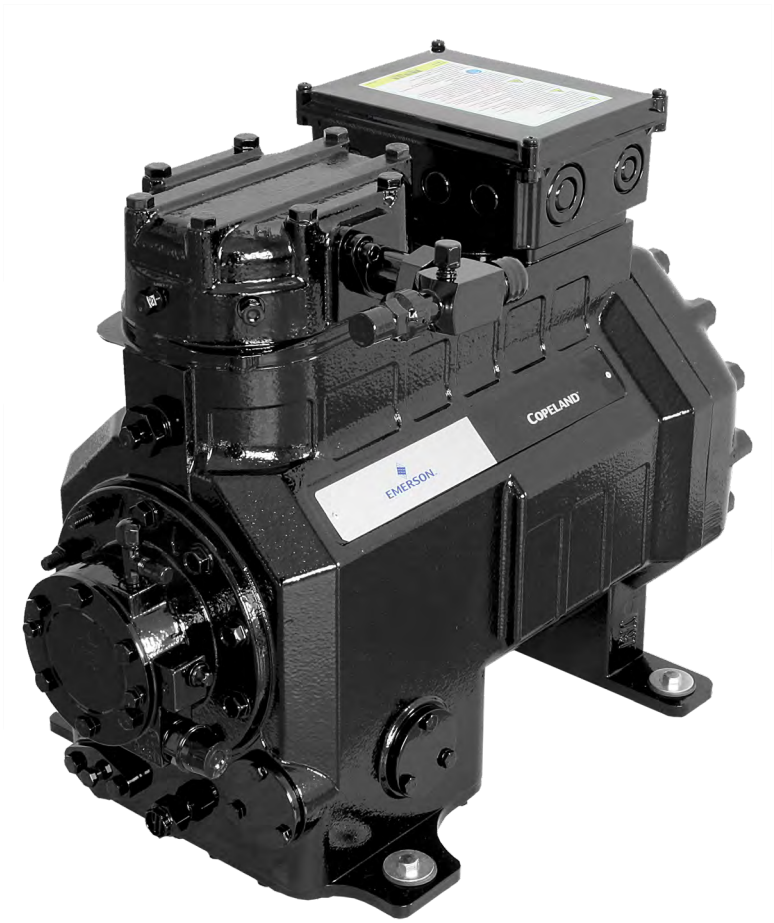
Application Guidelines

Copeland™ Semi-Hermetic Compressors for A2L & A1 Applications

2D*, 3D* & 8D*



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About these guidelines

The purpose of these guidelines is to provide guidance in the application of Copeland™ semi-hermetic compressors in users' systems. They are intended to answer the questions raised while designing, assembling and operating a system with these products.

Besides the support they provide, the instructions listed herein are also critical for the proper and safe functioning of the compressors. The performance and reliability of the product may be impacted if the product is not used according to these guidelines or is misused.

These application guidelines cover stationary applications only. For mobile applications, please contact the Application Engineering department at Emerson as other considerations may apply.

1 Safety instructions

Copeland semi-hermetic compressors are manufactured according to the latest relevant European safety standards. Particular emphasis has been placed on the user's safety.

Copeland semi-hermetic 2D*, 3D* and 8D* compressors are intended for installation in systems in accordance with the following directives and regulations:

Machinery Directive MD 2006/42/EC	Supply of Machinery (Safety) Regulation 2016
Low Voltage Directive LVD 2014/35/EU	Electrical Equipment (Safety) Regulation 2016

They can be used in the EU only if they have been installed in systems according to instructions and conform to the corresponding provisions of legislation. For relevant standards please refer to the Manufacturer's Declaration, available at www.climate.emerson.com/en-gb.

***NOTE:* Only dedicated compressors are allowed to be used with flammable refrigerants. Emerson marks all compressors that are qualified for flammable refrigerants with a sticker indicating the usage of such refrigerants. Systems using flammable refrigerants must be executed correctly while observing safety rules, as specified in corresponding safety standards such as, but not limited to EN 378. They must comply with any and all applicable legislation and regulations. Ensuring compliance remains the user's responsibility.**

The Material Safety Datasheet (MSDS) for the individual refrigerant shall be considered when working with these types of refrigerant - please check the document provided by the gas supplier.

These instructions shall be retained throughout the lifetime of the compressor.

You are strongly advised to follow these safety instructions.

1.1 Icon explanation

	**WARNING** This icon indicates instructions to avoid personal injury and material damage.		**Fire hazard** This icon indicates a risk of flammable atmosphere.
	**High voltage** This icon indicates operations with a danger of electric shock.		**CAUTION** This icon indicates instructions to avoid property damage and possible personal injury.
	**Danger of burning or frostbite** This icon indicates operations with a danger of burning or frostbite.		**IMPORTANT** This icon indicates instructions to avoid malfunction of the compressor.
	**Explosion hazard** This icon indicates operations with a danger of explosion.	***NOTE***	This word indicates a recommendation for easier operation.
	**Danger of explosive atmosphere** This icon indicates a risk of explosive atmosphere.		

1.2 Safety statements

- **Refrigerant compressors must be employed only for their intended use. The system has to be labelled according to the applicable standards and legislation.**
- **Only qualified and authorized RACHP (refrigeration, air conditioning and heat pump) personnel are permitted to install, commission and maintain this equipment.**
- **Electrical connections must be made by qualified electrical personnel.**
- **All valid standards for connecting electrical and refrigeration equipment must be observed.**
- **The national legislation and regulations regarding personnel protection must be observed.**

Additional requirements and statements for A2L-refrigerant compressor/systems:

- **Only competent personnel (as specified in EN 13313) qualified for flammable refrigerant handling are permitted to commission, initiate and maintain the compressor/refrigeration systems using flammable refrigerant; non-trained personnel, including the user, are not allowed to do so and must call on an expert.**
- **The maximum refrigerant charge is specified in standards such as, but not limited to EN 378, EN 60335-2-40 and EN 60335-2-89. The system designer shall implement all safety measures defined by the applicable standards and the maximum refrigerant charge shall not be exceeded.**
- **If a flammable atmosphere is detected, immediately take all necessary precautions to mitigate the risk as determined in the risk assessment.**

Use personal safety equipment. Safety goggles, gloves, protective clothing, safety boots and hard hats should be worn where necessary.

1.3 General instructions

WARNING
Pressurized system! Serious personal injuries and/or system breakdown! Accidental system start before complete set-up must be avoided. Never leave the system unattended without locking it out electrically when it is on vacuum and has no refrigerant charge, when it has a holding charge of nitrogen, or when the compressor service valves are closed.

WARNING
System breakdown! Personal injuries! Only approved refrigerants and refrigeration oils must be used.

WARNING
High shell temperature! Burning! Do not touch the compressor and piping until they have cooled down. Ensure that other materials in the area of the compressor do not come into contact with it. Lock and mark accessible sections.

CAUTION
Overheating! Bearing damage! Do not operate compressor without refrigerant charge or without it being connected to the system.

CAUTION
Contact with refrigerant oil! Material damage! Polyolester (POE) lubricant must be handled carefully and the proper protective equipment (gloves, eye protection, etc.) must be used at all times. Refrigerant oil must not come into contact with any surface or material that it might damage, including without limitation, certain polymers, eg, PVC/CPVC and polycarbonate.

IMPORTANT
Transit damage! Compressor malfunction! Use original packaging. Avoid collisions and tilting.

2 Product description

2.1 Compressor range

These application guidelines cover Copeland semi-hermetic compressor models 2D*, 3D* and 8D* with displacement ranging from 16.8 to 181 m^3/h. The optimized valve plate design of these compressors provides the highest energy efficiency.

Copeland semi-hermetic compressors are suitable for a wide range of applications in the form of either single compressors, condensing units or as multi-compressor equipment.

Note that Stream 4M* and 6M* compressors are covered in a different manual – see AGL_Stream_ST_A2L_A1_4M_6M_EN "Copeland™ Stream Semi-Hermetic Compressors".

NOTE: **The compressor is only one component which must be combined with many others to build a functional and efficient refrigeration system. Therefore, the information in this manual relates to Copeland semi-hermetic compressors with standard equipment and accessories only.**

2.2 Nomenclature

The model designation contains the following technical information about the standard and Discus compressors:

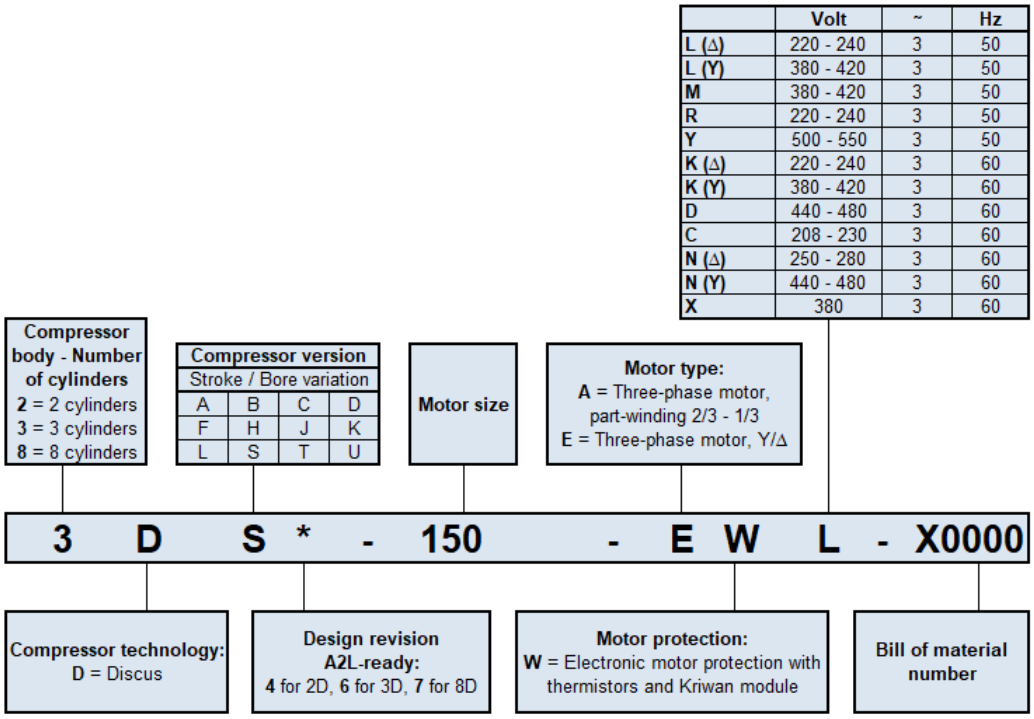


Figure 1: Nomenclature

The 2D*, 3D* and 8D* compressors have been modified internally to support operation with A2L refrigerants. The modified models can be identified by the new design revision number in the nomenclature – see also **Table 1** below. Only the compressors marked with the new design revision numbers are approved for operation with A2L refrigerants, or alternatively with A1 refrigerants. The compressor models with the revision numbers of the old design are not qualified for operation with A2L refrigerants and can only be operated with A1 refrigerants.

"Old" design revision number (A1 refrigerants)	"New" design revision number (A2L + A1 refrigerants)
2D*3	2D***4**
3D*5	3D***6**
8D*6	8D***7**

Table 1: Design revision numbers and corresponding refrigerant safety classes

The qualification and suitability for A2L operation and the changeover to updated design revision numbers in the nomenclature are of application from serial number 23B (production date February 2023) onwards.**

2.3 Nameplate information

All important information for identification of the compressor is printed on the nameplate.

The year and month of production are shown on the nameplate as part of the serial number (Jan = A, Feb = B, … Dec = L).

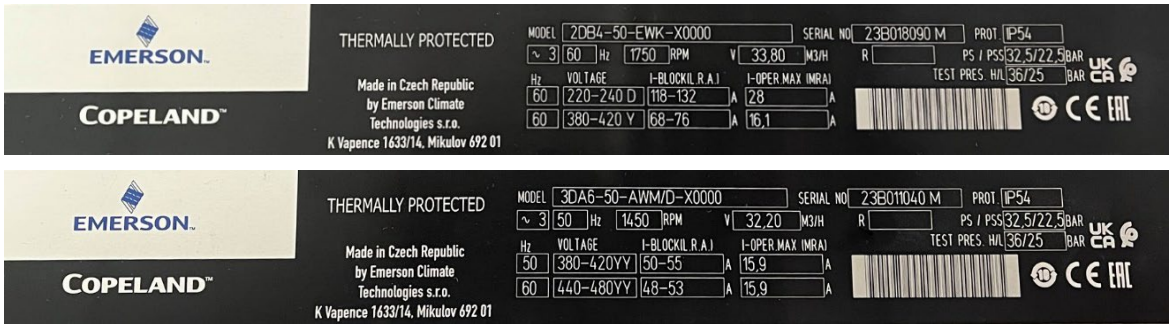


Figure 2: Examples of nameplate for 2D* & 3D* compressors

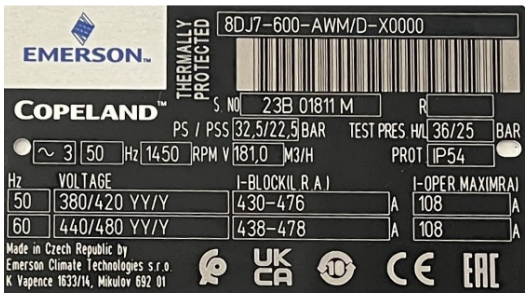


Figure 3: Example of nameplate for 8D* compressors

2.4 Application range

2.4.1 *Qualified refrigerants and oils*

IMPORTANT
Some refrigerant blends (for example R454C, R455A and R454A) have a significant temperature glide. It is essential that this glide be carefully considered when adjusting pressure and superheat controls.

