free. The accompanying soldered adapters help prevent flare connections and to make the system hermetic.

The stop valves of the condensing units with Maneurop® reciprocating piston compressors MTZ and NTZ are directly fitted into the suction and discharge rotalock ports of the compressor and on the receiver. The suction valve is provided with long, straight tube pieces in such a manner that soldered connections can be carried out without disassembling the Rotalock valve.



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Receiver
Pressure container ordinance

Liquid receiver is standard on Danfoss condensing units for use with expansion valves.

The expansion valve is regulating the level in the receiver buffer (the de- or increasing flow of the refrigerant). The receivers from an internal volume of 3 l onwards are equipped with a Rotolock Valve.

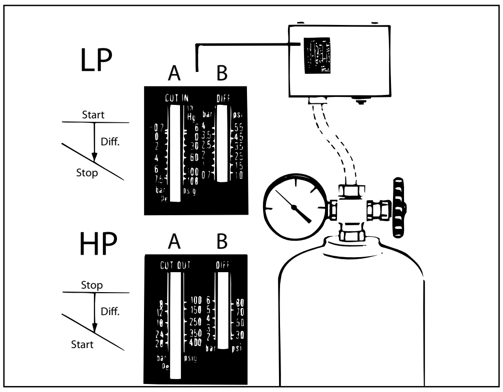
Am0_0005

Terminal box

The Danfoss condensing units are electrically pre-wired and equipped with a terminal box. Thus the power supply and additional electrical wiring can be easily fitted.
The terminal box of the condensing units with Maneurop® compressors is equipped with screw type connector blocks for both power and controls. The electrical connections of each component (compressor, fan(s), PTC, pressure switch) are centralised into this box. A wiring diagram is available in the cover of the electrical box. These terminal boxes are protected to a degree of IP 54.

Safety pressure monitors

Danfoss condensing units can be ordered with safety pressure switches KP 17 (W, B…). Condensing units that do not come equipped with pressure switches from the factory must be equipped with a pressure switch at least the high-pressure side in systems with thermostatic expansion valves as per EN 378.



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The following settings are recommended:

Refrigerant	Low pressure side		High pressure side	
	Cut in (bar)	Cut off (bar)	Cut in (bar)	Cut off (bar)
R407	2	1	21	25
R404A/R507 MBP	1.2	0.5	24	28
R404A/R507 LBP	1	0.1	24	28
R134a	1.2	0.4	14	18

Setup

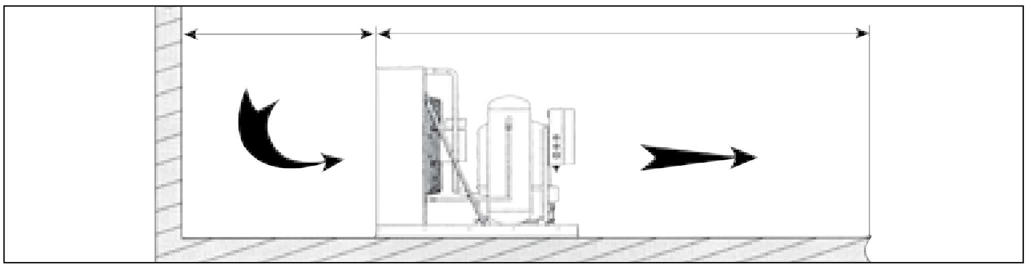
Danfoss condensing units must be set up in a well ventilated location.

You must ensure that there is sufficient fresh air for the condenser at the intake end.

In addition, you must ensure that no cross-flow occurs between the fresh air and the exhaust air.

The ventilator motor is connected in such a way that the air is drawn in via the condenser in the direction of the compressor.

For optimal operation of the condensing unit, the condenser must be cleaned regularly.



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Protective weather-resistant housing

Danfoss condensing units that are set up outside must be provided with a protective roof or with protective weather-resistant housing. The scope of delivery includes optional, high-quality protective weather-resistant housings. You can find the order numbers in the current price list or you can contact your nearest Danfoss representative

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Careful installation

More and more commercial cooling and air-conditioning systems are installed with condensing units that are equipped with hermetic compressors. High demands are put on the quality of the installation work and the alignment of such a cooling system.

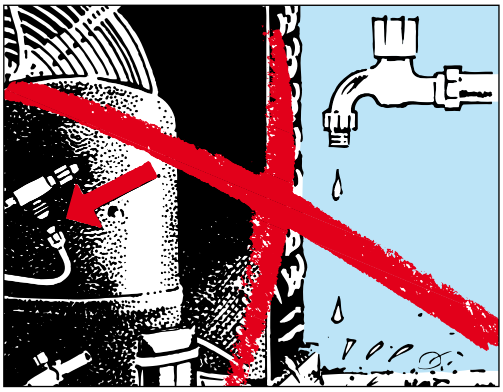
Contamination and foreign particles

Contamination and foreign particles are among the most frequent causes that negatively impact the reliability and lifespan of cooling systems. During the installation, the following types of contamination can enter the system:

- Scaling during soldering (oxidations)
- Flux residue from soldering
- Humidity and outside gasses
- Shavings and copper residues from deburring the tubing

For this reason, Danfoss recommends the following precautions:

- Use only clean and dry copper tubing and components that satisfy standard DIN 8964.
- Danfoss offers a comprehensive and integral range of products for the necessary cooling automation. Please contact your Danfoss dealer for additional information.



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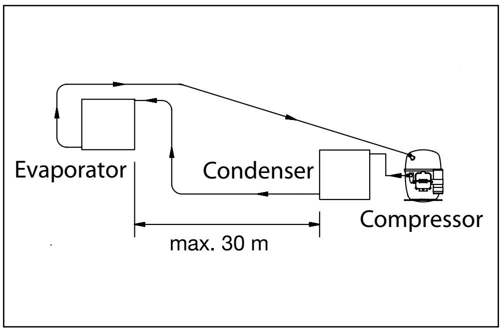
Doing the pipe work

When laying the tubing, you should try to make the shortest and most compact pipe work possible. Low-lying areas (oil traps), where oil might accumulate should be avoided.

Tubing layout of the condensing units with 1-cylinder compressors (types TL, FR, NL,SC and SC-TWIN)

1. **Condensing unit and evaporator are located on the same level.**
   The suction line should be arranged slightly downward from the compressor. The max. permissible distance between the condensing unit and the cooling position (vaporizer) is 30 m.



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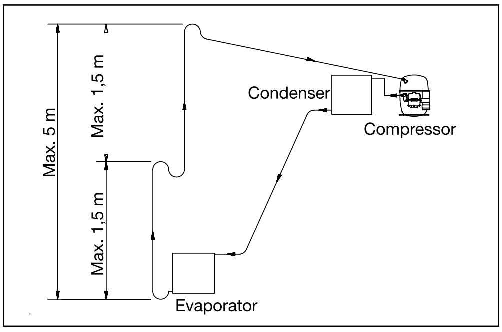
	Suction Line	Liquid Line
	Diameter copper pipe [mm]	
TL	8	6
FR	10	6
NL	10	6
SC	10	8
SC-TWIN	16	10

Tubing layout of the condensing units with 1-cylinder compressors (types TL, FR, NL,SC and SC-TWIN) (cont.)

To ensure the oil return, the following cross-sections are recommended for the intake and liquid lines:

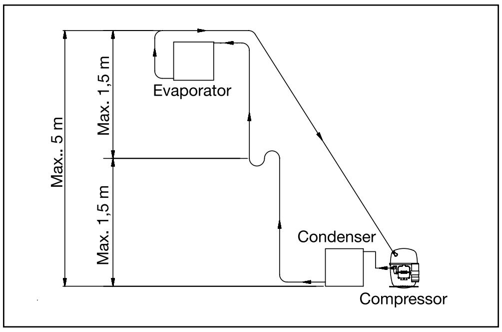
2. **The condensing unit is arranged above the evaporator.**
   The ideal height difference between the condensing unit and the evaporator position is a max. of 5 m. The tube length between the condensing unit and the evaporator should not exceed 30 m. The suction lines must be laid out with double arcs in the form of oil traps above and below. This is done using a U-shaped arc at the lower end and a P-shaped arc at the upper end of the vertical riser. The max. distance between the arcs is 1 to 1.5 m. To ensure the oil return, the following pipe diameters are recommended for the suction and liquid lines:



Am0_0011

	Suction Line	Liquid Line
	Diameter copper pipe [mm]	
TL	8	6
FR	10	6
NL	10	6
SC 12/15	10	8
All other SCs	12	8
SC TWIN	16	10

3. **The condensing unit is arranged under the evaporator.**
   The ideal height difference between the condensing unit and the evaporator is a max. of 5 m. The tube length between the condensing unit and the evaporator should not exceed 30 m. The suction lines must be laid out with double arcs in the form of oil traps above and below. This is done using a U-shaped arc at the lower end and a P-shaped arc at the upper end of the vertical riser. The max. distance between the arcs is 1 to 1.5 m. To ensure the oil return, the following pipe diameters are recommended for the suction and liquid lines:

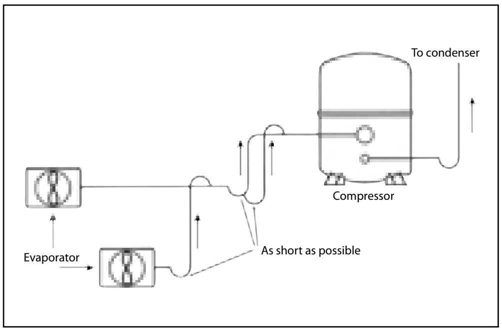


Am0_0012

	Suction Line	Liquid Line
	Diameter copper pipe [mm]	
TL	8	6
FR	10	6
NL	10	6
SC	12	8
SC TWIN	16	10

Tubing layout of the condensing units with hermetic Maneurop® reciprocating piston compressors, 1 -2-4 cylinder

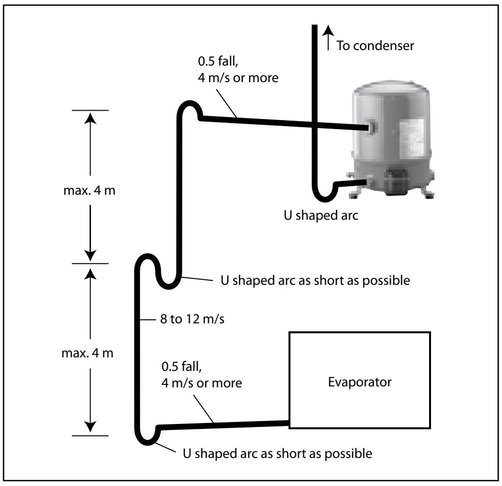
The tubes should be laid out to be flexible (dispersible in three planes or with "AnaConda"). When laying the tubing, you should try to make the shortest and most compact tubing network possible.



Am0_0013

Low-lying areas (oil traps), where oil might accumulate should be avoided. Horizontal lines should be laid inclined slightly downward toward the compressor. To guarantee the oil return, the suction speed at the risers must be at least 8-12 m/s.

For horizontal lines, the suction speed must not fall below 4 m/s. The vertical suction lines must be laid out with double arcs in the form of oil traps above and below. This is done using a U-shaped arc at the lower end and a P-shaped arc at the upper end of the vertical tubing. The maximum height of the riser is 4 m, unless a second U-shaped arc is attached.



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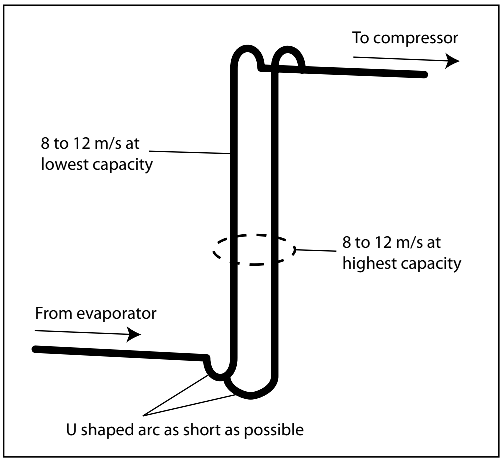
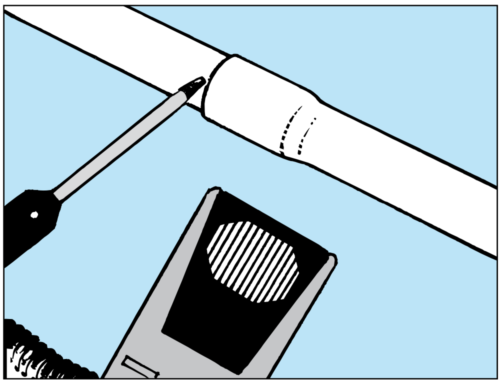
If the evaporator is mounted above the condensing unit, you must ensure that no liquid refrigerant enters the compressor during the work-stoppage phase. To avoid condensation droplets from forming and to prevent an unwanted rise of the intake gas over-heating, the suction line must generally be insulated. Adjusting the intake gas over-heating is done individually for each use. You can find more detailed information in the following sections under "max. permitted temperatures."



Am0_0015

Leak check

Danfoss condensing units are checked in the factory for leaks using helium. They are also filled with a protective gas and must therefore be evacuated from the system. In addition, the added refrigerant circuit must be leak-checked using nitrogen. The suction and liquid valves of the condensing unit remain closed during this. The use of coloured leak-checking agents will void the warranty.

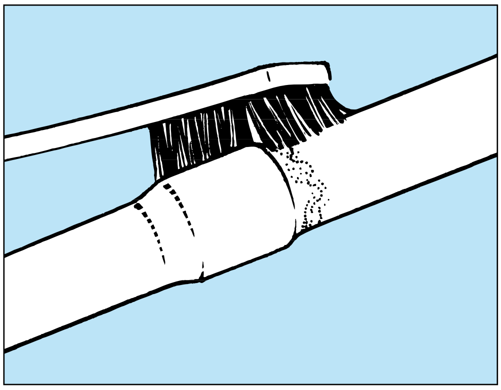


Ac0_0030

Soldering

The most common solders are alloys of 15% silver and with copper, zinc and tin, i.e. "silver solder". The melting point is between approx. 655°C and 755°C. The coated silver solder contains the flux needed for soldering. This should be removed after soldering.

Silver solder can be used to solder together various materials, e.g. steel/copper. Ag 15% solder is sufficient to solder copper to copper.



Ac0_0021

Protective gas

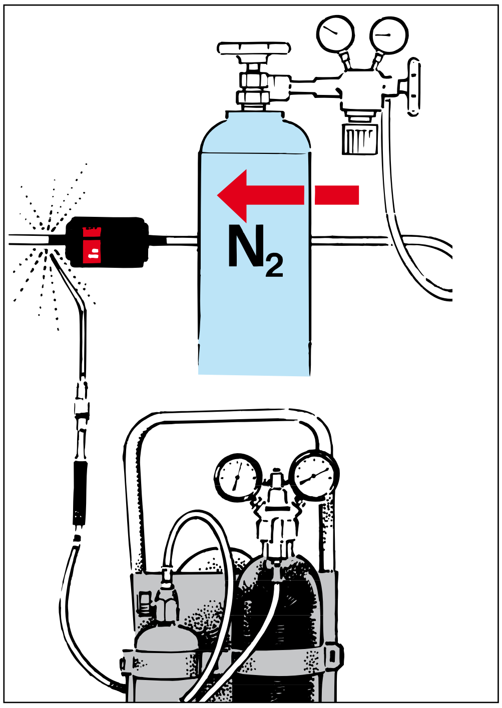
At the high soldering temperatures under the influence of ambient air, oxidation products form (scaling).

The system must therefore have protective gas flowing through it when soldering. Supply a weak stream of a dry, inactive gas through the tubes.

Only begin soldering when there is no atmospheric air left in the affected component. Initiate the work procedure with a strong stream of protective gas, which you can reduce to a minimum when you start soldering.

This weak flow of protective gas must be maintained during the entire soldering process.

The soldering must be done using nitrogen and gas with a gentle flame. Only add the solder when the melting point temperature has been reached.



Ac0_0019

Fork burner:

Am0_0018

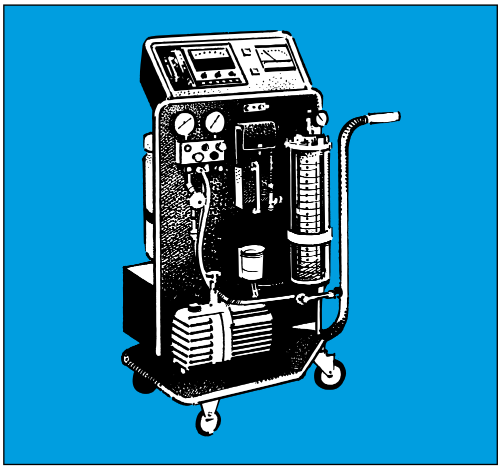
Danfoss compressors

Evacuating and filling

The vacuum pump should be able to suction off the system pressure to approx. 0.67 mbar, in two stages if possible.

Humidity, ambient air and protective gas should be removed. If possible, provide for a two-ended evacuation, from the suction and the liquid side of the condensing unit.

Use the connections at the suction and discharge valves of the condensing units.



Ac0_0023

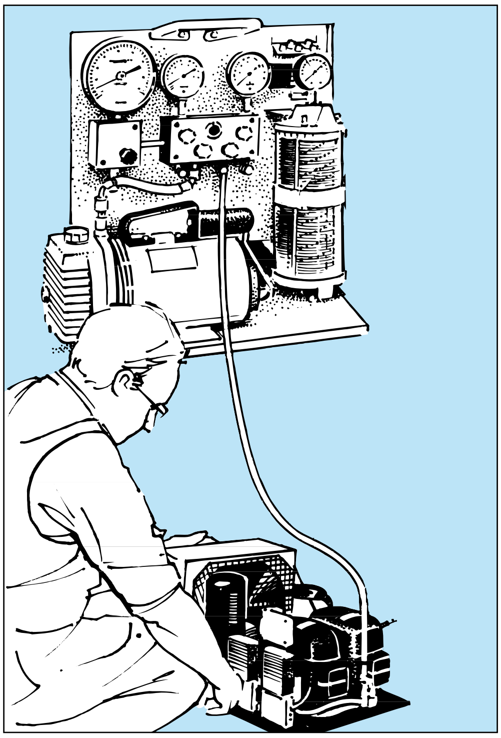
For filling the system, a filling level indicator, filling cylinder and/or a scale is used for smaller condensing units. The refrigerant can be fed into the liquid line in the form of a liquid if a filling valve is installed.

Otherwise, the refrigerant must be fed into the system in gaseous form via the suction stop valve while the compressor is running (break the vacuum beforehand).

Please observe that the refrigerants R404A, R507 and R407C are mixtures.

The refrigerant manufacturers recommend filling R507 as a liquid or gas, whereas R404A and especially R407C should be filled in liquid form. Therefore we must recommend that R404A, R507 and R407C are filled as described using a filling valve.

If the amount of refrigerant to be filled is unknown, continue filling until no bubbles are visible in the inspection glass. During this, you need to keep a constant watch on the condensing and suction gas temperature in order to guarantee normal operating temperatures.



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Please observe the following procedures for evacuating and filling the Danfoss condensing units with the 1-cylinder compressors, types TL, FR, NL, SC and SC TWIN.
For evacuating, both external hoses are connected to a service battery aid and the condensing unit is evacuated with stop-valves 1 and 2 open (spindle in the center position).

After evacuation, both valves (4 and 5) are connected to the service battery. Only then is the vacuum pump switched off.

The refrigerant bottle is connected at the centre connection of the service battery aid 3, and the filling piece is briefly vented.

The corresponding valve of service battery aid 4 is opened and the system is filled via the manometer connection of the suction stop valve with the maximum allowable refrigerant operating filling for a compressor that is in operation.

Evacuating and filling (cont.)

Please observe the following recommendation for evacuating and filling the Danfoss condensing units with condensing units with hermetic Maneurop® reciprocating piston compressors MTZ and NTZ.

We recommend that you carry out the evacuation as described in the following:

1. The service valves of the condensing unit must be closed.

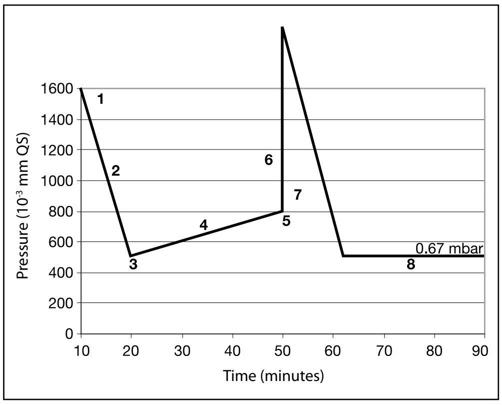
2. After the leak check, if possible, a two-ended evacuation should be carried out using a vacuum pump to 0.67 mbar (abs.)

   It is recommended that you use coupling lines with a large through-put and that you connect them to the service valves.

3. Once a vacuum of 0.67 is reached, the system is separated from the vacuum pump. During the next 30 minutes, the system must not rise. If the pressure rises quickly, the system has a leak.

   A new leak check and evacuation (after 1) must be carried out. If the pressure rises slowly, this is an indication that humidity is present. If this is the case, perform a new evacuation (after 3).

4. Open the service valves of the condensing unit and break the vacuum with nitrogen. Repeat procedures 2 and 3.



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General information:
The compressor should only be switched on if the vacuum has been broken.

For compressor operation with a vacuum in the compressor housing, there is a risk of voltage spark-over in the motor winding.

Exceeding the max. allowable operational filling capacity and setting up outdoors

If the refrigerant is filled beyond the max. allowable operational filling capacity or when setting up outdoors, protective precautions must be taken.

You can find the max. allowable operational filling capacities in the technical information and/or installation instructions for the Danfoss compressors. If there are any questions, your local Danfoss sales company will be glad to assist you.

One quick and easy solution for preventing refrigerant displacements during the shut-down phases is the use of a crank case heater.

Exceeding the max. allowable operational filling capacity and setting up outdoors *(cont.)*

For Danfoss condensing units that are equipped with 1-cylinder compressors, types TL, FR, NL,SC and SC TWIN, following size of crank case heaters can be used:

- Crank case heater for TL/FR/NL 35 W, order no. 192H2096
- Crank case heater for SC and SC-TWIN 55 W, order no. 192H2095

Housing heaters must be mounted directly above the welded seam. For TWIN compressors, both compressors must have a housing heater. The electrical connection can be carried out as follows:

For activated main switches, the change-over contact of the regulating thermostat (e.g. KP 61) takes over the switching function, i.e. compressor off – heater on, and vice versa. The housing heater should also be switched on approx. 2-3 hours before startup after a long down-time of the cooling system.
For setting up the condensing units outdoors, it is generally recommended to use housing heaters. Please observe the following wiring recommendations.

Am0_0020

The Danfoss condensing units with hermetic 1, 2 or 4-cylinder Maneurop® reciprocating piston compressors MTZ and NTZ come standard equipped with a self-regulating PTC 35 W crank case heater.

The self-regulating PTC heater protects against refrigerant displacement during the shutdown phase. However, reliable protection is only afforded when the oil temperature is 10 K above the saturation temperature of the refrigerant.

It is advisable to check by means of tests that a sufficient oil temperature is reached for both low and high ambient temperatures.

For condensing units that are set up outdoors and exposed to low ambient temperatures or for cooling applications with larger amounts of refrigerant, an additional belt crank case heater is often required for the compressor.

The heater should be mounted as close to the oil sump as possible in order to ensure efficient transfer of heat to the oil. Belt crank case heaters are not self-regulating.

The regulating is supposed to be achieved by the heater being switched on when the compressor is stopped and switched off when the compressor is running.

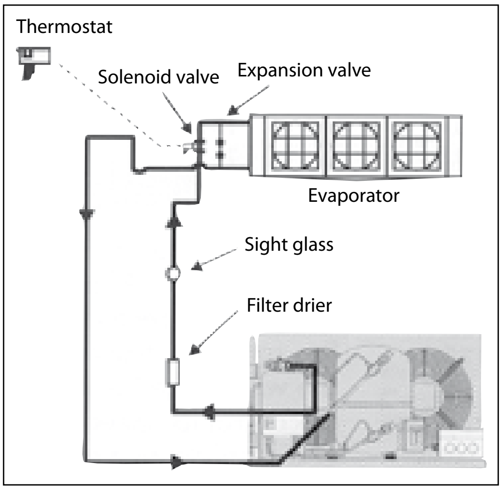
These measures prevent the refrigerant from condensing in the compressor. You must observe that the crank case heater is switched on at least 12 hours prior to the compressor start-up whenever the condensing units are being restarted after a long down-time.

"Pump-down switching"

If it is not possible to keep the oil temperature at 10 K over the saturation temperature of the refrigerant using the crank case heater during compressor down-time or when liquid refrigerant flows back, a pump-down switching process on the low pressure end must be used to prevent the further possibility of refrigerant displacement during shutdown phases.

The solenoid valve in the liquid line is controlled by a thermostat. If the solenoid valve closes, the compressor provides suction on the low pressure end until the low pressure switch switches off the compressor at the set switching point.

With "pump-down switching," the activation point of the low pressure switch must be set lower than the saturation pressure of the refrigerant at the lowest ambient temperature of the condensing unit and the evaporator.



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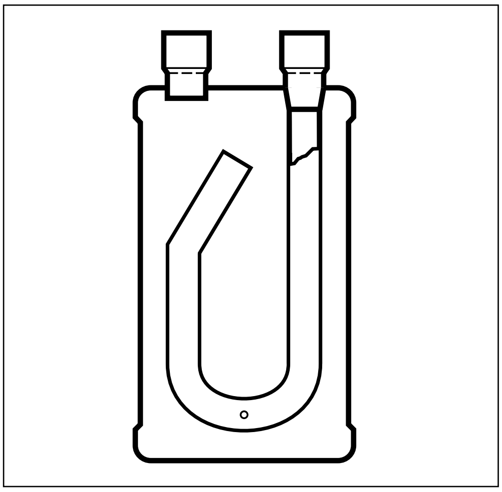
A liquid separator provides protection against refrigerant displacement at the start-up, during operation or after the hot gas defrosting process.

The liquid separator protects against refrigerant displacement during the shut-down period while the internal free volume of the suction end of the system is increased.

The liquid separator should be laid out according to the manufacturer's recommendations.

As a rule, Danfoss recommends that the holding capacity of the liquid separator not be less than 50% of the entire system's filling capacity.

A liquid separator should not be used in systems with zeotropic refrigerants such as R407C, for example.



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Danfoss compressors

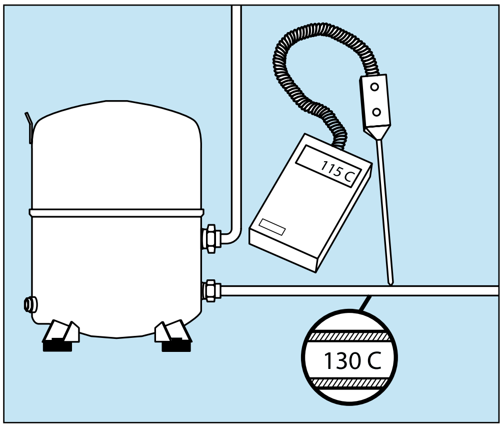
Max. allowable temperatures

For the Danfoss condensing units with 1-cylinder compressors (types TL, FR, NL,SC and SC TWIN), the evaporator superheat (measured at the sensor of the expansion valve meaning the temperature at pressure gauge) should be between 5 and 12 K.

The max. return gas temperature is measured at the compressor intake: 45°C. Impermissibly high intake gas over-heating leads inevitably to a quick rise in the discharge temperature.

This must not exceed 135°C for the SC compressor and 130°C for the TL, NL and FR compressors.

The pressure tube temperature is measured 50 mm away from the pressure connector of the compressor.



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For condensing units with hermetic Maneurop® reciprocating piston compressors MTZ and NTZ, the evaporator superheat (E-valve sensor) should be between 5 and 12 K.

The max. return gas temperature, measured at the compressor suction connector is 30°C.

Impermissibly high intake gas superheat inevitably leads to a rapid rise in the pressure gas temperature, the maximum value of which must not be exceeded (130°C).

For special applications (multi-evaporator systems), the use of an oil separator is recommended in the pressure line.

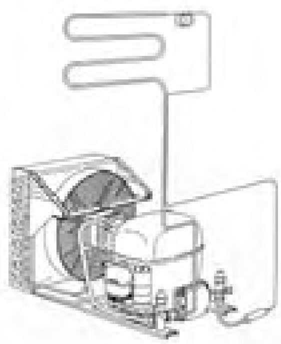
Contents

Notes

1.0 General

Repairs of refrigerators and freezers demand skilled technicians who are to perform this service on a variety of different refrigerator types. Previously service and repair were not as heavily regulated as now due to the new refrigerants, some of which are flammable.

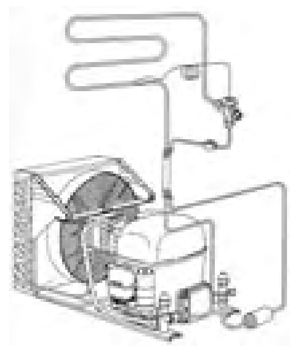
Fig. 1: Hermetic refrigeration system with capillary tubes



Am0_0107

Fig. 1 shows a hermetic refrigeration system with capillary tube as expansion device. This system type is used in most household refrigerators and in small commercial refrigerators, ice cream freezers and bottle coolers.
Fig. 2. shows a refrigeration system using a thermostatic expansion valve. This system type is mainly used in commercial refrigeration systems.

Fig. 2: Hermetic refrigeration system with expansion valve



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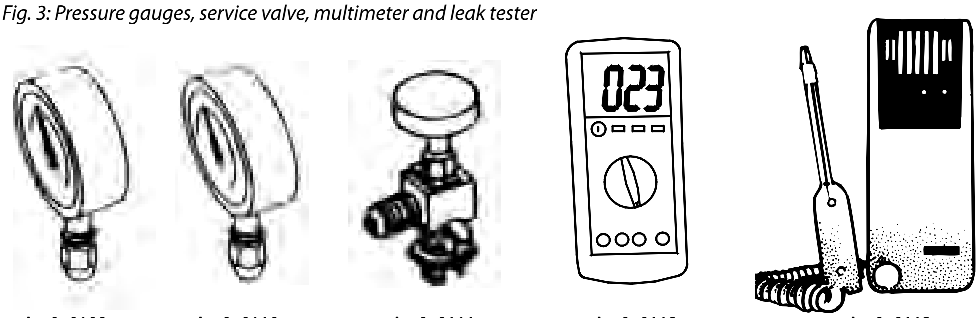
Repair and service is more difficult than new assembly, since working conditions "in the field" are normally worse than in a production site or in a workshop.
A precondition for satisfactory service work is that the technicians have the right qualifications, i.e. good workmanship, thorough knowledge of the product, precision and intuition.
The purpose of this guide is to increase the knowledge of repair work by going through the basic rules. The subject matter is primarily dealt with reference to repair of refrigeration systems for household refrigerators "in the field" but many of the procedures may also be transferred to commercial hermetic refrigeration installations.

1.1 Fault location

Before performing any operations on a refrigeration system the progress of the repair should be planned, i.e. all necessary replacement components and all resources must be available. To be able to make this planning the fault in the system must first be known. For fault location tools must be available as shown in fig. 3. Suction and discharge manometer, service valves, multimeter (voltage, current and resistance) and a leak tester.
In many cases it can be concluded from the user's statements which faults could be possible, and for most faults a relatively accurate diagnosis can be made. However, a precondition is that the service technician has the necessary knowledge of the functioning of the product and that the right resources are available. An elaborate fault location procedure will not be gone through here, however, the most common faults where the compressor does not start or run are mentioned in the following.

Fig. 3: Pressure gauges, service valve, multimeter and leak tester



Am0_0109 Am0_0110 Am0_0111 Am0_0112 Am0_0113

Main switch released
One potential fault may be a defective fuse, and the reason may be a fault in the motor windings or in the motor protector, a short circuit or a burnt current lead-in on the compressor. These faults require the compressor to be replaced.

Compressor
Starting device and compressor motor may be a wrong choice. Compressor motor or winding protector may be defective, and the compressor may be mechanically blocked.

Frequent reasons for reduced refrigeration capacity are coking or copper platings due to moisture or non-condensable gases in the system.

Blown gaskets or broken valve plates are due to too high peak pressures and short-time pressure peaks as a result of liquid hammering in the compressor, which may be due to a too high refrigerant charge in the system or a blocked capillary tube.

1.1
Fault location (cont.)

The voltage may be too low or the pressure too high for the compressor.
Non equalized pressure causes the motor protector to cut out after each start and will eventually result in a burnt motor winding.
A defective fan will also affect the compressor load and may cause motor protector cut outs or blown gaskets.

In case of unsuccessful start and cold compressor up to 15 minutes may pass until the winding protector cuts the compressor out. If the winding protector cuts out when the compressor is hot up to 45 minutes may pass until the protector cuts the compressor in again.
Before starting a systematic fault location it is a good rule to cut off the voltage to the compressor for 5 minutes. This ensures the PTC starting device, if any, to be cooled sufficiently to be able to start the compressor.

Should a brief power failure occur within the first minutes of a refrigeration process, a conflict situation (interlocking) may arise between the protector and the PTC. A compressor with a PTC starting device cannot start in a system that is not pressure-equalized, and the PTC cannot cool so quickly. In some cases it will take up to 1 hour until the refrigerator runs normally again.

High and low pressure switches
Cut out of the high pressure switch may be due to too high condensing pressure, probably caused by lack of fan cooling.
A cut-out low pressure switch may be due to insufficient refrigerant charge, leakage, evaporator frost formation or partial blockage of the expansion device.

The cut out may also be due to a mechanical failure, wrong difference setting, wrong cut-out pressure setting or irregularities in pressure.

Thermostat
A defective or incorrectly set thermostat may have cut out the compressor. If the thermostat loses sensor charge or if the temperature setting is too high, the compressor will not start. The fault may also be caused by a wrong electrical connection.
Too low a differential (difference between cut in and cut out temperature) will cause too short compressor standstill periods, and in connection with a LST compressor (low starting torque) this might lead to starting problems.
See also point 1.2 " Replacement of thermostat".

For further details please refer to "Fault location and prevention in refrigeration circuits with hermetic compressors".

A careful fault determination is necessary before opening the system, and especially before removing the compressor from the system. Repairs requiring operations in a refrigeration system are rather costly. Before opening old refrigeration systems it may therefore be appropriate to make sure that the compressor is not close to breaking down though it is still functional.
An estimation can be made by checking the compressor oil charge. A little oil is drained in to a clean test glass and is compared with a new oil sample. If the drained oil is dark, opaque and containing impurities, the compressor should be replaced.

1.2
Replacement of thermostat

Before replacing the compressor it is a good idea to check the thermostat.

A simple test can be made by short-circuiting the thermostat so the compressor gets power directly. If the compressor can operate like this the thermostat must be replaced.

For replacement it is essential to find a suitable type, which may be difficult with so many thermostat types in the market. To make this choice as easy as possible several manufacturers, i.e. Danfoss, have designed so-called "service thermostats" supplied in packages with all accessories necessary for thermostat service.
With eight packages, each covering one type of refrigerator and application, service can be made on almost all common refrigerators. See fig. 4.
The application area of each thermostat covers a wide range of thermostat types. Moreover, the thermostats have a temperature differential between cut in and cut out sufficient to ensure satisfactory pressure equalization in the system standstill periods.

Fig. 4: Service thermostat package

Am0_0114

In order to achieve the requested function the thermostat sensor (the last 100 mm of the capillary tube) must always be in close contact with the evaporator.

When replacing a thermostat it is important to check whether the compressor operates satisfactorily both in warm and cold position, and whether the standstill period is sufficient for the system pressure equalization when using a LST compressor.

With most thermostats it is possible to obtain a higher temperature differential by adjusting the differential screw. Before doing this it is recommended to seek advice in the thermostat data sheet which way the screw must be turned.
Another way of obtaining a higher differential is to place a piece of plastic between the sensor and the evaporator, since 1 mm plastic results in approx. 1°C higher differential.

1.3
Replacement of electrical equipment

The cause for faults may also be found in the electrical equipment of the compressor, where it is possible to replace starting relay/PTC starting device, motor protector, starting or run capacitor. A damaged starting capacitor may be caused by too low thermostat differential setting, since the starting capacitor must maximum cut in 10 times/hour.

If a fault is found on the winding protector built into many hermetic compressors the entire compressor must be replaced.

When replacing a compressor the electrical equipment must be replaced as well, since old electrical equipment used with a new compressor may cause a compressor breakdown later.

1.4
Replacement of compressor

If the failure is a defective compressor, the technician must take care to select a compressor with the correct characteristics for the appliance.
If a compressor corresponding to the defective one is available, and if it is intended for a non regulated refrigerant, no further problems will arise. However, in many cases it is impossible to provide the same compressor type as the defective one, and in this case the service technician must be aware of some factors.
If it is a question of changing from one compressor manufactured to another it can be difficult to select the correct compressor, and therefore different parameters have to be considered.
Compressor voltage and frequency must correspond to voltage and frequency on location.
Then the application area must be considered (low, medium or high evaporating temperatures).
The cooling capacity must correspond to the one of the previous compressor, but if the capacity is unknown a comparison of the compressor displacements will be applicable. It would be appropriate to select a compressor slightly larger than the defective one.
For a capillary tube system with pressure equalization during the standstill periods a LST compressor (low starting torque) can be used, and for a system with expansion valve or no pressure equalization a HST compressor (high starting torque) is to be chosen.
Of course a HST compressor may also be used in a capillary tube system.
Finally the compressor cooling conditions must also be considered. If the system has an oil cooling arrangement, a compressor with an oil cooler must be selected.
In a service situation a compressor with an oil cooler instead of a compressor without oil cooler can be used without problems, since the spiral can be completely ignored when it is not required.

1.5
Replacement of refrigerant

The best solution for a repair is to select the same refrigerant as used in the present system.
Danfoss compressors are supplied or were supplied in versions for the refrigerants R12, R22, R502, R134a, R404A/R507/R407C and for the flammable refrigerants R290 and R600a.
The refrigerants R12 and R502, which are covered by the regulations in the Montreal Protocol, may be used in very few countries only, and the refrigerants will eventually be phased out of production altogether.
For heat pump systems the refrigerant R407C is now used instead of R22 and R502.
The more environmentally acceptable refrigerant R134a has replaced R12, and the refrigerants R404A and R507 have replaced R22 and R502 in many applications.

The flammable refrigerants R290 and R600a
Maximum charge of these refrigerants in a system is 150 g according to today's relevant appliance standards, and they must be applied in small refrigerators only.
The flamable refrigerants must only be used in refrigeration systems meeting the requirements of EN/IEC 60335-2-24 or -2-89, including demands for flammable refrigerants. and the service personnel must be specially trained for the handling. This implies knowledge of tools, transport of compressors and refrigerant as well as all relevant rules and safety regulations.
If open fire or electrical tools are used near the refrigerants R600a and R290, this must take place in conformity with current regulations.
The refrigeration systems must always be opened with a tube cutter.

Change from the refrigerants R12 or R134a to R600a is not permitted, since the refrigerators are not approved for use with flammable refrigerants, and the electrical safety has not been tested according to current standards. The same applies to change from the refrigerants R22, R502 or R134a to R290.

Blend refrigerants

Refrigerant	Trade name	Composition	Replacing	Application area	Applicable oils
R401A	Suva MP39	R22, R152a, R124	R12	L - M	Alkylbenzene
R401B	Suva MP66	R22, R152a, R124	R12	L	Alkylbenzene
R402A	Suva HP80	R22, R125, R290	R502	L	Polyolester Alkylbenzene
R402B	Suva HP81	R22, R125, R290	R502	L - M	Polyolester Alkylbenzene

1.5
Replacement of refrigerant (cont.)

Refrigerant blends

At the same time as the new environmentally acceptable refrigerants (R134a and R404A) were introduced, some refrigerant blends for service purposes were also introduced. They were better environmentally acceptable than the previously used CFC refrigerants (R12 and R502).
In many countries the refrigerant blends were only permitted for a short period, which meant that they were not widely spread in connection with small hermetic refrigeration systems.
Use of these refrigerants cannot be recommended for series production but they can be used for repair in many cases, see the table on the previous page.

Add in

This designation is used when filling up an existing refrigeration system with another refrigerant than the one originally charged.
This is especially the case when problems arise which must be solved with as small an operation as possible.
Correspondingly, R22 systems were replenished with a small amount of R12 in order to improve the flow of oil back to the compressor.
In several countries it is not allowed to add in on CFC systems (R12, R502, …...)

Drop in

This term means that during service on an existing refrigeration system i.e. > 90% of the original mineral oil is poured out and replaced by synthetic oil, and a new suitable filter drier is mounted. Furthermore, the system is charged with another compatible refrigerant (i.e. blend).

Retrofit

The term retrofit is used about service on refrigeration systems replacing the CFC refrigerant by an environmentally acceptable HFC refrigerant.
The refrigeration system is flushed, and the compressor is replaced by an HFC compressor. Alternatively the compressor oil is replaced by a suitable Ester oil.
The oil must be changed several times after short operating periods, and the filter drier must be replaced.

In case of oilreplacement a statement from the compressor manufactorer on material compatibility is necessary.

2.0 Rules for repair work

To enable a hermetic refrigeration system to work as intended and to achieve a reasonable service life the content of impurities, moisture and non condensable gases must be kept on a low level. When assembling a new system these requirements are relatively easy to meet, but when repairing a defective refrigeration system the matter is more complicated. Among other things, this is due to the fact that faults in a refrigeration system often start disadvantageous chemical processes, and that opening a refrigeration system creates possibilities for contamination.
If a repair is to be carried out with a good result a series of preventive measures is necessary. Before stating any details about the repair work, some general rules and conditions have to be explained.

2.1 Opening of the system

Fig. 5: Hermetic refrigeration system with capillary tube

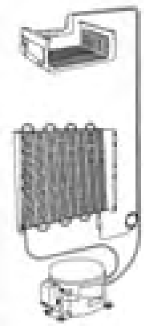


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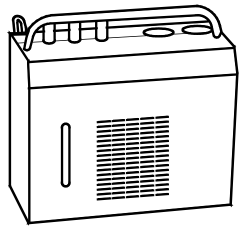
Fig. 8 Recovery unit for refrigerants



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If the refrigeration system contains a flammable refrigerant like e.g. R600a or R290, this will appear from the type label. A Danfoss compressor will be provided with a label as shown in fig. 6.

Fig. 6: Label on compressor for R600a

Am0_0117

Service and repair of such systems demand specially trained personnel. This implies knowledge of tools, transport of compressor and refrigerants as well as the relevant guidelines and safety rules.
When working with the refrigerants R600a and R290 open fire may only occur as described in existing guidelines.
Fig. 7 shows a piercing valve for mounting on the process tube, thus enabling an opening into the system for draining off and collecting the refrigerant as per instructions.

Fig. 7: Piercing valve

Am0_0111

Before starting to cut tubes in the refrigeration system it is recommended to clean the tubes with emery cloth in the places to be cut. Thus the tubes are prepared for the subsequent soldering, and entry of dirt grains into the system is avoided.

Only use tube cutter, never metal-cutting saw, for cutting tubing in a refrigeration system.
Merely a small burr left in the system can cause a subsequent compressor breakdown.
All refrigerants must be collected as per instructions.

When a capillary tube is cut it is essential not to admit burrs or deformations to the tube. The capillary tube can be cut with special pliers (see fig. 9), or with a file a trace can be produced in the tube which can then be broken.

Fig. 9: Special pliers for capillary tubes

Am0_0118

2.2 *Brazing under an inert protective gas*

A system charged with refrigerant must never be heated or soldered, especially not when the refrigerant is flammable.
Soldering on a system containing refrigerant will cause formation of refrigerant decomposition products.
Once the refrigerant is drained off an inert protective gas must be filled into the system. This is done by a thorough blow-through with dry nitrogen. Before the blow-through the system must be opened in one more place.

If the compressor is defective it would be appropriate to cut the suction and pressure tube outside the compressor connectors, not opening the process tube.
If, however, the compressor is functional, it is recommended to cut the process tube. Blow-through must be done first through evaporator and then through condenser. An inlet pressure of approx. 5 bar and a blow-through of approx. 1-2 minutes would be satisfactory on appliances.

2.3 *Filter drier*

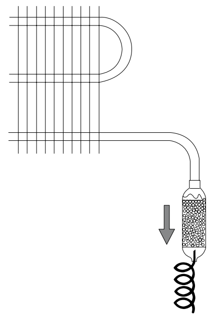
The filter drier is adsorbing the small water amounts released through the life of the system. Besides, it acts as a trap strainer and prevents blocking of the capillary tube inlet and problems with dirt in the expansion valve.

If a refrigeration system has been opened the filter drier must always be replaced to ensure sufficient dryness in the repaired system.

Replacement of a filter drier must always be done without use of a torch. When heating the filter drier there is a risk of transferring the adsorbed moisture amount to the system, and the possibility of a flammable refrigerant being present must also be considered.
In case of a non-flammable refrigerant, however, a blowpipe flame may be used but the capillary tube must be broken and then dry nitrogen must be blown through the filter towards the open air while the filter drier is detached.
Normally a filter drier can adsorb a water amount of approx. 10% of the desiccant weight. In most systems the capacity is not utilized, but in cases of doubt about the filter size it is better to use an oversized filter than one with too small a capacity.
The new filter drier must be dry. Normally this is no problem but it must always be ensured that the filter drier sealing is intact to prevent moisture collection during storage and transport.
The filter drier must be mounted in a way that flow direction and gravitation have an effect in the same direction.

Thus it is prevented that the Molecular Sieve (MS) balls wear each other and produce dust, which may block the capillary tube inlet. This vertical position also ensures a quicker pressure equalization in capillary tube systems. See fig. 10.

Fig. 10: Correct location of filter drier



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Since water has a molecule size of 2.8 Ångstrøm, molecular sieve filters with a pore size of 3 Ångstrøm are suitable for the normally used refrigerants, since the water molecules are adsorbed in the pores of the desiccant, whereas the refrigerant can freely pass through the filter.

Compressor	Filter drier
P and T	6 gram or more
F and N	10 gram or more
SC	15 gram or more

UOP Molecular Sieve Division, USA (earlier Union Carbide)	4A-XH6	4A-XH7	4A-XH9
R12	x	x	x
R22, R502	x		x
R134a, R404A		x	x
HFC/HCFC blends			x
R290, R600a		x	x
Grace Davision Chemical, USA		574	594
R12, R22, R502		x	x
R134a			x
HFC/HCFC blends			x
R290, R600a			x
CECA S.A., France		NL30R	Siliporite H3R
R12, R22, R502		x	x
R134a			x
HFC/HCFC blends			x
R290, R600a			x

Filter driers with a pore size of 3 Ångstrøm in relation to refrigerant:
In connection with service on commercial refrigeration systems Danfoss DML filters are recommended.

If a filter without aluminium oxide is required, Danfoss type DCC or DAS burnout filters for the refrigerants R134a and R404A are recommended. For R600a and R290 type DCLE032 can be used.

2.4
Moisture penetration during repair

A repair must always be done quickly, and no refrigeration system must be open to the atmosphere for more than 15 minutes to avoid moisture intake. Therefore it is a good rule to have all replacement components made ready before the system is opened.

If it is impossible to complete the repair continuously, the open system must be carefully sealed off and charged with a slight overpressure of dry nitrogen to avoid moisture penetration.

2.5
Preparation of compressor and electrical equipment

Rubber grommets are to be mounted in the compressor base plate while the compressor is standing on its base plate. If the compressor is placed upside down oil will gather in the connectors, which leads to soldering problems.
Never use rubber grommets from a defective compressor since they are often aged and harder than new rubber grommets.
Remove the cap (Capsolute) from the process connector of the new compressor and solder a process tube into the connector. Leave the compressor closed until it is to be soldered into the system.
Besides, it is recommended to plug all connectors on compressor, filter drier and system if for some reason the repair is delayed.

The aluminium caps on the connectors must not be left in the finished system.

The caps are only intended to protect the compressor during storage and transport and do not provide tightness in a system under pressure. The caps make sure that the compressor has not been opened after it left Danfoss. If the caps are missing or are damaged, the compressor should not be used until it has been dried and the oil has been replaced.

Never reuse old electrical equipment.

It is recommended always to use new electrical equipment with a new compressor, since use of old electrical equipment with a new compressor may lead to the compressor soon developing defects.
The compressor must not be started without a complete starting device.
Since part of the starting circuit resistance lies in the starting device, start without complete starting device does not provide good starting torque and may result in a very quick heating of the compressor start winding, causing it to be damaged.

The compressor must not be started in vacuum.

Start of compressor in vacuum may cause a breakdown inside between the pins of the current lead-in, since the insulation property of the air is reduced at falling pressure.

Fig. 11 shows a wiring diagram with PTC starting device and winding protector. A run capacitor connected to the terminals N and S will reduce energy consumption on compressors designed for this.

Fig. 11: Wiring diagram with PTC and winding protector

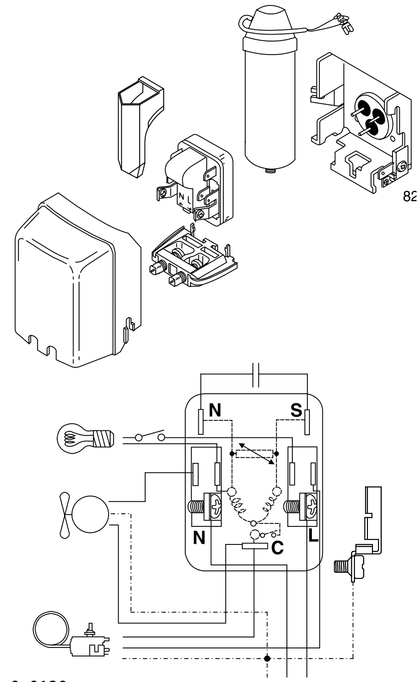

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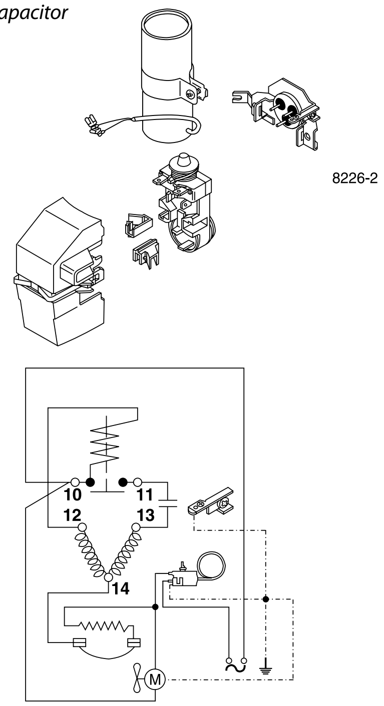
Fig. 12 shows a wiring diagram with starting relay and starting capacitor as well as a motor protector mounted outside the compressor.

Fig. 12: Wiring diagram with starting relay and starting capacitor



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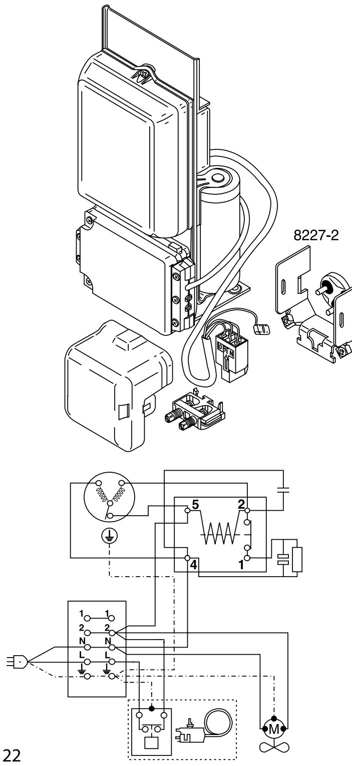
Danfoss compressors

2.5
Preparation of compressor and electrical equipment (cont.)

Fig. 13 shows a wiring diagram for large SC compressors with CSR motor.

Fig. 13: Wiring diagram for CSR motor



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2.6
Soldering

Creation of the correct soldering fit is important.

Recommended soldering gaps for brazing joints

	Material	Material
Silver brazing solder	Copper tubes	Steel tubes
Easy-flo	0.05 - 0.15 mm	0.04 - 0.15 mm
Argo-flo	0.05 - 0.25 mm	0.04 - 0.2 mm
Sil-fos	0.04 - 0.2 mm	Not suitable

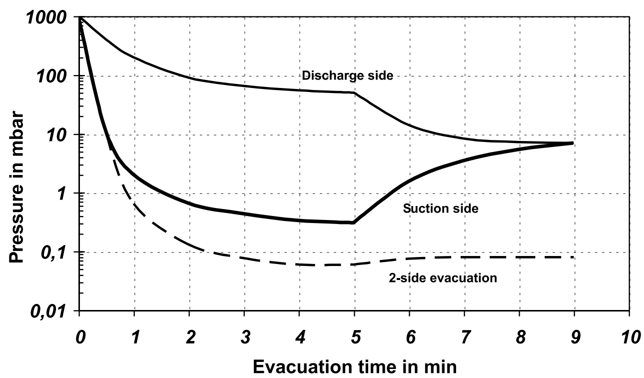
The connectors of most Danfoss compressors are copperplated steel tubes welded into the compressor housing, and the welded connections cannot be damaged by overheating during soldering.

Please see the section "Mounting instructions" for further details about soldering.

2.7 Evacuation

When a refrigeration system is assembled it must be carefully evacuated (remove air from the system), before it is charged with refrigerant. This is necessary to achieve a good repair result.
The main purpose of the evacuation is to reduce the amount of non-condensable gasses (NCG) in the system, and secondarily a limited drying will take place.
Moisture in the system may cause ice blocking, reaction with the refrigerant, ageing of the oil, acceleration of oxidation processes and hydrolysis with insulation materials.
Evacuation of refrigerating system.
Non-condensable gasses (NCG) in a refrigeration system may mean increased condensing pressure and thus greater risk of coking processes and a higher energy consumption.
The content of NCG must be kept below 1 vol. %.
The evacuation may be done in different ways depending on the volume conditions on the suction and discharge side of the system. If evaporator and compressor have a large volume one-sided evacuation may be used, otherwise double-sided evacuation is recommended.
One-sided evacuation is made through the compressor process tube but this method means slightly worse vacuum and slightly higher content of NCG. From the discharge side of the refrigeration system the air must be removed through the capillary tube, which results in a substantial restriction. The result will be a higher pressure on the discharge side than on the suction side.
The main factor for the NCG content after evacuation is the equalized pressure in the system, which is determined by the distribution of volumes.
Typically, the volume on the discharge side will constitute 10-20% of the total volume, and therefore the high end pressure has less influence on the equalized pressure here than the large volume and low pressure on the suction side.

Fig. 14: Evacuation process



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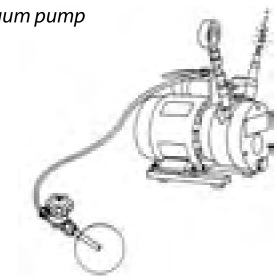
2.8 Vacuum pump and vacuum gauge

In order to perform a sufficient evacuation a good vacuum pump must be available. See fig. 15.

Fig. 15: Vacuum pump



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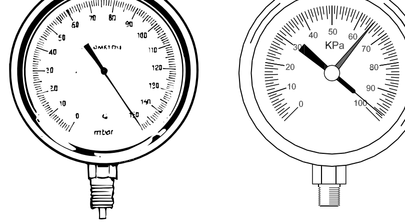
For stationary use a two-stage 20 m^3/h vacuum pump can be recommended but for service a smaller two-stage 10 m^3/h vacuum pump is better suited due to its lower weight.
A hermetic refrigeration compressor is not suitable for the purpose since it is not able to produce a sufficiently low pressure, and also a compressor used as a vacuum pump would be overheated and damaged.
The insulation resistance of the air is reduced at falling pressure, and therefore there electrical breakdown at the current lead-in or in the motor of the hermetic compressor will quickly occur.

The same vacuum pump may be used for all types of refrigerants provided that it is charged with Ester oil.
A flameproof vacuum pump must be used for refrigeration systems containing the flammable refrigerants R600a and R290.

There is no point in having a suitable vacuum pump available if the vacuum obtained cannot be measured. Therefore it is strongly recommended to use an appropriate robust vacuum gauge (fig. 16) able to measure pressure below 1 mbar.

Fig. 16: Vacuum gauge



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Danfoss compressors

3.0 Handling of refrigerants

To ensure a reasonable refrigeration system life the refrigerant must have a maximum moisture content of max 20 ppm (20 mg/kg).
Do not fill refrigerant from a large container into a filling bottle through several container sizes, since with every drawing-off the water content in the refrigerant is increased considerably.

Flammable refrigerants R290 and R600a
R600a must be stored and transported in approved containers only and must be handled according to existing guidelines.

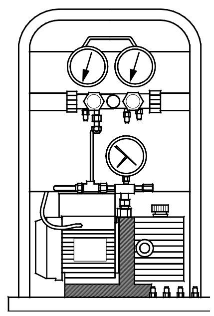
Do not use open fire near the refrigerants R600a and R290.
The refrigeration systems must be opened with a tube cutter.

Conversion from refrigerants R12 or R134a to R600a is not permitted, since the refrigerators are not approved for operation with flammable refrigerants, and the electrical safety has not been tested according to existing standards either. The same applies to conversion from refrigerants R22, R502 or R134a to R290.

3.1 Charging with refrigerant

Normally, charging with refrigerant is no problem with a suitable charging and provided that the equipment present charging amount of the refrigeration system is known. See fig. 17.

Fig. 17: Charging board for refrigerant



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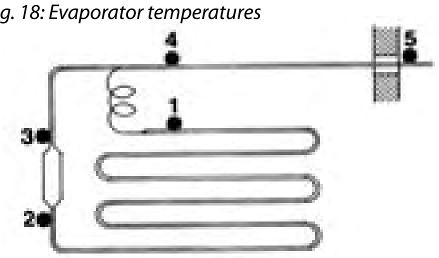
Always charge the refrigerant amount and type stated by the refrigerator manufacturer.
In most cases this information is stated on the refrigerator type label. The different compressor brands contain different amounts of oil, so when converting to another brand it may be advisable to correct the amount of refrigerant.
Charge of refrigerant can be made by weight or by volume. Flammable refrigerants like R600a and R290 must always be charged by weight. Charging by volume must be made with a refrigerant charging cylinder.
The refrigerant R404A and all other refrigerants in the 400 series must always be charged as liquid.
If the charging amount is unknown, charging must be done gradually until the temperature distribution above the evaporator is correct.
However, mostly it will be more appropriate to overcharge the system and then gradually draw off refrigerant until the correct charge has been obtained. The refrigerant charge must be made with running compressor, refrigerator without load and with the door closed.
The correct charge is characterized by the temperature being the same from inlet to outlet of the evaporator.
At the compressor suction connector the temperature must be approx. ambient temperature. Thus transfer of moisture to the refrigerator insulation is avoided. See fig. 18.

Fig. 18: Evaporator temperatures



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Systems with expansion valve must be charged with refrigerant until there are no bubbles in the sight glass, which should be placed as close to the expansion valve as possible.

3.2 Maximum refrigerant charge

If the permissible limit of refrigerant charge stated in the compressor data sheet is exceeded the oil will foam in the compressor after a cold start and may result in a damaged valve system in the compressor.
The refrigerant charge must never exceed the amount that can be contained in the condenser side of the system.

Compressor Type	Max. refrigerant charge			
	R134a	R600a	R290	R404A
P	300 g	120 g		
T	400 g	150 g	150 g	600 g
TL….G	600 g	150 g	150 g	
N	400 g	150 g	150 g	
F	900 g	150 g		850 g
SC	1300 g		150 g	1300 g
SC-Twin	2200 g			

Please also refer to the compressor data sheets, as the present maximum refrigerant charge may deviate on single types from the statements in the form.
The maximum charge of 150 g for R600a and R290 is an upper safety limit of the appliance standards, whereas the other weights are stated to avoid liquid hammer.

3.3
Test

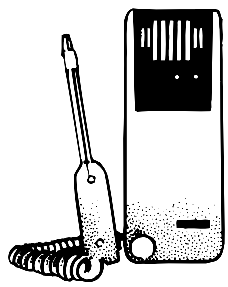
Before finishing a repair the complete refrigerator must be tested to make sure that the expected result has been achieved. It must be ensured that the evaporator can be cooled down and thus enable the requested temperatures to be obtained.
For systems with capillary tube as throttling device it is important to check if the compressor runs satisfactorily on the thermostat. Further it must be checked if the thermostat differential allows for sufficient standstill periods for pressure equalization so an LST compressor (low starting torque), if any, can start and operate without tripping on the motor protector.
In areas where undervoltage may occur it is important to test operating conditions at 85% of the nominal voltage, since both starting and stall torque of the motor will decline when the voltage is falling.

3.4
Leak test

A hermetic refrigeration system must be tight, and if a refrigerator is to have a reasonable lifetime it is necessary to keep any leaks below 1 gram refrigerant annually.
Since many refrigeration systems with the flammable refrigerants R600a and R290 have charging amounts below 50 g, in these cases the leaks should be below 0.5 g refrigerant annually. This requires a high-quality electronical test equipment that can measure these small leak rates.
It is relevant to test all soldered joints of the system, also in places where no repair has been made.
The joints on the discharge side of the system (from the compressor discharge connector until condenser and filter drier) must be examined during operation of the compressor, which results in the highest pressures.
Evaporator, suction tube and compressor must be examined while the compressor is not operating and the pressure in the system is equalized, since this results in the highest pressures here. See fig. 19.

If no electronic detector (fig. 19) is available the joints may be examined with soapy water or with spray, but of course small leaks cannot be found with these methods.

Fig. 19: Leak detector



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4.0
Replacement of defective compressor

In the following a procedure for replacement of a defective compressor in a hermetic refrigeration system is outlined, following the fundamental rules.
A precondition is that there is a refrigerant overpressure in the system and that the system is not contaminated with moisture. The refrigerant must correspond to the original refrigerant.
During fault finding the compressor is found to be defective. If it turns out that the motor has burnt resulting in strong contamination of the system another procedure is required.

4.1
Preparation of components

By starting with preparation of the replacement components later delays with opened system are avoided, and thus also increased risk for admission of moisture and impurities.
A process tube with process valve must be mounted into the process connector of the new compressor.
In some case it may be an advantage to mount a piece of connecting tube into the compressor suction connector.
By doing so the later connection of the suction tube to the compressor can take place further away from the compressor if mounting conditions in the machine compartment are narrow.
When the compressor is ready process valve and connectors must be closed. Further, the correct filter drier type must be ready but the cover must remain intact.

4.2
Removal of charge

Place a piercing valve with connection to a recovery unit on the compressor process tube.
Puncture the tube and collect the refrigerant according to guidelines.
Follow the rules described earlier.

4.3
Removal of defective compressor

Cut the compressor suction and discharge tube with a tube cutter approx. 25-30 mm from the connectors in question, but previously the places to be cut must be trimmed with emery cloth preparing the soldering.
If the compressor is to be tested later, the tube ends must be closed with rubber plugs.
To facilitate any analysis or guarantee repair later the compressor must be provided with the cause for the fault and the refrigerator production date.
Compressors for R600a and R290 must always be evacuated and sealed before they are returned to refrigerator manufacturer or dealer.

4.4
Removal of refrigerant residues

To avoid decomposition of any refrigerant residues in the system during the subsequent soldering operations the system must be thoroughly blown through with dry nitrogen.
This is done by connecting the connection tube from the bottle with dry nitrogen first to the cut suction tube and afterwards to the cut discharge tube.

4.5
Removal of filter drier

The filter drier at the condenser outlet should be cut with a tube cutter but another method may also be used.
Produce a slight flow of dry nitrogen through the discharge tube to the condenser and maintain this flow while the filter is carefully removed with a torch. Avoid heating the filter enclosure itself.

4.6
Cleaning of solder joints and reassembly

Soldering silver must be removed from the condenser outlet. This is best done by brushing it off while the soldering silver is still liquid.
The other tube ends are to be prepared for soldering in case this was not yet done. Take care that dirt and metal grains are not admitted to the system when trimming soldered joints.
If necessary, blow through with dry nitrogen while trimming.
The new filter drier must be mounted at the condenser outlet, and the filter must be kept covered until assembly can take place. Avoid heating the filter enclosure itself with the flame.
Before soldering the capillary tube into the filter a slight stop must be produced on the tube as described earlier to ensure the tube end to be at the right place in the filter to avoid blockings.
Be careful during soldering of the capillary tube and avoid burnings.
Mount the compressor, which already during preparation must be provided with rubber grommets.
Mount the electrical equipment and connect the wires. Evacuation and charge are to be made as described in paragraphs 2.7 and 3.1.
Test to be made as described in paragraphs 3.3 and 3.4.
When the process tube is squeezed and soldered the process valve must be removed.

5.0 From R12 to other refrigerants

As long as new or recycled R12 refrigerant is available this should be used. Is it impossible to provide R12 or is it illegal to use it, it should be thoroughly considered whether repair is worth while.

It is hardly worth it to repair old small refrigeration systems if it involves replacement of the compressor.
Another consideration is use of an alternative refrigerant instead of R12.

5.1 From R12 to alternative refrigerant

For low and medium evaporating temperatures R401A and for low evaporating temperatures R401B has been used as replacement for R12, however, use of these so-called refrigerant blends cannot be recommended.

If R12 is not available or if it is not permitted to use, R134a is recommended. See also paragraph 1.5.

5.2 From R12 to R134a

A conversion from R12 to R134a involves a considerable risk of possible residues of decomposed refrigerant, especially chlorine ions, or intact refrigerant and residues of mineral oil or alkylbenzenes staying in the system. Therefore a procedure must be established during which these undesirable substances are brought down to a level not causing substantial inconvenience in the repaired refrigeration system.
Before starting conversion to R134a it must be ensured that the original compressor motor has not "burnt". If this is the case, the compressor should not be replaced since the contamination risk is too high.
Conversion to R134a always requires a compressor replacement since an original R134a compressor must be mounted even if the R12 compressor is intact.

The following procedure must be performed continuously. If interruptions should occur anyway, all open tubes and tube connections must be plugged. It is assumed that the system is clean and that there is a simple evaporating circuit.

- If the system has lost its charge the leak must be traced.
- Mount a service valve on the compressor process tube.
- Collect the refrigerant which is left.
- Equalize to atmospheric pressure with dry nitrogen.
- Remove compressor and filter drier from the system.
- Flush through all system components with dry nitrogen.
- Perform the repair.
- Mount a new R134a compressor with corresponding cooling capacity.
- Mount a new filter drier with desiccant 4AXH7 or 4AXH9 or equivalent.
- Evacuate and charge the system with R134a.