***NOTE:* R454C, R455A and R454A are classified as A2L (mildly flammable) refrigerants.**

***NOTE:* For applications with A1 refrigerants (R448A, R449A, R407A, R407F, R404A, R407C, R513A, R450A, R134a and R22), the flammable refrigerant sticker is not of application and can be removed from the compressor.**

Compressors	**2D*, 3D* & 8D***		
Qualified refrigerants	**R454C, R455A & R454A**	**R448A, R449A, R407A, R407F, R404A, R407C, R513A, R450A & R134a**	**R22**
Qualified oils (factory charged)	RL32 3MAF	RL32 3MAF	Suniso 3 GS
Servicing oils	RL32 3MAF	RL32 3MAF Mobil EAL Arctic 22 CC	Shell 22-12, Suniso 3 GS Fuchs Reniso KM 32 Capella WF 32

Table 2: Qualified refrigerants and oils for recharging and topping up

Oil recharge values can be taken from Copeland Select software available at www.climate.emerson.com/en-gb.

To recharge:

- When the compressor is completely empty of oil, the amount of oil to be "recharged" is typically 0.12 litre less than the original oil charge (oil will already be present in the system).

To top up:

- During commissioning, planned maintenance or servicing, add oil so that the compressor oil level is between min ¼ and max ¾ of the sight glass.

2.4.2 Application limits

CAUTION
Inadequate lubrication! Compressor breakdown! The superheat at the compressor suction inlet must always be sufficient to ensure that no refrigerant droplets enter the compressor. For a typical evaporator-expansion valve configuration a minimum stable superheat of at least 10 K is required.

For application envelopes and technical data, please see Select software available at www.climate.emerson.com/en-gb.

2.4.3 PED category and maximum allowable pressure PS

The Pressure Equipment Directive PED 2014/68/EU does not apply to 2D*, 3D* and 8D* semi-hermetic compressors.

The pressure PS is the maximum allowable pressure at the low- and high-pressure sides of the compressor. The maximum pressure value PS for the individual compressor type is printed on the nameplate of the compressor. Safety is established in compliance with the relevant standards applicable to the given product. Also refer to **section 3.2.6 "Maximum allowable pressures"**.

Compressor	PS High-pressure side	PS Low-pressure side
2D*, 3D* & 8D*	32.5 bar(g)	22.5 bar(g)

Table 3: Maximum allowable pressures

2.5 Design features

2.5.1 Compressor construction

The semi-hermetic compressors covered in these guidelines are suction-gas cooled compressor models 2D*, 3D* and 8D* with 2, 3 and 8 cylinders respectively and a displacement between 16.8 and 181 m³/hr. They are fitted with Discus™ valve plates.

Each cylinder head has a plugged 1/8" - 27 NPTF tapped hole for connecting a high-pressure switch. The high-pressure switches must be calibrated and tested before putting the compressor into service. They must stop the compressor if the allowable pressure is exceeded.

The complete cylinder head is under discharge pressure.

2.5.2 Compressor cooling

With suction-gas cooled compressors, the motor is cooled by the incoming refrigerant, which enters the compressor and is then passed over the motor area. An additional fan may be required depending upon the operating conditions – see Select software at www.climate.emerson.com/en-gb.

2.5.3 Liquid injection / Demand cooling

WARNING
Ignition source in a potentially flammable atmosphere! Fire hazard! The solenoid valve of the liquid injection is not an ignition source during normal operation in an A2L-refrigerant system but could become one if not installed properly. Never operate the solenoid coil when not positioned on the solenoid valve. Secure the installation with a screw.

Liquid injection may be required for low-temperature applications in order to keep the compressor within safe discharge temperature limits.

Additional liquid cooling can be applied in the low-temperature model versions of 2D* and 3D* compressors. With this solution, an additional discharge temperature sensor, a separate Demand Cooling driver and a liquid injection valve kit work together.

For more information also see **Section 4.6 "Demand Cooling™"**.

NOTE: **For corresponding application envelopes, please see Select software available at www.climate.emerson.com/en-gb.**

2.5.4 Unloaded start

WARNING
Ignition source in a potentially flammable atmosphere! Fire hazard! The solenoid valve of the unloaded start is not an ignition source during normal operation in an A2L-refrigerant system but could become one if not installed properly. Never operate the solenoid coil when not positioned on the solenoid valve. Secure the installation with a screw.

Unloaded start is mainly required for compressors connected for part-winding start (for example with motor version AWM) or star-delta start (motor version EWM).

2.5.4.1 Unloaded start for 2D* and 3D* models

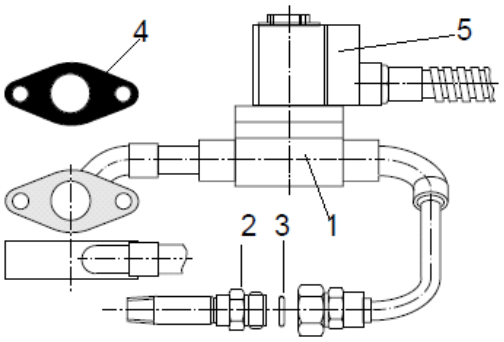
As a result of the compressor design of the 2D* and 3D* models, the components for unloaded start are mounted outside the compressor housing. The unloaded start kit consists of a very short bypass line that connects the high-pressure side of the compressor to the suction side. A solenoid valve is installed in this bypass line.

When the compressor is switched on, the solenoid valve opens the bypass line and holds it open during the starting phase. The refrigerant vapour is short-circuited without any significant increase in pressure, and the motor is unloaded.

After completion of the starting procedure, ie, after energizing of the second part-winding or changeover from star to delta or short-circuiting of starting resistors, the solenoid valve is de-energized, closing off the bypass line.

A Non-Return Valve (NRV) must be installed in the discharge line to prevent the refrigerant from flowing back from the condenser to the suction side.

The kit consists of the following parts:



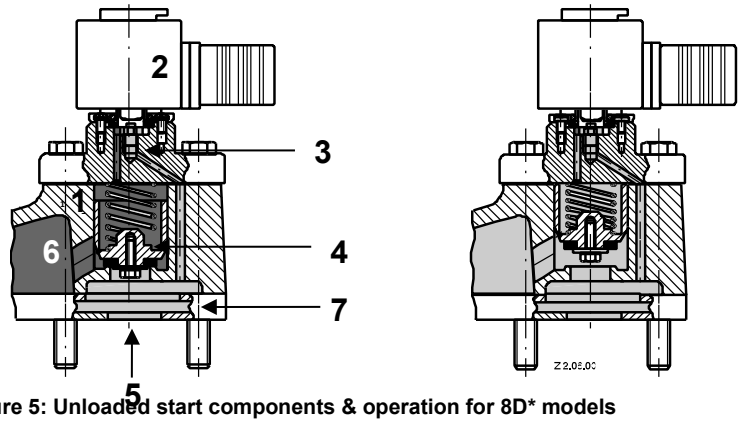
- **1 x Pipe assembly and valve body (1)**
- **1 x Rotalock stub (2)**
- **1 x Rotalock seal (3)**
- **1 x Gasket - flange to cylinder head (4)**
- **1 x Gasket - flange to Rotalock valve (4)**
- **1 x Solenoid valve coil (5)**
- **1 x Check valve**
- **x Screws ½" – 13 UNC X 2¾"**

Figure 4: Unloaded start components for 2D* and 3D* models

2.5.4.2 Unloaded start for 8D* models

8D* compressors can be equipped with an internal unloaded start system, to be ordered as an option. The compressor prepared for unloaded start is supplied with a special cylinder head. The control valve and coil are positioned on the top of the cylinder head. An additional check valve must be installed in the discharge piping. Recommended inbuild position for the check valve is approximately 50-100 cm to the compressor discharge connection.

A. Standard operation **B. Unloaded start operation**



1 **Special cylinder head**
2 **Solenoid**
3 **Valve**
4 **Spring-loaded control piston**
5 **Suction side**
6 **High side in the cylinder head**
7 **Valve plate**

Figure 5: Unloaded start components & operation for 8D* models

Usually, the unloaded start is activated once for about 5-10 seconds shortly before compressor start and then kept closed during operation. The unloaded start solenoid valve opens a suction channel in the valve plate and the pressure in the discharge line equalizes to the suction side.

Assembly

Installation of the modified cylinder head and valve plate for unloaded start is only possible at certain positions on the compressor. Therefore all 8D* compressor models have fixed cylinder head positions for unloaded start.

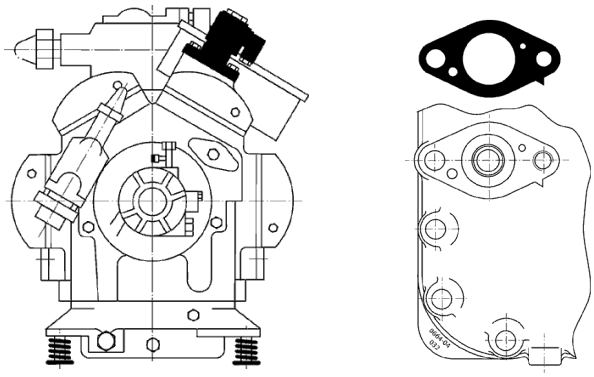


Figure 6: Unloaded start position for 8D* models

2.5.5 Capacity control

WARNING
Ignition source in a potentially flammable atmosphere! Fire hazard! The solenoid valve of the capacity control is not an ignition source during normal operation in an A2L-refrigerant system but could become one if not installed properly. Never operate the solenoid coil when not positioned on the solenoid valve. Secure the installation with a screw.

A mechanical capacity control is available for 8D* compressors. The system used is blocked suction. The suction port of the valve plate will be closed by a control piston. When an 8D* compressor is ordered with capacity control, it is equipped with one or two special cylinder heads. The capacity control valves with coils are positioned on the top of the cylinder head. Not all cylinder bank positions are possible for the capacity control cylinder head.

Capacity control must be fitted in the following positions:

- 8D* 1st step 25 % Lower cylinder head on terminal box side
- 8D* 2nd step 50 % Lower cylinder head on discharge valve side

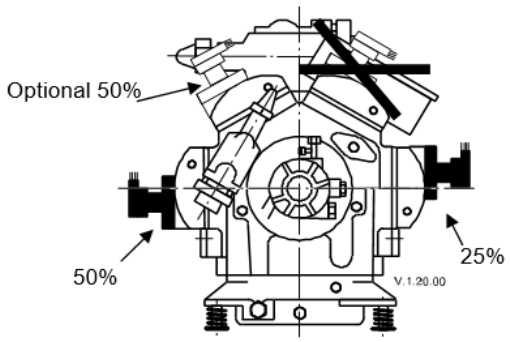


Figure 7: Capacity control position on 8D* models

2.5.6 Oil pump

All 2D*, 3D* and 8D* compressors are equipped with an external oil pump. The oil pump will always work in the correct direction of rotation, regardless of the rotation direction of the compressor. The compressors are designed to accommodate fittings for an OPS2 oil safety system (OPS2 oil sensor included in the oil pump) or any conventional oil pressure switch.

2.5.7 Oil pressure

Normal oil pressure is between 1 and 4.2 bar higher than crankcase pressure. Net oil pressure can be read by connecting two pressure gauges to the compressor and comparing the readings. One

gauge should be connected to the oil pump. The second gauge should be connected to the crankcase (oil service plug or any other crankcase connection plug).

NOTE: **The pressure measured on the suction service valve, where the refrigerant enters the compressor housing, does not correspond to the crankcase pressure and should not be used as a reference for the indication of oil differential pressure.**

2.5.8 Oil circulation

Oil returns with the suction gases through a suction strainer and separates in the motor chamber reaching the crankcase by way of oil return relief valve in the partition between motor housing and crankcase. This relief valve closes on compressor start-up due to the pressure difference arising between motor side and crankcase, thus slowing down pressure decrease in the crankcase over a certain period of time. It reduces the foaming of the oil/refrigerant mixture that would occur if the pressure decreased rapidly.

The valve does not reopen until the pressure has been equalized by means of a crankcase ventilating valve. This second valve connects the crankcase and suction side cylinder head. It reduces the pressure difference by means of a very small bore in the plate of the valve so slowly that oil foams less and only limited oil/refrigerant foam is transferred to the oil pump.

2.5.9 Oil level

The 2D*, 3D* and 8D* compressors are supplied with sufficient oil for normal operation – see individual oil quantities in Select. The optimum oil level should be checked by operating the compressor until the system is stable then comparing the sight glass reading with the corresponding oil level in **Figure 8** below. For 8-cylinder compressors, a higher oil level may be accepted if an oil regulator is used.

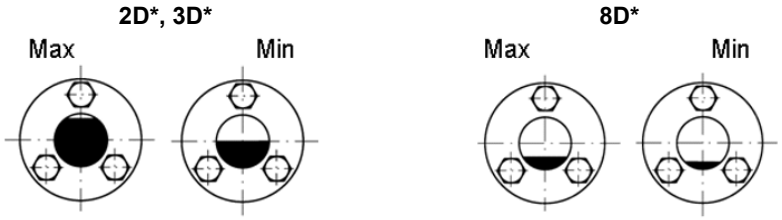


Figure 8: Oil level

2.5.10 System oil return

CAUTION
Inadequate lubrication! Bearing and moving parts destruction! Ensure adequate oil return from the system into the compressor at any time. No liquid refrigerant return to the compressor. Liquid refrigerant dilutes the oil, could wash the oil off the bearings and moving parts and could lead to overheating and compressor failure.

The system piping must be carefully designed to ensure sufficient refrigerant gas velocity, so that oil returns to the compressor at all times and conditions. Individual piping diameter calculation depends on the refrigerant properties, pressure level, mass flow, and density.

Once a new system design is set and assembled, a functional test is required. The functional test includes a qualification for the general system oil return. Systems with multiple compressors (two, three, or more) require additional oil balancing qualification between the parallel compressors.