For LBP systems the optimum R134a charge will be smaller than the original R12 charge. It is recommended to start by charging 75% of the original charge and then gradually increase the charge until the system is balanced.

- Seal the process tube.
- Check if there are leaks.
- Operate the system.
- After finished repair it should always be marked on the system which refrigerant and compressor oil type it contains.
- After reassembly the system will be functional but minor oil residues from the R12 system will circulate, which may in periods disturb injection in the evaporator, especially in capillary tube systems. Whether this is vital for the practical use of the refrigeration system depends on the amount of the oil residue.

5.3 From R134a to R12

A procedure corresponding to the one described in paragraph 5.2 can be used. Use an original R12 compressor, R12 refrigerant and a filter drier of the type 4A-XH6, 4A-XH7 or 4A-XH9.

Note that the R12 charge will be bigger than the original R134a charge and that in most countries the use of R12 is not permitted, but in some special cases it can be an alternative.

5.4 From R502 to R404A

It is assumed that the compressor is defective and has to be replaced by an original R404A compressor but the new compressor must be charged with approved Polyolester oil.
The filter drier must be replaced by a new filter with a desiccant of the type 4A-XH9.
Oil residues from the original compressor, mineral oil or alkyl benzene, must be removed from the system components.

If the system is very contaminated it must be thoroughly flushed with dry nitrogen.
In exceptional cases the compressor oil can be replaced.
The subsequent procedure is as described in paragraph 5.2.

6.0 Systems contaminated with moisture

For systems contaminated with moisture it applies that the degree of contamination may be very varying, and the scope of the repair will vary accordingly.
Systems containing moisture can be divided into two categories, namely the ones with a low degree of contamination and the ones with a high degree of contamination.

Systems with a low degree of contamination are intact and maintain a refrigerant overpressure. Systems with a high degree of contamination, however, are characterized by having been in contact with the atmosphere or moisture has been added directly. The two types of defect will be treated independently.

6.1 Low degree of contamination

This defect is usually characterized by the cooling often being interrupted due to ice blocking in the capillary tube or in the expansion valve. With heat supply the ice blocking is gradually removed, but if the refrigerant circulates the blocking will quickly build up again.
This defect may be due to following reasons.
The system has not been assembled carefully enough.
The components used may have been moist.
A refrigerant with too high a moisture content may have been used.
The system will often be new or it has just been repaired. Usually the moisture amounts are small, and therefore the defect can normally be remedied by replacement of refrigerant and filter drier. The procedure is as follows.

a) Open the system at the process tube and collect the refrigerant.
It is an advantage to first let the compressor run until it is hot. In this way the moisture and refrigerant amount left in the motor or in the oil is reduced.
When ice is blocking capillary tube or expansion valve it is possible to run the compressor hot but the system will not run.
If capillary tube or expansion valve are accessible, the place of blocking may be kept hot with a heating lamp or a cloth with hot water to obtain circulation of the refrigerant.
The evaporating temperature in the system may also be increased by heating the evaporator. Do not use an open flame for heating.

b) After collecting the refrigerant the system must be blown through with dry nitrogen. Nitrogen injection must take place through the compressor process tube, and first the suction side and then the discharge side must be blown through, first directing the nitrogen flow from the compressor through the suction tube and evaporator and out through the capillary tube, then through compressor and condenser and out through the filter drier at the condenser outlet.
It is an advantage to blow through with so much pressure that any oil in the components is removed.

c) Replace filter drier and process tube as described earlier. It pays to use an oversized filter drier.

d) When the system is reassembled, evacuation must be carried out very carefully.
Charge and test according to earlier mentioned guidelines.

6.2 High degree of contamination

If there is a rupture in a refrigeration system and the refrigerant overpressure escapes, moisture contamination will take place. The longer time the system is open to the atmosphere the higher the degree of contamination. If the compressor is operating at the same time, conditions are further worsened. The admitted moisture amount will distribute in compressor, filter drier and other system components depending on their ability to hold the moisture.
In the compressor it will especially be the oil charge that absorbs the water. In evaporator, condenser and tubes the contamination will primarily be determined by the oil amounts present here.
Of course the largest water amounts will be in compressor and filter drier. There is also a high risk that valve coking has started damaging the compressor Therefore compressor and filter drier must be replaced during the normal repair procedure.

a) Remove the compressor from the system with a tube cutter.

b) Break the capillary tube at the condenser outlet, and blow through the condenser with dry nitrogen as protective gas.
Remove the filter drier.
Repeat the blow-through with increased pressure to remove oil from the condenser, if any. Cover condenser inlet and outlet.

c) Treat suction line heat exchanger and evaporator in the same way. The opportunity of an efficient blow-through is improved if the capillary tube is broken off at the evaporator inlet. Blow-through with nitrogen will then take place in two paces; first suction tube and evaporator, then capillary tubes.
If the reason for the repair is a broken capillary tube the operations must be changed to replace the entire heat exchanger.

d) Reassemble the system with a new compressor and a new filter drier in the right size.

6.2
High degree of contamination (cont.)

Evacuation must be done with special care, and subsequently charge and test according to normal rules. The outlined procedure is best suited for simple refrigeration systems. If the system has difficult access and the design is complex the following procedure may be better suited.

e) Remove the compressor from the system and treat it according to point a.

f) Break the capillary tube at the condenser outlet.
Blow through with nitrogen through suction and discharge tube.

g) Mount a new oversized filter drier at the condenser outlet. Connect the capillary tube to the filter drier.

h) When the system, excl. compressor, is intact again carry out a drying.
This is made by at the same time connecting suction and discharge tube to a vacuum pump and evacuate to a pressure lower than 10 mbar.
Pressure equalize with dry nitrogen.
Repeat evacuation and pressure equalization.

i) Mount the new compressor.
Then evacuate, charge and test.

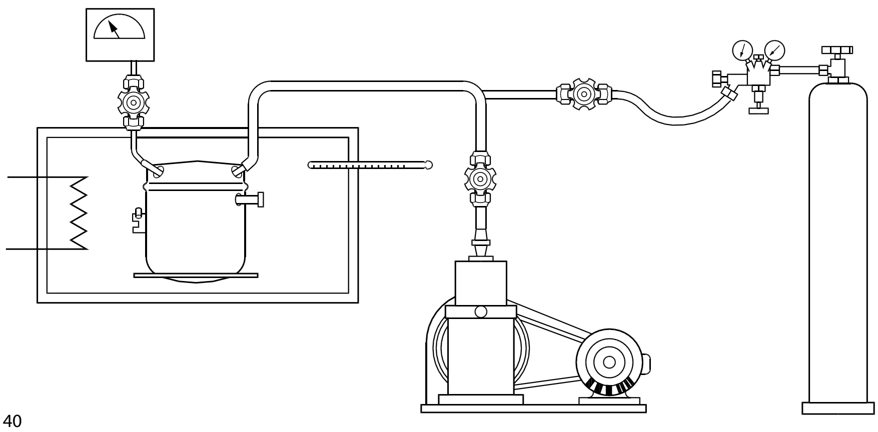
6.3
Drying of compressor

In some markets it may be necessary to repair a moist compressor in a workshop, and one is then obliged to manage somehow.
The drying process described here can give the wanted result, provided that the process is closely complied with.
Draw off the compressor oil charge.
Then flush the compressor inside with ½-1 litres of a non-flammable low pressure refrigerant or solvent.
Plug the compressor with the solvent inside and shake it thoroughly in all directions to get the refrigerant in touch with all inside surfaces.
Collect the solvent as stipulated.
Repeat the operation once or twice to ensure that no substantial oil residues are left in the compressor.
Blow through the compressor with dry nitrogen.
Connect the compressor to an arrangement as shown in fig. 20.

Plug the discharge connector.
The connections to the compressor suction connector must be vacuum tight. This can be achieved by soldered joints or by use of a suitable vacuum hose.

Bring the compressor up to a temperature between 115°C and 130°C before starting the evacuation. Then start the evacuation that must bring the pressure in the compressor down to 0.2 mbar or lower.
The joints in the vacuum system must be tight in order to achieve the required vacuum. The moisture content in the compressor will also influence the time for reaching the vacuum.
If the compressor is highly contaminated a few pressure equalizations with dry nitrogen to atmospheric pressure will enhance the process.
Shut off the connection to the vacuum instrument during the pressure equalization.
Temperature and vacuum must be maintained for approx. 4 hours.
On finishing the drying process the pressure in the compressor must be equalized to atmospheric pressure with dry nitrogen and the connectors must be sealed.
Charge the compressor with the specified oil type and amount and mount it into the refrigeration system.

Fig. 20: Drying of compressor



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6.4
Oil charge

In some cases it can be necessary to *replenish* a compressor with oil if it has lost some of the charge.
On some Danfoss compressors the amount of oil is stated on the type label, however, not on all, so the present oil type and amount must be found in the compressor datasheet.

It is absolutely essential to use the oil approved for the compressor in question. If a lost oil charge in a compressor must be replaced, it must generally be assumed that approx. 50 ccm of the oil charge will be left in the compressor when it is emptied completely by draining oil off from a connector.

7.0 Lost refrigerant charge

The term "lost charge" covers cases where the wanted cooling function is not achieved because there is not sufficient amount of refrigerant in the system.
The repair procedure implies a refrigerant overpressure in the system so that the contamination problems that may be caused by penetrating moisture can be disregarded.
"Lost charge" is characterized by the fact that the intended cooling is not achieved. The running time is long, and the compressor may run continuously. The build-up of rime on the evaporator is only partly and perhaps only around the injection place. The compressor will operate at low evaporating pressures, and this means low power and current consumption. The compressor will have a higher temperature than normal due to the reduced refrigerant transport.
The difference between "lost charge" and "blocked capillary tube" consists in the prevailing condenser pressure, however, after some time the pressure will be the same in both cases.
"Blocked capillary tube" results in the refrigerant being pumped into the condenser, and the pressure will become high. As the evaporator is pumped empty, however, the condenser will become cold.
If the blocking is complete no pressure equalization will take place during standstill.
With "lost charge", however, the pressure in the condenser will be lower than normal.
A considerable part of the repair procedure consists of finding the cause of the defect. If this is not done it will only be a question of time until the defect occurs again.
In case of blocking of the capillary tube in small systems they will normally be scrapped, but if large expensive systems are concerned a replacement of the suction line heat exchanger may be approproate.

The main steps in the repair procedure can be as follows (only for non-flammable refrigerants).

a) Mount a service valve on the compressor process tube.
Mount a pressure gauge and use this for fault determination.

b) Increase the refrigerant pressure in the system to 5 bar.

c) Examine all joints to see if there is any oil oozing out.
Perform a thorough search with leak test equipment until the leak is found.

d) Release the overpressure from the system.
Break the capillary tube at the condenser outlet.
Blow through the system with dry nitrogen.

e) Replace filter drier as described earlier.
Replace the process tube and repair the leak.

f) Evacuate the system and charge it with refrigerant.
Subsequently make a new leak test and test out the system.
After a pressure test of the system with high pressure perform a slowly starting evacuation with a large vacuum pump since otherwise the oil can be pumped out of the system.

8.0 Burnt compressor motor

A burnt motor has destroyed wire insulation
By burning is meant motors where the wire insulation is decomposed.

A real burning is characterized by the wire insulation in the motor having been exposed to critical temperatures for a long time.
If the temperature conditions in a compressor are changed in a way that the insulation material assumes a critical temperature for long time a burning will take place.
Such critical conditions may arise when the ventilation conditions are reduced (e.g. due to a defective fan), when the condenser is dirty or at abnormal voltage conditions.
The fault "lost charge" may have a corresponding effect. Part of the motor cooling is done by means of the circulating refrigerant. When the refrigeration system loses charge the evaporating pressure becomes abnormally low, less refrigerant is circulated per time unit, and the cooling is reduced.
In many cases a motor protector mounted in the electrical equipment cannot protect against such conditions. The motor protector is activated both by current and by temperature. If the current consumption is low, a high temperature is required around the protector to cause cut-out. However, at falling evaporating temperatures the temperature difference between motor and compressor housing will increase due to the poorer heat transmission.
Winding protectors placed directly in most motors provide a better protection in this situation, since they are primarily activated by the motor winding temperature.
If the wire insulation is decomposed very high temperatures will arise at the short-circuited wires. This may cause further decomposition of refrigerant and oil. As long as the compressor is functional, the entire process may cause circulation of breakdown products and thus contaminate the system.
When certain refrigerants are breaking up acid may be generated. If no cleaning is made in connection with a compressor replacement, the start of the next breakdown is already programmed.
Motor defects in hermetic compressors in household refrigerators are relatively rare. Normally, failures in the start winding are not causing contamination of the system but a short-circuit in the main winding may very well result in contamination.

8.1 Oil acidity

Since a burnt motor may result in contamination of the system with acid products, the acidity can be taken as a criterion whether the system requires a thorough cleaning.
The compressor itself and the discharge side of the system up to the filter drier will be the most contaminated part of the system. Once the refrigerant is removed from the system the compressor oil will show contamination or acidity.

A simple assessment can be made with an oil sample in a clean test glass. If the oil is dark, sludgy and perhaps contaminated with decomposed particles from the motor insulation, and if it also smells acidly there is something wrong.

8.2 Burnt system

Repair of a burnt system with products of decomposition is not recommended, and if a repair has to be performed anyway it is absolutely necessary to remove the products of decomposition from the system to avoid contamination and thus breakdown of the new compressor.
The following procedure can be used.

a) Remove the defective compressor.
   Blow through the tubes to remove old oil.

b) Mount a new compressor and a Danfoss DAS suction line burnout filter in the suction tube in front of the compressor to protect it against contamination products.
   Replace the filter drier at the condenser with a DAS filter.

c) Evacuate and charge the system.
   Then let the system operate continuously for at least 6 hours.

d) Check the oil for acidity.
   If the oil is ok no further cleaning is required.
   Remove the filter in the suction line.
   Blow through the capillary tube thoroughly.
   Mount a new filter drier at the condenser outlet, e.g. Danfoss DML.
   Evacuate the system and charge it with refrigerant.

e) If the oil is acid under item d, replace the suction line filter and let the system operate for another 48 hours and then check the oil.
   If the oil is ok, follow item d.

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Notes

Refrigerant R290, or propane, is a possible replacement for other refrigerants, which have high impact on environment, in small hermetic systems, like factory made commercial refrigerators and freezers. It has zero ozone depletion potential ODP and a neglectible global warming potential GWP. Furthermore it is a substance which is a part of petrol gases from natural sources.

The refrigerant R290 has been in use in refrigeration plants in the past, and is still used in some industrial plants. In domestic heat pumps and air conditioners R290 has been used in Germany for some years, however, with different level of success. Because of the availability of propane allover the world it has been discussed widely for CFC replacement.

Propane R290 is a possible refrigerant for this application, with good energy efficiency, but special care has to be taken to the flammability of propane.

1.0 Refrigerant

The properties of R290 differ from other refrigerants commonly used in small hermetic systems, as shown in table 1. This leads to a different design of details in many cases.

Table 1: Refrigerant data comparison

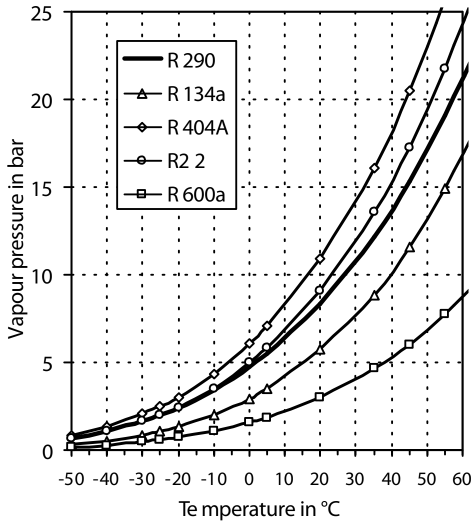
Refrigerant	R290	R134a	R404A	R22	R600a
Name	Propane	1,1,1,2-Tetra-flouro-ethane	Mixture R125 R143a R134a	Chloro-difluoro-methane	Isobutane
Formula	C_3H_8	CF_3-CH_2F	44/ 52/4	CHF_2 Cl	$(CH_3)_3$ CH
Critical temperature in °C	96.7	101	72.5	96.1	135
Molecular weight in kg/kmol	44.1	102	97.6	86.5	58.1
Normal boiling point in °C	–42.1	–26.5	–45.8	–40.8	–11.6
Pressure at –25 °C in bar (absolute)	2.03	1.07	2.50	2.01	0.58
Liquid density at –25 °C in kg/l	0.56	1.37	1.24	1.36	0.60
Vapour density at t_o –25/+32 °C in kg/m³	3.6	4.4	10.0	7.0	1.3
Volumetric capacity at –25/55/32 °C in kJ/m³	1164	658	1334	1244	373
Enthalpy of vaporisation at –25 °C in kJ/kg	406	216	186	223	376
Pressure at +20 °C in bar (absolute)	8.4	5.7	11.0	9.1	3.0

1.1 Pressure

A difference between R290 and R134a is found in the pressure level, which is closer to R22 and R404A, e.g. at -25 °C evaporation the pressure is roughly 190 % of R134a, 81 % of R404A, 350% of R600a or almost exactly that of R22. In connection with this the normal boiling point is close to R22 also. Evaporators will thus have to be designed similar as for R22 or R404A.

The pressure level and critical temperature are almost like R22. However, the discharge temperature is much lower. This gives the opportunity to work at higher pressure ratios, means lower evaporating temperatures, or at higher suction gas temperatures.

Fig. 1: Vapour pressure of different refrigerants versus temperature



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Danfoss compressors

1.2
Capacity

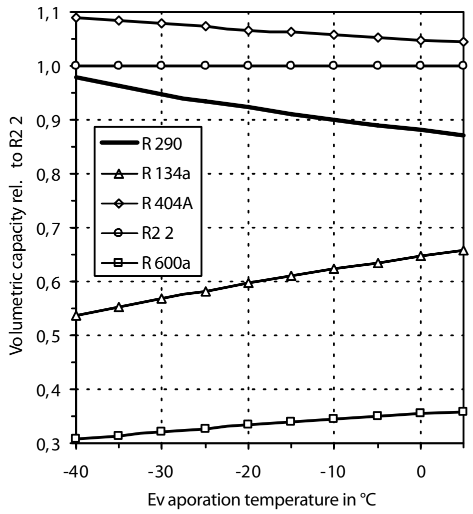
R290 has roughly 90 % of R22 or 150 % of R134a volumetric capacity at 45 °C condensing temperature, as seen in fig. 2.

Because of this the necessary compressor swept volume is close to R22 also, and 10 % to 20 % larger than for R404A.

The volumetric capacity is approx. 2.5 to 3 times that of R600a. Thus the choice for either R290 or R600a will lead to differences in system design because of very different necessary volume flow for same refrigeration need.

The volumetric cooling capacity is a value calculated from suction gas density and enthalpy difference of evaporation.

Fig. 2: Volumetric capacity of R290, R134a, R404A and R600a, relative to R22, over evaporation temperature, at 45 °C condensing and 32 °C suction gas temperature, no subcooling



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1.3
Refrigerant charge

If R290 would be charged into an unchanged refrigeration system, charge amount counted in grams would be much lower. However, calculated in cm³, the charge would be roughly the same liquid volume in the system. This gives charges of approx. 40 % of R22 or R404A charge in grams, according to the data from table 1, which also corresponds with empirical values.

Maximum charge according to safety regulations is 150 g for household refrigerators and similar applications, which corresponds to approx. 360 g of R22 or R404A.

1.4
Purity

Refrigerant R290 specification is not found in international standards. Some data are enclosed in the German standard DIN 8960 of 1998, which is an extended version of ISO 916. The purity of the refrigerant has to be judged from chemical and stability side, for compressor and system lifetime, and from thermodynamic side regarding refrigeration system behaviour and controllability.

The specification in DIN 8960 is a safe general hydrocarbons refrigerant specification, adopted from other refrigerants criteria catalogue and covering propane, isobutane, normal butane, and others. Some points can possibly be accepted a little less narrow for specific refrigerants and impurities combinations after extensive evaluation.

For the time being no refrigerant quality according to an official standard is on the market. The specifications of possible qualities have to be checked with the supplier in details. Liquified petrol gas LPG for fuel applications or technical grade 95 % purity is not sufficient for hermetic refrigeration. Water, sulfur and reactive compounds contents has to be on a lower level than guaranteed for those products. Technical grade 99.5 %, also called 2.5, is widely used.

Table 2: Specification of R290 according to DIN 8960 - 1998

	Specification	**Unit**
Refrigerant content 1)	≥ 99.5	% by mass
Organic impurities 2)	≤ 99.5	% by mass
1.3-Butadoeme 3)	≤ 5	ppm by mass
Normal Hezane	≤ 50	ppm by mass
Benzene 4)	≤ 1	ppm per substance
Sulfur	≤ 2	ppm by mass
Temperature glide of evap.	≤ 0.5	K (at 5 to 97 % destill.)
Non condensable gasses	≤ 1.5	% vol. of vapour phase
Water 5)	≤ 25	ppm by mass
Acid content	≤ 0.02	mg KOH/g Neutralization
Evaporation residue	≤ 50	ppm by mass
Particles/solids	no	Visual check

1) This content is not explicitly stated in DIN 8960. Only the impurities are listed and limited. The main content is the rest up to 100 %.
2) From compressor point of view a butane content up to approx. 1 % is acceptable in the R290.
3) This is a maximum value for every single substance of the multiple unsaturated hydro-carbons.
4) This is a maximum value for every single aromatic compound.
5) This is a preliminary value, to be reviewed with growing experience.

2.0 Materials

Refrigerant R290 is used with polyolester oil in Danfoss compressors, so material compatibility is almost identical to R134a or R404A situation from oil side. R290 is chemically inactive in refrigeration circuits, so no specific problems should occur there. Solubility with ester oil is good. Direct material compatibility is less problematic. On some rubbers, plastics and especially chlorinated plastics however, problems have been observed, but these materials are normally not present in small hermetic systems. Some materials, on which problems have been reported by different testers, are listed in the table 3. On critical materials test have to be performed for the specified use.

Table 3: Material compatibility

Material	compatible
Butylic rubber	no
Natural rubber	no
Polyethylene	depends on conditions
PP	no
PVC	no
PVDF	no
EPDM	no
CSM	no

2.1 Driers

For domestic refrigerators the common desiccant is a molecular sieve, a zeolithe. For R290 a material with 3 Å pores is recommended, like for R134a, e.g. UOP XH 7, XH 9 or XH 11, Grace 594, CECA Siliporite H3R. Pencil driers for R134a can possibly be used for R290, if they are tested according to IEC / EN 60 335 burst pressure demands.

If hardcore driers are to be used, please ask the manufacturer for compatibility to R290. Danfoss type DCL driers can be used.

3.0 Flammability and safety

The main disadvantage discussed in connection with R290 use is the risk based in its flammability. This leads to necessity for very careful handling and safety precautions.

Table 4: Flammability of propane

Lower explosion limit (LEL)	2.1%	approx. 39 g/m^3
Upper explosion limit (UEL)	9.5%	approx. 177 g/m^3
Minimum ignition temperature	470 °C	

Because of the flammability of propane in a wide concentration range safety precautions are necessary, on the appliance itself and in the manufacturing factory. The risk assessments behind these two situations are quite different. Main common starting point is, that accidents need to have two essential preconditions. One is the flammable mixture of gas and air and the other is the ignition source of a certain energy level or temperature.

These two have to be present together for combustions, so avoidance of this combination has to be proven.

Danfoss Compressors for R290 have in-ternal protectors and PTC starters or special relays, both preventing from sparks coming out near the compressor, because it can not be guaranteed

to hold surrounding air below LEL in case of leaks close to the compressor. They are equipped with a yellow label warning for flammable gas, like shown in fig. 3.

Fig. 3: Yellow label warning

Am0_0030

3.1
Appliance

For safety testing of household refrigerators and similar applications a standard has been established in Europe, IEC Technical Sheet TS 95006. It is also transferred to an amendment to IEC / EN 60 335-2-24, which is the normal electrical safety standard.

Approvals of refrigerators using hydrocarbons as refrigerant are done according to the proceedures of the TS in Europe since 1994.

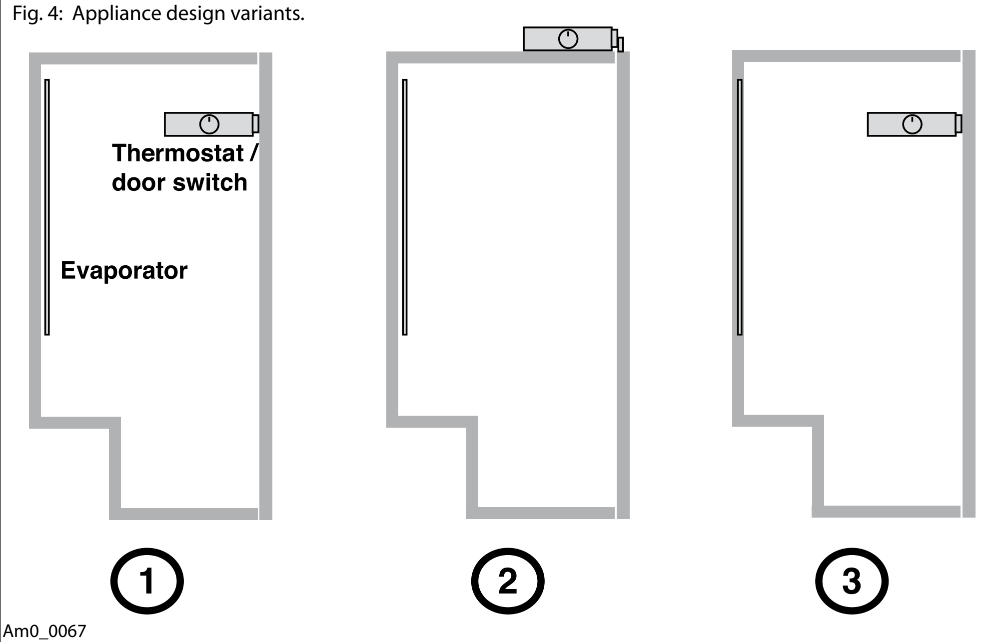
The methodology of TS and the amendments derived from this are base for the following short description.

Other applications have to take different national standards and legislation into account, e.g. EN 378, DIN 7003, BS 4344, SN 253 130, which can have different demands.

- All electrical elements switching during normal operation are taken to be possible ignition sources. This includes thermostat, door contacts for lighting, on/off and other switches, like superfrost, compressor relays, external klixon, defrost timers and so on.
- All refrigerant containing parts are taken to be possible refrigerant sources through leaks. This includes evaporators, condensers, door heaters, tubings and the compressor
- Maximum refrigerant charge is set to be 150 g. By keeping the charge to max. 25 % of lower explosion level LEL, which is approx. 8 g/m3, for a standard kitchen, ignition risk is very low, even if refrigerant distribution in case of leakage is uneven for some time first

The main target of the safety precautions is to seperate rooms with refrigerant containing parts from rooms with switching elements.

Fig. 4: Appliance design variants.



In fig. 4 three principal possibilities are shown. Option 1 has evaporator and thermostat/door switch both located in the storage volume. This is critical for flammable refrigerants and should not be used. Option 2 has evaporator inside and thermostat/door switch outside, on top. This normally gives a safe solution. Option 3 has thermostat/door switch inside, but evaporator foamed in place behind the inner liner. This is a possible solution used in many cases. Choosen option has to be designed and proven in leakage test according to TS 95006 and IEC / EN 60335 demands.

On many refrigerator or freezer designs this separation is already the existing situation.

- Large free standing bottle coolers and freezers often have all electrical switches in the top panel.
- Some refrigerators have the evaporators hidden behind the liner, in the foam, means not in the cabinet space where thermostats and so on are allowed in this case.

Critical situation is given whenever it is not possible to avoid evaporator and thermostat or switches being in the cabinet. In this case two possibilities are left.

- Thermostats and switches have to be changed to sealed versions preventing gas from penetrating them and thus reaching the switching contacts. Danfoss offers electronic thermostats suitable for this application.
- Fans inside the refrigerated compartment have to be safe and sparkfree even if blocked.
- Electrical connectors and lamp holders have to be proven according to certain specifiations.

3.1
Appliance (continued)

Every R290 appliance type has to be tested and approved according to the TS / IEC / EN proceedures, by an independent institute, even if all above mentioned criteria are included in the design. Please see the standards for details.

Instructions for use should contain some informations and warnings for careful handling, like not to defrost freezer compartments with knives, and for installing in a room with at least 1 m^3 of space per 8 g of charge, the latter to be seen on the type label.

Systems using relays or other electrical components near the compressor must meet the specifications. These are including

- Fans at the condenser or compressor must be sparkfree even when blocked or over loaded. Either they have to be designed not to need a thermal switch, or this switch has to meet IEC 60079-15.
- Relays have to meet IEC 60079-15 or being placed where a leakage can not produce a flammable mixture with air, e.g. in a sealed box or at high altitude. The starting accessory of Danfoss SC compressors is delivered with a long cable for placing in a separate electrical installation box.

The refrigerant containing system and the safety system design is to be approved and controlled regularly by local authorities normally. Below the design principles for installations in Germany are given. In many details this is based on regulations for liquified gas installations. Specialities are found around the charging stations, where gas connectors are to be handled frequently and a charging of the appliances occurs.

3.2
Factory

The basic principles for safety are

- Forced ventilation to avoid local accumulation of gas.
- Standard electrical equipment except for the ventilation fans and safety systems.
- Gas sensors continuously monitoring in possible leakage areas like around charging stations, with alarm and doubling of ventilation at 15 % to 20 % of LEL and with disconnection of all non explosion proof electrics in the monitored area at 30 % to 35 % of LEL, leaving the fans running at full speed.
- Leakage test on appliances before charging to avoid charging of leaking systems.
- Charging stations designed for flammable refrigerants and connected to the safety systems.

Safety system design can be supported by suppliers of charging stations and gas sensing equipment in many cases.
For handling of R290 in small containers, the rules are less strict in some countries.

4.0
Refrigeration system design

In many cases of transition from non flammable refrigerants to R290 the appliance cabinet has to be modified for safety reasons as listed in section 3.1. But changes can additionally be necessary for other reasons.

Refrigerant containing system parts have according to IEC / EN 60335 to withstand a specified pressure without leaking. High pressure side has to withstand saturation overpressure of 70 °C times 3.5, low pressure side has to withstand saturation overpressure of 20 °C times 5. This gives the following for R290:

- 87 bar overpressure High Pressure side
- 36.8 bar overpressure Low Pressure side

National standards could have different specifications, depending on the application.

4.1
Heat exchangers

The refrigeration system efficiency will normally not cause a need for changing evaporator or condenser size, means outer surface can be left the same as with R22 or R404A.

Inside design of the evaporator possibly needs some modification, because the refrigerant volume flow is different, according to the compressor swept volume. To keep the refrigerant flow speed within the recommended range of 3 to 5 m/s it may be necessary to adopt the cross flow sections.

Rollbond evaporators can maybe not be used because of the high demands on burst pressure. Special care has to be taken when designing the accumulator in the system. When using R22 or R134a the refrigerant is heavier than the oil used, while with R290 the refrigerant is less heavy, as can be seen in the data table 1.

This can lead to oil accumulation if the accumulator is too large, especially too high, and has a flow path which does not guarantee emptying sufficiently during startup phase of the system.

4.2
Capillary

For R290 experience shows the need for a capillary flow rate almost similar to R404A. At least this is a good starting point for optimization.

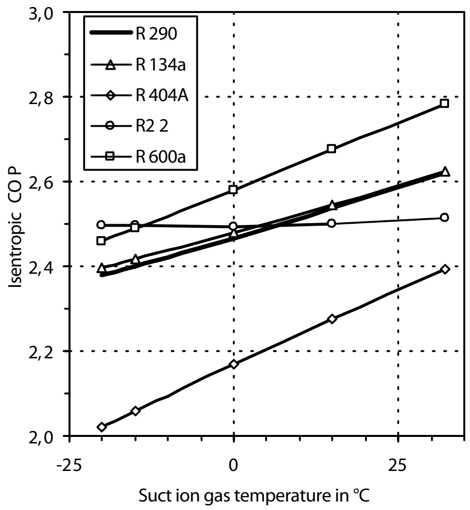
As with R134a, R404A and R600a the suction line heat exchanger is very important for system energy efficiency of R290, which it was not for R22, see fig. 5. The figure shows increase of COP with superheat from few K up to +32 °C return gas temperature, where a range from +20 °C to approx. +32 °C is usual for small hermetic systems.

This large increase in COP for R290 is caused by a high vapour heat capacity. In combination with the need for keeping the refrigerant charge close to maximum possible in the system, thus giving no superheat at evaporator outlet, the suction line heat exchanger has to be very efficient for preventing air humidity condensation on the suction tube. In many cases an elongation of the suction line and capillary gives efficiency improvements.

The capillary itself has to be in good heat exchanging contact with the suction line for as long a part of total length as possible.

At high superheat, with good internal heat exchange, the theoretical COP of R290, R600a and R134a is higher than for R22. At very low superheat the COP of R290, R600a and R134a is lower than for R22. The R290 behaviour is similar to R134a, with respect to internal heat exchange.

Fig. 5: Theoretical COP increase of different refrigerants versus suction temperature with adiabatic compression, internal heat exchange, at -25 °C evaporation, 45 °C condensation, no subcooling before internal heat exchanger



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4.3
Evacuation

Generally the same rules for evacuation and processing are valid as for R22, R134a or R404A systems. The maximum allowable content of non condensable gases is 1 %.

Too high level of non condensables increases energy consumption because of higher condensing temperature and a portion of the transported gas being inactive. It can additionally increase flow noise.

4.4
Cleanliness of components

The specifications for cleanliness are generally comparable to R22 or R134a. The only official standard on cleanliness of components for refrigeration use is the DIN 8964, which also is used in several countries outside Germany.

It specifies maximum contents of soluble, insoluble and other residues. The methods for determining soluble and insoluble contents are to be modified for the actual refrigerant R290, but in principle the same limits are useful.

5.0
Service

Servicing and repair of R290 systems is possible for skilled and well trained service technicians. Please see note CN.73.C for details.

Local laws and regulations have to be taken into account also. It needs very careful handling because of the flammability of the gas, which is a potential danger during work on the refrigeration system.

A good ventilation of the room is necessary and the discharge of the vacuum pump has to be lead to open air.

The equipment of the service technician has to meet the requirements of R290 in terms of evacuation quality and refrigerant charge accuracy. An electronic scales is recommended to control refrigerant charge to within the needed accuracy.

Conversion of a R22, R502 or R134a system to R290 is not recommended by Danfoss, because these systems are not approved for flammable refrigerant use, so electrical safety is not proven to be according to the needed standards.

References

TS 95006	Refrigerators, food-freezers and ice-makers using flammable refrigerants, Safety Requirements, Ammendment to IEC 60 335-2-24, CENELEC, July 1995
CN.86.A	Driers and Molecular Sieves Desiccants
CN.82.A	Evaporators for Refrigerators
CN.73.C	Service on Household Refrigerators and Freezers with New Refrigerants
CN.60.E	Practical Application of Refrigerant R600a Isobutane in Domestic Refrigerator Systems
EN 60335-2-24	Safety of household and similar appliances Part 2: Particular requirements for refrigerators, food freezers and ice-makers

This chapter is devided into two sections:

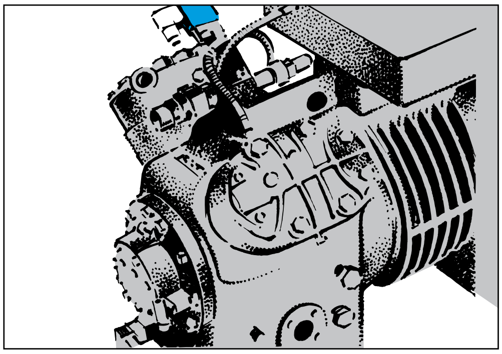
Contents

Notes

Installation requirements

More and more commercial refrigeration systems and air conditioning plants of a similar size are built up around hermetic and semihermetic compressors. These compressors, as compared to the open type, are normally more vulnerable to impurities in the refrigerant system and to incorrect operating conditions.

Therefore, in modern refrigeration systems, there are special demands on the quality of installation work and commissioning.



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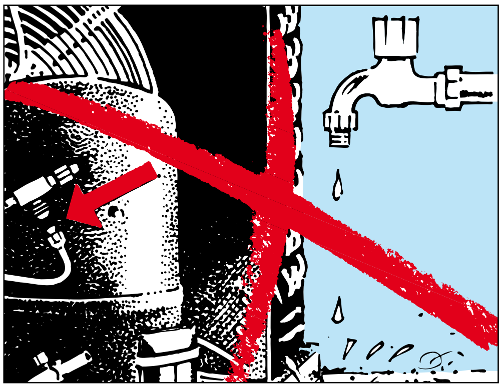
Tubing must be kept clean

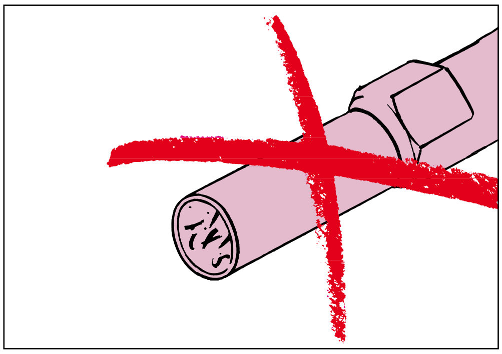
A well-dimensioned, correctly installed and correctly commissioned refrigerant system is fundamental to a reliable refrigeration system with a long operating life.
An absolute requirement on the refrigerant system is that it shall remain completely free of foreign bodies (impurities).
Installation work must therefore be performed with a high degree of cleanliness. This applies especially to systems containing the new refrigerants.



Ac0_0010

Particularly damaging impurities

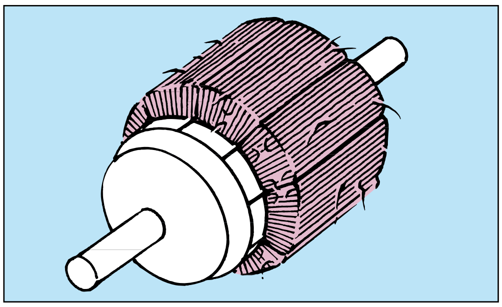
- Moisture
- Atmospheric air
- Soldering flux
- Rust, copper oxide, scale
- Metal swarf
- Unstable oils
- Certain fluorinated solutions (e.g. R11 or carbon tetrachloride)
- Dirt or dust of any description.



Ac0_0037

Problems caused by moisture in the system

- Water separation and ice formation (blockage) in the expansion valve
- Acid formation
- Ageing and breakdown of the oil
- Corrosion
- Copper precipitation (dissolved copper from tubing deposited on bright steel parts in the compressor)
- Damage to the insulating lacquer on motor windings.



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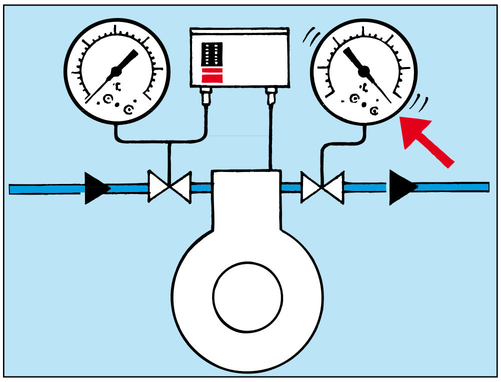
Practical tips

Problems caused by atmospheric air

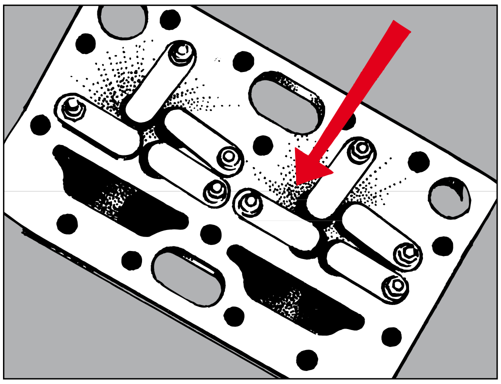
- Aeration
- Chemical reaction between refrigerant and oil
- Increased condensing pressure.



Ac0_0038

Problems caused by oil and refrigerant breakdown

- Formation of organic and inorganic acids
- Corrosion
- Poor lubrication
- Abnormal wear
- Oil discolouration (darkening)
- Sludge formation
- Leaking discharge valves because of oil carbon deposits
- Increased discharge gas temperature
- Compressor damage
- Motor burnout



Ac0_0046

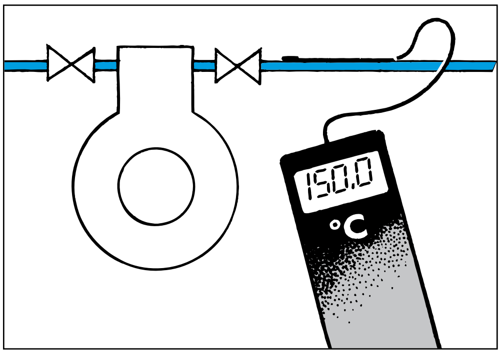
Problems caused by other impurities

The other impurities mentioned can cause:

- Accelerated chemical processes (breakdown)
- Mechanical or electrical faults

High temperature accelerates the breakdown processes, therefore abnormally high condensing temperatures and, especially, abnormally high discharge pipe temperatures must be avoided.

For the reasons just mentioned, a number of requirements must be met. Some of these are described in the next chapter.



Ac0_0047

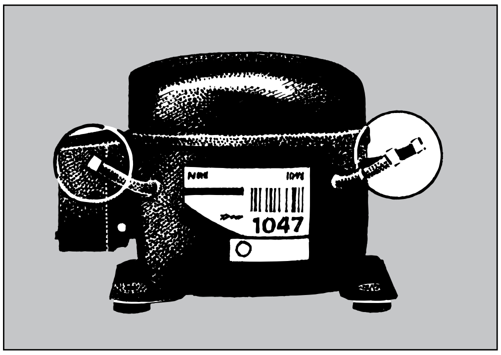
Component and material requirements

Components

Compressors for refrigeration and heat pump systems are put through a comprehensive cleaning process by the manufacturer so that, practically speaking, all traces of moisture and other impurities are removed.

All other components in the system should be of the same standard.

All components must fulfil cleanliness requirements. In cases of doubt, components should be checked.



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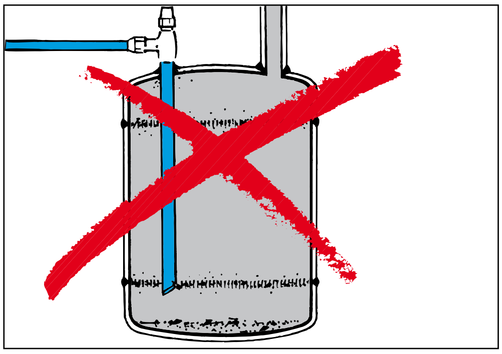
Impurities and moisture

Impurities that might appear if component manufacturers are less thorough than they should be:

- Rust and scale (loose or embedded)
- Old oil
- Flux
- Metal swarf
- Moisture



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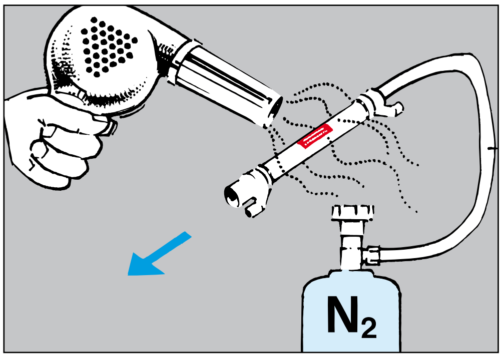
Moisture in smaller quantities in components can be removed by simultaneous heating and blowing through with dry nitrogen (N_2).

It is almost pointless to try removing other impurities. Components containing such impurities should not be used in systems with halogenous refrigerants.



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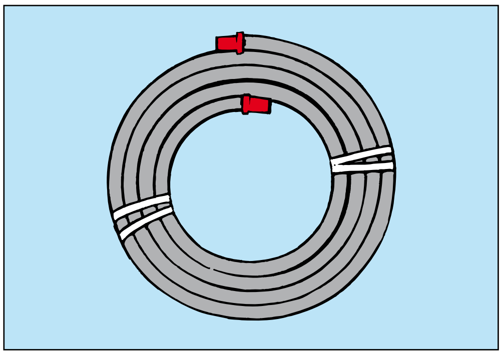
Copper tubing

Special copper tubing must be used for refrigerant systems, tubing that is completely clean and dry. In addition, the ends of tubes must be hermetically sealed.

Tubing other than the type just described must not be used in refrigerant systems, unless it fulfils the same cleanliness requirements.

All components must remain tightly sealed until the moment they are installed in the system.



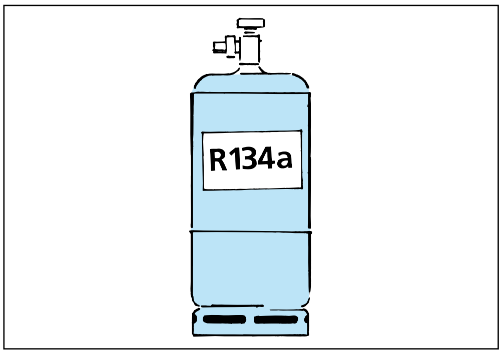
Ac0_0049

Refrigerant requirements

Refrigerants should only be purchased from accredited distributors.
Refrigerants for hermetic systems must not contain more than:

- 10 ppm = 0.001% water
- 100 ppm = 0.01% high-boiling refrigerant
- 0 ppm = 0% acid
- 15000 ppm = 1.5% non-condensable gases

Care must therefore be exercised when using regenerated refrigerant.



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Compressor oil requirements

Compressor oil must be approved by the compressor manufacturer and must not contain more than 25 ppm (0.0025%) water and 0% acid.

Ac0_0007

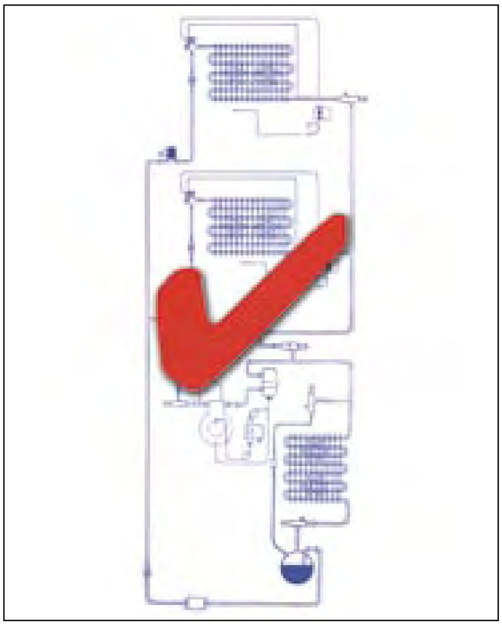
Contents

Notes

Installation process

Process:

- Planning of component location and tubing layout
- Setting up of main components
- Piping and component installation
- Evacuation
- Flushing
- Pressure testing
- Leak testing
- Charging
- Setting safety equipment
- Testing safety equipment
- Setting controls
- Testing the complete system and readjusting controls, etc.



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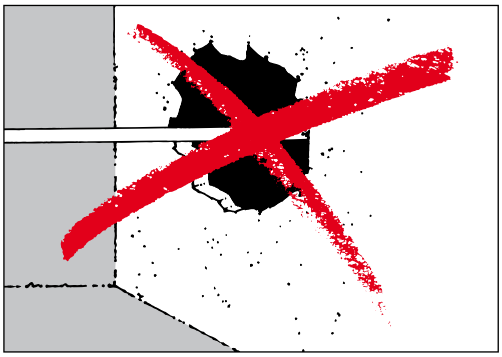
Planning

Installation must be planned so that

- Damage to building sections, including cold room insulation, is minimal.
- Components are located functionally correctly (e.g. adequate air flow to compressor, condenser, evaporator).
- Pipe runs are as short as feasibly possible.



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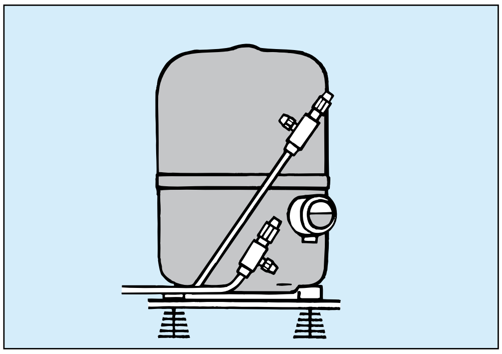
Location of main components

Main components (compressor, condenser, evaporator, etc.) must be mounted securely in position, using the accompanying brackets and in accordance with the manufacturer's instructions.

The compressor must always be secured to a horizontal base. If vibration dampers are supplied, they must also be fitted.



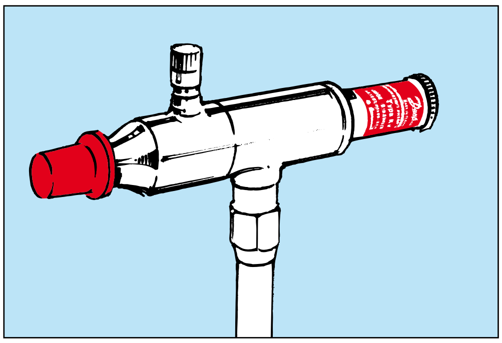
Ac0_0009

Installation of refrigeration system

Installation must be as rapid as possible so that significant quantities of moisture, air or other impurities have little chance of collecting in the system.

Compressors and filter driers should therefore be installed last, immediately before evacuating and charging the system.

All openings into the refrigerant system - with absolutely no exception - must be completely sealed against air and water vapour for the duration of any pauses that might occur in installation work.



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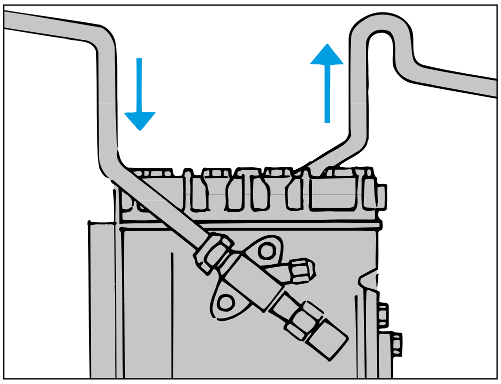
Piping installation

As far as possible, piping must be horizontal or vertical. The exceptions are:

- Suction lines, which can be given a slight fall towards the compressor.
- Discharge lines, which can have a slight fall away from the compressor.

Pipe fixing brackets, clips, etc. must be pitched to suit the pipe diameter and load from components mounted in the lines.

If vibration dampers are fitted to the compressor, then suitable vibration eliminators should be fitted to suction and discharge piping.



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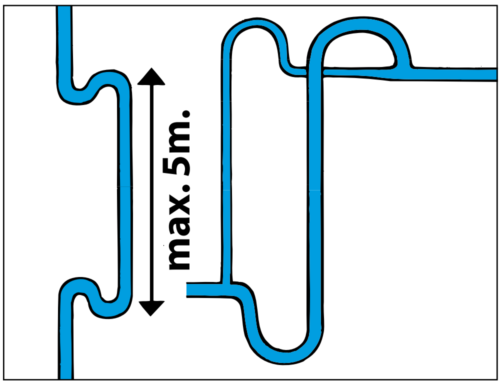
Oil locks must be mounted in vertical suction lines at a pitch of 1.5 to 5 m depending on running time per cycle. In systems with large load variations it can be necessary to introduce double risers.

Suction lines must also be installed to take account of oil return to the compressor.

In systems with varying loads, the demands are particularly critical at low loads.



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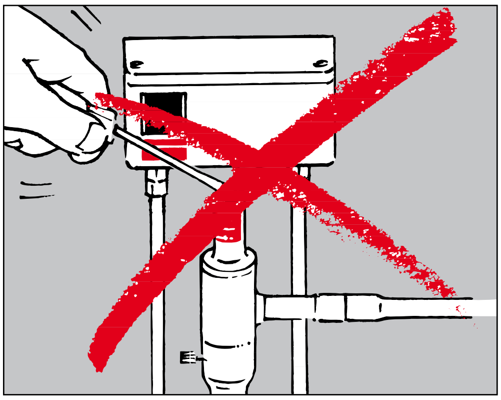
Location of other components

All components should be installed so that they are easily accessible for service and possible repair.

Controls and safety equipment must be located so that testing and adjustment can easily be performed using ordinary tools.



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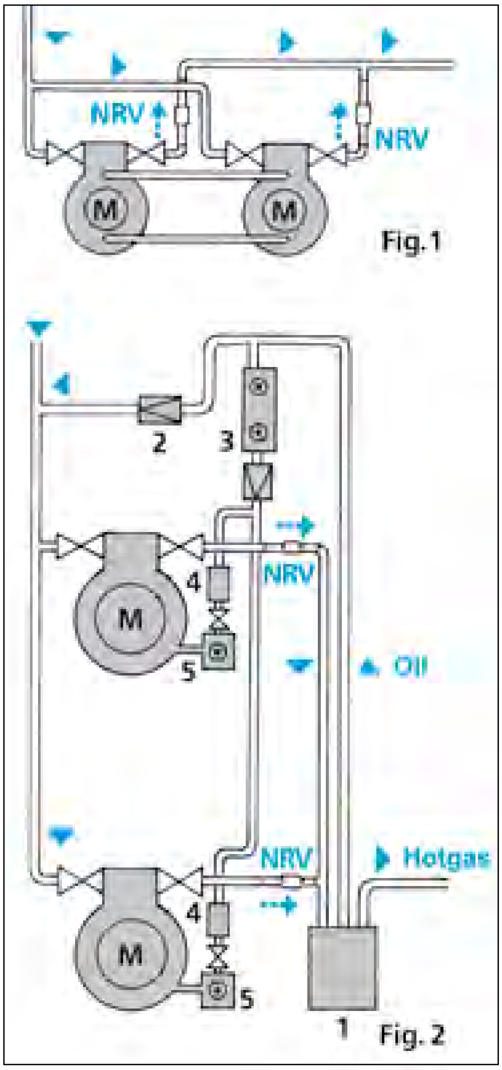
Compressors in parallel installation

Compressors in parallel must be installed with oil equalization between compressor crankcases, otherwise whichever compressor(s) run most will „steal" oil from the other compressor(s). Oil equalization can be introduced by installing an equalizing tube between oil sumps. In systems with one equalizing tube, the tube must be installed between compressor oil sumps and must be of such a diameter that both oil and refrigerant vapour are able to flow through it unhindered.



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With two equalizing tubes (fig. 1)
One tube must be installed between compressor oil sumps, the other between compressor vapour chambers (crankcases). When installing oil equalization in either of the forms described, the compressors must be set up in exactly the same horizontal plane.

Oil level controls (fig. 2)
Oil equalization is also possible using oil level regulators.
If these are used, the compressors can be installed at different levels. However, level controls are much more expensive than equalizing pipes.
The following components are necessary with oil level regulation:

- Oil separator (1)
- Pressure equalizing valve (2)
- Oil reservoir (3)
- Oil filter (4)
- Oil level regulator (5)

Remember that each compressor must be protected with a high-pressure control, e.g. KP7.

Important installation processes

The processes that might give rise to contamination of refrigerant systems are:

- Component storage
- Pipe cutting
- Cleaning pipe ends
- Soldering
- Flare connections

Component storage

All components must have a temperature not lower than that of their surroundings - before they are opened. This prevents condensation in the components.

For example, components must not be installed immediately after they have been brought from a cold service van into a warm room.

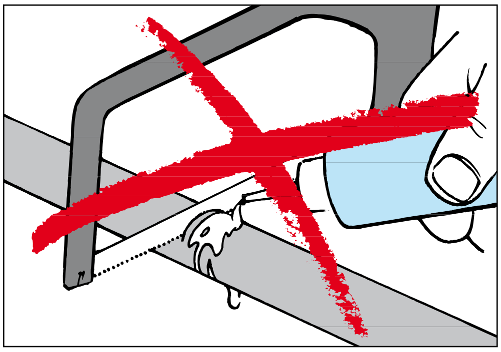

Ac0_0013

Pipe cutting

Tubing must be cut with a pipe cutter or be sawn. Never use any kind of lubricant/coolant.

Remove internal and external burrs with a special deburring tool.

Avoid copper swarf entering the pipe. Use calibration tools to ensure the correct diameter and roundness.



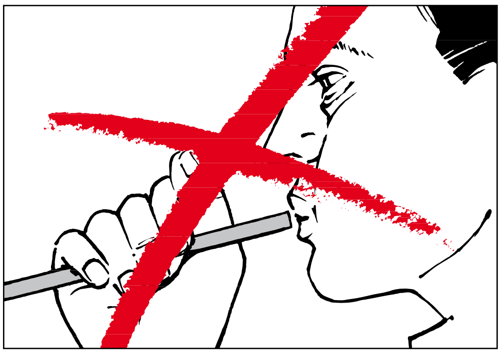
Ac0_0014

Pipe cleaning

Blow through the pipe using a blast of dry compressed air or dry nitrogen.

Never use ordinary compressed air; it contains too much moisture. Never blow through piping by mouth.

Piping which has been prepared for later use must be laid ready, with sealed ends, together with the other components.



Ac0_0015

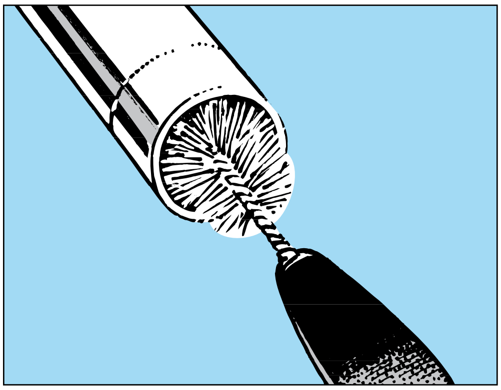
Silver soldering (brazing)

Silver solder consists of 30% silver, copper, zinc and tin. The melting range is just over 655°C to about 755°C.

Silver solder will bind only with clean, non-oxidized metal surfaces.

Clean the pipe ends with a special brush and apply flux at once, immediately before soldering.

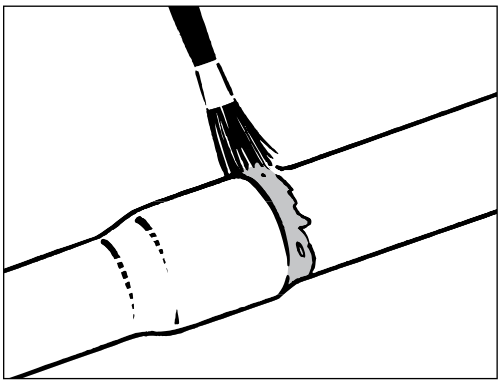
Silver soldering flux must be suspended in spirit, never water.



Ac0_0016

Smear a thin layer of flux around the soldering point after the parts have been joined.

Silver solder can then be used to permanently join different materials, e.g. brass/copper and iron/copper.



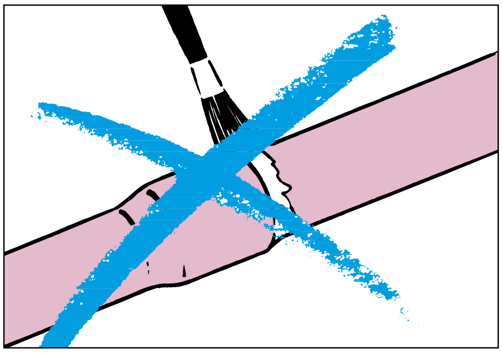
Ac0_0017

Phosphor solder

Phosphor solder consists of 2-15% silver with copper and phosphor. The melting range is about 640°C to 740°C.

Flux must not be used when making phosphor solder connections.

Phosphor solder can only be used to join copper to copper.



Ac0_0018

Use of inert gas when soldering

At the high temperatures used in soldering, oxidation products (scale) form immediately if the pipe comes into contact with atmospheric air while soldering is taking place.

An inert gas must therefore be blown through the system during soldering. Send a slight flow of dry nitrogen or another kind of inert gas through the tubing.

Do not begin soldering until there is no more air in the component(s) concerned.

Start the operation with a strong flow of inert gas.

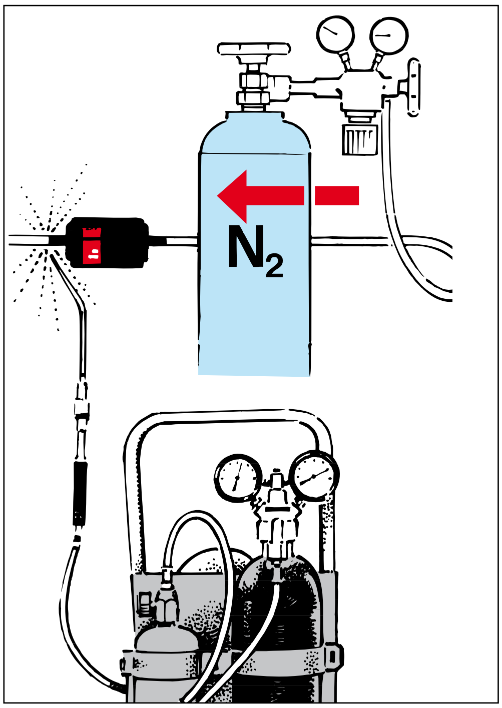
Closely observe that no air flow goes into the pipe with inert gas flow.

Reduce the flow to a minimum when soldering is started.

Maintain this slight flow of shielding gas during the whole soldering process.

Soldering must be performed with oxygen and gas, with a slight oxygen deficit and a relatively large burner jet.

The solder must not be applied until the melting temperature is reached on the parts being connected.

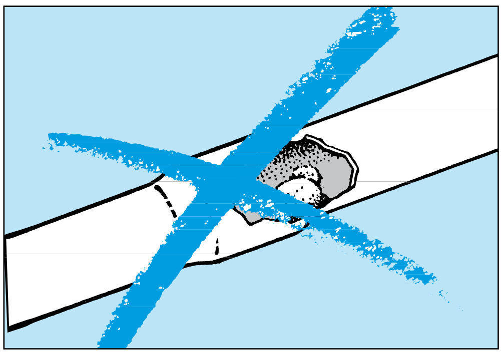


Ac0_0019

Economic soldering

Never use more solder than necessary, otherwise there is a risk of blocking the pipe partially or completely.

Solder quickly so that the oxygen absorption property of the flux is not impaired, i.e. for no longer than about 15 seconds.



Ac0_0020

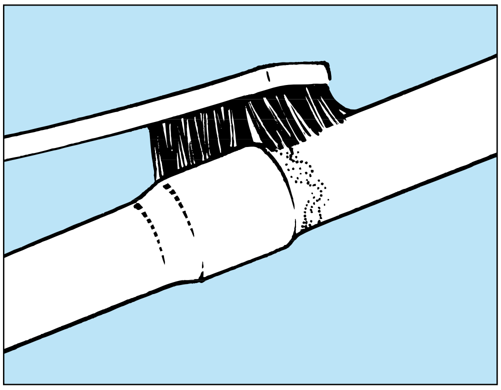
Be careful with the temperature

The temperature must not be higher than necessary.

Therefore draw the flame back slowly when the melting temperature is reached.

External flux residue must be removed by brushing with hot water.

Alloys based on tin or lead are not recommended as solders for refrigerant systems.



Ac0_0021

Flare connections (copper piping)

Use only approved refrigeration copper piping.

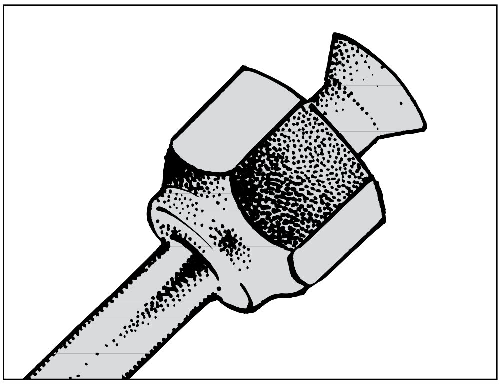
Cut ends at right angles to the piping.

Remove all internal and external burrs.

Make the flare the right size, neither too small nor too large.

Do not compress the flare so severely that it becomes hard.

Leave final tightening up until actual installation.



Ac0_0022

Evacuation, flushing and charging

Steps to follow:
On completing installation work, the next steps are:

- Evacuation and refrigerant charging
- Leak testing
- Starting up and adjustment.

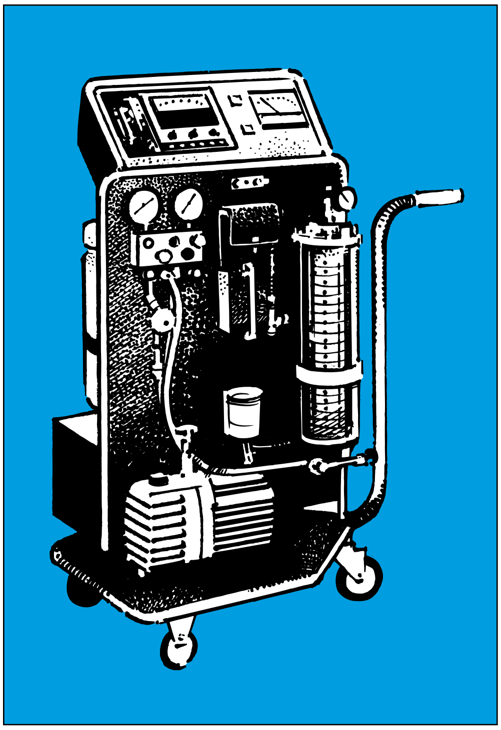
Faults, which occur after the system has been started, can necessitate:

- Repair of the system.

Necessary equipment

- Vacuum pump
- Vacuum gauge
- Charging bottle (or service cylinder containing refrigerant)
  (Vacuum pump, vacuum gauge and charging bottle can be obtained assembled as an evacuation and charging board.)
- Charging hoses
- Leak detector

Remove moisture, atmospheric air and inert gas from the system when evacuating.



Ac0_0023

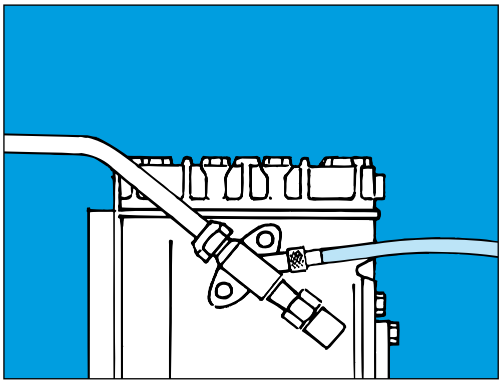
Vacuum pump

The vacuum pump should be capable of quickly bringing the system pressure down to about 0.05 mbar.