System engineers should review the system design and operation to identify the critical conditions and to check oil return and oil balancing. Typically, the following situations should be considered:

- **In single compressor systems:** to check oil return, testing conditions shall be at minimum mass flow and minimum density of suction gas in continuous and frequent start/stop-cycling.
- **In multiple compressor systems:** to check oil return and oil balancing in the tandem or rack, testing conditions shall be at the corner points of the system application envelope in continuous and frequent start/stop-cycling.
- The system shall also be tested with regards to liquid refrigerant flood-back and the superheat level of the refrigerant gas at compressor suction.

These checks should be carried out for standard operation, but also for special conditions such as compressor frequent start/stop, compressor start after long off time with migration, defrost, low load, load changes, fans or pumps cycling at low load and more.

2.6 Dimensions

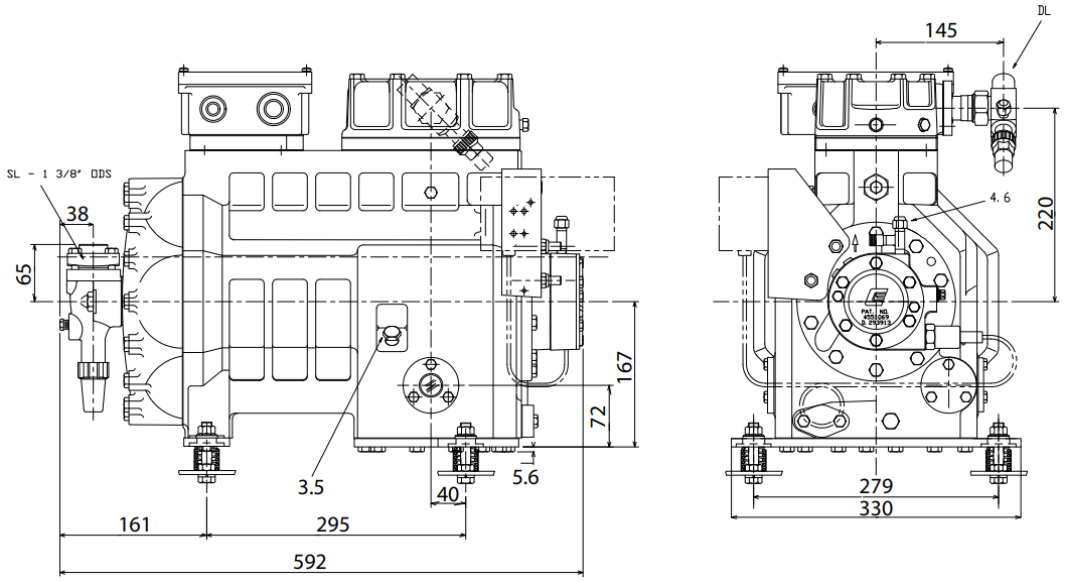


Figure 9: 2D* compressors dimensions

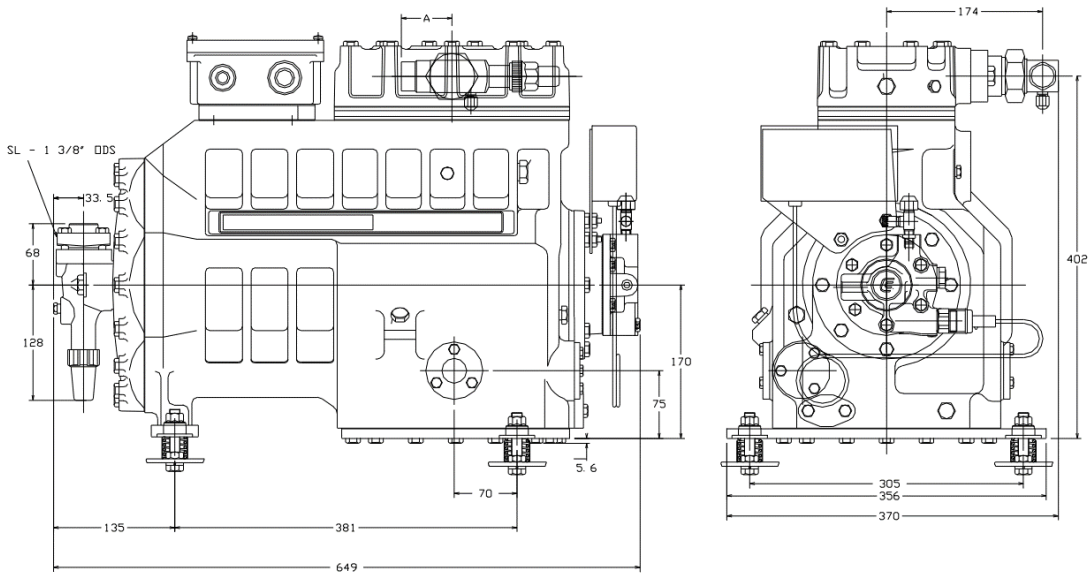


Figure 10: 3D* compressors dimensions

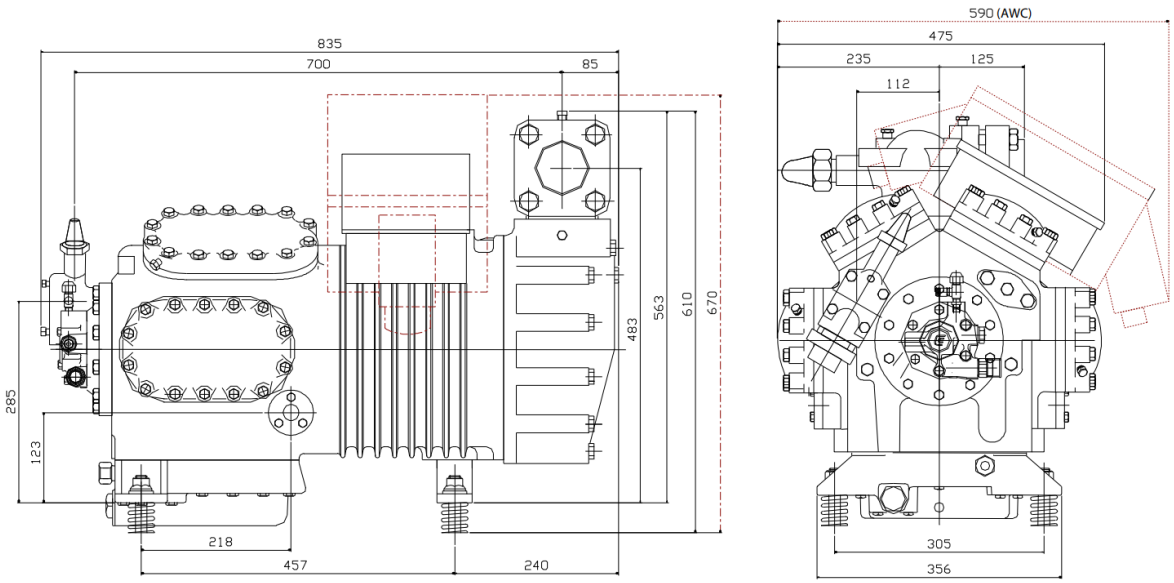


Figure 11: 8D* compressors dimensions

3 Installation

WARNING
High pressure! Injury to skin and eyes possible! Be careful when opening connections on a pressurized item.

3.1 Compressor handling

3.1.1 Delivery

Please check whether the delivery is correct and complete. Any deficiency should be reported immediately in writing. Standard delivery:

- Suction and discharge shut-off valves
- Oil charge, oil sight glass
- Mounting kit
- Motor protection system
- Holding charge up to 2.5 bar(g) (dry air)

Compressors are individually packed and may be delivered on pallets depending on quantity and size. Cooling fans are delivered in separate boxes. Accessories may be mounted or delivered loose. Solenoid valves are never mounted.

3.1.2 Transport and storage

WARNING
Risk of collapse! Personal injuries! Move compressors only with appropriate handling equipment according to weight. Keep in the upright position. Respect stacking loads according to **Figure 12**. Check the tilting stability and if needed take action to ensure the stability of the stacked loads. Keep the packaging dry at all times.

Respect the maximum number of identical packages which may be stacked on one another, where "n" is the limiting number:

- **Transport: n = 1 for 8D* / n = 2 for 3D* / n = 3 for 2D***
- **Storage: n = 1 for single box 8D* / n = 2 for 2D* & 3D***

Figure 12: Maximum stacking loads for transport and storage

***NOTE*: The compressor is pre-charged with dry air to avoid any moisture contamination.**

3.1.3 Positioning and securing

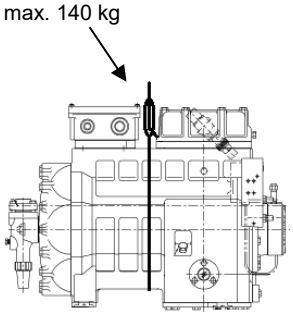
IMPORTANT
Handling damage! Compressor malfunction! Only use the lifting eyes whenever the compressor requires positioning. Using discharge or suction connections for lifting may cause damage or leaks.

If possible, the compressor should be kept horizontal during handling.

In order to avoid refrigerant leaks or other damage the compressors should not be lifted by the service valves or other accessories.

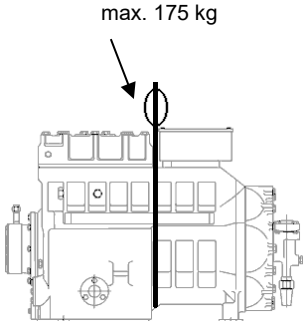
2D*

max. 140 kg



3D*

max. 175 kg



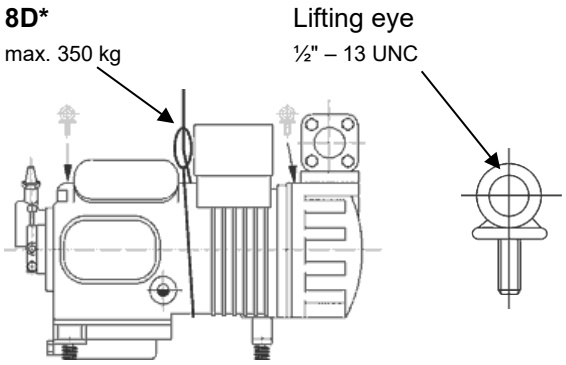


Figure 13: Compressor lifting methods

3.1.4 Installation location

Ensure the compressors are installed on a solid level base.

For multiple compressor parallel configurations, the compressors must be positioned completely vertically on a totally horizontal surface or rail.

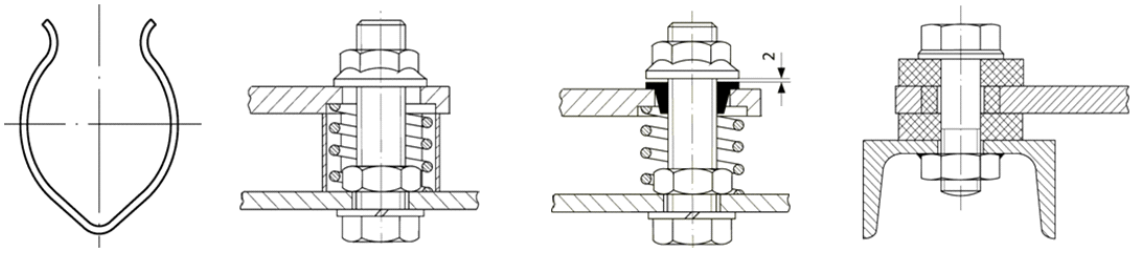
3.1.5 Mounting parts

To minimize vibration and start/stop impulses flexible mounting should be used. For this purpose one specific set of spring mounting parts is delivered with each compressor model.

A compressor may be rigidly mounted, ie, without springs. In this case more shock and vibration loading will be transmitted to the frame.

If the installation requires a very high level of vibration absorption, additional vibration absorbers – available on the market – can be fitted between the rails and the foundation.

To ensure proper lubrication of moving parts, the compressor should be installed horizontally on both axes.



Transport clamp | **Transport position** | **Operating position** | **Grommets for twin compressors**

Figure 14: Position of vibration dampers during transport and operation

3.2 Pressure safety controls

3.2.1 High-pressure protection

Applicable regulations and standards, for example EN 378-2, shall be followed to apply appropriate control and ensure that the pressure never exceeds the maximum limit.

High-pressure protection is required to stop the compressor operating outside the allowable pressure limits. The high-pressure control must be installed correctly, which means that no service valve is allowed between the compressor and the pressure protection.

The high-pressure cut-out setting shall be determined according to the applicable standard, the type of system, the refrigerant and the maximum allowable pressure PS.

The high-pressure cut-out should have a manual reset feature for the highest level of system protection.

3.2.2 Low-pressure protection

CAUTION
Operation outside the application envelope! Compressor breakdown! A low-pressure protection shall be fitted in the suction line to stop the compressor when it operates outside the envelope limits. Do not bridge or by-pass the low-pressure limiter.

CAUTION
Low suction pressure operation! Compressor damage! Do not operate compressor with a restricted suction or with the low-pressure limiter bridged. Do not operate compressor at pressures that are not allowed by the operating envelope. Allowing the suction pressure to drop below the envelope limit for more than a few seconds may overheat the pistons and cause damage to parts.

Applicable regulations and standards shall be followed to apply appropriate control and ensure that the pressure is always above the required minimum limit.

The low-pressure control must be installed correctly into the suction line, which means that no service valve is allowed between the compressor and the pressure protection.

The minimum cut-out setting shall be determined according to the refrigerant and the allowed operation envelope – see Select software at www.climate.emerson.com/en-gb.

The low-pressure cut-out should have a manual reset feature for the highest level of system protection.

3.2.3 Protection of A2L-refrigerant systems operating below atmospheric pressure

WARNING
Operation below atmospheric pressure! Fire hazard! During operation below atmospheric pressure, a flammable mixture can form inside the system. Ensure system tightness to prevent any ingress of air.

CAUTION
Operation outside the application envelope! Compressor breakdown! A low-pressure protection shall be fitted in the suction line to stop the compressor when it operates outside the envelope limits.