Pump capacity, e.g. 20 l/minute. Effective evacuation requires large pipe diameters.

Therefore evacuation through "Schraeder" valves is not advisable. Use a "Quick Connector" for compressors with process tube or use the process connectors on the compressor suction and perhaps the discharge stop valve.

The valve spindle must be in its mid position.



Ac0_0024

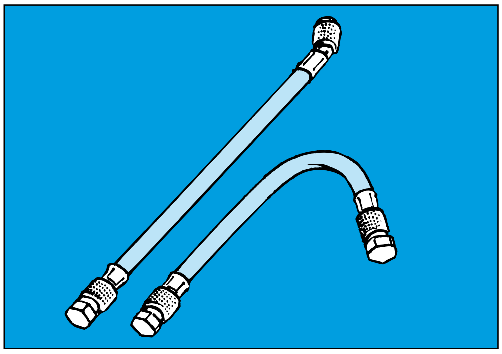
Vacuum hoses

Vacuum hoses and tubes must be as short as possible and the diameter sufficiently large.

Normally, an ordinary 1/4" charging hose not more than 1 m in length can be used.

Evacuate in two stages with refrigerant flushing between.

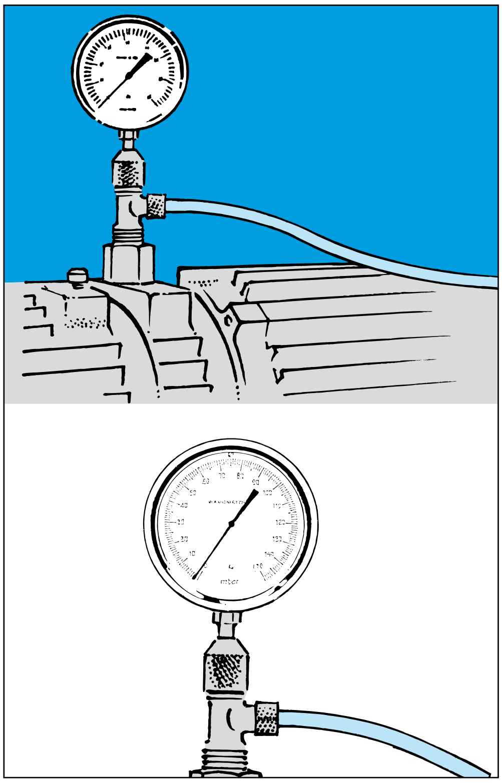
The process of evacuation, flushing and charging is described below.



Ac0_0025

Checking the vacuum pump and hoses

a) Mount the charging hoses between charging board and compressor. Shut off the connections between charging hoses and compressor.
b) Start the pump and allow it to suck the pressure down as far as possible.
c) Shut off the pump from the rest of the system.
d) Stop the pump.
e) Read off and register the pressure on the vacuum gauge. The pressure must not be more than 0.05 mbar.
f) Check to ensure that the vacuum can be maintained. If not, replace charging hoses and/or leaking valves and/or vacuum oil in the vacuum pump.

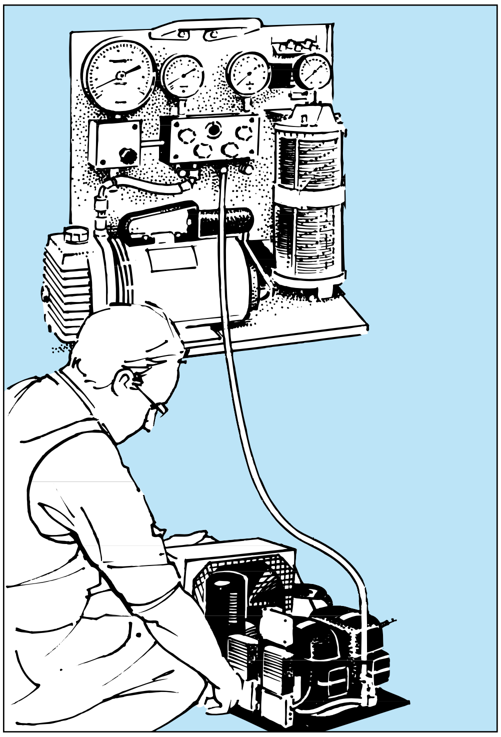


Ac0_0026

First evacuation

Evacuation from suction side of compressor and possibly also the discharge side.

- Charging hose(s) mounted between charging board and compressor.
- All valves, incl. solenoid valves, open.
- Automatic regulating valves at maximum opening.
- Evacuate system, if possible down to the pressure previously indicated by the vacuum gauge.



Ac0_0028

System vacuum test

To be performed as described under „Checking the vacuum pump and hoses".
If any leakage is detected:

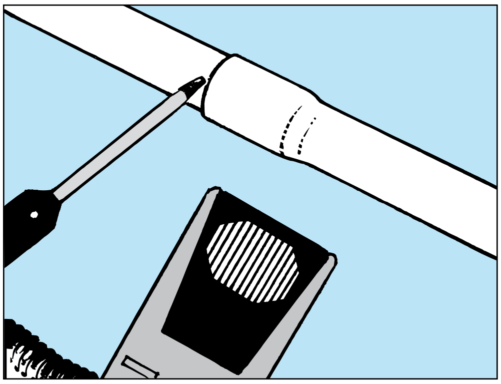
- Approximately localize the leakage by shutting off sections of the system. Retighten flare and/or flange connections. Repeat evacuation.
- Repeat the test until vacuum is maintained or continue with the next point.

Flushing and provisional leak testing

- Apply refrigerant pressure to the system (approx. 2 bar overpressure).
- Leak-test all connections.

If leakage is detected:

- Use a recycling unit and vacuum pump to remove refrigerant from the system.
- Repair the leakage.
- Repeat the process until no system leakage remains.

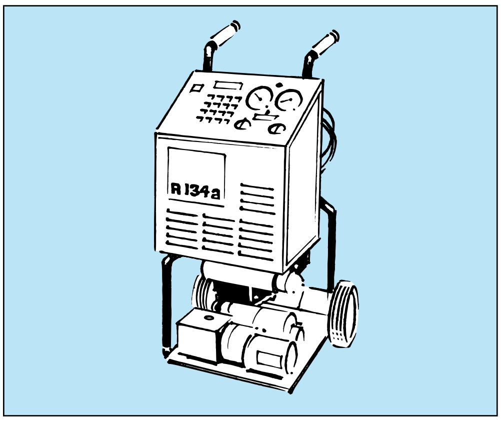


Ac0_0030

Second evacuation

- If overpressure remains on the system, use the recycling unit to empty it of refrigerant.
- Then evacuate again as described under "First evacuation".

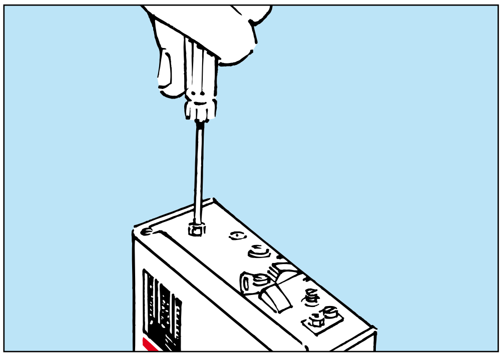
This will further remove any air and moisture remaining in the refrigerant system.



Ac0_0029

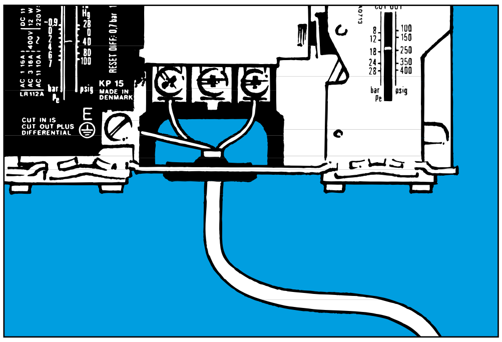
Provisional setting of safety equipment

- Check and set high-pressure control and any other safety equipment, incl. motor protector (setting in accordance with scale values).


Ac0_0031

Checking the electrics

- Check all wiring.
- Test the control system with compressor motor disconnected.
- Check the direction of rotation of the motor. Swap two phases if necessary.


Ac0_0032

Refrigerant charging

After final evacuation, the system can be charged with refrigerant.

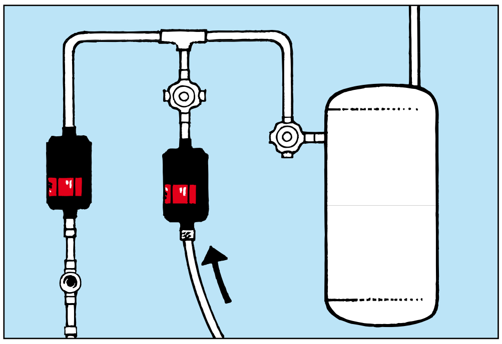
A charging board can be used for the purpose and will, with sufficient accuracy, dose the correct quantity of refrigerant for the system. High accuracy is needed in systems without receiver.

If the system has a charging valve, refrigerant can be supplied in the form of liquid to the liquid line. Otherwise the refrigerant can be supplied as vapour to the compressor suction stop valve with the compressor running.

Caution:
Too little superheating during the charging process can cause liquid hammer in the compressor.

Charging must be continued until no vapour formation appears in the sight glass - unless vapour formation is due to other faults, see the section "Trouble shooting - Fault location".
If the necessary quantity of refrigerant is not known, use the method last described.

Here however, it is necessary the whole time to check that the condensing pressure and suction pressure remain normal and that the Thermostatic expansion valve superheat is not too low.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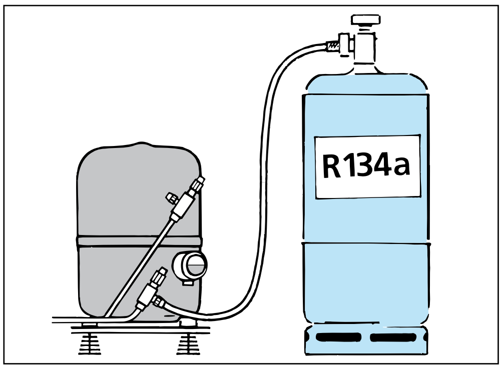

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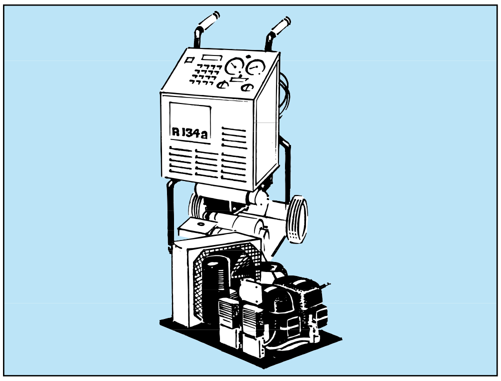
Condensing pressure too high

Too high a condensing pressure during the charging process can mean that the system has been overcharged with refrigerant and must be partly drained.

Always use the recycling unit if it becomes necessary to drain off refrigerant.



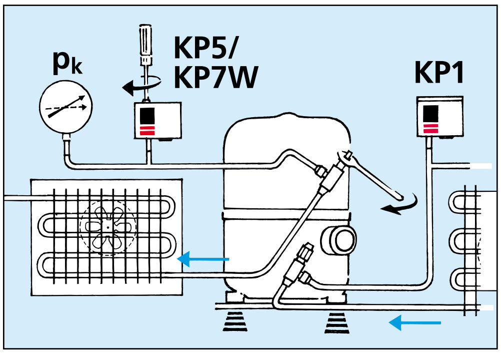
Ac0_0035

Setting and testing safety equipment

Conditions

Final setting and testing of safety equipment must be performed with all mechanical and electrical equipment installed and the system running.

The functions must be checked with accurate instruments. See also the chapter "Trouble Shooting", section "Measuring Instruments" with reference to the instructions for the equipment concerned.

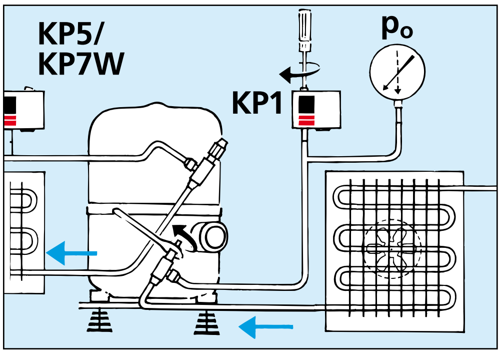


Ac0_0039

Setting and testing regulation equipment

Procedure

- If a constant-pressure valve is installed, make a coarse setting.
- Set the expansion valve superheat.
- Using a pressure gauge, set the constant pressure valve.
- Set the capacity regulator, if installed.
- Set the thermostats (using a thermometer).



Ac0_0062

Setting the high-pressure control

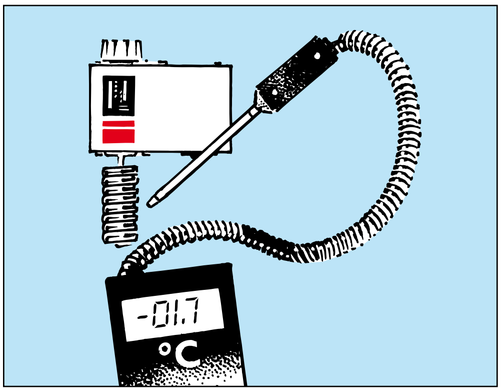
- Increase the condensing pressure to permissible maximum and use a pressure gauge to set the high-pressure control.

Setting the low-pressure control

- Reduce the suction pressure to the permissible minimum and use a pressure gauge to set the low-pressure control.

Attention:
When making the above settings, constantly check whether the system is operating normally (pressure, etc.).

Finally - ensure that correct refrigerant identification labels are affixed to the system in order that correct future servicing is ensured.



Ac0_0045

This chapter is divided into four sections:

Contents

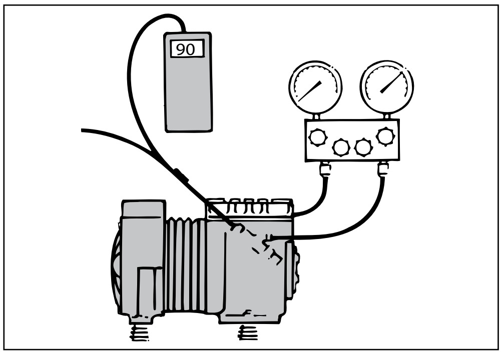
Notes

Measuring Instruments

Instruments for fault location

The items of equipment most often used for locating faults in refrigeration systems are as follows:

1. Pressure gauge
2. Thermometer
3. Hygrometer
4. Leak detector
5. Vacuum gauge
6. Clamp ammeter
7. Megger
8. Pole finder



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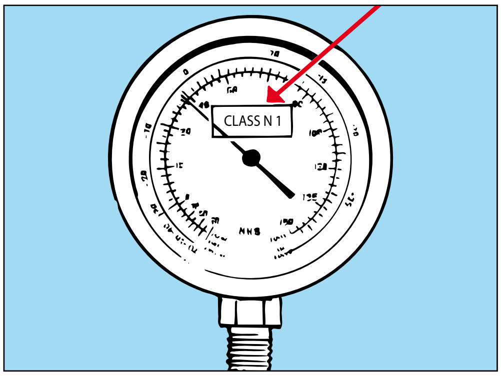
Classification of instruments

Instruments for fault location and servicing on refrigeration systems should fulfil certain reliability requirements.
Some of these requirements can be categorised thus:

a. Uncertainty
b. Resolution
c. Reproducibility
d. Long-term stability
e. Temperature stability

The most important of these are a, b, and e.

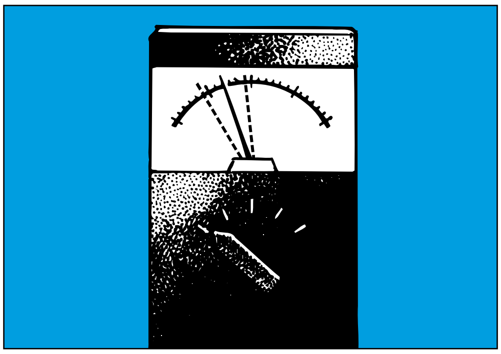


Ae0_0046

a. Uncertainty

The uncertainty (accuracy) of an instrument is the accuracy with which it is able to give the value of the measured variable.

Uncertainty is often expressed in % (±) of either: Full scale (FS) or the measuring value.
An example of uncertainty for a particular instrument is ±2% of measuring value, i.e. less uncertain (more accurate) than if the uncertainty is ±2% of FS.



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b. Resolution

The resolution of an instrument is the smallest unit of measurement that can be read from it.

For example, a digital thermometer that shows 0.1°C as the last digit in the reading has a resolution of 0.1°C.

Resolution is not an expression of accuracy. Even with a resolution of 0.1°C, an accuracy as poor as 2 K is not uncommon.

It is therefore very important to distinguish between the two.

Ah0_0006

c. Reproducibility

The reproducibility of an instrument is its ability to repeatedly show the same result for a constant measuring value.

Reproducibility is given in % (±).

d. Long-term stability
Long-term stability is an expression how much the absolute accuracy of the instrument changes in, say, one year.

Long-term stability is given in % per year.

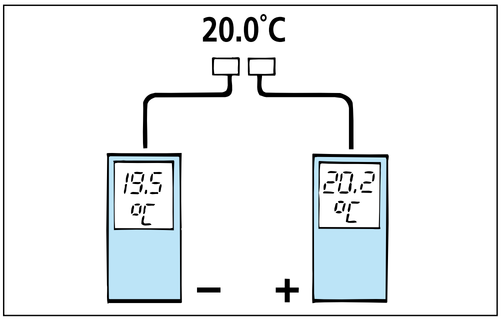
Ae0_0003

e. Temperature stability

The temperature stability of an instrument is how much its absolute accuracy changes for each °C temperature change the instrument is exposed to.

Temperature stability is given in % per °C.

Knowledge of the temperature stability of the instrument is of course important if it is taken into a cold room or deep freeze store.



Ae0_0004

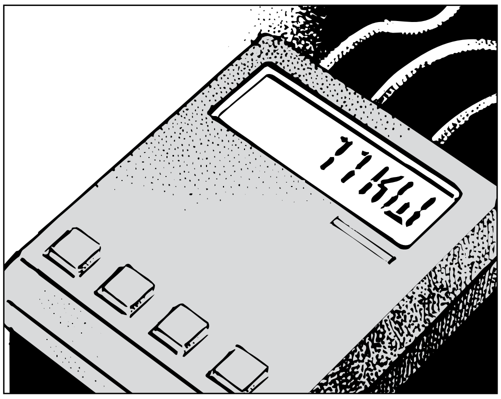
Electronic instruments

Electronic instruments can be sensitive to humidity.

Some can be damaged by condensate if operated immediately after they have been moved from cold to warmer surroundings.

They must not be operated until the whole instrument has been given time to assume the ambient temperature.

Never use electronic equipment immediately after it has been taken from a cold service vehicle into warmer surroundings.



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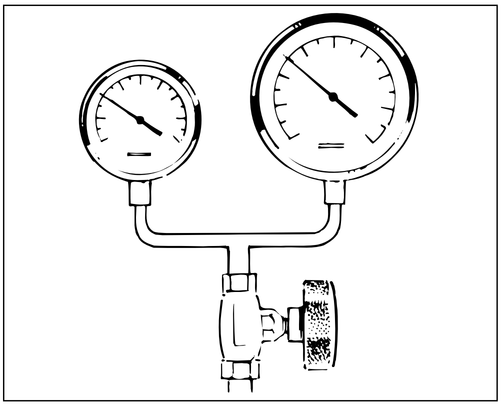
Check and adjustment

Readings from ordinary instruments, and perhaps some of their characteristics, change with time.

Nearly all instruments should therefore be checked at regular intervals and adjusted if necessary.

Simple checks that can be made are described below, although they cannot replace the kind of inspection mentioned above.



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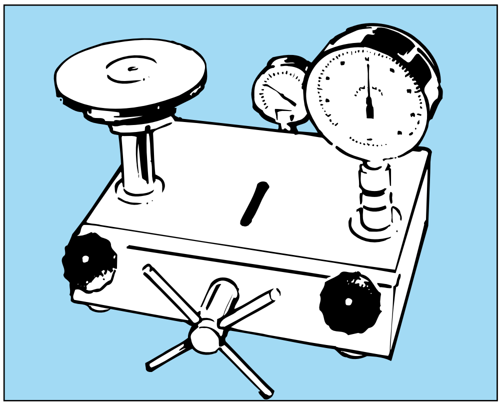
Check and adjustment (cont.)

The proper final inspection and adjustment of instruments can be performed by approved test institutions.



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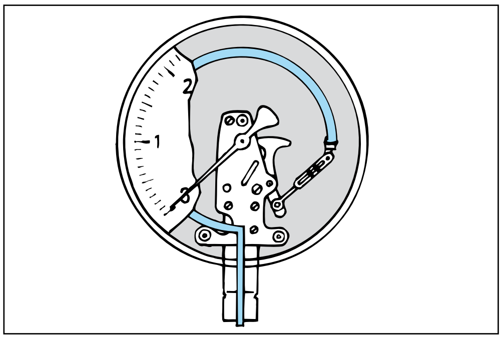
Adjustment and calibration

Pressure gauges

Pressure gauges for fault location and servicing are as a rule of the Bourdon tube type. Pressure gauges in systems are also usually of this type.

In practice, pressure is nearly always measured as overpressure.
The zero point for the pressure scale is equal to the normal barometer reading.

Therefore pressure gauges have a scale from −1 bar (−100 kPa) greater than 0 to + maximum reading. Pressure gauges with a scale in absolute pressure show about 1 bar in atmospheric pressure.



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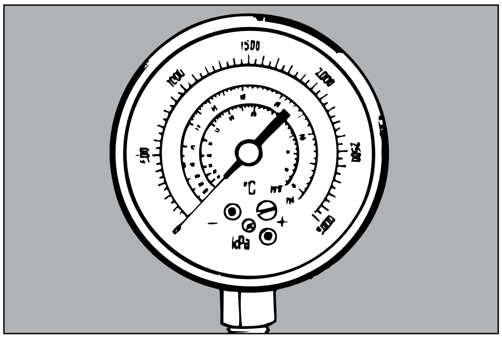
Service pressure gauges

As a rule, service pressure gauges have one or more temperature scales for the saturation temperature of common refrigerants.

Pressure gauges should have an accessible setting screw for zero point adjustment, i.e. a Bourdon tube becomes set if the instrument has been exposed to high pressure for some time.

Pressure gauges should be regularly checked against an accurate instrument. A daily check should be made to ensure that the pressure gauge shows 0 bar at atmospheric pressure.



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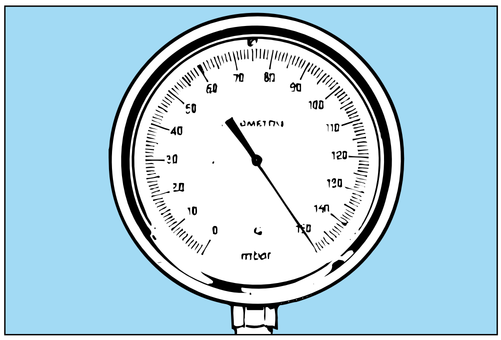
Vacuum gauges

Vacuum gauges are used in refrigeration to measure the pressure in the pipework during and after an evacuation process.

Vacuum gauges always show absolute pres-sure (zero point corresponding to absolute vacuum).

Vacuum gauges should not normally be exposed to marked overpressure and should therefore be installed together with a safety valve set for the maximum permissible pressure of the vacuum gauge.



Ae0_0010

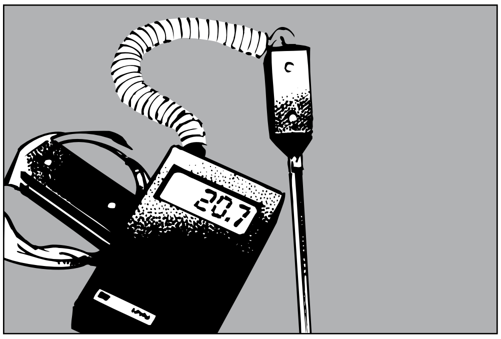
Trouble shooting

Thermometer

Electronic thermometers with digital read-out are in widespread use for servicing. Examples of sensor versions are surface sensors, room sensors and insertion sensors.

Thermometer uncertainty should not be greater than 0.1 K and the resolution should be 0.1°C.

A pointer thermometer with vapour charged bulb and capillary tube is often recommended for setting thermostatic expansion valves.
As a rule it is easier to follow temperature variations with this type of thermometer.



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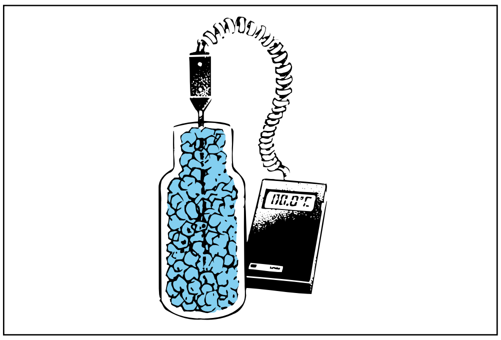
Thermometers can be relatively easily checked at 0°C in that the bulb can be inserted 150 to 200 mm down into a thermos bottle containing a mixture of crushed ice (from distilled water) and distilled water. The crushed ice must fill the whole bottle.

If the bulb will withstand boiling water, it can be held in the surface of boilover water from a container with lid. These are two reasonable checks for 0°C and 100°C.

A proper check can be performed by a recognised test institute.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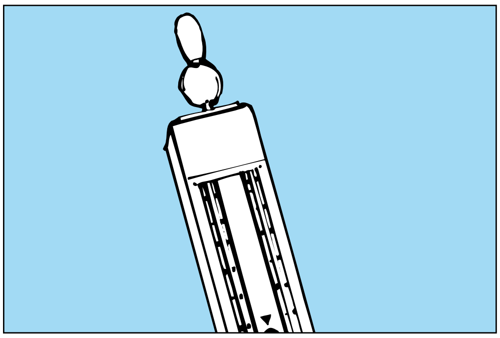
Hygrometer

There are different types of hygrometers for measuring the humidity in cold rooms and air conditioned rooms or ducts:

- Hair hygrometer
- Psychrometer
- Diverse electronic hygrometers

A hair hygrometer needs adjustment each time it is used if reasonable accuracy is to be maintained. A psychrometer (wet and dry thermometer) does not require adjustment if its thermometers are of high quality.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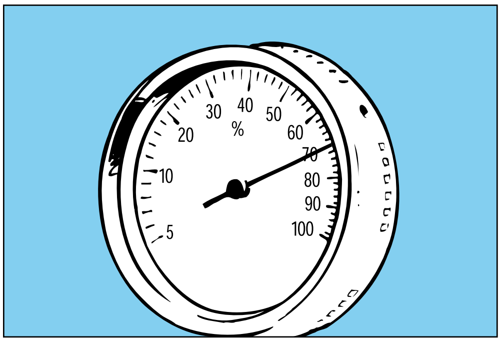
At low temperature and high humidity, the temperature differential between wet and dry thermometers will be small.

Therefore, with psychrometers the uncertainty is high under such conditions and an adjusted hair hygrometer or one of the electronic hygrometers will be more suitable.



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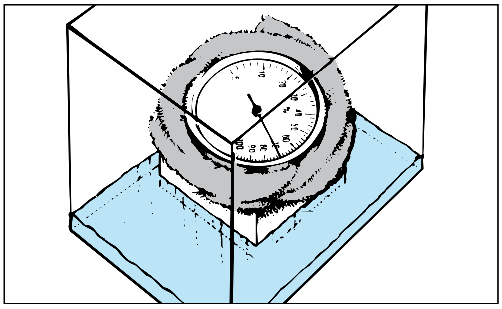
Hygrometer (continued)

A hair hygrometer can be adjusted by winding a clean, damp cloth around it and then placing it in an airtight container with water at the bottom (no water must be allowed to enter the hygrometer or come into contact with its bulb).

The container with hygrometer is then allowed to stand for at least two hours in the same temperature as that at which measurements are to be taken.

The hygrometer must now show 100%. If it does not, the setting screw can be adjusted.



Ae0_0049

Trouble shooting

Contents

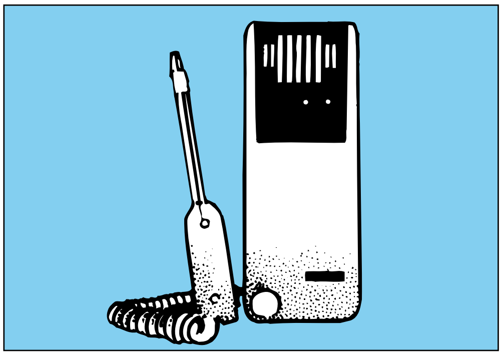
Notes

Faults on refrigeration systems, general

This booklet deals with common faults in small, relatively simple refrigeration systems.

The faults, fault causes, remedies and effects on system operation mentioned also apply to more complicated and large systems.

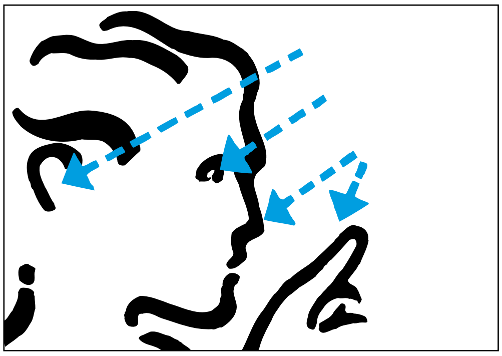
However, other faults can occur in such systems. These and faults in electronic regulators are not dealt with here.



Ae0_0001

Fault location without the use of instruments

After gaining a little experience, many common faults in a refrigeration system can be localised visually, by hearing, by feel, and sometimes by smell. Other faults can only be detected by instruments.

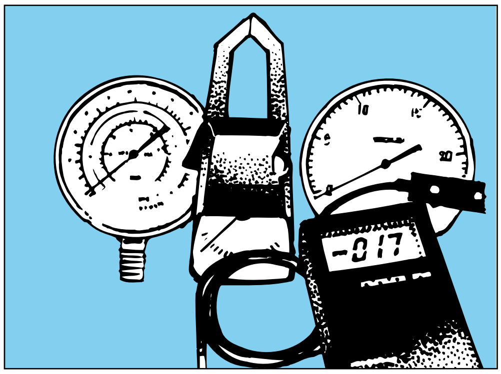


Ae0_0012

Categorisation

This booklet is divided into two sections. The first section deals exclusively with faults that can be observed directly with the senses. Here, symptoms, possible causes and the effect on operation are given.

The second section deals with faults that can be observed directly with the senses, and those that can only be detected by instruments. Here, symptoms and possible causes are given, together with instructions on remedial action.

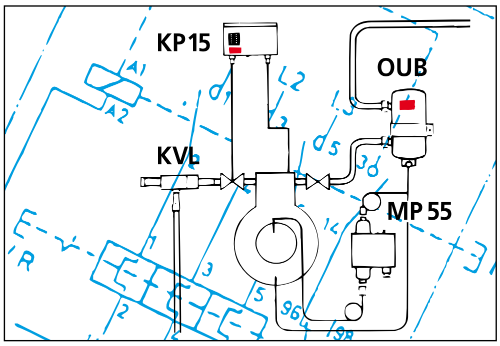


Ae0_0028

Knowledge of the system is required

An important element in the fault location procedure is familiarity with how the system is built up, its function and control, both mechanical and electrical.

Unfamiliarity with the system ought to be remedied by carefully looking at piping layouts and other key diagrams and by getting to know the form of the system (piping, component placing, and any connected systems, e.g. cooling towers and brine systems).



Ae0_0029

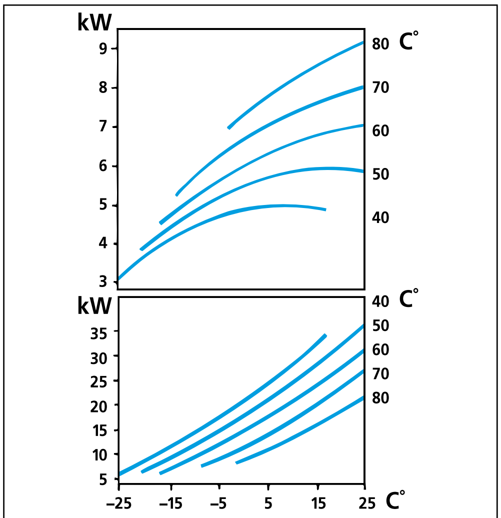
Theoretical knowledge is necessary

A certain amount of theoretical knowledge is required if faults and incorrect operation are to be discovered and corrected.

The location of all forms of faults on even relatively simple refrigeration systems is conditional on a thorough knowledge of such factors as:

- The build-up of all components, their mode of operation and characteristics.
- Necessary measuring equipment and measuring techniques.
- All refrigeration processes in the system.
- The influence of the surroundings on system operation.
- The function and setting of controls and safety equipment.
- Legislation on the safety of refrigeration systems and their inspection.

Before examining faults in refrigeration systems, it could be advantageous to look briefly at the most important instruments used in fault location.