CAUTION
Low suction pressure operation! Compressor damage! Do not operate compressor with a restricted suction or with the low-pressure limiter bridged. Do not operate compressor at pressures that are not allowed by the operating envelope. Allowing the suction pressure to drop below the envelope limit for more than a few seconds may overheat the pistons and cause damage to parts.

Special requirements for safety and tightness apply to 2D*, 3D* or 8D* compressor systems that are to be operated below atmospheric pressure. The following precautions must be observed:

- Check all the critical points on the system and piping connections; tightness has to be ensured also at very low pressure.
- Minimum absolute working pressure: 0.5 bar.
- The installation of mechanical high-pressure and low-pressure cut-outs is mandatory. For systems provided with a service shut-off valve on the discharge side of the compressor, only mechanical pressure cut-outs shall be used. Electronic pressure limiters, which could cause delayed sensor response, are not allowed.
- The high- and low-pressure cut-outs must be installed correctly on the discharge and suction lines, which means that no service valve is allowed between the compressor and the pressure protection (refer to EN 378 or ISO 5149).
- A discharge temperature control is mandatory to stop the compressor when the maximum discharge temperature is exceeded.
- Additional warning notices shall be affixed to any system equipped with shut-off valves. The warnings must contain instructions to open the shut-off valves completely after each repair or

maintenance work. The compressors may only be energized when the safety measures (high- and low-pressure cut-outs and discharge temperature cut-out) have been checked and verified to be operational.

***NOTE:* All of the above points must be fulfilled. If any of them cannot be met, the compressor must not be operated below atmospheric pressure.**

3.2.4 Internal pressure relief valve

8D* compressors are equipped with an internal pressure relief valve placed between the suction chamber and the discharge chamber. The valve protects the compressor against bursting if the discharge shut-off valve is accidentally fully closed.

***NOTE:* The valve will not protect the installation against dangerous system pressures!**

Before operating the compressors, the pressure switches and other safety devices must be installed correctly. The maximum allowable pressures must not be exceeded.

Each cylinder head has a plugged 1/8" – 27 NPTF tapped hole for connecting a high-pressure switch.

3.2.5 Oil differential pressure control

The oil pressure switch breaks the control circuit when the pressure difference between the oil pump outlet and the crankcase is too low. If the oil differential pressure drops below the minimum acceptable value the compressor will be stopped after a 120-second delay. After having solved the problem the control has to be reset manually. The switch must be properly adjusted and tamper-proof.

The following oil pressure switches can be delivered as accessories:

- Electronic oil pressure switch OPS2
- Mechanical oil pressure switch Alco Controls FD-113ZU, applicable only with A1 refrigerants

For more information on the oil pressure switches and wiring diagrams, see **Section 4.7 "Oil differential pressure control"**.

***NOTE:* Proper oil pressure safety control with an approved switch is a condition of warranty!**

3.2.6 Maximum allowable pressures

The maximum allowable pressures according to EN 12693 are shown on the compressor nameplate. They are obligatory and must not be exceeded.

- High-pressure side (HP): 32.5 bar (g)
- Low-pressure side (LP): 22.5 bar (g)

***NOTE:* The compressor operating range may be restricted for various reasons. Check the application range limitations in Select software at www.climate.emerson.com/en-gb.**

3.3 Brazing procedure

WARNING
Air/flammable refrigerant mixture! Creation of a potentially flammable atmosphere! Fire hazard! Remove all refrigerant before opening the system. When working on a refrigerant-filled system, make sure to follow the safety and working instructions given in **Chapter 6 "Maintenance & repair"**.

WARNING
High temperature! Burning! Proceed with caution when brazing system components. Do not touch the compressor until it has cooled down. Ensure that other materials in the area of the compressor do not come into contact with it.

CAUTION
Blockage! Compressor breakdown! Maintain a flow of oxygen-free nitrogen through the system at very low-pressure during brazing. Nitrogen displaces the air and prevents the formation of copper oxides in the system. If allowed to form, the copper oxide material can later be swept through the system and block screens such as those protecting capillary tubes, thermal expansion valves, and accumulator oil return orifices.

CAUTION
Contamination or moisture! Bearing failure! Do not remove the connection plugs until the compressor is set into the unit. This minimises any entry of contaminants and moisture.

Refer to **Figure 15** and procedure below for the brazing of the suction and discharge lines:

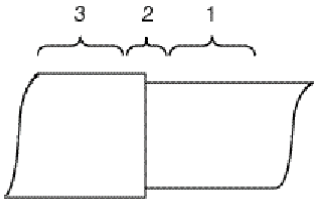


Figure 15: Brazing areas

- Flushing oxygen-free nitrogen through the piping during the brazing process is recommended for applications with A1 refrigerants and mandatory for applications with flammable A2L refrigerants.
- The copper-coated steel tubes on semi-hermetic compressors can be brazed in approximately the same manner as any copper tube.

- Recommended brazing material: any Silfos material is recommended, preferably with a minimum of 5 % silver. However, 0 % silver is acceptable. For brazing connections where dissimilar or ferric metals are joined a silver alloy rod with a minimum silver content of 30 % shall be used being either flux-coated or with a separate flux.
- Be sure tube fitting inner and outer surfaces are clean prior to assembly.
- Using a double-tipped torch, apply heat in area 1.
- As the tube approaches brazing temperature, move the torch flame to area 2.
- Heat area 2 until braze temperature is attained, moving the torch up and down and rotating around the tube as necessary to heat the tube evenly. Add braze material to the joint while moving the torch around the joint to flow braze material around the circumference.
- After the braze material flows around the joint, move the torch to heat area 3. This will draw the braze material down into the joint. The time spent heating area 3 should be minimal.
- As with any brazed joint, overheating may be detrimental to the final result.

3.4 Filter screens

CAUTION
Screen blocking! Compressor breakdown! Use screens with at least 0.6 mm openings.

The use of screens finer than 30 x 30 meshes (0.6 mm openings) anywhere in the system should be avoided with these compressors. Field experience has shown that finer mesh screens used to protect thermal expansion valves, capillary tubes or accumulators can become temporarily or permanently plugged with normal system debris and block the flow of either oil or refrigerant to the compressor. Such blockage can result in compressor failure.

3.5 Insulation material

Insulation material is commonly used in a system to insulate the suction line, suction accumulator, expansion valve bulb or discharge line thermostat. When choosing the insulation material for A2L applications, particular attention shall be paid to its non-electrostatic properties, as it could be a potential ignition source.

4 Electrical connection

4.1 General recommendations

The compressor terminal box has a wiring diagram on the inside of its cover. Before connecting the compressor, ensure the supply voltage, the phases and the frequency match the nameplate data.

When the compressor is shipped the motor protector is mounted in the terminal box. The thermistors are factory connected. The power supply and the control circuit must be wired according to the wiring diagram on the inside of the terminal box cover. For more information on the wiring diagrams, please also visit www.climate.emerson.com/en-gb.

The knockouts on the terminal box have to be removed before the electrical glands can be installed. First make sure that the terminal box is closed with its cover. Emerson recommends to use a subland twist driller to avoid any damage to the box while removing the knockouts.

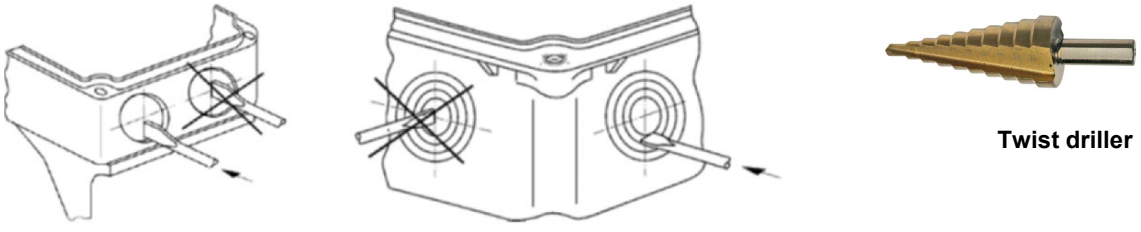


Figure 16: Terminal box preparation for cable gland fitting

Position at terminal box	Hole diameter at terminal box (mm)	Cable bushing metric	Outside diameter (mm)
1	20.6	M20 x 1.5	20
2	32.5	M32 x 1.5	32
3	50.5	M50 x 1.5	50
4	63.5	M63 x 1.5	63

Table 4: Characteristics of the holes for cable bushings

The protection class of each terminal box according to IEC 60529 is given in **Table 5** hereunder. Also refer to **Section 4.3 "Terminal box"**.

Models	Class	Option
2D*	IP54	-
3D*	IP54	IP56
8D*	IP54	IP56

Table 5: Protection class

For safety reasons, Emerson recommends that the electrical installation be executed in compliance with standard EN 60204-1 and/or other standards and regulations of application when dealing with A2L mildly flammable refrigerants such as R454C, R455A and R454A.

When installing 2D*, 3D* or 8D* compressors in A2L systems, the following measures must be taken:

- To ensure the wires are properly terminated, the correct terminal and clamping tool for the selected wire size must be used.
- The ground wiring must conform to local regulations and codes of practice (only the provided parts must be used).
- The grounding screw must be torqued to 4.5 to 5.7 Nm.
- A cable strain-relief device must be added.
- Cable and wires must be protected against sharp edges.

4.2 Electrical installation

WARNING
Conductor cables! Electrical shock hazard! Shut off power supply before undertaking any task on electrical equipment.

WARNING
Ignition source in a potentially flammable atmosphere! Fire hazard! The electrical connection of the compressor is not an ignition source during normal operation in an A2L-refrigerant system but could become one if not installed properly according to installation instructions. Ensure correct mechanical and electrical installation.
Follow the installation and torque instructions below.
System capacitors may remain charged for several minutes after shutdown. Before starting to work on the electrical installation make sure sparking is not possible. Continuously check if the ambient atmosphere is non-flammable when working on the electrical installation.

WARNING
Ignition source in a potentially flammable atmosphere! Fire hazard! Electrical connections of compressor accessories, eg, crankcase heater, solenoid valves, Copeland protection modules, etc. are not ignition sources during normal operation in A2L-refrigerant systems but could become one if not installed properly according to installation instructions. All cable ends must be fixed properly in the terminal blocks. Ensure permanent and safe connection of all cable connections.

NOTE: **For correct installation of the electrical fasteners on the terminal plate connections, a tightening torque of 8.5 to 9.6 Nm is required for the fixation of the nuts.**

NOTE: **It is recommended to install a residual current device (RCD) in any electrical system associated with 2D*, 3D* and 8D* compressors and A2L flammable refrigerants such as R454C, R455A and R454A. The purpose of the RCD is to detect current leaks to the ground in case of electrical issues, for example with the terminal connection pins or electrical accessories.**

Figure 17: Residual current device (RCD)

The 2D*, 3D* and 8D* compressors are available in different three-phase motor versions. They all can be started Direct-On-Line. In addition to the direct-online start, motor versions for part-winding or star-delta start can be used.

The position of bridges required for Direct-On-Line start (depending on type of motor and/or mains voltage) is shown in **section 4.2.3 "Terminal box jumpers positions**Terminal box jumpers position**"**.

4.2.1 Part-winding motors (YY/Y) – Code A

Part-winding motors contain two separate windings (2/3 + 1/3) which are internally connected in star and operated in parallel.

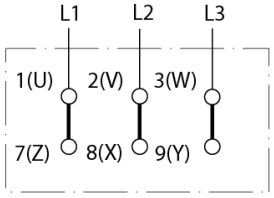
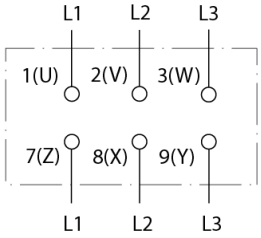
The first part-winding, ie, the 2/3 winding on terminals 1-2-3, can be used for part-winding start by removing the bridges. After a time delay of 1 ± 0.1 seconds the second part-winding, ie, the 1/3 winding on terminals 7-8-9, must be brought on line.

4.2.2 Star / Delta motors (Y/Δ) – Code E

This motor is interchangeable for star (Y) or delta (Δ) operation by means of bridges. It is suitable for two voltage ranges, eg, 220-240 V in delta, 380-420 V in star connection. If the supply voltage and the nominal voltage of the motor in Δ-connection are identical, the star connection motor can also be used for starting (remove bridges!).

4.2.3 Terminal box jumpers positions

Part-winding motors can be connected direct-on-line or part-winding start:

	Direct-on-line start Y-Y	Part-winding start First start step 1-2-3 Y-Y
Part-winding motor: Y-Y **Code A**		

Star / Delta motors can be connected direct-on-line or Star / Delta start:

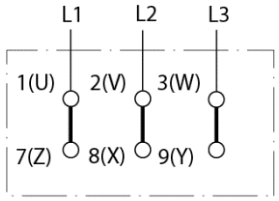
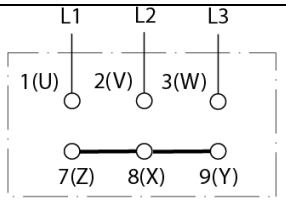
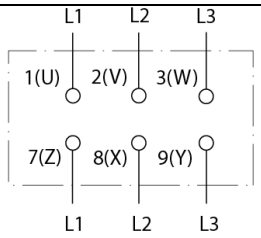
	Direct-on-line start Δ	Direct-on-line start Y	Star/Delta start Y-Δ
Star/Delta motor Y-Δ **Code E**			

Figure 18: Jumpers positions

4.3 Terminal box

WARNING
Ignition source in a potentially flammable atmosphere! Fire hazard!
Particular attention must be paid in A2L-refrigerant systems as any work on the energized terminals in the compressor terminal box could create an ignition. Do not touch the energized terminals with a tool or cable when the compressor is energized.
Compressors operating with flammable refrigerants shall use only the qualified terminal box supplied with the compressor.