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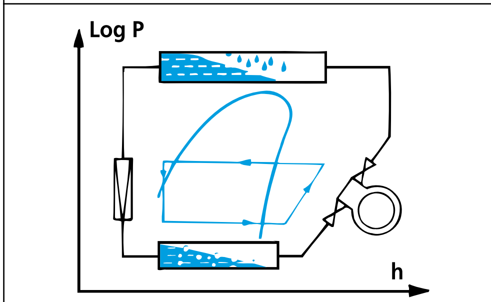
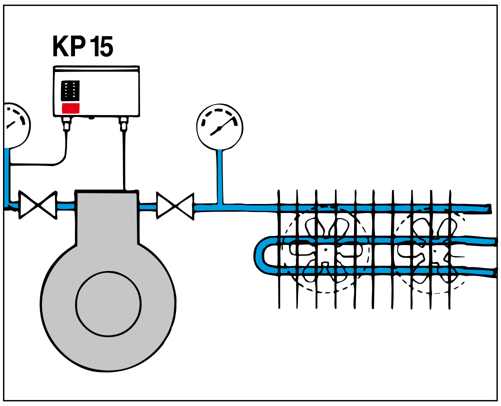


Ae0_0034

In the following description of faults in refrigeration systems, sections 1 and 2 take as their starting points the piping diagrams, fig. 1, 2 and 3.

The systems are dealt with in the direction followed by the circuit. Fault symptoms that can occur are described in circuit order. The description starts after the compressor discharge side and proceeds in the direction of the arrows.



Ae0_0016

Visible faults and the effect on the system operation

Text in [ ] indicates fault cause

Visible faults	Effect on system operation
Air-cooled condenser a) Dirt, e.g. grease or dust, sawdust, dried leaves. [Lack of maintenance] b) Fan stopped. [Motor defect] [Motor protector cut-out] c) Fan rotates in wrong direction. [Installation error] d) Fan blades damaged. e) Fins deformed [Rough treatment]	Faults under a), b), c), d), e) create: - Increased condensing pressure. - Reduced refrigeration output. - Increased energy consumption. For an air-cooled condenser, the difference between air inlet and condensing temperatures should lie between 10 K and 20 K, preferably at the lower end.
Water-cooled condenser with sight glass: See "Receiver".	For a water-cooled condenser, the difference between condensing and water inlet temperatures should lie between 10 K and 20 K, preferably at the lower end.
Receiver with sight glass Liquid level too low. [Insufficient refrigerant in system] [Overcharged evaporator] [Overcharged condenser during cold period] Liquid level too high. [Overcharged system]	Vapour/vapour bubbles in liquid line. Low suction pressure or compressor cycling. Low suction pressure or compressor cycling. Excessive condensing pressure possible.
Receiver stop valve a) Valve closed. b) Valve partly closed.	System stopped via low-pressure control. Vapour bubbles in liquid line. Low suction pressure or compressor cycling.
Liquid line a) Too small [Sizing error] b) Too long [Sizing error] c) Sharp bends and/or deformed [Installation error]	Faults under a), b) and c) cause: Large pressure drop in liquid line. Vapour in liquid line.
Filter drier Dew or frost formation on surface. [Filter partly blocked with dirt on inlet side]	Vapour in liquid line.
Sight glass a) Yellow [Moisture in system] b) Brown [Dirt particles in system] c) Pure vapour in sight glass. [Insufficient liquid in system] [Valve in liquid line closed] [Complete blockage, e.g. of filter drier] d) Liquid and vapour bubbles in sight glass. [Insufficient liquid in system] [Valve in liquid line partly closed] [Partial blockage, e.g. of filter drier] [No subcooling]	**Risk of:** Acid formation, corrosion, motor burn-out, water freezing in thermostatic expansion valve. Risk of wear in moving parts and blockage in valves and filters. Standstill via low-pressure control or compressor cycling. Standstill via low-pressure control. Standstill via low-pressure control. All faults under d): Compressor cycling or running at low suction pressure.

Visible faults and the effect on the system operation *(cont.)*

Text in [ ] indicates fault cause

Visible faults	Effect on system operation
Thermostatic expansion valve	
a) Thermostatic expansion valve heavily frosted, frost on evaporator only near valve. [Dirt strainer partly blocked] [Bulb charge partly lost] [Previously described faults causing vapour bubbles in liquid line]	Faults under a) cause operation at low suction pressure or compressor cycling via low-pressure control.
b) Thermostatic expansion valve without external pressure equalisation, evaporator with liquid distributor. [Sizing or installation error] c) Thermostatic expansion valve with external pressure equalisation, equalising tube not mounted. [Installation error]	Faults under b), c) cause operation at low suction pressure or compressor cycling via low-pressure control. or compressor cycling via low-pressure control.
d) Bulb not firmly secured. [Installation error] e) Entire bulb length not in contact with tube. [Installation error] f) Bulb placed in air current. [Installation error]	Faults under d), e), f) lead to overcharged evaporator with risk of liquid flow to compressor and compressor damage.
Air cooler	
a) Evaporator frosted only on inlet side, thermostatic expansion valve heavily frosted. [Thermal valve fault] [All previously described faults that cause vapour in liquid line]	Faults under a) cause: High superheat at evaporator outlet and operation at mostly low suction pressure.
b) Front blocked with frost. [Lacking, incorrect or wrongly set up defrost procedure] c) Fan does not run. [Motor defect or motor protector cut-out] d) Fan blades defective. e) Fins deformed. [Rough treatment]	Faults under a), b), c), d), e) cause: - Operation with mostly low suction pressure. - Reduced refrigeration output. - Increased energy consumption. For thermostatic expansion valve controlled evaporators: The difference between air inlet and evaporating temperatures should lie between 6 K and 15 K, preferably at the lower end. For level-controlled evaporators: The difference between air inlet and evaporating temperatures should lie between 2 K and 8 K, preferably at the lower end.
Liquid cooler	
a) Thermostatic expansion valve bulb not firmly secured. [Installation error]	Causes overcharged evaporator with risk of liquid flow to compressor and compressor damage.
b) Thermostatic expansion valve without external pressure equalising on liquid cooler with high pressure drop, e.g. coaxial evaporator. [Sizing or installation error] c) Thermostatic expansion valve with external pressure equalisation, equalising tube not mounted. [Installation error]	Faults b), c) cause: - Operation with mostly low suction pressure. - Reduced refrigeration output. - Increased energy consumption. For thermostatic expansion valve controlled evaporators: The difference between air inlet and evaporating temperatures should lie between 6 K and 15 K, preferably at the lower end. For level-controlled evaporators: The difference between air inlet and evaporating temperatures should lie between 2 K and 8 K, preferably at the lower end.

Visible faults and the effect on the system operation *(cont.)*

Text in [ ] indicates fault cause

Visible faults	Effect on system operation
Suction line	
a) Abnormally severe frosting. [Thermal valve superheat too low]	Risk of liquid flow to compressor and compressor damage.
b) Sharp bends and/or deformation. [Installation error]	Low suction pressure or compressor cycling.
Regulators in suction line	
Dew/frost after regulator, no dew/frost ahead of regulator. [Thermal valve superheat too low]	Risk of liquid flow to compressor and compressor damage.
Compressor	
a) Dew or frost on compressor inlet side. [Superheat at evaporator outlet too low]	Liquid flow to compressor with risk of compressor damage.
b) Oil level too low in crankcase.	
[Insufficient oil in system]	System stop via oil differential pressure control (if fitted).
[Oil collection in evaporator]	Causes wear of moving parts.
c) Oil level too high in crankcase.	
[Oil overfilling] [Refrigerant mixed with oil in too cold a compressor] [Refrigerant mixed with oil because superheat too low at evaporator outlet]	Liquid hammer in cylinders, risk of compressor damage: - Damage to working valves. - Damage to other moving parts. - Mechanical overload.
d) Oil boils in crankcase during start. [Refrigerant mixed with oil in too cold a compressor]	Liquid hammer, damage as under c)
e) Oil boils in crankcase during operation. [Refrigerant mixed with oil because superheat too low at evaporator outlet]	Liquid hammer, damage as under c)
Cold Room	
a) Dry surface on meat, limp vegetables. [Air humidity too low - evaporator probably too small]	Leads to poor food quality and/or wastage.
b) Door not tight, or defective.	Can give rise to personal injury.
c) Defective or missing alarm sign.	Can give rise to personal injury.
d) Defective or missing exit sign.	Can give rise to personal injury.
For b), c), d): [Lack of maintenance or sizing error]	
e) No alarm system. [Sizing error]	Can give rise to personal injury.
General	
a) Oil drops under joints and/or oil spots on floor. [Possible leakage at joints]	Oil and refrigerant leakage.
b) Blown fuses. [Overload on system or short-circuiting]	System stopped.
c) Motor protector cut-out. [Overload on system or short circuiting]	System stopped.
d) Cut-out pressure controls or thermostats, etc.	
[Setting error]	System stopped.
[Equipment defect]	System stopped.

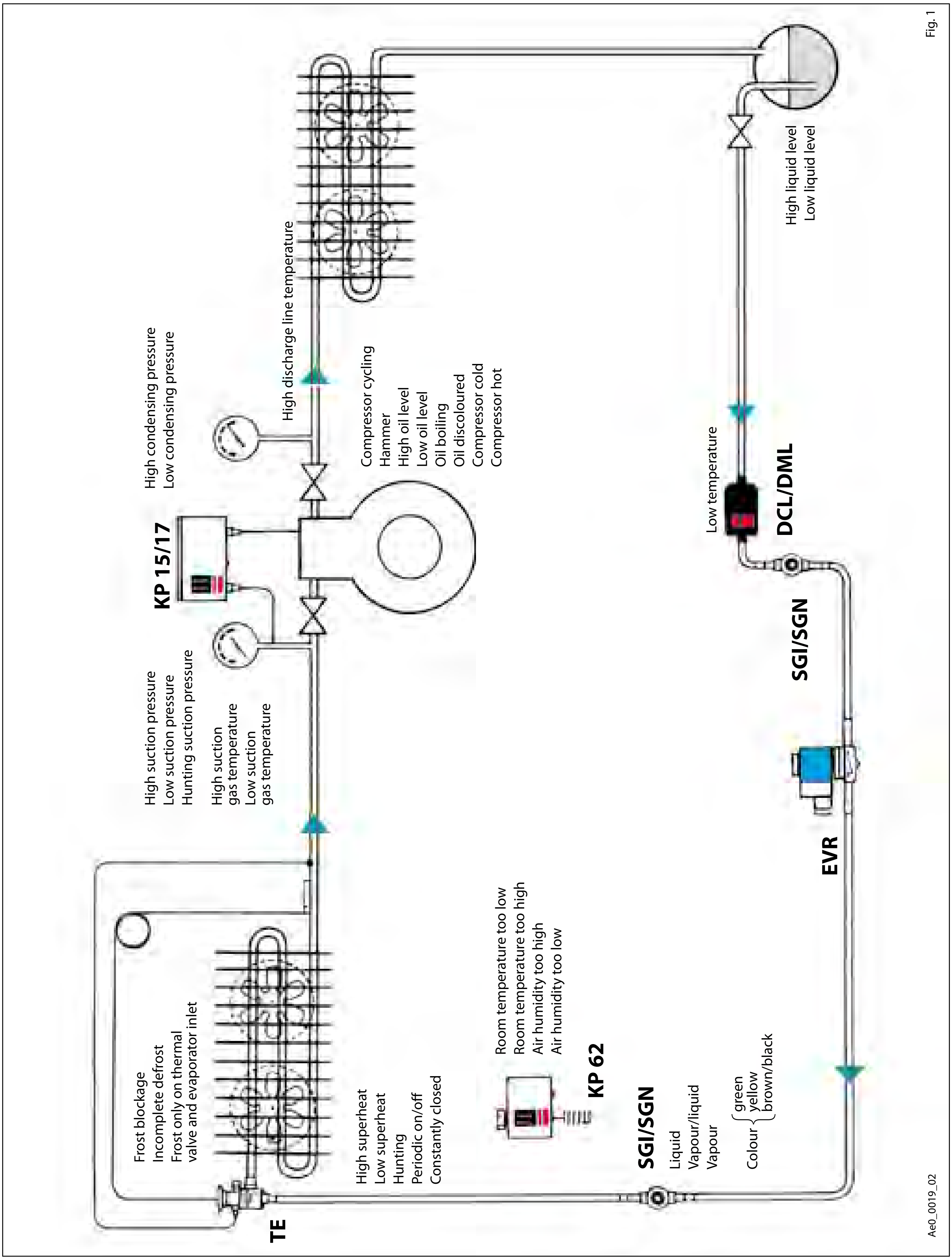
Trouble shooting

Faults that can be felt, heard or smelled and the effect on the system operation

Text in [ ] indicates fault cause

Faults that can be felt	Effect on system operation
Solenoid valve	
Colder than the tubing ahead of the solenoid valve.	
[Solenoid valve sticks, partly open]	Vapour in liquid line.
Same temperature as tubing ahead of solenoid valve.	
[Solenoid valve closed]	System stopped via low-pressure control.
Filter drier	
Filter colder than tubing ahead of filter.	
[Filter partly blocked with dirt on inlet side]	Vapour in liquid line.
Faults that can be heard	**Effect on system operation**
Regulators in suction line	
Whining sound from evaporating pressure regulator or another regulator.	
[Regulator too large (sizing error)]	Unstable operation.
Compressor	
a) Knocking sound on starting.	
[Oil boiling]	Liquid hammer.
b) Knocking sound during operation.	Risk of compressor damage.
[Oil boiling]	Liquid hammer.
[Wear on moving parts]	Risk of compressor damage.
Cold room	
Defective alarm system.	
[Lack of maintenance]	Can give rise to personal injury.
Faults that can be smelled	**Effect on system operation**
Cold room	
Bad smell in meat cold room.	
[Air humidity too high because evaporator too large or load too low]	Leads to poor food quality and/or wastage.

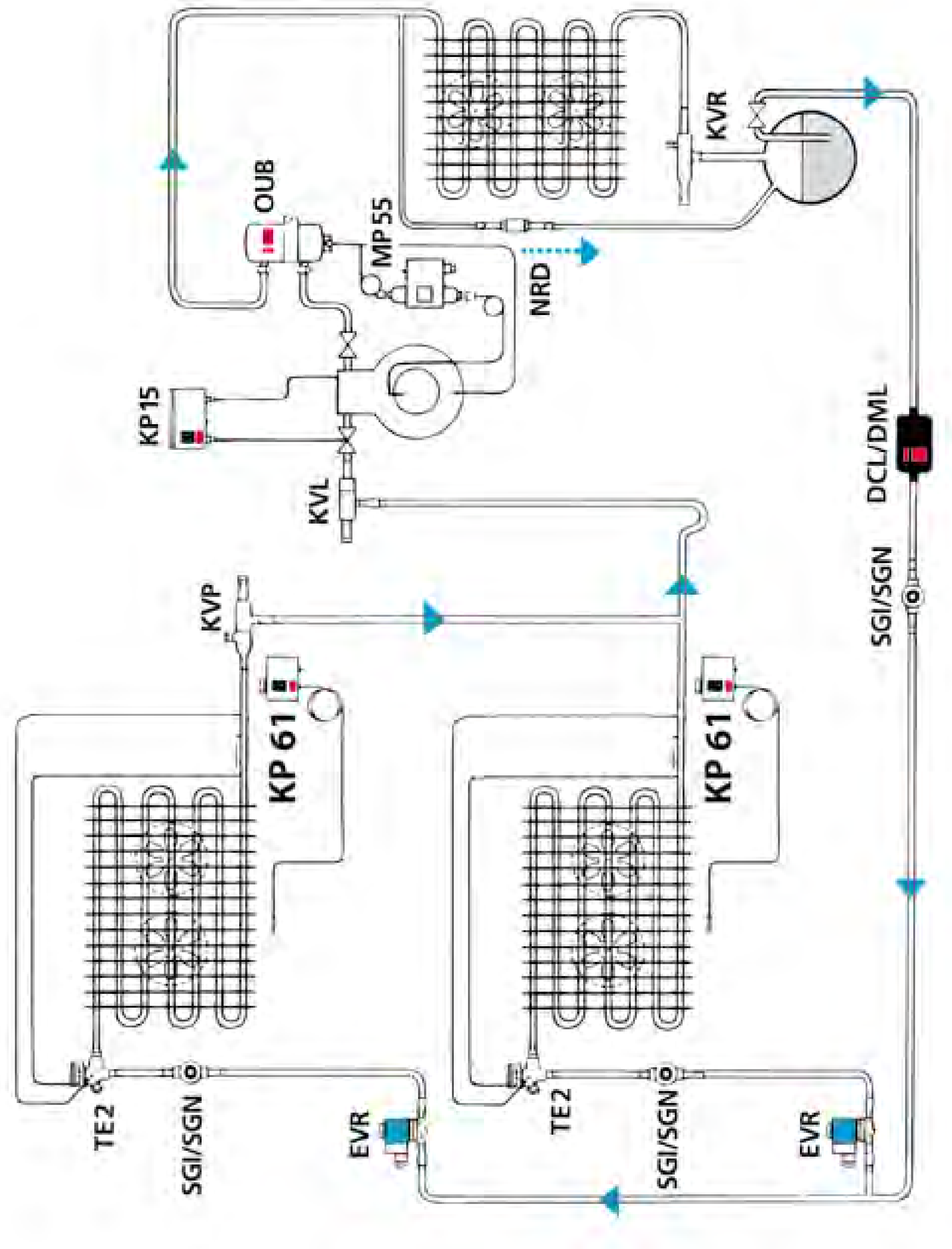
Refrigeration system with air cooler and air-cooled condenser



Trouble shooting

Refrigeration system with two air coolers and air-cooled condenser

Fig. 2



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Refrigeration system with liquid cooler and water-cooled condenser

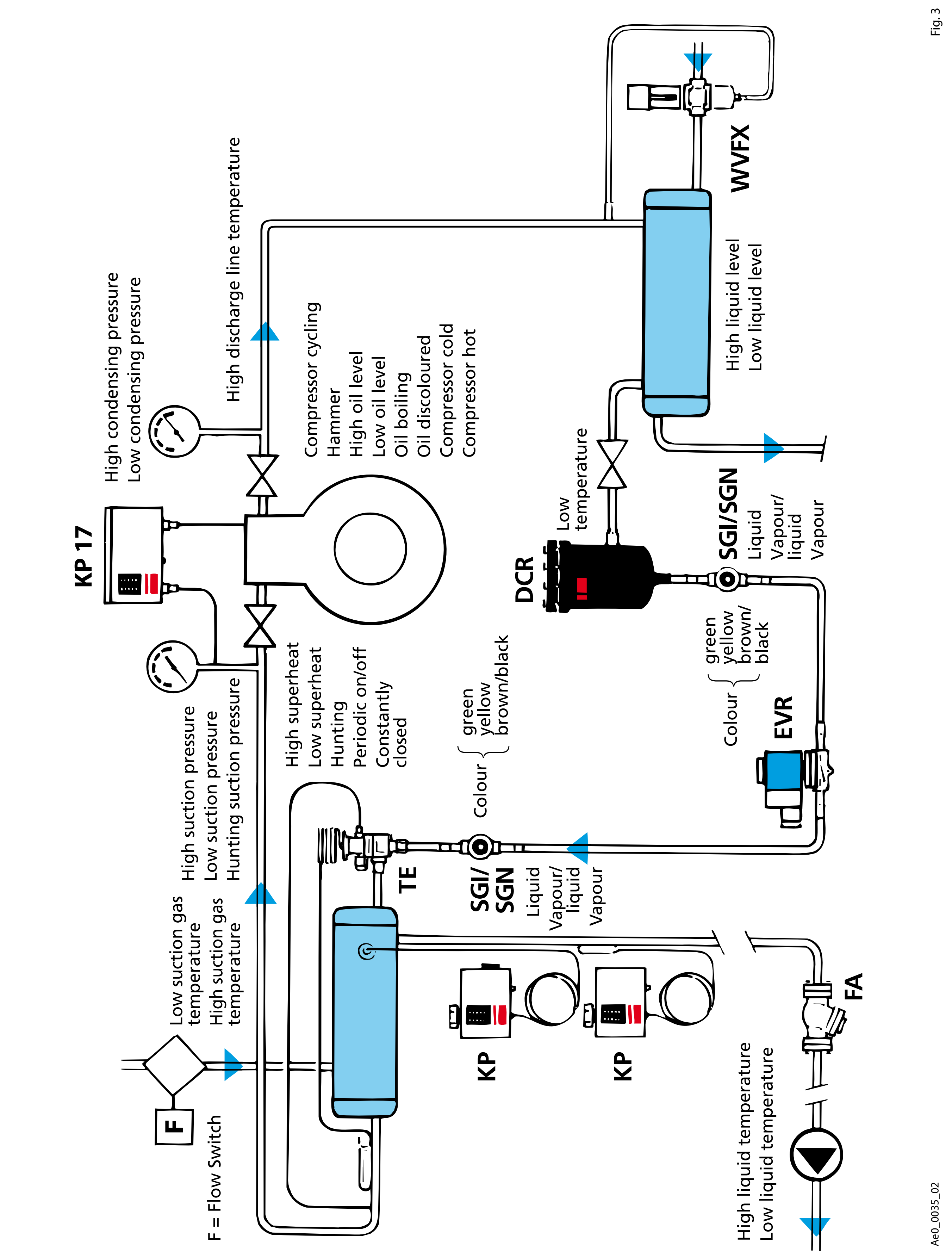


Fig. 3

Guide to fault location

Follow the arrows in the diagrams, figs. 1 and 3, p. 10/12. Begin after the compressor

Page

System fault location

Symptom	Possible cause	Action
Condensing pressure too high Air- and water-cooled condensers.	a) Air or other non-condensable gases in refrigerant system.	Purge the condenser by using reclaim system, start and run system until it reaches running temperature. Purge again if necessary.
	b) Condenser surface too small.	Replace condenser with larger size.
	c) Refrigerant system charge too large (liquid collection in condenser).	Recover refrigerant until condensing pressure is normal. The sight glass must remain full.
	d) Condensing pressure regulation set for too high a pressure.	Set for the correct pressure.
Condensing pressure too high Air-cooled condensers.	a) Dirt on condenser surface.	Clean condenser.
	b) Fan motor or blade defective or too small.	Replace motor or fan blade or both.
	c) Air flow to condenser restricted.	Remove air inlet obstruction or move condenser.
	d) Ambient temperature too high.	Create fresh air inlet or move condenser.
	e) Incorrect air flow direction through condenser.	Change rotation of fan motor. On condensing units, air must flow through condenser and then to compressor.
	f) Short-circuit between condenser fan airside pressure and suction sides.	Install a suitable duct, possibly to outdoor air.
Condensing pressure too high Water-cooled condensers.	a) Cooling water temperature too high.	Ensure lower water temperature.
	b) Water quantity too small.	Increase water quantity, possibly using automatic water valve.
	c) Deposits on inside of water pipes (scale etc).	Clean out condenser water tubes, possibly by deacidification.
	d) Cooling water pump defective or stopped.	Investigate cause, replace or repair cooling water pump if fitted.
Condensing pressure too low Air- and water-cooled condensers.	a) Condenser surface too large.	Establish condensing pressure regulation or replace condenser.
	b) Low load on evaporator.	Establish condensing pressure regulation.
	c) Suction pressure too low, e.g. insufficient liquid in evaporator.	Locate fault on line between condenser and thermostatic expansion valve (see "Suction pressure too low").
	d) Compressor suction and discharge valves might be leaking.	Replace compressor valve plate.
	e) Condensing pressure regulator set for too low a pressure.	Set condensing pressure regulator for correct pressure.
	f) Un-insulated receiver placed too cold in relation to condenser (receiver acts as condenser).	Move receiver or fit it with suitable insulating cover.
Condensing pressure too low Air-cooled condensers.	a) Temperature of cooled air too low.	Establish condensing pressure regulation.
	b) Air quantity for condenser too large.	Replace fan with smaller unit or establish motor speed regulation.
Condensing pressure too low Water-cooled condensers.	a) Water quantity too large.	Install WVFX automatic water valve or set existing valve.
	b) Water temperature too low.	Reduce water quantity by using a WVFX automatic water valve, for example.
Condensing pressure hunts	a) Differential on start/stop pressure control for condenser fan too large. Can cause vapour formation in liquid line for some time after start of condenser fan because of refrigerant collection in condenser.	Set differential on lower value or use valve regulation (KVD + KVR) or use fan motor speed regulation.
	b) Thermostatic expansion valve hunting.	Set thermostatic expansion valve for higher superheat or replace orifice with smaller size.
	c) Fault in KVR/KVD condensing pressure regulating valves (orifice too large).	Replace valves with smaller size.
	d) Consequence of hunting suction pressure.	See "Suction pressure hunts".
	e) Wrong sized or located check valve in condenser line.	Check sizing. Mount check valve below condensor and close to receiver inlet.

System fault location *(cont.)*

Symptom	Possible cause	Action
Discharge line temperature too high	a) Suction pressure too low because of: 1) Insufficient liquid in evaporator. 2) Low evaporator load. 3) Leaking suction or discharge valves. 4) Superheat too high in internal heat exchanger or suction accumulator in suction line. b) Condensing pressure too high.	 Locate fault on line from receiver to suction line (see "Suction pressure too low"). Ditto. Replace compressor valve plate. Omit heat exchange or possibly select smaller heat exchanger. See "Condensing pressure too high".
Discharge line temperature too low	a) Liquid flow to compressor (thermal valve superheat setting too low or bulb location incorrect). b) Condensing pressure too low.	See pages 175 and 176. See "Condensing pressure too low".
Liquid level in receiver too low	a) Insufficient refrigerant in system. b) Evaporator overcharged. 1) Low load, leading to refrigerant collection in evaporator. 2) Thermostatic expansion valve fault (e.g. superheat setting too low, bulb location wrong). c) Refrigerant collection in condenser because condensing pressure is too low.	Investigate cause (leakage, overcharge in evaporator), repair fault and charge system if necessary. See pages 175 and 176. See pages 175 and 176. Air-cooled condensers: Establish condensing pressure regulation by fan motor speed regulation, e.g. type RGE.
Liquid level in receiver too high Refrigeration output normal.	Refrigerant charge in system too large.	Recover a suitable quantity of refrigerant, but condensing pressure must remain normal and the sight glass free of vapour.
Liquid level in receiver too high Refrigeration output too low (possible compressor cycling).	a) Partial blockage of a component in liquid line. b) Thermostatic expansion valve fault (e.g. superheat too high, orifice too small, lost charge, partial blockage).	Find the component and clean or replace it. See pages 175 and 176.
Filter drier cold, dew or frosting possible.	a) Partial blocking of dirt strainer in filter drier. b) Filter drier completely or partly saturated with water or acid.	Check whether there are impurities in the system, clean out where necessary, replace filter drier. Check whether there is moisture or acid in the system, clean out where necessary and replace filter drier (burn-out filter) several times if necessary. If acid contamination is severe, replace refrigerant and oil charge, install DCR filter drier with interchangeable core in suction line.
Moisture indicator discoloured Yellow. Brown or black.	Moisture in system. Impurities, i.e. small particles in system.	Check system for leakage. Repair if necessary. Check system for acid. Replace filter drier, several times if necessary. In severe cases it can be necessary to change refrigerant and oil. Clean out system if necessary. Replace SGI/SGN sight glass and filter drier.

System fault location *(cont.)*

Symptom	Possible cause	Action
Vapour bubbles in sight glass ahead of thermostatic expansion valve	a) Insufficient liquid subcooling from large pressure drop in liquid line because: 1) Liquid line too long in relation to diameter.	 Replace liquid line with tube of suitable diameter.
	2) Liquid line diameter too small.	Replace liquid line with tube of suitable diameter.
	3) Sharp bends, etc. in liquid line.	Replace sharp bends and components causing too large a pressure drop.
	4) Partial blockage of filter drier.	Check for impurities, clean out if necessary, replace filter drier.
	5) Solenoid valve defect.	See the chapter "Solenoid valves".
	b) Insufficient liquid subcooling because of heat penetration of liquid line, possibly from high temperature around liquid line.	Reduce ambient temperature or install heat exchanger between liquid and suction lines or insulate liquid line, possibly together with suction line.
	c) Water-cooled condensers: Insufficient subcooling because of wrong cooling water flow direction.	Swap over cooling water inlet and outlet. (Water and refrigerant flow must be opposite).
	d) Condensing pressure too low.	See "Condensing pressure too low".
	e) Receiver stop valve too small or not fully open.	Replace valve or open it fully.
	f) Hydrostatic pressure drop in liquid line too high (height difference between thermostatic expansion valve and receiver too large).	Install heat exchanger between liquid and suction lines ahead of rise in liquid line.
	g) Badly or incorrectly set condensing pressure regulation causing liquid collection in condenser.	Replace or reset KVR regulator at correct value.
	h) Condenser pressure regulation by start/stop of condenser fan can cause vapour in liquid line for some time after fan start.	If necessary, replace regulation with condensing pressure regulation via valves (KVD + KVR) or with fan motor speed regulation, type VLT.
	i) Insufficient liquid in system.	Recharge system, but first make sure that none of the faults named under a), b), c), d), e), f), g), h) are present, otherwise there is a risk of the system becoming overcharged.
Air coolers Evaporator blocked by frost.	a) Lack of or poor defrost procedure.	Install defrost system or adjust defrost procedure.
	b) Air humidity in cold room too high because of moisture load from: 1) Unpackaged items.	 Recommend packaging of items or adjust defrost procedure.
	2) Air ingress into room through fissures or open door.	Repair fissures. Recommend that door be kept closed.
Air coolers Evaporator frosted only on line near thermostatic expansion valve, severe frost on thermostatic expansion valve.	Refrigerant supply to evaporator too small because of: a) Thermostatic expansion valve defect, e.g. 1) Orifice too small. 2) Superheat too high. 3) Partial loss of bulb charge. 4) Dirt strainer partly blocked. 5) Orifice partly blocked by ice.	 See pages 175 and 176.
	b) Fault as described under "Vapour bubbles in sight glass".	See "Vapour bubbles in sight glass".
Air coolers Evaporator damaged.	Fins deformed.	Straighten fins using a fin comb.

System fault location *(cont.)*

Symptom	Possible cause	Action
Air humidity in cold room too high, room temperature normal	a) Evaporator surface too large. Causes operation at excessive evaporating temperature during short running periods.	Replace evaporator with smaller size.
	Load on room too low, e.g. during winter (insufficient dehumidification because of short total running time per 24 hours).	Establish humidity regulation with hygrometer, heating elements and KP62 safety thermostat.
Air humidity in room too low	a) Cold room poorly insulated.	Recommend improved insulation.
	b) High internal energy consumption, e.g. lights and fans.	Recommend less internal energy consumption.
	c) Evaporator surface too small, causes long running times at mainly low evaporating temperatures.	Replace evaporator with larger size.
Air temperature in cold room too high	a) Room thermostat defect.	See the chapter "Thermostats:".
	b) Compressor capacity too small.	See "Compressor".
	c) Load on room too high because of:	
	1) Loading of non-cooled items.	Recommend placing of smaller load or increased system capacity.
	2) High energy consumption, e.g. for lights and fans.	Recommend reduction of energy consumption or increased system consumption.
	3) Cold room poorly insulated.	Recommend better insulation.
	4) High air ingress.	Recommend repair of fissures and least possible door opening.
	d) Evaporator too small.	Replace evaporator with larger size.
	e) Insufficient or no refrigerant supply to evaporator.	See "Vapour bubbles in sight glass ahead of thermal valve" and pages 175 and 176.
	f) Evaporating pressure regulator set for too high an evaporating pressure.	Set evaporating pressure regulator at correct value. Use a pressure gauge.
	g) Cut-out pressure on low-pressure control set too high.	Set low-pressure control at correct cut-out pressure. Use a pressure gauge.
	h) Capacity regulating valve opens at too high an evaporating pressure.	Set capacity regulating valve at lower opening pressure.
	i) Opening pressure of crankcase pressure regulator set too low.	Set valve for higher opening pressure if the compressor will withstand it.
Air temperature in cold room too low	a) Room thermostat defect: 1) Cut-out temperature set too low. 2) Bulb location wrong.	See page 180.
	b) Ambient temperature very low.	If absolutely necessary, establish thermostat controlled electrical heating.
Suction pressure too high	a) Compressor too small.	Replace compressor with larger size.
	b) One or more compressor disc valves leaking.	Replace valve plate.
	c) Capacity regulation defective or incorrectly set.	Replace, repair or adjust capacity regulation.
	d) System load too high.	Recommend less load or replace compressor with larger size, or install KVL crankcase pressure regulator.
	e) Hot gas defrost valve leaking.	Replace valve.
Suction pressure too high and suction gas temperature too low	a) Thermostatic expansion valve superheat setting too low or bulb located incorrectly.	See pages 175 and 176.
	b) Thermostatic expansion valve orifice too large.	Replace orifice with smaller size.
	c) Leaking liquid line in heat exchanger between liquid and suction lines.	Replace HE heat exchanger.
Suction pressure too low, constant running	Low-pressure control set incorrectly, or defective.	Adjust or replace low-pressure control KP 1 or combined pressure control KP 15.

System fault location *(cont.)*

Symptom	Possible cause	Action
Suction pressure too low, normal operation or compressor cycling	a) Low system load.	Establish capacity regulation or increase lowpressure control differential.
	b) Insufficient refrigerant in evaporator, because of:	
	1) Insufficient refrigerant in receiver.	See "Liquid level in receiver too low".
	2) Liquid line too long.	See "Vapour bubbles in sight glass."
	3) Liquid line too small.	Ditto.
	4) Sharp bends, etc. in liquid line.	Ditto.
	5) Filter drier partly blocked.	See "Vapour bubbles in sight glass".
	6) Solenoid valve sticks.	Ditto.
	7) Inadequate liquid subcooling.	Ditto.
	8) Fault at thermal valve.	See pages 175 and 176.
	c) Evaporator too small.	Replace with larger evaporator.
	d) Evaporator fan defective.	Replace or repair fan.
	e) Pressure drop in evaporator and/or suction line too large.	If necessary, replace evaporator and/or suction line.
	f) Lack of or inadequate defrosting of air cooler.	Establish a defrost system or adjust defrost procedure.
	g) Freezing in brine cooler.	Increase brine concentration and check frost protection equipment.
	h) Insufficient air or brine through cooler.	Check cause and correct fault. See "Air coolers" and "Liquid coolers".
	i) Oil collection in evaporator.	See "Oil level in crankcase ton low"
Suction pressure hunts Thermostatic expansion valve operation.	a) Thermostatic expansion valve superheat too low.	See pages 175 and 176.
	b) Thermostatic expansion valve orifice too large.	
	c) Capacity regulation fault	
	1) Capacity regulating valve too large.	Replace KVC capacity regulating valve with smaller size.
	2) Pressure control(s) for stage regulation incorrectly set.	Set for greater difference between cut-in and cut-out pressures.
Suction pressure hunts Electronic expansion valve operation.	Hunting normal	None
Suction gas temperature too high	Refrigerant supply to evaporator too small because:	
	a) System refrigerant charge too small.	Charge refrigerant to correct level.
	b) Defect in liquid line or components in that line	See these entries: "Liquid level in receiver", "Filter drier cold", "Vapour bubbles in sight glass", "Suction pressure too low".
	c) Thermostatic expansion valve super- heat setting too high, or bulb charge partly lost.	See pages 175 and 176.
Suction gas temperature too low	Refrigerant supply to evaporator too large because:	
	a) Thermostatic expansion valve superheat set too low.	See pages 175 and 176.
	b) Thermostatic expansion valve bulb located incorrectly (too warm or in poor contact with piping).	See pages 175 and 176.
Compressor Compressor cycling (cut-out via low-pressure control).	a) Compressor capacity too high in relation to load at any given time.	Establish capacity regulation using KVC capacity regulating valve or parallel-coupled compressors.
	b) Compressor too large.	Replace compressors with smaller size.
	c) Opening pressure of evaporating pressure regulator set too high.	Using a pressure gauge, set KVP regulator at correct value.

System fault location *(cont.)*

Symptom	Possible cause	Action
Compressor Compressor cycling (cut-out via high-pressure control).	a) Condensing pressure too high. b) High-pressure control defect. c) High-pressure control cut-out set too low.	See "Condensing pressure too high". Replace high-pressure control KP 5 / 7 or combined pressure control KP 15 / 17. Using a pressure gauge, set pressure control at correct value. Avoid compressor cycling by using high-pressure control with manual reset.
Discharge pipe temperature too high	Discharge pipe temperature too high.	Replace valve plate. See also "Discharge temperature too high".
Compressor Compressor too cold.	Flow of liquid refrigerant from evaporator to suction line and possibly to compressor because of incorrectly set thermostatic expansion valve.	Set thermostatic expansion valve for lower superheat using MSS method, see the chapter (Thermostatic expantion valves" or pages 175 and 176.".
Compressor Compressor too hot.	a) Compressor and possibly motor overloaded because evaporator load and thereby suction pressure too high. b) Poor motor and cylinder cooling because of: 1) Insufficient liquid in evaporator. 2) Low evaporator load. 3) Suction and discharge valves not tight. 4) Superheat too severe in heat exchanger, or in suction accumulator in suction line. c) Condensing pressure too high.	Reduce evaporator load or replace compressor with larger size. Locate fault on line between condenser and thermostatic expansion valve (see "Suction pressure too low"). Ditto Replace valve plate. Omit heat exchange or possibly select smaller HE heat exchanger. See "Condensing pressure too high".
Knocking sound: a) Constant. b) During start.	a) Liquid hammer in cylinder because of liquid flow to compressor. b) Oil boiling because of liquid build up in crankcase. c) Wear on moving compressor parts, especially bearings.	Set thermostatic expansion valve for lower superheat using MSS method. Install heating element in or under compressor crankcase. Repair or replace compressor.
Compressor Oil level in crankcase too high. On high load, otherwise not. During standstill or start	Oil quantity too large. Refrigerant absorption in crankcase oil because of too low an ambient temperature.	Drain oil to correct level, but first ensure that the large quantity is not due to refrigerant absorption in the oil. Install heating element in or under compressor crankcase.
Compressor Oil level in crankcase too low.	a) Oil quantity too small. b) Poor oil return from evaporator because: 1) Diameter of vertical suction lines too large. 2) No oil separator. 3) Insufficient fall on horizontal suction line. c) Wear on piston/piston rings and cylinder. d) On compressors in parallel: 1) With oil equalising tube: Compressors not on same horizontal plane. Equalising pipe too small. 2) With oil level regulation: Float valve partly or wholly blocked. Float valve sticking. e) Oil return from oil separator partly or wholly blocked, or float valve sticking.	Fill oil to correct level, but first be sure that the oil quantity in the crankcase is not a result of oil collection in the evaporator. Install oil lock at 1.2 m to 1.5 m from vertical suction lines. If liquid supply is at the bottom of the evaporator it can be necessary to swap inlet and outlet tubes (liquid supply uppermost) Replace worn components. In all circumstances: the compressor started last is most subject to oil starvation. Line up compressors so that they are in same horizontal plane. Install larger equalising pipe. Fit vapour equalising pipe if necessary. Clean or replace level container with float valve. Ditto. Clean or replace oil return pipe or replace float valve or whole oil separator.

System fault location *(cont.)*

Symptom	Possible cause	Action
Compressor Oil boils during start.	a) High refrigerant absorption in crankcase oil because of low ambient temperature. b) Systems with oil separator: Too much absorption of refrigerant in oil in separator during standstill.	Install heating element in or under compressor crankcase. Oil separator too cold during start. Install thermostat-controlled heating element or solenoid valve with time delay in oil return tube. Fit non return valve in discharge pipe after oil separator.
Compressor Oil boiling during operation.	a) Flow of liquid refrigerant from evaporator to compressor crankcase. b) Systems with oil separator: Float valve not closing completely.	Set thermostatic expansion valve for higher superheat using MSS method. Replace float valve or whole oil separator.
Compressor Oil discoloured.	System contamination arising from: a) Cleanliness not observed during installation. b) Oil breakdown because of moisture in system. c) Oil breakdown because of high discharge pipe temperature. d) Wear particles from moving parts. e) Inadequate cleaning after motor burn-out.	In all circumstances: Change oil and filter drier. Clean out refrigerant system if necessary. Clean out refrigerant system if necessary. Locate and remedy cause of excessive discharge pipe temperature. See "Discharge pipe temperature too high". Clean out system if necessary. Clean out refrigerant system if necessary. Replace worn parts or install new compressor. Clean out refrigerant system. Fit DA "burn-out" filter. Replace filter several times if necessary.
Compressor Will not start.	a) Insufficient or no voltage for fuse group. b) Blown group fuses. c) Fuse in control circuit blown. d) Main switch not on. e) Thermal protection in motor starter cut out or defective, e.g. as a result of: 1) Excessive suction pressure. 2) Condensing pressure too high. 3) Dirt or copper deposition in compressor bearings, etc. 4) Supply voltage too low. 5) Single phase drop out. 6) Short-circuited motor windings (motor burn-out). f) Motor winding protectors cut out because of excessive current consumption. g) Contactors in motor starter burnt out because: 1) Starting current too high. 2) Contactor undersized. h) Other safety equipment cut out, incorrectly set or defective: Oil differential control. (no oil, oil boiling). High-pressure control. Low-pressure control. Flow switch. (insufficient brine concentration, brine pump failure, blocked brine circuit filter, evaporating temperature too low). Frost protection thermostat (insufficient brine concentration, brine pump failure, blocked brine circuit filter, evaporating temperature too low).	Telephone electricity company. Locate fault. Have fault repaired and change fuses. Locate fault. Have fault repaired and change fuses. Switch on. Locate and repair fault or replace protector. See "Suction pressure too high". See "Condensing pressure too high". Clean out refrigerant system, replace compressor and filter drier. Telephone electricity company. Locate and remedy fault (often blown fuse). Clean out refrigerant system if necessary, replace compressor and filter drier. Locate and remedy cause of excessive current consumption, start system when windings have cooled down (can take a long time). Locate and remedy cause of motor overload, replace contactor. Replace contactor with larger size. In all circumstances, locate and repair fault before starting system: See "Compressor, Oil level too low" and "Compressor, Oil boiling...." See "Condensing pressure too high". See "Suction pressure too low". Locate and remedy cause of reduced or no flow in brine circuit. See "Liquid coolers". Locate and remedy cause of excessively low temperature in brine circuit. See "Liquid coolers".

System fault location *(cont.)*

Symptom	Possible cause	Action
Compressor Will not start.	i) Regulating equipment cut out, incorrectly set or defective: Low-pressure control, Room thermostat.	Locate and repair fault. Start system. See "Suction pressure too low" and page 179. See also pages 175 and 176.
	j) Motor windings burnt out.	
	1) Open compressor:	
	Compressor and motor overloaded.	Locate and remedy cause of overload, replace motor.
	Motor undersized.	Replace motor with larger size.
	2) Hermetic and semihermetic compressor:	
	Compressor and motor overloaded.	Locate and remedy cause of overload, replace compressor.
	Acid formation in refrigerant system.	Locate and remedy cause of acid formation, remove compressor, clean out refrigerant system if necessary, fit new "burn-out" filter, refill with oil and refrigerant, install new compressor.
	k) Bearing or cylinder seizing because of:	
	1) Dirt particles in refrigerant system.	Clean out system and install new filter drier and new compressor.
	2) Copper deposition on machined parts because of acid formation in refrigerant system.	Clean out system and install new filter drier and new compressor.
	3) Insufficient or no lubrication as a result of:	In all circumstances: Locate and remedy the fault, replace defective parts or install new compressor.
	Defective oil pump.	
	Oil boiling in crankcase.	See "Compressor, Oil boiling".
	Insufficient oil.	See "Compressor, Oil level in crankcase too low".
	Oil collection in evaporator.	See "Compressor, Oil level in crankcase too low".
	Poor or no oil equalisation between parallel-coupled compressors (oil starvation in compressor started last).	See "Compressor, Oil level in crankcase too low"
Compressor runs constantly, suction pressure too low.	Cut-out pressure of low-pressure control set too low, or defective control.	See "Suction pressure too low".
Compressor runs constantly, suction pressure too high.	a) Compressor suction and/or discharge valve not tight.	Replace valve plate,
	b) Compressor capacity too low in relation to load at any given time.	Recommend lower load, or replace compressor with larger size.

Fault location on the thermostatic expansion valve

Symptom	Possible cause	Remedy
Room temperature too high	Pressure drop across evaporator too high.	Replace expansion valve with valve having external pressure equalization. Reset superheat on expansion valve if necessary.
	Lack of subcooling ahead of expansion valve.	Check refrigerant subcooling ahead of expansion valve. Establish greater subcooling.
	Pressure drop across expansion valve less than the pressure drop the valve is sized for.	Check pressure drop across expansion valve. Try replacement with larger orifice assembly and/or valve. Reset superheat on expansion valve if necessary.
	Bulb located to far from evaporator outlet or after an internal heat exchanger or too close to large valves, flanges, etc.	Check bulb location. Locate bulb away from large valves, flanges, etc.
	Expansion valve blocked with ice, wax or other impurities.	Clean ice, wax or other impurities from the valve. Check sight glass for colour change (green means too much moisture). Replace filter drier if fitted. Check oil in the refrigeration system. Has the oil been changed or replenished? Has the compressor been replaced? Clean the filter.
	Expansion valve too small.	Check refrigeration system capacity and compare with expansion valve capacity. Replace with larger valve or orifice. Reset superheat on expansion valve.
	Charge lost from expansion valve.	Check expansion valve for loss of charge. Replace expansion valve. Reset superheat on expansion valve.
	Charge migration in expansion valve.	Check whether expansion valve charge is correct. Identify and remove cause of charge migration. Reset superheat on expansion valve if necessary.
Room temperature too high	Expansion valve bulb not in good contact with suction line.	Ensure that bulb is secured on suction line. Insulate bulb if necessary.
	Evaporator completely or partly iced up.	De-ice evaporator if necessary.
Refrigeration system hunts	Expansion valve superheat set at too small a value.	Reset superheat on expansion valve.
	Expansion valve capacity too high.	Replace expansion valve or orifice with smaller size. Reset superheat on expansion valve if necessary.
Refrigeration system hunts at too high a room temperature	Expansion valve bulb location inappropriate, e.g. on collection tube, riser after oil lock, near large valves, flanges or similar or after an internal heat exchanger.	Check bulb location. Locate bulb so that it receives a reliable signal. Ensure that bulb is secured on suction line. Set superheat on expansion valve if necessary.
Suction pressure too high	Liquid flow Expansion valve too large. Expansion valve setting incorrect.	Check refrigeration system capacity and compare with expansion valve capacity. Replace with larger valve or orifice. Reset superheat on expansion valve.
	Charge lost from expansion valve.	Check expansion valve for loss of charge. Replace expansion valve. Reset superheat on expansion valve.
	Charge migration in expansion valve.	Increase superheat on expansion valve. Check expansion valve capacity in relation to evaporator duty. Replace expansion valve or orifice with smaller size. Reset superheat on expansion valve if necessary.

Fault location on the thermostatic expansion valve *(cont.)*

Symptom	Possible cause	Remedy
Suction pressure too low	Pressure drop across evaporator too high.	Replace expansion valve with valve having external pressure equalization. Reset superheat on expansion valve if necessary.
	Lack of subcooling ahead of expansion valve.	Check refrigerant subcooling ahead of expansion valve. Establish greater subcooling.
	Evaporator superheat too high.	Check superheat. Reset superheat on expansion valve.
	Pressure drop across expansion valve less than pressure drop valve is sized for.	Check pressure drop across expansion valve. Replace with larger orifice assembly and/or valve if necessary.
	Bulb located too cold, e.g. in cold air flow or near large valves, flanges, etc.	Check bulb location. Insulate bulb if necessary. Locate bulb away from large valves, flanges, etc.
	Expansion valve too small.	Check refrigeration system capacity and compare with expansion valve capacity. Replace with larger valve or orifice. Reset superheat on expansion valve.
	Expansion valve blocked with ice, wax or other impurities.	Clean ice, wax and other impurities from valve. Check sight glass for colour change (yellow means too much moisture). Replace filter drier if fitted. Check oil in the refrigeration system. Has the oil been changed or replenished? Has the compressor been replaced? Clean the filter.
	Charge lost from expansion valve.	Check expansion valve for loss of charge. Replace expansion valve. Reset superheat on expansion valve.
	Charge migration in expansion valve.	Check charge in expansion valve. Reset superheat on expansion valve if necessary.
	Evaporator wholly or partly iced up.	De-ice evaporator if necessary.
Liquid hammer in compressor	Expansion valve capacity too large.	Replace expansion valve or orifice with smaller size. Reset superheat on expansion valve if necessary.
	Superheat on expansion valve set too low.	Increase superheat on expansion valve.
	Expansion valve bulb not in good contact with suction line.	Ensure that bulb is secured on suction line. Insulate bulb if necessary.
	Bulb located too warm or near large valves, flanges, etc.	Check bulb location on suction line. Move bulb to better position.

Fault location on the solenoid valve

Symptom	Possible cause	Remedy
Solenoid valve does not open	No voltage on coil	Check whether the valve is open or closed 1) use a magnetic field detector 2) lift the coil and feel whether there is resistance. **NOTE!** Never take the coil off the valve if voltage is applied - the coil can burn out. Check the wiring diagram and wiring itself. Check relay contacts. Check lead connections. Check fuses.
	Incorrect voltage/frequency.	Compare coil data with installation data. Measure operating voltage at the coil. – Permissible variation: 10% higher than rated voltage. 15% lower than rated voltage. Replace with correct coil if necessary.
	Burnt-out coil	See symptom "Burnt-out coil"
	Differential pressure too high	Check technical data and differential pressure of valve. Replace with suitable valve. Reduce differential. pressure e.g. inlet pressure.
	Differential pressure too low	Check technical data and differential pressure of valve. Replace with suitable valve. Check diaphragm and/or piston rings and replace O-rings and gaskets *) Replace O-rings and gaskets *)
	Damaged or bent armature tube	Replace defective components *) Replace O-rings and gaskets *)
	Impurities in diaphragm/piston	Replace defective components *) Replace O-rings and gaskets *)
	Impurities in valve seat. Impurities in armature/armature	Clean out impurities. Replace defective parts *) Replace O-rings and gaskets *)
	Corrosion/cavitation	Replace defective parts *) Replace O-rings and gaskets *)
	Missing components after dismantling valve	Fit missing components. Replace O-rings and gaskets *)
Solenoid valve opens partially	Differential pressure too low	Check valve technical data and differential pressure. Replace with suitable valve. Check diaphragm and/or piston rings and replace O-rings and gaskets *)
	Damaged or bent armature tube	Replace defective components *) Replace O-rings and gaskets *)
	Impurities in diaphragm/piston	Clean out impurities. Replace defective components *) Replace O-rings and gaskets *)
	Impurities in valve seat Impurities in armature/armature tube	Clean out impurities. Replace defective parts *) Replace O-rings and gaskets *)
	Corrosion/cavitation	Replace defective parts *) Replace O-rings and gaskets *)
	Missing components after dismantling of valve	Fit missing components *) Replace O-rings and gaskets *)

* See cross section in the instruction. See also the spare parts documentation on http://www.danfoss.com

Fault location on the solenoid valve *(cont.)*

Symptom	Possible cause	Remedy
Solenoid valve does not close/ closes partially	Continuous voltage on coil	Lift coil and feel whether there is any resistance. **NOTE!** Never take the coil off if voltage is applied - the coil can burn out. Check the wiring diagram and wiring itself. Check relay contacts. Check lead connections.
	Manual spindle not screwed back after use	Check spindle position.
	Pulsation in discharge line. Differential pressure too high in open position. Pressure in outlet side sometimes higher than in inlet.	Check technical data of valve. Check pressure and flow condition Replace with suitable valve. Check remainder of system.
	Damaged or bent armature tube	Replace defective components *) Replace O-rings and gaskets *)
	Defective valve plate, diaphragm or valve seat	Check pressure and flow conditions. Replace defective components *) Replace O-rings and gaskets *)
	Diaphragm or support plate wrong way round	Check for correct valve assembly *) Replace O-rings and gaskets *)
	Impurities in valve plate. Impurities in pilot orifice. Impurities in armature tube.	Clean out impurities. Replace O-rings and gaskets *)
Solenoid valve does not close/ closes partially	Corrosion/cavitation of pilot/main orifice	Replace defective parts *) Replace O-rings and gaskets *)
	Missing components after dismantling of valve	Replace missing components *) Replace O-rings and gaskets *)
Solenoid valve noisy	Frequency noise (hum)	The solenoid valve is not the cause. Check electrical supply.
	Liquid hammer when solenoid valve opens	See the chapter "Solenoid valves"
	Liquid hammer when solenoid valve closes	See the chapter "Solenoid valves"
	Differential pressure too high and/or pulsation in discharge line	Check technical data of valve. Check pressure and flow conditions. Replace with suitable valve. Check remainder of system.
Burnt-out coil (Coil cold with voltage on)	Incorrect voltage/frequency	Check coil data. Replace with correct coil if necessary. Check wiring diagram or wiring itself. Check max. voltage variation. - Permissible variation: 10% higher than rated voltage 15% lower than rated voltage.
	Short-circuit in coil (can be moisture in coil).	Check remainder of system for short-circuiting. Check lead connections at coil. After remedying fault, replace coil (make sure voltage is correct). Check O-rings fitted on armature tube and inside top nut.
	Armature will not lift in armature tube a) Damaged or bent armature tube b) Damaged armature c) Impurities in armature tube	Replace defective components. Clean out impurities *) Replace O-rings and gaskets *)
	Temperature of medium too high	Compare valve and coil data installation data. Replace with suitable valve.
	Ambient temperature too high	Change of valve position might be necessary. Compare valve and coil data with installation data. Increase ventilation around valve and coil.
	Damaged piston, piston rings (on servo-operated solenoid valves type EVRA)	Replace defective parts. Replace O-rings and gaskets *)

* See cross section in the instruction. See also the spare parts documentation on http://www.danfoss.com

Fault location on the pressure control

Symptom	Possible cause	Remedy
High-pressure control disconnected. Warning: Do not start the system before the fault has been located and rectified!	Condensing pressure too high because: Dirty/clogged condenser surfaces. Fans stopped/water supply failure. Defective phase/fuse, fan motor. Too much refrigerant in system. Air in system.	Rectify the stated faults.
The low-pressure control fails to stop the compressor	a) Differential setting too high so that cut-out pressure falls below –1 bar. b) Differential setting too high so that compressor cannot pull down to cut-out pressure.	Increase the range setting or reduce the differential.
Compressor running time too short	a) Differential setting on low pressure control too low. b) High-pressure control setting too low, i.e. too close to normal operating pressure. c) Condensing pressure too high because of: Dirty/clogged condenser surfaces. Fans stopped/water supply failure. Defective phase/fuse, fan motor. Too much refrigerant in system. Air in system.	a) Increase the differential setting. b) Check the high-pressure control setting. Increase it if the system data allows. c) Rectify the stated faults.
Cut-out pressure for KP 7 or KP 17, HP side, does not match the scale value	The fail-safe system in the bellows element is activated if the deviations have been greater than 3 bar.	Replace the pressure control.
Differential spindle on single unit is bent and the unit does not function	Tumbler action failure arising from attempt to test wiring manually from righthand side of unit.	Replace unit and avoid manual test in any way other than that recommended by Danfoss.
High-pressure control chatters	Liquid-filled bellows multifies the damping orifice in the inlet connection.	Install the pressure control so that liquid cannot collect in the bellows element (see instruction). Eliminate cold air flow around the pressure control. Cold air can create condensate in the bellows element. Fit a damping orifice (code no. 060-1048) in the end of the control connection furthest away from the control.
Periodic contact failure on computer-controlled regulation, with minimum voltage and current	Transition resistance in contacts too high.	Fit KP with gold contacts.

Fault location on the thermostat

Symptom	Possible cause	Remedy
Compressor running time too short and temperature in cold room too high **Refrigeration system runs with too high a temperature differential**	Capillary tube on thermostat with vapour charge touching evaporator, or suction line colder than sensor. a) Reduced air circulation around thermostat sensor. b) Refrigeration system temperature changes so fast that the thermostat can not keep pace. c) Room thermostat mounted on a cold wall in the cold room.	Locate capillary tube so that the sensor is **always** the coldest part. a) Find a better sensor location with higher air velocity or better contact with evaporator. b) Use a thermostat with a smaller sensor. Reduce the differential. Ensure that the sensor has better contact. c) Insulate the thermostat from the cold wall.
Thermostat does not start compressor, even when sensor temperature is higher than the set value. The thermostat does not react to hand-warming of the sensor	a) Completely or partially lost charge because of fractured capillary tube. b) Part of the capillary tube in a thermostat with vapour charge is colder than the sensor.	a) Replace thermostat and mount sensor/capillary tube correctly. b) Find a better location for the thermostat so that the sensor is always the coldest part. Change to thermostat with adsorption charge.
Compressor continues to run, even when thermostat sensor is colder than the set value (range setting minus differential)	A thermostat with vapour charge has been set without taking account of graph curves in the instruction sheet.	At low range setting the differential of the thermostat is larger than indicated in the scale (See diagram in the instruction sheet).
Thermostat with absorp-tion charge unstable in operation	Large variation in ambient temperature gives enclosure-sensitivity.	Avoid ambient temperature variations around thermostat. If possible, use a thermostat with vapour charge (not sensitive to ambient temperature variations). Replace thermostat with unit having a larger sensor.
Differential spindle on single unit is bent and the unit does not function	Tumbler action failure arising from attempt to test wiring manually from righthand side of thermostat.	Replace thermostat and avoid manual test in any way other than that recommended by Danfoss.

Fault location on the water valve

Symptom	Possible cause	Remedy
Condensing pressure too high, water-cooled condensers	WV water valve set for too high a pressure (water quantity too small).	Increase the water quantity by setting the water valve at a lower pressure.
	Filter ahead of WV water valve blocked.	Clean filter and flush water valve after opening it to allow full flow (two screwdrivers, see instruction).
	Leaking bellows in WV water valve.	Check bellows for leakage, using a leak detector if necessary. Replace bellows element. See spare parts catalogue*. There must be no pressure on bellows element during removal and refitting.
	Capillary tube between WV water valve and condenser blocked or deformed.	Check capillary tube for blockage or deformation. Replace capillary tube.
	WV water valve closed because of defective upper diaphragm.	Check water valve for cracks in diaphragm. Replace diaphragm. See spare parts catalogue*. There must be no pressure on bellows element during removal and refitting.
Condensing pressure too low, water-cooled condensers	Water quantity too large.	Set WV water valve for smaller water quantity, i.e. higher pressure.
	WV water valve open because of defective lower diaphragm.	Check water valve for cracks in diaphragm. Replace diaphragm. See spare parts catalogue*. There must be no pressure on bellows element during removal and refitting.
	WV water valve cannot close because of dirt in the seat. Valve cone sticks because of dirt.	Check water valve for dirt and clean it. Replace parts as necessary. See spare parts catalogue*. There must be no pressure on bellows element during removal and refitting. Install a filter ahead of the water valve.
Condensing pressure hunts	WV water valve too large.	Replace water valve with a smaller size.

*) Find spare part documentation on http://www.danfoss.com

Fault location on the filter or sight glass

Symptom	Possible cause	Action
Sight glass indicator shows yellow	Too much moisture in system.	Replace filter drier*
Insufficient evaporator capacity	Pressure drop across filter too high.	Compare filter size with system capacity. Replace filter drier*
	Filter clogged.	Replace filter drier*
	Filter under-sized.	Compare filter size with system capacity. Replace filter drier*
Bubbles in sight glass after filter	Pressure drop across filter too high.	Compare filter size with system capacity. Replace filter drier*
	Filter clogged.	Replace filter drier*
	Filter under-sized.	Compare filter size with system capacity. Replace filter drier*
	Insufficient sub-cooling.	Check reason for insufficient subcooling. Do not charge refrigerant only because of insufficient sub-cooling.
	Insufficient refrigerant charge.	Charge necessary refrigerant.
Filter outlet side colder than inlet side (can be iced up)	Pressure drop across filter too high.	Compare filter size with system capacity. Replace filter drier*
	Filter clogged.	Replace filter drier*
	Filter under-sized.	Compare filter size with system capacity. Replace filter drier*

* Rember to seal the old filter after removal.

Fault location on the KV pressure regulator

Symptom	Possible cause	Action
Room temperature too high	KVP evaporating pressure regulator set too high.	Reduce the setting of the evaporating pressure regulator. The setting should be about 8-10 K lower than required room temperature. Remember to screw on protective cap after final setting.
	Bellows leak in KVP evaporating pressure regulator.	Slowly loosen protective cap. If pressure or traces of refrigerant exist under the cap, there is a leak in the bellows. Replace the valve.
Room temperature too low	KVP evaporating pressure regulator set too low.	Increase the setting of the evaporating pressure regulator. The setting should be about 8-10 K lower than the required room temperature. Remember to screw on protective cap after final setting.
Suction pressure hunts	KVP evaporating pressure regulator too large.	Replace evaporating pressure regulator with smaller size. Remember to screw on the protective cap after final setting.
	KVC capacity regulator too large.	Replace capacity regulator with smaller size. Remember to screw on protective cap after final setting.
Suction pressure too high	KVC capacity regulator defective or set too high.	Replace capacity regulator. Set capacity regulator at lower pressure. Remember to screw on protective cap after final setting.
Condensing pressure too high, air-cooled condensers	KVR condensing pressure regulator set too high.	Set condensing pressure regulator at correct pressure. Remember to screw on protective cap after final setting.
Condensing pressure too high, water-cooled condensers	Bellows in KVR condensing pressure regulator might be leaking.	Slowly loosen protective cap. If pressure or traces of refrigerant exist under the cap, there is a leak in the bellows. Replace valve.
Crankcase pressure regulator setting drift	Bellows leak in KVL crankcase pressure regulator.	Slowly loosen protective cap. If pressure or traces of refrigerant exist under the cap, there is a leak in the bellows. Replace the valve.
Compressor discharge pipe too hot	Probable bellows leak in KVC capacity regulator.	Slowly loosen protective cap. If pressure or traces of refrigerant exist under the cap, there is a leak in the bellows. Replace valve.
	Hot gas quantity too large.	If necessary, set the KVC capacity regulator at lower pressure. An injection valve (e.g. TE2) can be installed in the suction line.
Temperature in receiver too high No subcooled liquid	KVD receiver pressure regulator set for too low a pressure.	Set the receiver pressure regulator at a higher pressure. It might also be necessary to increase the setting of the condensing pressure regulator.
	Bellows in KVD receiver pressure regulator might be leaking.	Slowly loosen protective cap. If pressure or traces of refrigerant exist under the cap, there is a leak in the bellows. Replace valve.

Contents **Page**

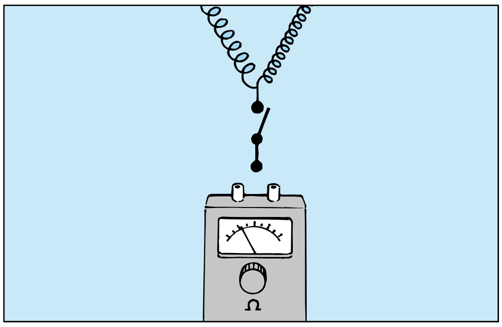
Notes

1.0
Compressor/system does not run (start)

Main switch drop-out	Blown fuse Short-circuiting to frame Motor defect Defective current lead-in Electrical equipment
Compressor	Compressor motor/motor protector mechanically blocked. Overload Voltage/frequency Pressure irregularity Refrigerant type Pressure equalisation Fan drop-out
High and low-pressure switches	Mechanical defect Incorrect connection Incorrect differential setting Incorrect cutout setting Pressure irregularity
Thermostat	Mechanical defect Incorrect connection Differential too small Incorrect cutout value

1.1

If the main fuse blows, the cause must be found. This will most often be a defect in the motor windings or motor protector, short-circuiting to frame or a burnt current lead-in which, in turn, causes main fuse drop-out. If a compressor motor refuses to start, always check the resistances first. All compressors have their main and start windings located as shown in the sketch. Resistance values are stated in the individual data sheets.



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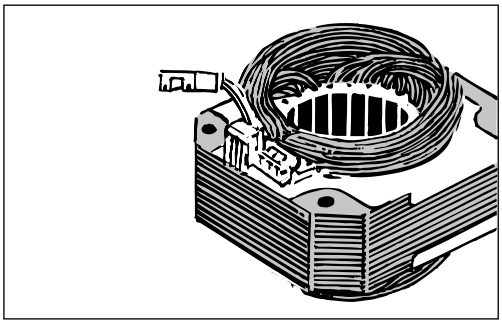
1.2

As a rule, a motor protection is built into all compressor motors. If the winding protector cuts out the motor, due to the heat accumulated in the motor the cut-out period can be relatively long (up to 45 minutes). When the motor will no longer run, resistance measurement will confirm whether a motor protector has cut out or whether a winding is defective. A mechanical seizure in the compressor will show itself by repeated start attempts accompanied by high current consumption and high winding temperatures that cause motor protector cutout.



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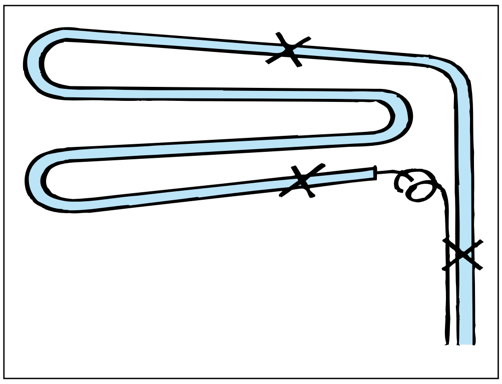
1.3

Compressor overload can be recognised by the compressor refusing to start or by starting and then stopping again after a very short time (via the motor protector). If the com-pressor is used outside its allowed application limits the usual result is overload. Application limits such as voltage tolerances, frequencies, temperature/ pressure and refrige-rant type are given in the individual data sheet. In systems not protected by a high-pressure cut-out switch on the discharge side, a fan motor which is defective or cut out via a motor protector can lead to compressor overload. Generally, the refrigerant quantity must be determined precisely. In capillary tube systems the most certain method is to take temperature measurements on the evaporator and suction line.



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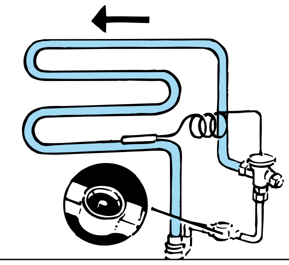
Trouble shooting

1.4

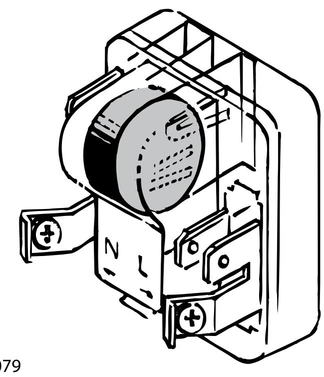
In systems with thermostatic expansion valve, charging must be checked using a sight glass. In both systems, the refrigerant quantity must be less than the quantity that can be accommodated in the free volume on the discharge side.