The terminal box is IP54 for all 2D*, 3D* and 8D* semi-hermetic compressor models.

Cable glands have an influence on the protection class of the terminal box. Factory-fitted cable glands reduce the protection class to IP41. The use of appropriate cable glands is strongly recommended in order to maintain the IP protection class.

Figure 19: Cable glands

4.4 Electrical protection

Independently from the internal motor protection, fuses must be installed before the compressor. The selection of fuses has to be made according to VDE 0635, DIN 57635, IEC 269-1 or EN 60-269-1.

4.5 Compressor protection

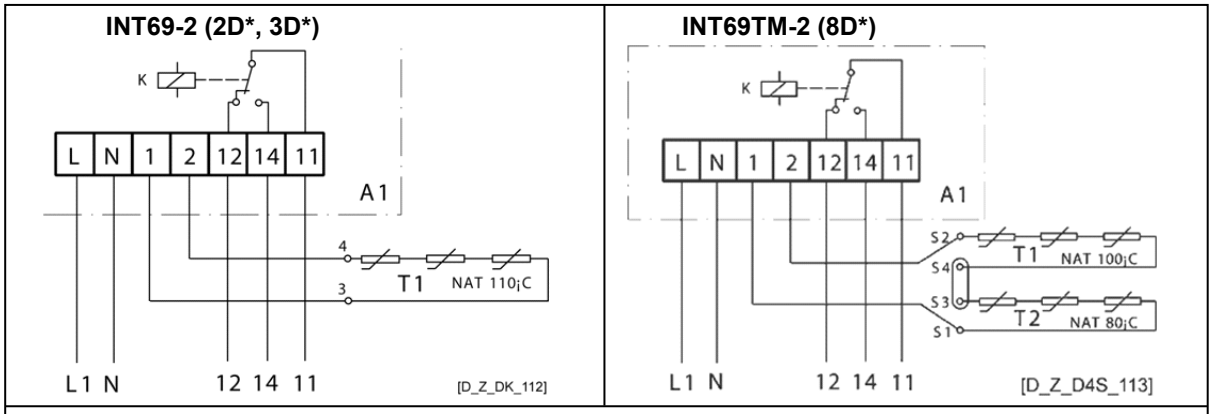
All Copeland 2D*, 3D* and 8D* compressor models are factory-fitted with a compressor protection. The letter "W" in the motor code of the 3-phase motors indicates a thermistor protection device. The temperature-dependent resistance of the thermistor (PTC-resistance) is used to sense the winding temperature. One chain of three thermistors (on 2D* and 3D* compressors) or two chains of three thermistors (on 8D* compressors), each connected in series, are embedded in the motor windings in such a manner that the temperature of the thermistors can follow with little inertia.

The 2D*, 3D* and 8D* compressors use the Kriwan modules INT69-2 and INT69TM-2, a new generation of thermistor protection that has the same main features as the previous one (INT69 & INT69TM). The motor protection module is connected to the thermistors in the terminal box. It switches a control relay depending on the thermistor resistance:

- INT69-2: one or two thermistor chains and 5-minute time delay
- INT69TM-2: two thermistor chains

Caution: The maximum test voltage for thermistors is 3 V.

The total resistance of the thermistor chains on a cold compressor should be ≤ 1800 Ω.



Legend

L ..... Voltage connection
N..... Neutral connection
1+2 ... Thermistor chain connection
12 ..... Alarm connection
14 ..... Control circuit
11 ..... Control voltage connection
A1..... Release module
3+4 ..... Cable bushings of thermistor connections in terminal box
S1-S4 .... Cable bushings of thermistor connections in terminal box (8D*)
T1+T2.... Thermistor chain (about 90 Ω to 750 Ω per chain at +20 °C)
NAT ..... Nominal response temperature

Figure 20: Internal wiring

Protection class of the protection module: IP20.

IMPORTANT
Different sources for power supply and contact 11-14! Module malfunction! Use the same potential for the power supply and the switch contact of the control loop (11-14).

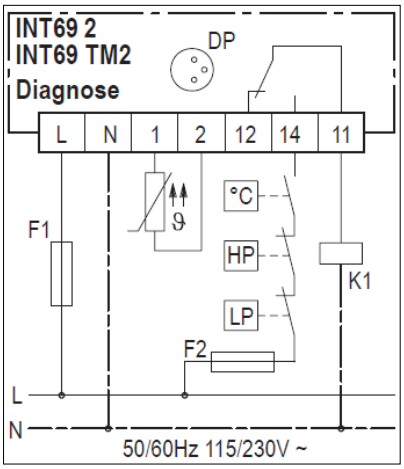


Figure 21: Control circuit wiring

4.6 Demand Cooling™

Liquid injection with "Demand Cooling™" can be used to extend application limits of 2D* and 3D* compressors in low-temperature applications with refrigerants such as R448A, R449A, R407A and R407F.

The Demand Cooling system uses modern electronics. A temperature sensor in the cylinder head measures the discharge temperature and gives temperature signals to the Demand Cooling driver. Once critical temperatures are reached, the driver energizes an injection valve which meters a controlled amount of saturated liquid refrigerant into the compressor suction cavity to cool the suction gas.

Demand Cooling is available as an optional compressor accessory. The Demand Cooling kit consists of temperature sensor, electronic driver, electronic expansion valve, parts for tubing, filter-dryer, sight glass and mounting bracket.

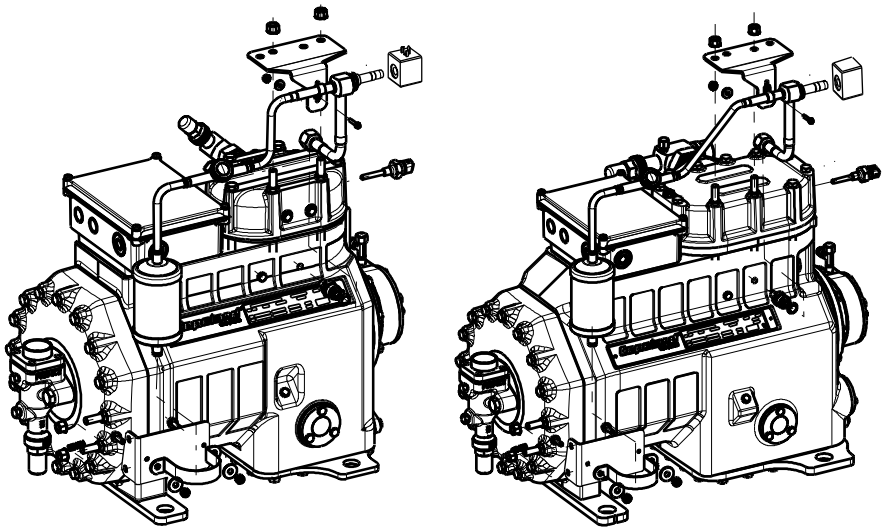


Figure 22: Injection parts on 2D* and 3D* compressors

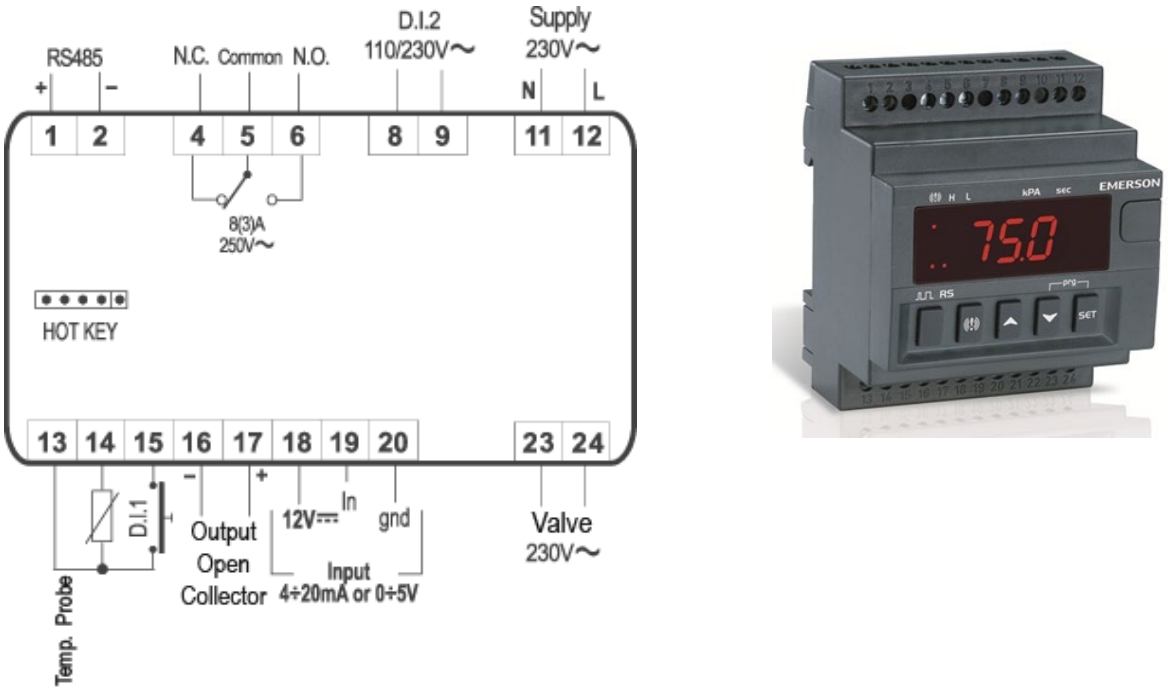
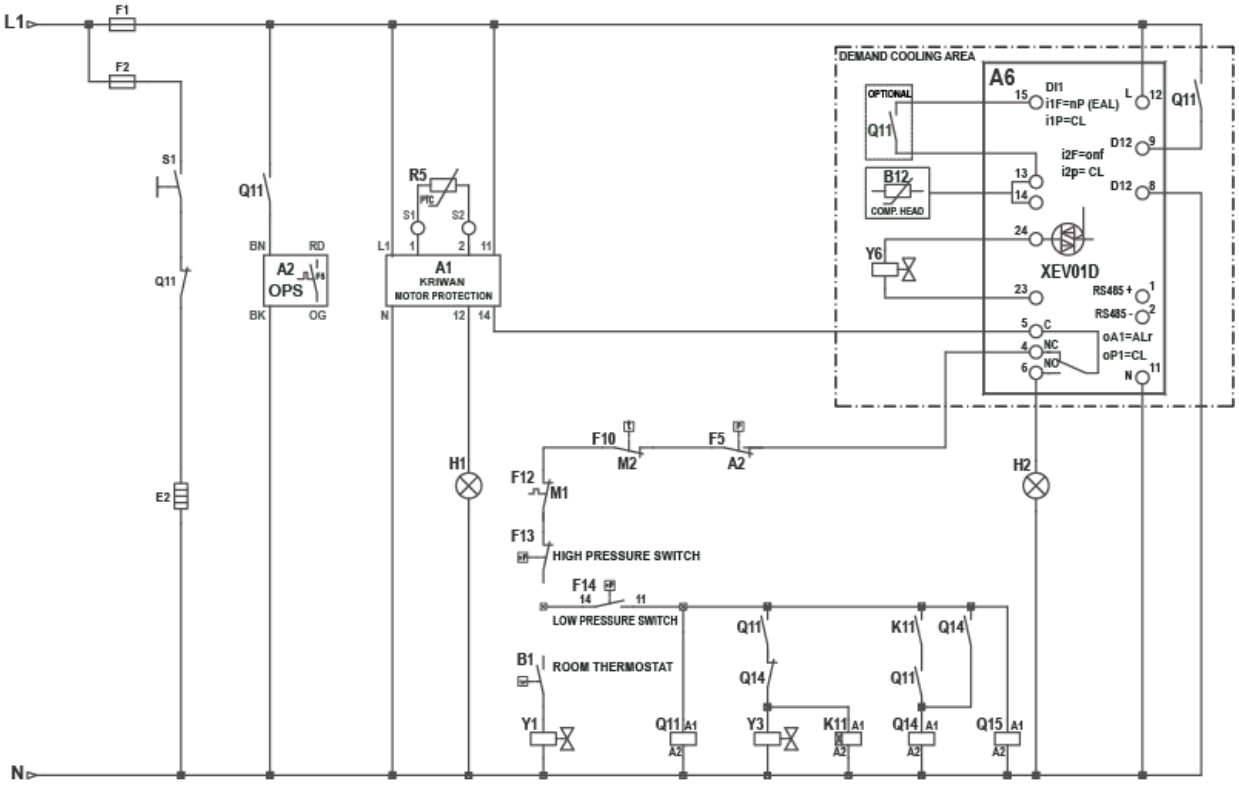


Figure 23: Demand Cooling driver connections



Legend

A1 ..... Kriwan motor protection
A2 ..... Oil pressure switch
A6 ..... Demand Cooling driver / XEV01D
B1 ..... Room thermostat
B12 ... Demand Cooling discharge temperature sensor
E2 ..... Crankcase heater
F1 ..... Fuse for control circuit
F2 ..... Fuse for crankcase heater
F5 ..... Fuse for oil pressure switch
F10 ... Fan motor thermal protection
F12 .... Compressor overcurrent protection
F13 ... High-pressure safety switch
F14 .... Low-pressure safety switch
H1 ..... Signal lamp / Kriwan module alarm
H2 ..... Signal lamp / Demand Cooling driver
K11 ... Time relay - delay part-winding start
M1 .... Compressor motor
M2 .... Additional fan motor
N ..... Neutral
Q11 .. Contactor for first part-winding
Q14 .... Contactor for second part-winding
Q15 .. Contactor for additional fan motor
R5 ..... Contactor for additional fan motor
S1 ..... Auxiliary switch for crankcase heater R2
Y1 ..... Solenoid valve liquid line
Y3 ..... Solenoid valve for unloaded start
Y6 ..... Demand Cooling injection valve

WH = White **BK** = Black **OG** = Orange **RD** = Red

Figure 24: Demand Cooling wiring diagram

4.7 Oil differential pressure control

4.7.1 Electronic oil pressure switch OPS2

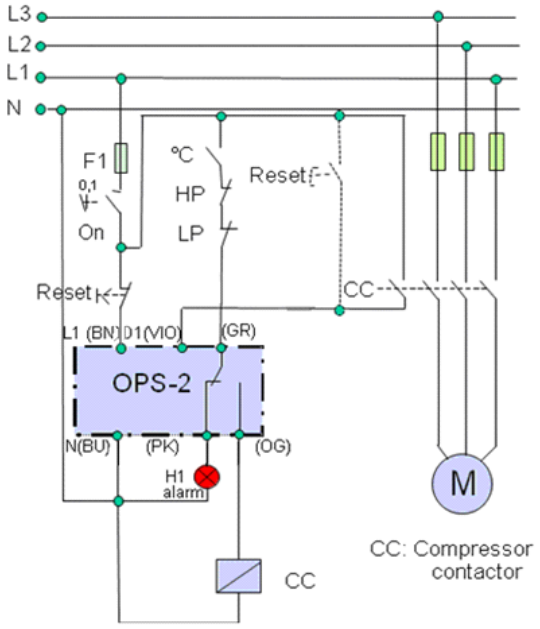
WARNING
Ignition source in a potentially flammable atmosphere! Fire hazard! The electronic oil pressure switch is not an ignition source during normal operation in an A2L-refrigerant system but could become one if not installed and connected properly.

The specifications for the OPS2 oil pressure switch are as follows:

- Differential pressure: 0.95 ± 0.15 bar
- Time delay: 120 ± 15 sec

Where there is a 5-wire cable connection between the electrical control panel and the compressor terminal box to the OPS module, the same wires can be applied to the OPS2 which will give the functions of an OPS1 module.

To obtain use of all of the features of the OPS2 a 7-wire cable between the electrical control cabinet and the compressor terminal box should be used. Wiring diagrams for OPS2 are shown in Technical Information D7.8.3 "DWM Copeland™ Semi-hermetic Compressor Oil Pressure Differential Switch OPS2" available at www.climate.emerson.com/en-gb. The wiring diagram in **Figure 25** below relates to an option using a 7-wire cable.



Wiring:

Brown (BN) = Power supply input

Violet (VIO) = Running signal from the compressor

Grey (GR) = Input changeover contact from the daisy chain

Orange (OG) = Output changeover contact linked to the compressor contactor

Pink (PK) = Output changeover contact linked to the alarm

Blue (BU) = Power supply output

Figure 25: Wiring diagram OPS2

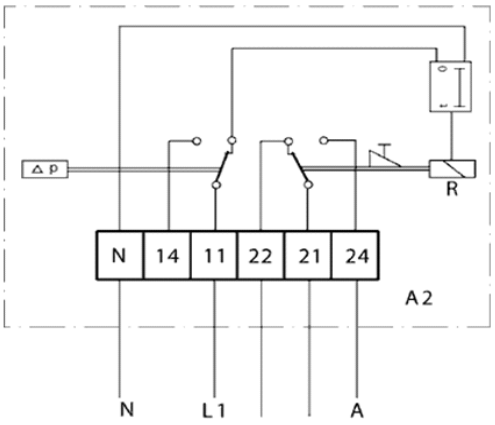
***NOTE:* Where a 5- or 7-wire cable is stated a 4- or 6-wire cable is required. In some countries only a 5- or 7-wire cable is available. See more information about OPS2 in Technical Information D7.8.3 "DWM Copeland™ Semi-hermetic Compressor Oil Pressure Differential Switch OPS2".**

4.7.2 Electro-mechanical oil pressure switch – Alco Controls FD-113ZU

The oil differential pressure switch FD-113ZU from Alco Controls is released for A1 refrigerants only. Application with A2L refrigerants is not possible.

The specifications for the FD-113ZU electro-mechanical oil pressure switch are as follows:

- Cut-out pressure: 0.63 ± 0.14 bar
- Cut-in pressure: 0.9 ± 0.1 bar
- Time delay: 120 ± 15 sec



Legend:
11 = Voltage connection
21 = Control voltage connection
22 = Control circuit
24 = Alarm connection
A5 = Compressor terminal box
R = Relay
N = Neutral connection
t = Time delay

Figure 26: Wiring diagram FD-113ZU

Protection class: IP30.

4.8 Crankcase heaters

WARNING
Ignition source in a potentially flammable atmosphere due to hot surface temperature! Fire hazard! The crankcase heater is not an ignition source during normal operation in an A2L-refrigerant system but could become one if not installed properly according to installation instructions.
Ensure correct mechanical installation of the crankcase heater into the sleeve or compressor housing. Use heat transfer paste for adequate heat transfer.

CAUTION
Overheating and burnout! Compressor damage! Never apply power to the crankcase heater in free air, before the crankcase heater is installed on the compressor or when it is not in complete contact with the compressor shell.

IMPORTANT
Oil dilution! Bearing malfunction! Turn the crankcase heater on 12 hours before starting the compressor.

A crankcase heater is used to prevent refrigerant from migrating into the shell during standstill periods.

The crankcase heater must remain energized during compressor off cycles. The initial start-up in the field is a very critical period for any compressor because all load-bearing surfaces are new and require a short break-in period to carry high loads under adverse conditions.

The crankcase heater must be turned on a minimum of 12 hours prior to starting the compressor. This will prevent oil dilution and bearing stress on initial start-up.

4.8.1 70-Watt and 100-Watt heater element

- The 70-Watt heater for 2D* compressors is screwed into a pocket.
- Heaters for 3D* compressors are screwed into a sleeve – see **Figure 27**.

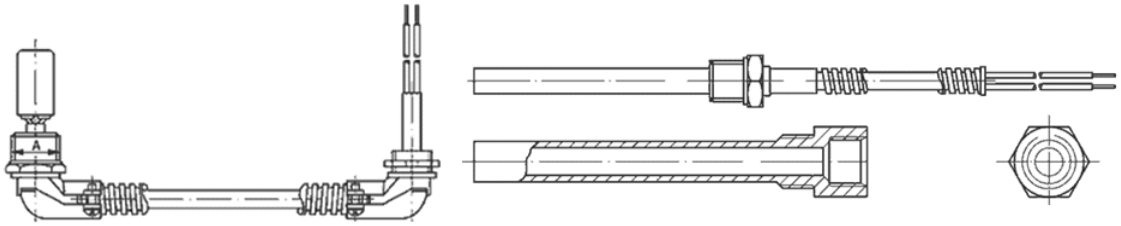
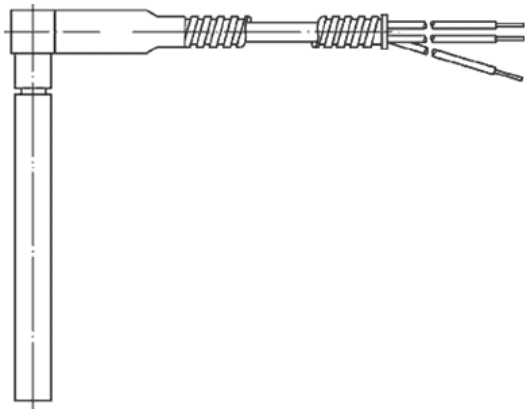
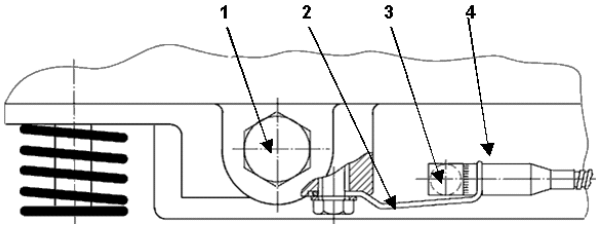


Figure 27: 70-Watt & 100-Watt crankcase heater elements

4.8.2 200-Watt heater element

In compressors equipped with a deep oil sump, the heater element is inserted into a special chamber and fixed to the compressor body.





1. **Magnetic plug**
2. **Securing piece**
3. **Heater element 200 W**
4. **Deep oil sump**

Figure 28: 200-Watt crankcase heater element

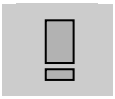
5 Start-up & operation

WARNING
Diesel effect! Compressor destruction! The mixture of air and oil at high temperature can lead to an explosion. Avoid operating with air.

WARNING
Air/flammable refrigerant mixture! Creation of a flammable atmosphere! Make sure the atmosphere is non-flammable before starting the system. Ensure that the system contains only refrigerant.

5.1 Compressor tightness test

WARNING
High pressure! Personal injuries! Consider personal safety requirements and refer to test pressures prior to test.



IMPORTANT
System contamination! Bearing malfunction! Use only dry inert gases (for example nitrogen) for leak testing. DO NOT USE other industrial gases.

The compressor has been tested for tightness in the Emerson factory.

All compressors get a factory holding charge of dry air (about 1 to 2.5 bar, relative pressure). The presence of an intact holding charge serves as a proof of quality against penetrating moisture.

When removing plugs from the compressor in order to connect a pressure gauge or to fill in oil, the plugs may pop out under pressure and oil can spurt.

Any later modification to compressor connections (plugs, screws, etc.) can have an impact on the compressor tightness. Always leak-pressure test the compressor after opening or modifying the connections.

Never add refrigerant to the test gas (as leak indicator).

5.2 System evacuation

Before the installation is put into commission, it has to be evacuated with a vacuum pump. For A2L systems, the vacuum pump and all tools have to be approved for A2L refrigerant/air mixture. The installation should be evacuated down to an absolute pressure of 3 mbar. Proper evacuation reduces residual moisture to 50 ppm. During the initial procedure, suction and discharge shut-off valves on the compressor remain closed. The installation of adequately sized access valves at the furthest point from the compressor in the suction and liquid lines is advisable. The pressure must be measured using a vacuum pressure gauge on the access valves and not on the vacuum pump; this serves to avoid incorrect measurements resulting from the pressure gradient along the connecting lines to the pump.

The highest demands are placed on the leak-proof design of the installation and on the leak testing methods – please refer to EN 378.

The whole installation including the compressor shall be tested for tightness before the system is charged with refrigerant. Procedure and acceptance criteria shall conform with the applicable standard, eg, EN 378.

5.3 Preliminary checks – Pre-starting

WARNING
Air/A2L refrigerant mixture in a potentially flammable or explosive atmosphere! Fire and explosion hazard! Whenever starting up a system charged with A2L refrigerant, eg, after filling, repair, or maintenance, make sure not to start and operate accidentally in a flammable or explosive atmosphere.

Discuss details of the installation with the installer. If possible, obtain drawings, wiring diagrams, etc. It is ideal to use a checklist but always check the following:

- no explosive atmosphere or flammable gas in the ambient, especially for systems with A2L refrigerants;

- suitable ventilation according to the room volume and to the refrigerant charge, especially for systems with A2L refrigerants;
- visual check of the electrics, wiring, fuses etc;
- cable glands in good state, all electrical connections well connected and terminal box closed to ensure corresponding IP protection;
- visual check of the plant for leaks, loose component parts such as TXV bulbs or solenoid valve coil, loose wires in electrical installation, etc;
- functional test of HP & LP switches and any pressure-actuated valves;
- check setting and operation of all safety features and protection devices;
- all valves in the correct running position;
- pressure and compound gauges fitted;
- correctly charged with refrigerant;
- compressor electrical auxiliary switch location and position.

5.4 Charging procedure

WARNING
Air/A2L refrigerant mixture in a potentially flammable or explosive atmosphere! Fire and explosion hazard! Only use filling equipment designed and approved for use and operation with A2L refrigerants. Make sure all connections are tight to avoid leakage. Make sure to fill with pure A2L refrigerant.

CAUTION
Low suction pressure operation! Compressor Damage! Do not operate compressor with a restricted suction or with the low-pressure cut-out bridged. Do not operate compressor at pressures that are not allowed by the operating envelope.

Prior to charging or re-charging, the refrigerant system must be leak- and pressure-tested with appropriate purging gas.

Ensure that the refrigerant system is grounded prior to charging with refrigerant, especially for systems with A2L refrigerants.

The system shall be liquid-charged through the liquid-receiver shut-off valve or through a valve in the liquid line. The use of a filter drier in the charging line is highly recommended. Systems shall be liquid-charged on both the high and low sides simultaneously to ensure a positive refrigerant pressure is present in the compressor before it runs. The majority of the charge shall be placed in the high side of the system to prevent bearing washout during first-time start on the assembly line.

Extreme care shall be taken not to overfill the system with refrigerant.

***NOTE:* For all systems with A2L refrigerants, the system manufacturer/installer must respect the charge limitations according to valid standards, such as EN 378.**

5.5 Initial start-up

CAUTION
Oil dilution! Bearing malfunction! It is important to ensure that new compressors are not subjected to liquid abuse. Turn the crankcase heater on 12 hours before starting the compressor.

CAUTION
High discharge pressure operation! Compressor damage! Do not use compressor to test opening setpoint of high-pressure cut-out. Bearings are susceptible to damage before they have had several hours of normal running in.

Liquid and high-pressure loads could be detrimental to new bearings. It is therefore important to ensure that new compressors are not subjected to liquid abuse and high-pressure run tests. It is not good practice to use the compressor to test the high-pressure switch function on the production line. The switch function can be tested with nitrogen prior to installation and the wiring can be checked by disconnecting the high-pressure switch during the run test.

Copeland 2D*, 3D* and 8D* compressors must be equipped with the correct accessories, according to Emerson documentation and considering the application intended. Make sure this requirement is met before start-up.

Bolt torque settings are listed in **Appendix 2**.

With the exception of rubber-coated metallic gaskets (Wolverine) all gaskets should be oiled before fitting. O-rings should also be oiled.