Am0_0078

1.5

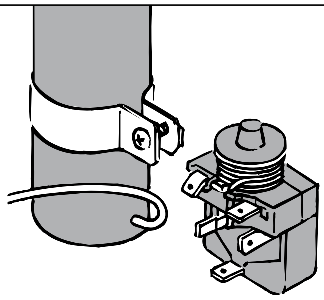
Compressors for capillary tube systems are usually equipped with a PTC LST starting device. Starting via a PTC requires complete pressure equalisation between the high and low-pressure sides on every start. In addition, before it can operate, the PTC requires a standstill time of about 5 minutes to ensure that the PTC component is cooled down in order to achieve maximum starting torque. When a "cold" compressor is started and the current is cut off a short time after, conflict can arise between the PTC and the motor protector. Because the motor retains heat, up to approx. 1 hour can elapse before normal start is possible.



Am0_0079

1.6

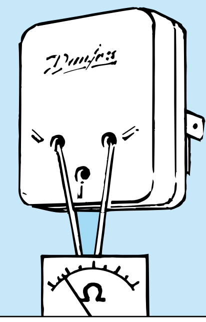
In systems where pressure equalisation on starting is not certain, the compressor must be equipped with an HST starting device. This also applies to capillary tube systems with a standstill time of less than 5 minutes. Defective or incorrect relays and starting capacitors can cause starting problems or that the compressor is cut out via the motor protector. Note the manufacturer's compressor data. If the starting device is thought to be defective the whole equipment must be replaced, including the relay and starting capacitor.



Am0_0080

1.7

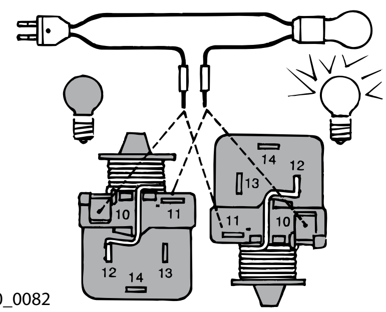
The PTC (25 Ω for 220 V mains and approx. 5 Ω for 115 V mains) can be checked using an ohmmeter.



Am0_0081

1.8

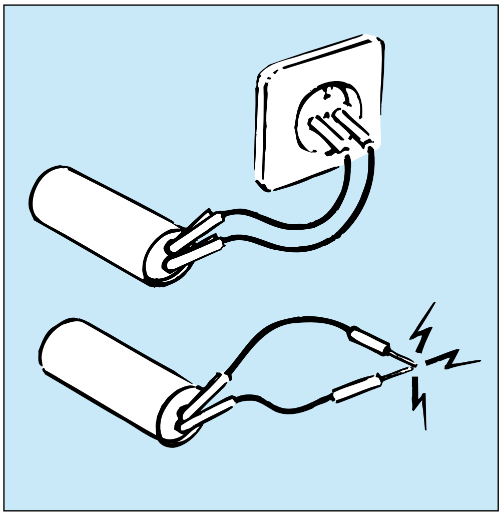
A starting relay can be checked with a lamp, see sketch. The relay is in order if the lamp does not light up when the relay is upright. The relay is also in order if the lamp lights up when the relay is upside down.



Am0_0082

1.9

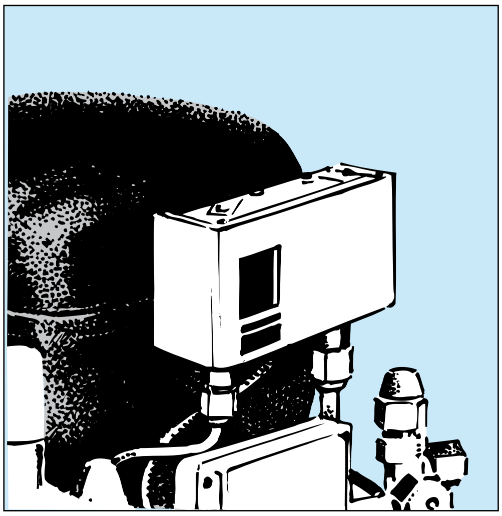
A starting capacitor can also be checked by applying rated mains voltage to it for a few seconds and then short-circuiting the leads. If sparks appear, the capacitor is in order.



Am0_0083

1.10

In some markets, Danfoss offers condensing units with combined high and low-pressure switches that protect the compressor against excessive pressure on the discharge side and too low pressures on the suction side. If the high-pressure switch has cut out the system, a check should be made to see whether pressure irregularity is occurring. If the low-pressure switch has cut out, the cause can be insufficient refrigerant amount, leakage, evaporator icing and/or partial blockage of the throttling device.
If there is no pressure irregularity on the high or low-pressure sides, the pressure switch itself must be checked. See also the chapter "Pressure controls".

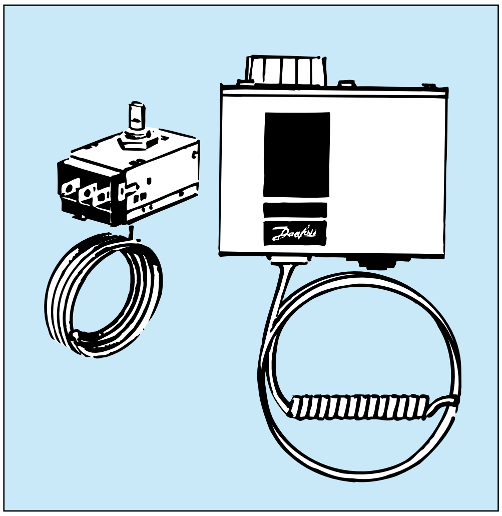


Am0_0084

1.11

The system can also cut out because of a defective or incorrectly set/sized thermostat. If the thermostat loses charge or if the temperature setting is too high, the system will not start. If the temperature differential is set too low, compressor standstill periods will be short and there might be starting problems with an LST starting device and shortened compressor life with an HST starting device. The guideline for pressure equalisation time using an LST starting device is 5 to 8 minutes for refrigerators and 7 to 10 minutes for freezers.

If an HST starting device is used, the aim is to keep the cut-in periods per hour as few as possible. Under no circumstances must there be more than ten starts per hour. See also the chapter "Thermostats".



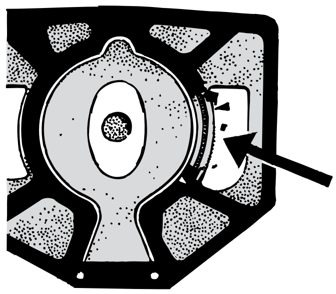
Am0_0085

2.0
The compressor/system runs, but with reduced refrigeration capacity

Compressor	Leakage Coking
Pressure irregularity	Blockage Non-condensible gases Moisture Dirt Fan defect Refrigerant loss Refrigerant overcharge Icing
Throttling device Capillary tube/thermostatic expansion valve	Static superheat setting Orifice size/diameter

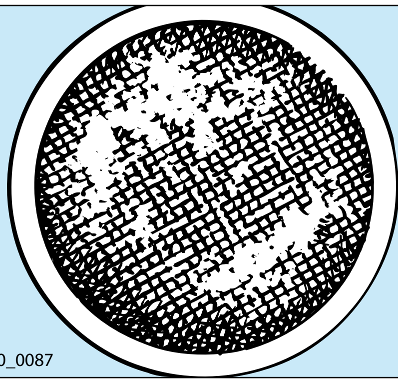
2.1

Frequent causes of reduced refrigeration capacity are coking, and copper plating which lead to reduced life time of the compressor and burst gaskets in the compressor valve system.
Coking occurs mainly as a result of moisture in the refrigeration system. In high temperatures, the presence of moisture also causes copper plating on valve seats. The burst gaskets are the result of an excessive condensing pressure and excessively high short-lived pressure peaks >60 bar (liquid hammer).


Am0_0086

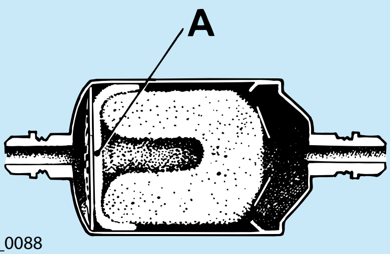
2.2

We recommend the installation of good quality filter driers. If the filter material is of poor quality, wear will occur which will not only cause the partial blockage of capillary tube and the filter in the thermostatic expansion valve, but it will also damage the compressor (mainly seizure).


Am0_0087

2.3

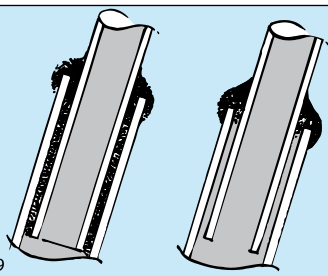
In general, commercial refrigeration systems must be equippd with filters having a solid core, e.g. type DML. See also the chapter "Filter driers & sight glasses".
The filter drier must be replaced after every repair. When replacing a "pencil drier" (often used in refrigerators) care must be taken to ensure that the filter material used is suitable for the refrigerant and that there is sufficient material for the application.



Am0_0088

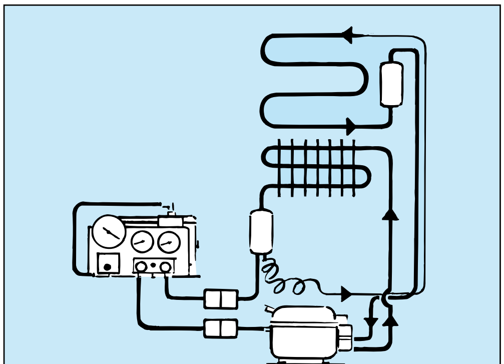
2.4

Poorly soldered joints can also cause system blockage. Making good soldered joints is conditional on using the correct soldering metal containing the correct percentage of silver.
The use of flux should be limited and kept to as minimum as possible.


Am0_0089

2.5

Poorly soldered joints can also cause leakage and thereby coking. In a refrigeration circuit the proportion of non-condensible gases should be kept below 2%, otherwise the pressure level will rise. The main purpose of evacuation is to remove non-condensible gases before the refrigerant is charged. This also produces a drying effect in the refrigeration system. Evacuation can be performed either from both discharge and suction sides, or from the suction side only. Evacuation from both sides gives the best vacuum. Evacuation from the suction side only makes it difficult to obtain sufficient vacuum on the discharge side. Therefore, with one-sided evacuation, intermediate flushing with dry Nitrogen is recommended until pressure equalisation is achieved.



Am0_0090

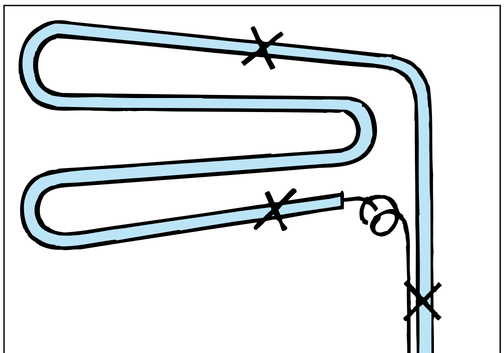
2.6

Dirt on the condenser and a fan motor defect can cause excessive condensing pressure and thereby reduced refrigeration capacity. In such cases the built-in high-pressure switch provides overload protection on the condenser side.
Note: The built-in motor protector does not give the compressor optimum protection if the condensing pressure rises as a result of a fan motor drop-out. The temperature of the motor protector does not rise quickly enough to ensure the protector cutout. This also applies when the refrigerant quantity is greater than can be accommodated in the free volume on the discharge side.

Am0_0091

2.7

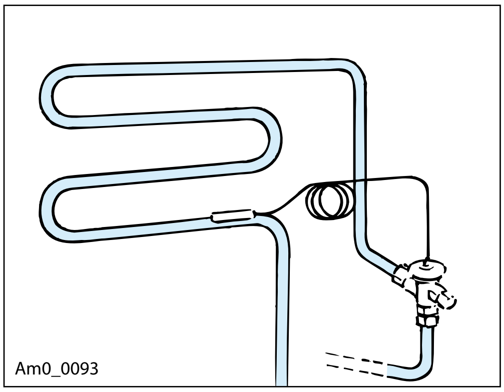
It is important to determine the quantity of refrigerant precisely – especially in capillary tube systems. The guidelines are that the temperature on the evaporator inlet must, as far as possible, be the same as the temperature at its outlet, and that as much superheating as possible must be obtained between the evaporator outlet and the compressor inlet. (The inlet temperature on the compressor must be about 10 K less than the condensing temperature).



Am0_0092

2.8

Overcharging of a refrigeration system equipped with a thermostatic expansion valve becomes critical when the charging quantity in liquid condition is greater than can be accommodated by the free volume in the receiver, i.e. the condenser area is reduced and the condensing pressure rises.

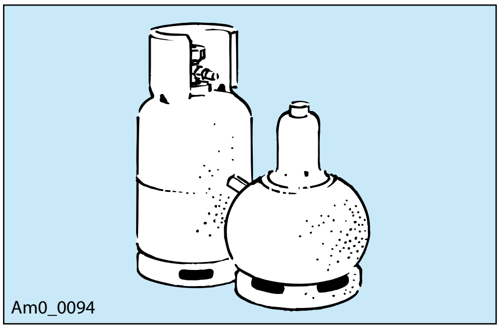


Am0_0093

Trouble shooting

2.9

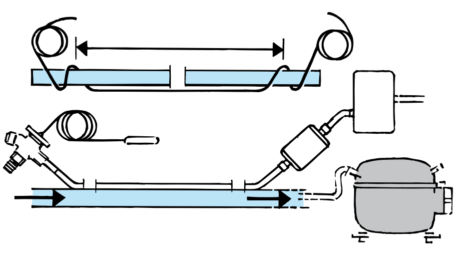
It is very seldom that there is too little refrigerant in a system, unless leakage occurs. Irregular icing on the evaporator is often a sign of insufficient refrigerant. This irregular icing does not only reduce the refrigeration output, it can also give problems in evaporator defrosting because the defrost thermostat sensor does not register the presence of ice. Therefore, precise determination of the refrigerant charge is recommended as a way of making sure that ice on the evaporator is evenly distributed.



Am0_0094

2.10

The optimum system efficiency is obtained when a heat exchanger is fitted to ensure subcooling: about 5 K in systems with thermostatic expansion valve and about 3 K in systems with capillary tube. In systems with a thermostatic expansion valve the suction and liquid lines must be soldered together over a distance of 0.5 to 1.0 m. In capillary tube systems the capillary tube and suction line must be soldered together for 1.5 to 2.0 m.



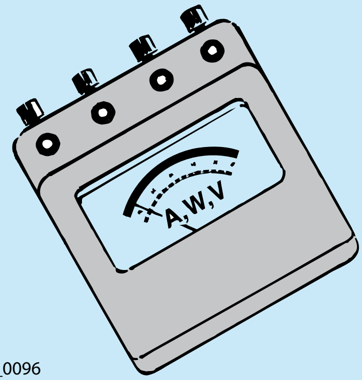
Am0_0095

3.0 Power consumption too high

Compressor	Signs of compressor wear Motor defect Reduced refrigeration capacity Compressor cooling
Pressure irregularity	Blockage Non-condensible gases Moisture Dirt Fan defect
Overload	Application limits exceeded Voltage/frequency Pressure irregularity Temperature Refrigerant type

3.1

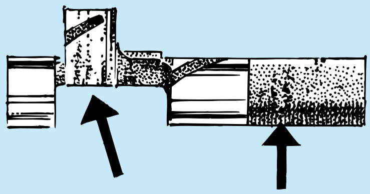
Pressure irregularity and overload often cause compressor defects that show themselves in the form of increased power consumption. Refer to the previous pages for information on problems with pressure irregularity and compressor overload seen from the system side.
Excessive evaporating and condensing pressures cause compressor motor overload which leads to increased power consumption. This problem also arises if the compressor is not sufficiently cooled, or if extreme overvoltage occurs. Undervoltage is not normally a problem in Western Europe because here the voltage rarely drops below 198 V.



Am0_0096

3.2

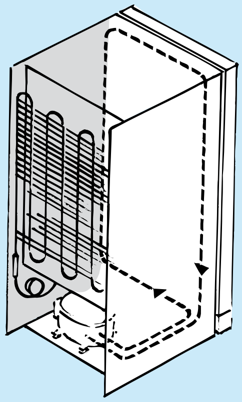
Constant overload will give signs of wear in compressor bearings and valve systems. Overload that causes frequent winding protector cutouts can also produce an increased number of electrical drop-outs.
In cases where the application limits are exceeded, the system must be adapted. For example, by the use of a thermostatic expansion valve with an MOP that will limit the evaporating pressure, a pressure regulator, or a condensing pressure regulator. See also the chapter "Thermostatic expansion valves" and the chapter "Pressure regulators".



Am0_0097

3.3

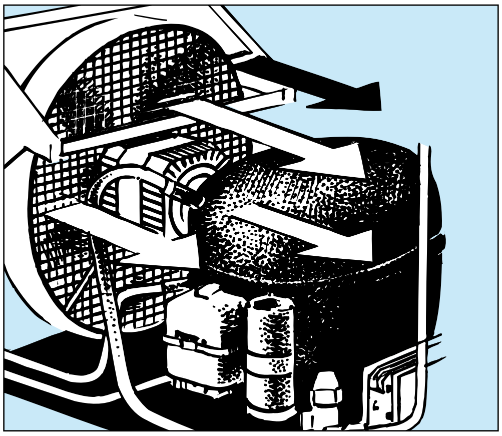
Static cooling (in certain circumstances an oil cooler) is sufficient for most household refrigeration appliances, provided that the clearances specified by the manufacturer are maintained, especially where a built-in appliance is concerned.



Am0_0098

3.4

Commercial equipment should be fan-cooled. The normal recommended air velocity across condenser and compressor is 3 m/s.



Am0_0099

3.5

A further recommendation is regular service on the refrigeration system, including cleaning of the condenser.

Am0_0100

4.0 Noise

Compressor	Pressure circuit Oil level Clearance: piston/cylinder Valve system
Fan	Deformed fan blades Bearing wear Baseplate
Valves	Whistling« from thermostatic expansion valves »Chatter« from solenoid and check valves
System noise	Liquid noise (mainly in evaporator)
Installation	Piping Compressor, fan and condenser brackets

4.1

Danfoss compressors and condensing units do not normally give rise to complaints about noise. The noise level of compressors and, above all, fans is well in agreement with the demands made by the market. If occasional complaints are received, they usually arise from installation or system errors.

Am0_0101

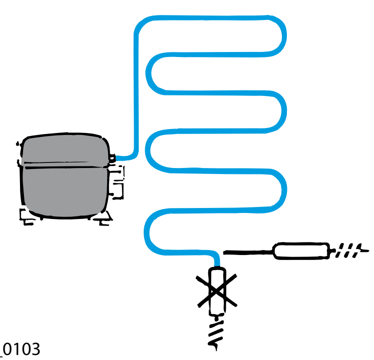
4.2

The rare noise problems that do occur are mostly because of production faults, e.g. discharge line touching the compressor housing, oil level too high/low, too much clearance between piston and cylinder, faulty assembly of the valve system. Such noise is easy to diagnose with a screwdriver used as a "stethoscope".

Am0_0102

4.3

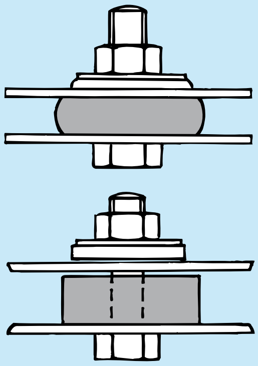
System noise is a critical factor in household appliances. Here, liquid noise at the evaporator inlet is characteristic. On the system side it is difficult to remedy this problem because what is involved is a mass produced equipment. If the filter is mounted vertically, it might help to mount it horizontally instead. However, it should be remembered that noise can be amplified by structure, e.g. with a built-in appliance. In such a situation, the manufacturer should be contacted.



Am0_0103

4.5

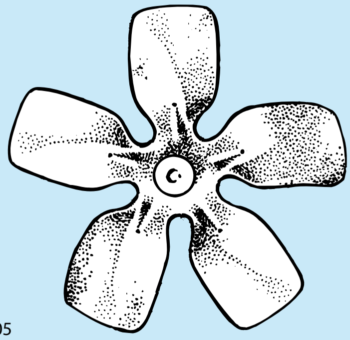
To prevent noise transfer, pipework should not be allowed to touch the compressor, the heat exchanger or the side walls.
When installing a compressor, the fittings and grommet sleeves supplied must be used to avoid the rubber pads being compressed so much that they lose their noise-suppression properties.



Am0_0104

4.6

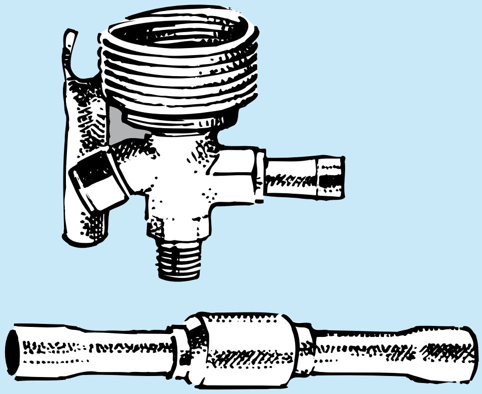
Fans are used mostly in commercial refrigeration systems. Noise will be generated if the fan blades become deformed or touch the heat exchanger fins. Worn bearings also produce a great deal of noise. Additionally, the fan unit must be firmly secured so that it does not move in relation to its mounting bracket. Normally, fans have a higher noise level than compressors. In some circumstances, it is possible to reduce the noise level by installing a smaller fan motor, but this can only be recommended when the condenser area is over-sized.



Am0_0105

4.7

If the noise comes from the valves, the cause is usually incorrect sizing. Solenoid and check valves must never be sized to suit the pipe connections, but in accordance with the k_v value. This ensures the min. pressure drop necessary to open the valve and keep it open without valve "chatter". Another phenomenon is "whistling" in thermostatic expansion valves. Here a check should be made to ensure that the size of the orifice corresponds to the system characteristics and that above all there is sufficient liquid sub-cooling ahead of the expansion valve [approx. 5 K].



Am0_0106

Contents

Notes

General

This section is directed especially to the service network, for household appliances and similar. It deals mainly with PL, TL, NL and FR compressors for 220-240V.
For detailed information on compressors see the data sheets.

Compressors type PL, TL, NL, FR and partly SC are equipped with a PTC starting device (fig. 1) or a relay and start capacitor (fig. 2). The motor protector is built into the windings.

In the event of a start failure, with a cold compressor, up to 15 minutes can elapse before the protector cuts out the compressor.

When the protector cuts out and the compressor is warm, it can take up to 1 hour before the protector cuts in the compressor again.

The compressor must not be started without the electrical equipment.

Fig. 1: PTC starting device

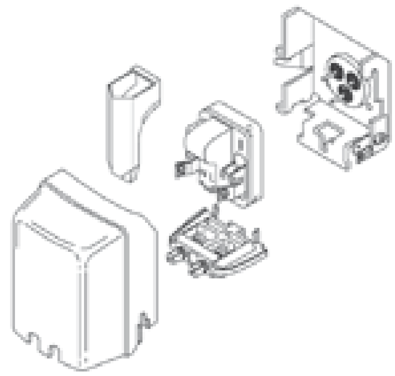


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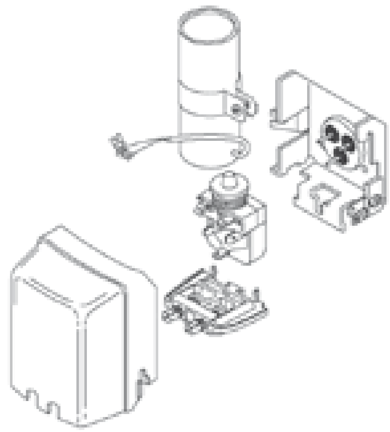
Fig. 2: Starting relay



Am0_0070

Fault location

Before beginning systematic fault location, a good rule is to cut the supply voltage for at least 5 minutes. This ensures that the PTC starting device has cooled off and is ready for start.

A voltage drop or blackout within the first minutes of a pull down of the appliance with cold compressor, can lead to an interlocking situation.

A compressor with PTC can not start at non equalized pressure and the PTC does not cool down so fast. It can take more than 1 hour until the appliance then operates normally again.

Electrical compressor quick check

To avoid unneccessary protector operation and consequent waiting time, it is important to carry out fault location in the sequence given below. Tests are made according to desriptions on following page.

- Remove electrical equipment
- Check electrical connection between main and start pins of compressor terminal
- Check electrical connection between main and common pins of
- Compressor terminal
- Replace compressor, if above connection checks failed
- Else, replace electrical equipment

If the compressor still does not operate, most probably it is no electrical compressor failure. For more detailed fault location, see the tables.

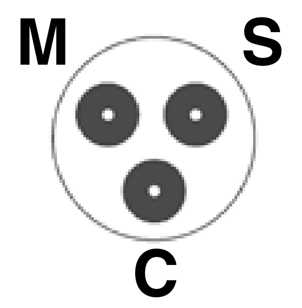
Check main and start winding

- Resistance between pins M (main) and S (start) on compressor terminals is measured with an ohm-meter, see fig. 3.

Connection →	Main and start windings normally OK →	Replace relay	
No connection →	Main or start winding defective →	Replace compressor	

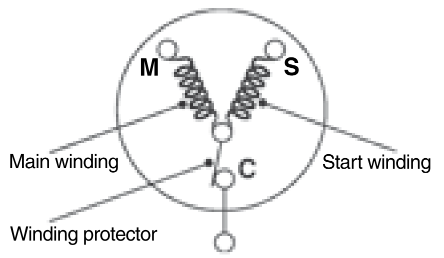
At cold compressor (ca. 25°C) the values are ca. 10 to 100 Ohm for 220-240 V compressors. For partial short circuit detection, exact values are needed from data sheets of the specific compressor, which can be found on the Danfoss Compressors homepage.

Fig. 3: Compressor terminals



Am0_0071

Fig. 4: Windings and protector



Am0_0072

Check protector

- Resistance between pins M (main) and C (common) on compressor terminals is measured with an ohm-meter, see fig. 3 and 4.

Connection →	Protector OK		
No connection →	Compressor cold →	Protector defective →	Replace compressor
	Compressor hot →	Protector could be OK, but cut out →	Wait for reset

Check relay

- Remove relay from compressor.
- Measure connection between connectors 10 and 12 (see fig. 5):

No connection →	Relay defective →	Replace relay	

- Measure connection between connectors 10 and 11:
- In normal vertical position (like mounted, solenoid upward):

Connection →	Relay defective →	Replace relay	
No connection →	OK		

- In top-down position (solenoid downward):

Connection →	OK		
No connection →	Relay defective →	Replace relay	

Check PTC

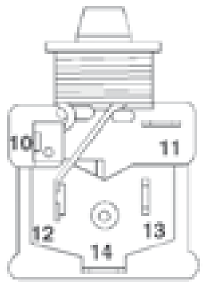
- Remove PTC from compressor.
- Shake by hand. Pin C can slightly rattle.

Internal rattle noise (except pin C) →	PTC defect →	Replace PTC	

- Measure resistance between pins M and S, see fig. 6.
- Resistance value between 10 and 100 Ohm at room temperature for 220 V PTC.

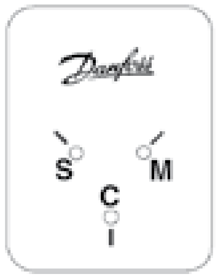
Connection →	PTC working →	OK	
No connection →	PTC defect →	Replace PTC	

Fig. 5: Relay connections



Am0_0073

Fig. 6: PTC connections (backside)



Am0_0074

Fault location

Most common fault reasons, detectable before dis-mounting compressor.

Customer claim	First analysis	Possible cause	Check	Activity (depends on result)
No/reduced cooling	Compressor does not run	Compressor gets no or bad power supply	Voltage at plug and fuse	
			Aplicance energized	
			Thermostat function	
			Cables and connections in appliance	
			Voltage at compressor terminals	
		Defective relay	Relay function by shaking to hear if armature is working	Replace relay
		Defective start cap	Start capacitor function	Replace start capacitor
		PTC defective	PTC by shaking	Replace if noise appears
			PTC resistance 10 to 100 Ohm between M and S pin	Replace PTC, if not 10 to 100 Ohm
		Compressor with PTC can not start at pressure difference	Stop time long enough for pressure equalization	Adjust thermostat difference
		PTC defective	PTC resistance 10 to 100 Ohm between M and S pin	Replace PTC
		Relay defective	Relay function by shaking, to hear moving of armature	Replace relay and capacitor
		Compressor overloaded	Condenser pressure and ventilation	Ensure proper ventilation
			Ambient temperature too high according to type label of appliance	
		Defective motor windings	Check winding resistances	Replace compressor
		Defective protector	Check protector with ohmmeter	Replace compressor
		Mechanically blocked compressor	Start with proper starting equipment, voltage and conditions, windings and protector OK	Replace compressor
	Compressor runs 100%	No or low refrigerant charge	Recharge and search for leaks	Ensure leakfree system and proper charge
		Too high ambient temperature	Ambient temperature according to type label of appliance	Replace drier
		Too high condensing temperature	Condenser and compressor ventilation	Ensure proper ventilation and wall distance
		Capillary partly blocked	Recharge and search for leaks, measure suction pressure. Capillary blocked, if pressure very low	
		Valves coked or damaged	Recharge and search for leaks	Replace compressor, if still not cooling properly
	Compressor runs on/off	Thermostat not OK	Thermostat type and function	Replace thermostat
		Wrong refrigerant charge	Recharge and search for leaks	Ensure leakfree system and proper charge,
		Ice block built up on evaporator	Check for ice on evaporator	Replace drier
			Thermostat function and settings	Defrost properly
			Internal no-frost fan function	Replace thermostat
		Compressors trips on motor protector	Compressor load, compressor and condenser ventilation	Ensure proper ventilation and wall distance
			Compressor voltage supply for minimum 187 V	Ensure proper power supply
			Compressor voltage supply for drop outs. Check thermostat and appliance cables for loose connections	Fix all connections
			Motor windings resistance for partly short circuit or earth connection	Replace compressor

Fault location
(continued)

Customer claim	First analysis	Possible cause	Check	Activity (depends on result)
Noise	Rattle or humming	Tube touching cabinet	Tube placing	Bend tube to their right place, carefully
		Compressor touching cabinet	Compressor mounting and rubber feet	Place rubber feet and mounting accessories correctly
		Broken internal suspension spring or discharge tube	Listen to compressor with screw-driver against compressor with edge and to your ear with grip	Replace compressor, if abnor-mal sounds
		Resonance	Find vibrating mounting parts	Place or fix correctly
		Fan noise	Vibration of fan or fan mounting	Fix fan and blade, replace, if defective
	Banging at start or stop of compressor	Compressor block hitting housing internally	Compressor overload by pressure	Clean condenser if dusty. Make sure, that ventilation gaps for air circulation are satisfactory
			Fan function	
			Refrigerant charge	Recharge, if too high
			Pressure equalization before start and num-ber of on/off cycles	Adjust thermostat, if stop time less than 5 min
			Ambient temperature according to type label	Take appliance out of function, if ambient too hot
	Relay clicking frequently after start	Compressor over-loaded	Ventilation to compressor and condenser. Check fan function	Clean condenser if dusty. Make sure, that ventilation gaps for air circulation are satisfactory
		Relay defective	Right relay type for compressor	Replace relay, if wrong
Fuses are blown by appliance	Short circuit in appliance	Defective cabling in appliance	All connecting cables and power supply cord for loose connections, short circuits	Fix connections properly
		Defective thermostat	Thermostat connections	Fix connections properly
		Ground connection	Resistance from line/neutral to earth	
	Short circuit in compressor	Defective terminals	For burns on the terminal pins	Replace electrical accessories
		Short circuit between cables at terminals	Connectors and cables at compressor	Insulate cables and connectors
		Short circuit in compressor motor	Resistance values in windings	Replace compressor, if short circuited
			Resistance between terminals and earth	
	Fuse blows at compressor start	Supply voltage too low	Supply voltage at compresor start >187 V	
		Fuse loaded by too many appliances	Total fuse load	Connect appliance to different fuse
		Resettable fuse too quick acting	Fuse load and type	If possible replace by slightly slower type
		Partly short circuit to earth	Resistance between terminals and earth	Replace compressor, if short circuited
	Starting capacitor exploded	Defective relay	Relay function by shaking, to hear moving of armature	Replace relay and capacitor
		Wrong relay type	Relay type	Replace relay and cap
		Extremely many starts and stops of compressor	Relay type	Replace relay and cap
			Thermostat defect or differences too small	Adjust or replace thermostat
	Starting relay cap blown off	Short circuit in compressor motor	Compressor motor resistances	Replace compressor

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The Danfoss product range for the refrigeration and air conditioning industry

Danfoss Refrigeration & Air Conditioning is a worldwide manufacturer with a leading position in industrial, commercial and supermarket refrigeration as well as air conditioning and climate solutions.

We focus on our core business of making quality products, components and systems that enhance performance and reduce total life cycle costs – the key to major savings.

Controls for Commercial Refrigeration

Controls for Industrial Refrigeration

Electronic Controls & Sensors

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Household Compressors

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Sub-Assemblies

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We are offering a single source for one of the widest ranges of innovative refrigeration and air conditioning components and systems in the world. And, we back technical solutions with business solution to help your company reduce costs, streamline processes and achieve your business goals.

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