NOTE: **A compressor should never be operated beyond its approved application range! Check by consulting the appropriate data sheet. To avoid motor damage, NEVER start the compressor or carry out high-potential testing when the compressor is under vacuum.**

5.6 Minimum run time

Emerson recommends a maximum of 10 starts per hour. The most critical consideration is the minimum run time required to return oil to the compressor after start-up. The minimum on time becomes the time required for oil lost during compressor start-up to return to the compressor sump. Cycling the compressor for a shorter period than this, for instance to maintain very tight temperature control, will result in progressive loss of oil and damage to the compressor.

5.7 Recommended inverter range

2D*, 3D* and 8D* semi-hermetic compressors are released for inverter applications. However, the operation of semi-hermetic compressors with A2L refrigerants, eg, R454C, R455A or R454A and variable frequency has not been officially qualified at this time.

Over a frequency range the compressor system combination can have frequency bands with higher vibration. The degree of vibration and frequency bands are highly dependent on the system. To help reduce these vibration levels rubber mounting can be used on all inverter-driven compressors.

Active oil management should be used for all inverter-driven compressors.

Copeland compressors are released for operation with frequency variations from 25 to 60 Hz.

6 Maintenance & repair

WARNING
Conductor cables! Electrical shock hazard! Follow the lockout/tag out procedure and the national regulations before undertaking any maintenance or service work on the system.
Use compressor with grounded system only. Screwed electrical connections must be used in all applications. Refer to original equipment wiring diagrams. Electrical connections must be made by qualified electrical personnel.

WARNING
Explosive flame! Fire hazard! Oil/refrigerant mixtures are highly flammable. Remove all refrigerant before opening the system. Avoid working with an unshielded flame in a refrigerant-charged system.

WARNING
Ignition source in a potentially flammable or explosive atmosphere! Fire and explosion hazard! When opening an A2L-refrigerant system, the atmosphere could be explosive. All electrical components that are a source of ignition must always be switched off during service and maintenance. Ensure that the surface temperatures of the components never exceed the limits set by the applicable safety standard, eg, EN 378-2.
Air/flammable refrigerant mixture! Fire and explosion hazard! Remove all refrigerant before opening the system. Make sure to remove refrigerant completely from all components such as heat exchangers, refrigerant accumulators, etc. Flush the system and the components with inert gas before undertaking any work and before brazing.

WARNING
Open flame in a potentially flammable or explosive atmosphere! Fire and explosion hazard! The area shall be checked with an appropriate refrigerant detector prior to and during work on an A2L-refrigerant system, to ensure the technician is aware of a potentially toxic or flammable atmosphere. Ensure that the leak detection equipment being used is suitable for use with all applicable refrigerants.
Personnel performing work on a refrigeration system that involves exposing the pipework shall avoid using any ignition source in a way that could lead to a fire or explosion hazard. All sources of ignition shall be kept sufficiently far from the site of installation, repair, removal or disposal during the entire time when refrigerant could be released into the surrounding space.
Open flames and smoking are strictly forbidden at all times.
During service make sure that:
- the area is well ventilated;
- the materials and equipment used are suitable for use under flammable conditions;
- only non-sparking tools are used;
- antistatic gloves and clothes are used;
- build-up of electrostatic charges is avoided;
- no unshielded or naked flame is used.

If parts of the refrigeration system are charged with flammable refrigerant, make sure that all the valves are tightly closed and that the open pipes after the valves are free of refrigerant and oil.

WARNING
Air/flammable refrigerant mixture! Fire and explosion hazard! After opening the compressor for service or repair, ensure accurate closing and hermetic sealing of the opened parts. Check the sealing surface for any contamination and use new and proper gasket material. Use the correct tightening torques for screws and apply Loctite material wherever necessary. Always ensure adequate evacuation process and system leak check before re-filling with refrigerant.

A risk analysis to evaluate all possible risks shall be carried out by the service technician before any repair work on an A2L system.

The compressor shall be tested for tightness before it is charged with refrigerant. For proper tightness test, see applicable standards, eg, EN 378. All joints shall be tested with detection equipment with a capability of 5 g/year of refrigerant or better.

6.1 Qualification of workers

Personnel working on the maintenance, repair and decommissioning of an A2L-refrigerant system shall be adequately trained. Any work procedure affecting safety shall only be executed by qualified and trained personnel in compliance with national or other equivalent certification systems.

Examples of such work procedures are:

- breaking into the refrigerating circuit;
- opening sealed components;
- opening ventilated enclosures…

6.2 Preparation and work procedure

For all A2L-refrigerant systems, a work procedure shall be provided in the preparation stage. All personnel working at the site, whether maintenance or other, shall be instructed on the nature of the work being carried out.

If any work is to be conducted on the refrigeration systems or any associated parts, appropriate fire extinguishing equipment shall be provided. Dry powder or CO_2 fire extinguishers are considered appropriate. Confirm that appropriate fire extinguishing equipment is available near the work area.

Prior to starting to work on systems containing flammable refrigerants, safety checks are necessary to ensure that the risk of ignition is minimized.

Work shall be undertaken under a controlled procedure so as to minimize the risk of a flammable gas or vapour being present while the work is being performed.

Avoid working on systems filled with flammable refrigerant in a confined space.

6.3 Unbrazing system components

WARNING
Explosive flame! Fire hazard! Oil-refrigerant mixtures are highly flammable. Remove all refrigerant before opening the system. Avoid working with an unshielded flame in a refrigerant-charged system.

Before opening up a system it is important to remove all refrigerant from both the high and low sides of the system. If a brazing torch is then applied to the low side while the low side shell and suction line contain pressure, the pressurized refrigerant and oil mixture could ignite when it escapes and contacts the brazing flame. To prevent this occurrence, it is important to check both the high and low sides with manifold gauges before unbrazing. Instructions should be provided in appropriate product literature and assembly (line repair) areas. If compressor removal is required, the compressor should be cut out of system rather than unbrazed.

6.4 Disassembling system components

Follow the steps described hereunder when disassembling system components:

1. For A1-refrigerant systems (R448A, R449A, R407A, R407F, R404A, R407C, R513A, R450A and R134a), recover refrigerant and evacuate system using a recovery unit and vacuum pump. All the refrigerant shall be recovered to avoid significant release.
2. For A2L-refrigerant systems (R454C, R455A and R454A), recover refrigerant and evacuate system using an A2L-dedicated recovery unit and vacuum pump. Ensure that the outlet of the vacuum pump is not close to any potential ignition source and that ventilation is available.
3. Flush system with inert gas (dry nitrogen). Compressed air or oxygen shall not be used for purging refrigerant systems.
4. For A2L-refrigerant systems, the procedure of evacuation and flushing with oxygen-free nitrogen may need to be repeated until no refrigerant is present in the system. When the final oxygen-

free nitrogen charge is used, the system shall be vented down to atmospheric pressure to enable work to take place.

5. Disassemble components with a cutting tool.
6. Drain, recover and dispose of compressor oil as appropriate.

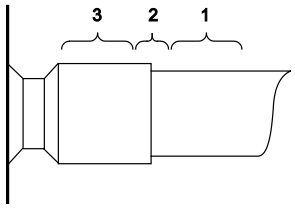


Figure 29: Tube connecting areas

To disconnect:

- Using a pipe cutting tool, cut off the suction and discharge lines in such a manner that the new compressor can easily be re-connected into the system.
- Heat joint areas 2 and 3 slowly and uniformly until the braze material softens and the tube end can be pulled out from the fitting.

To reconnect:

- Recommended brazing material: Silfos with minimum 5 % silver or silver braze used on other compressors.
- Due to the different thermal properties of steel and copper, brazing procedures may have to be changed from those commonly used.

6.5 Exchanging the refrigerant

WARNING
Air/A2L mixture in a potentially flammable or explosive atmosphere! Fire and explosion hazard! For applications with A2L refrigerants, air/A2L mixture in the refrigeration system must be avoided in any case. Make sure that the system is filled with pure A2L refrigerant. In the event that the refrigerant needs replacing, the charge should be recovered using A2L-qualified refrigerant recovery unit and recycling bottles.

CAUTION
Low suction pressure operation! Compressor damage! Do not operate compressor with a restricted suction or with the low-pressure limiter bridged. Do not operate compressor at pressures that are not allowed by the operating envelope. Allowing the suction pressure to drop below the envelope limit for more than a few seconds may overheat the pistons and cause damage to parts.

Qualified refrigerants and oils are given in **Section 2.4.1**.

It is not necessary to replace the refrigerant unless contamination, for example due to an error such as topping up the system with a non-condensable gas or incorrect refrigerant, is suspected. To verify correct refrigerant composition, a sample can be taken for chemical analysis. A check can be made during shutdown by comparing the refrigerant temperature and pressure using precision measurements at a location in the system where liquid and vapour phases are present and when the temperatures have stabilised.

6.6 Replacing a compressor

CAUTION
Inadequate lubrication! Bearing destruction! For systems with refrigerant accumulator, exchange the accumulator after replacing a compressor with a burned-out motor. The accumulator oil return orifice or screen may be plugged with debris or may become plugged. This will result in starvation of oil to the new compressor and a second failure.
Remove the refrigerant and oil completely from the replaced compressor.

6.6.1 Compressor replacement

When replacing an A2L-refrigerant compressor, the oil has to be drained out of the compressor and the compressor should be flushed with dry nitrogen. DO NOT close the stubs with plugs.

In the case of a motor burnout, the majority of contaminated oil will be removed with the compressor. The rest of the oil is cleaned through the use of suction and liquid line filter driers. A 100 % activated

alumina suction line filter-dryer is recommended but must be removed after 72 hours. When a single compressor or a compressor in a parallel configuration is exchanged in the field, it is possible that a major portion of the oil may still be in the system. While this may not affect the reliability of the replacement compressor, the extra oil will add to rotor drag and increase power usage.

6.6.2 Compressor return procedure for A2L systems

Compressors from A1-refrigerant systems can be sent back to Emerson for diagnosis with closed suction and discharge valves and the oil filling inside. However, the refrigerant should be removed first. In addition, the warning sticker with the flammable symbol should be removed so that the compressors are not misdeclared on receipt at the factory.

For all systems with A2L refrigerants, if a compressor has to be returned to the manufacturer for analysis, the refrigerant and the oil have to be removed completely. For the shipping process, all compressor connections must remain open and warning stickers for flammable refrigerant must be placed on the shipping box.

- During the entire working procedure continuously check if the ambient atmosphere is flammable. If a flammable atmosphere is detected, ensure proper ventilation of the working space and immediately cut-off the power supply.
- Resume working after the atmosphere is no longer dangerous.
- Recover the refrigerant from the system using a suitable recovery unit. During this action, the compressor crankcase heater could be energized – immediately de-energize in case a flammable atmosphere is detected.
- Recover to 3 mbar absolute pressure or lower. For best results and to recover also the refrigerant dissolved in the oil, run the recovery unit two or three times as necessary.
- Flush the whole system with oxygen-free dry nitrogen.
- Disassemble the compressor by removing the discharge and suction valves or using a cutting tool. Drain and recover compressor oil properly. Purge the compressor with dry nitrogen again for a few minutes.
- The compressor should be returned free of oil and with connections open – do not close connections with valves or plugs.
- Collect and secure the oil properly. Provide information about the quantity of oil drained from the compressor and its colour. Ideally, send a good picture.
- Dispose of the oil according to local rules and regulations.
- Use a proper cardboard box package when preparing the compressor for shipment. Place warning icons  on each side and on the top of the box. Mention the following message on the box: **"Warning! Flammable A2L refrigerant compressor for analysis"**.
- The compressor must be kept in the upright position – mark the box accordingly.
- If more than one compressor have to be returned, each compressor must be packed individually.

NOTE: **Check with the transport company that all the requirements that apply to such shipments are complied with.**

6.7 Lubrication and oil removal

WARNING
Air/A2L flammable refrigerant mixture! Flammable and explosive atmosphere! Fire and explosion hazard! When removing oil from an A2L-refrigerant system, use suitable recovery unit and recycling bottles also for oil disposal as A2L refrigerant may still be solved in the oil.

CAUTION
Chemical reaction! Compressor destruction! Do not mix up ester oils with mineral oil and/or alkyl benzene.

The compressor is supplied with an initial oil charge. The standard oil charge for use with 2D*, 3D* and 8D* compressors is a polyolester (POE) lubricant Emkarate RL 32 3MAF. See nameplate for original oil charge shown in litres. A field recharge is from 0.05 to 0.1 litre less. Oil recharge values can be taken from Select software at www.climate.emerson.com/en-gb.

One disadvantage of POE is that it is far more hygroscopic than mineral oil – see **Figure 30**. Only brief exposure to ambient air is needed for POE to absorb sufficient moisture to make it unacceptable for use in a refrigeration system. Since POE holds moisture more readily than mineral oil it is more difficult to remove it through the use of vacuum. The compressors supplied by Emerson contain oil with low moisture content, which may rise during the system assembling process. Therefore, it is recommended that a properly sized filter-drier be installed in all POE systems. This will maintain the moisture level in the oil to less than 50 ppm. If oil is charged into a system, it is recommended to use POE with a moisture content no higher than 50 ppm.

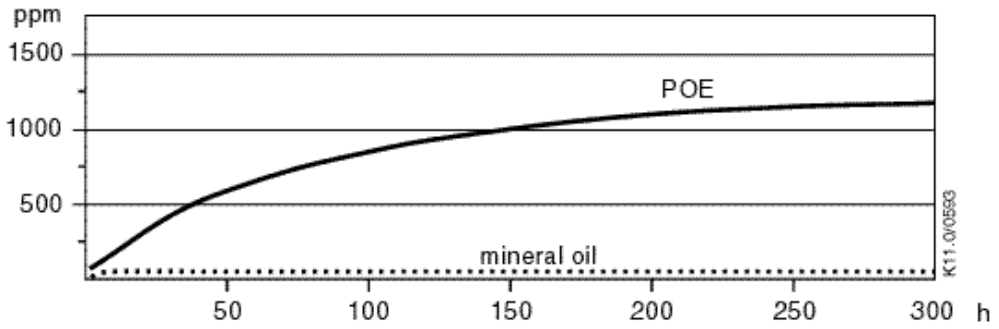


Figure 30: Absorption of moisture in ester oil in comparison to mineral oil in ppm by weight at 25 °C and 50 % relative humidity (h= hours)

If the moisture content of the oil in a refrigeration system reaches unacceptably high levels, corrosion and copper plating may occur. The system should be evacuated down to 3 mbar or lower. If there is uncertainty as to the moisture content in the system, an oil sample should be taken and tested for moisture. Sight glass/moisture indicators currently available can be used with the HFC refrigerants and lubricants; however, the moisture indicator will just show the moisture content of the refrigerant. The actual moisture level of POE would be higher than the sight glass indicates. This is due to the high hygroscopicity of the POE oil. To determine the actual moisture content of the lubricant, samples have to be taken from the system and analysed.

6.8 Oil additives

Although Emerson cannot comment on any specific product, from our own testing and past experience, we do not recommend the use of any additive to reduce compressor bearing losses or for any other purpose. Furthermore, the long-term chemical stability of any additive in the presence of refrigerant, low and high temperatures, and materials commonly found in refrigeration systems is complex and difficult to evaluate without rigorously controlled chemical laboratory testing. The use of additives without adequate testing may result in malfunction or premature failure of components in the system and, in specific cases, in voiding the warranty on the component.

7 Troubleshooting

The prevention of failures is one of the primary responsibilities of the installer. Otherwise the user will not get the benefit of factory-guaranteed quality.

7.1 Lubrication

Compressors are delivered with an initial oil charge. The correct oil level is shown in **Section 2.5.9 "Oil level"**.

Some, but not all lubrication problems are listed below:

- **Oil pump-out due to high on/off cycling rate:** The number of cycles should be limited to 10-12 per hour. A high cycling rate will pump oil into the system and lead to lubrication failure. Oil leaves the compressor at start-up and the short running time is insufficient to return the oil to the compressor via the suction side, the result being lubrication damage.
- **Incorrect calculation of pipe sizes:** It should be remembered that the entire system will be coated with oil to some extent. Oil viscosity changes with temperature. More oil stays in the system than was originally expected.
- **Low gas velocity:** System gas velocity changes depending on temperature and load (capacity control). In low load conditions the gas velocity may not be high enough to return oil to the compressor.
- **Faulty or badly designed oil return system.**
- **Incorrect pipework.**
- **Leaks.**

In time, lubrication problems lead to failure of the main moving parts. A standard oil pressure switch protects the compressor against low oil pressure if the problem lasts for some considerable time.

The typical breakdown symptom of a compressor with inadequate lubrication is failure of the bearing furthest away from the oil supply, the nearest having just enough oil to be properly lubricated.

7.2 Oil dilution

During the off-cycle a certain refrigerant concentration is always present in the compressor oil. This depends on the compressor temperature and crankcase pressure. The rapid reduction of pressure on start-up causes the refrigerant to evaporate from the oil. This causes oil foaming which can be seen in the compressor oil sight glass. The oil pump draws in significant amounts of diluted oil and foam and cannot build up oil pressure. If this cycle is repeated often enough bearing failure will eventually occur. To prevent this type of failure a crankcase heater and/or a pumpdown system should be fitted.

7.3 Inadequate suction superheat

The suction superheat should not fall below 10 K. Low superheat will cause valve plate, piston, cylinder wall and connecting rod damage. Low superheat can be caused by a defective or badly adjusted expansion valve, incorrect sensor bulb mounting or by very short refrigeration lines. If refrigeration lines are very short the installation of a heat exchanger or an accumulator is recommended.

7.4 Acid formation

Acid forms in the presence of moisture, oxygen, metal salts and metal oxides, and/or high discharge temperatures. The chemical reactions are accelerated at higher temperatures. Oil and acid react with each other. Acid formation leads to damage of the moving parts and in extreme cases to motor burn-out. Different test methods can be used to test for acid formation. If acid is present, a complete oil change (including the oil in the oil separator) will help. A suction filter that removes acid should also be fitted. Check filter-dryer condition.

7.5 Inadequate compressor cooling

For some compressor models and applications, cylinder head fans can be options to improve compressor cooling. If the fan does not provide sufficient cooling high discharge temperatures can result. The only solution is to fit an appropriate cooling fan.

7.6 High discharge temperatures

The limit is 120 °C measured on the discharge line a few centimetres from the service valve. Symptoms of high discharge temperatures are cutting-out on the high-pressure switch (dirty condenser), oil carbonisation, black oil and acid formation. Inadequate lubrication is the result. The condenser should be cleaned regularly. The evaporating temperature should not be allowed to fall below the application limit of the compressor.

7.7 Motor burnout due to undersized contactors

If contactors are undersized the contacts can weld. Complete motor burnout on all three phases despite the presence of a functioning protection system can be the result. If the application point of a compressor is changed the contactor sizing should be rechecked.

7.8 Motor burnout due to by-passed or disconnected protectors

If large sections of the windings are burned out, it must be assumed that the protector was either not connected or by-passed.

8 Dismantling & disposal

Removing oil and refrigerant:

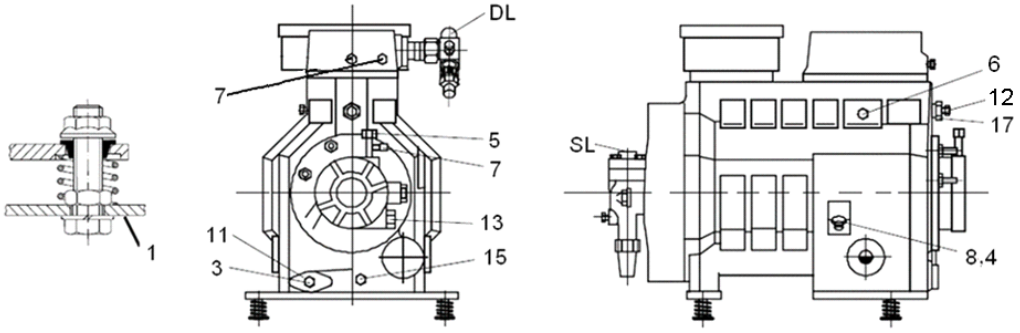
- **Do not disperse refrigerant in the environment.**
- **Use the correct equipment and method of removal.**
- **Dispose of oil and refrigerant in compliance with national legislation and regulations.**

Dispose of compressor in compliance with national legislation and regulations.

Appendix 1: Compressor connections

2D*

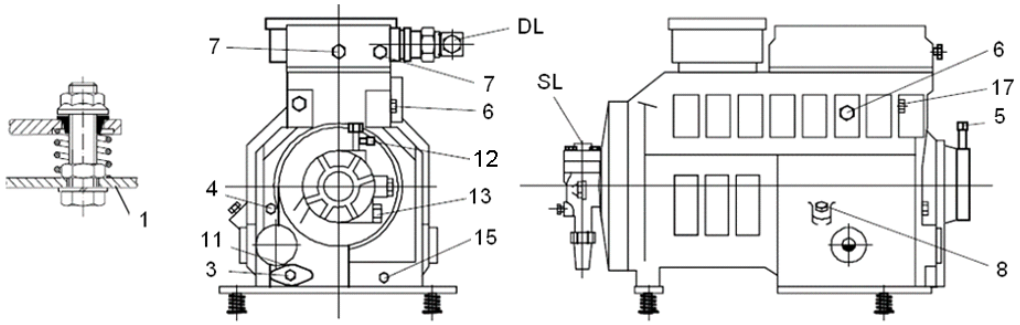
2DC-50 2DD-50
2DL-40 2DB-50
2DL-75 2DB-75



DL	Discharge line size (sweat) 2DC-50, 2DD-50, 2DL-40, 2DB-50	Ø 7/8"	DL	Discharge line size (sweat) 2DL-75, 2DB-75	Ø 1 1/2"
SL	Suction line size (sweat)	Ø 1 3/8"	8	Plug oil charge	1/4" - 18 NPTF
1	Base mountings	Ø 14 mm	11	Oil screen built-in	
3	Magnetic plug	1/8" - 27 NPTF	12	Oil pressure connection, Schraeder	7/16" - UNF
4	Plug oil-pressure control LP	1/4" - 18 NPTF	13	Sensor connection OPS	
5	Connection oil pressure control HP	1/4" - 6 mm	15	Sleeve (crankcase heater)	3/8" - 18 NPSL
6	Plug low-pressure connection	1/8" - 27 NPTF	17	Plug low-pressure connection	1/2" - 14 NPTF
7	Plug high-pressure connection	1/8" - 27 NPTF			

3D*

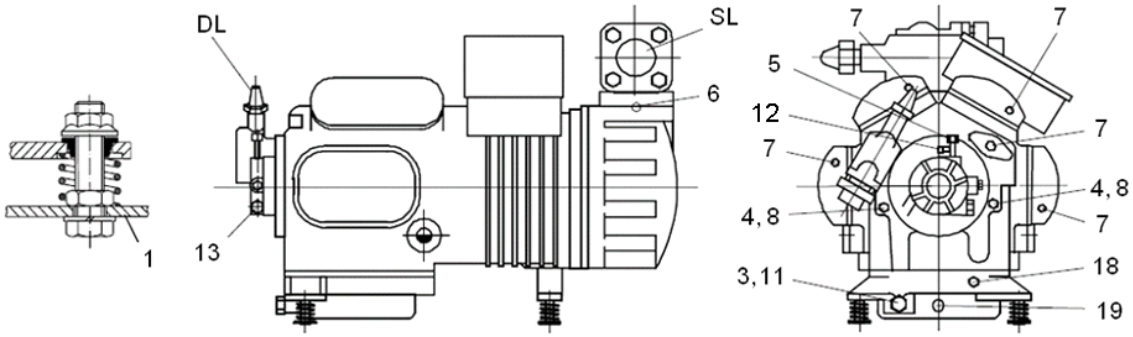
3DA-50 3DC-75 3DS-100
3DA-75 3DC-100 3DS-150



SL	Suction line size (sweat) 3DA-50, 3DA-75, 3DC-75, 3DC-100, 3DS-100	Ø 1 3/8"	DL	Discharge line size (sweat) 3DA-50	Ø 7/8"
SL	Suction line size (sweat) 3DS-150	Ø 1 5/8"	DL	Discharge line size (sweat) 3DA-75, 3DC-75, 3DC-100, 3DS-100, 3DS-150	Ø 1 1/8"
1	Base mountings	Ø 14 mm	8	Plug oil charge	1/8" - 18 NPTF
3	Magnetic plug	1/8" - 27 NPTF	11	Oil screen built-in	
4	Plug oil pressure control LP	1/4" - 18 NPTF	12	Oil pressure connection, Schraeder	7/16" - UNF
5	Connection oil pressure control HP	1/4" - 6 mm	13	Sensor connection OPS	
6	Plug low pressure connection	1/8" - 27 NPTF	15	Sleeve (crankcase heater)	3/8" - 18 NPSL
7	Plug high pressure connection	1/8" - 27 NPTF	17	Plug low pressure connection	1/2" - 14 NPTF

8D*

8DL-370 8DH-500
8DT-450 8DJ-600



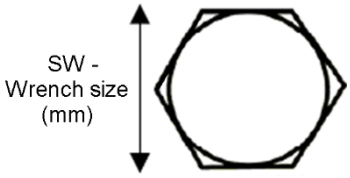
SL	Suction line size (sweat) 8DL-370, 8DH-500	Ø - 2 5/8"	SL	Suction line size (sweat) 8DT-450, 8DJ-600	Ø - 3 1/8"
DL	Discharge line size (sweat)	Ø 15/8"	8	Plug oil charge	1/4" - 18 NPTF
1	Base mountings	Ø 18 mm	11	Oil screen built-in	
3	Magnetic plug	1" - 16 UN	12	Oil pressure connection, Schraeder	7/16" - UNF
4	Plug oil-pressure control LP	1/4" - 18 NPTF	13	Sensor connection OPS	
5	Connection oil pressure control HP	1/4" - 6 mm	18	Plug crankcase heater	1/2" - 14 NPTF
6	Plug low pressure connection	1/8" - 27 NPTF	19	Bore crankcase heater	Ø 1/2"
7	Plug high pressure connection	1/8" - 27 NPTF			

Appendix 2: Tightening torques (Nm)

	2D*	3D*	8D*
Suction shut-off valve	1/2"-13 UNC 69 - 85 Nm SW 19		5/8"-11 UNC 104 - 164 Nm SW 23.8
Discharge shut-off valve [1)]	5/16"-18 UNC 33 - 39 Nm SW 12.7	1/2"-13 UNC 53 - 84 Nm SW 19	1/2"-13 UNC 53 - 84 Nm SW 19
Rotalock nut	1 3/4"-12 UNF 41 - 54 Nm SW 50		- - -
Plug 4, 8, 16	1/4"-18 NPTF 27 - 50 Nm SW 17.5		1/4"-18 NPTF 27 - 50 Nm SW 17.5
Plug 17	1/2"-14 NPTF 57 - 80 Nm SW 27.0		- - -
Plug 18 (crankcase heater)	- - -		1/2"-14 NPTF 45 - 57 Nm SW 17.5
Oil sight glass	1 1/8"-12 UNF 4.5 - 6 Nm SW 11	1/4"-20 UNC 4.5 - 6 Nm SW 11	
Blind flange for oil screen	5/16"-18 UNC 26 - 32 Nm SW 12.7		- - -
Blind flange for oil sight glass	1/4"-20 UNC 13 - 17 Nm SW 11.1		- - -
Oil pump	5/16"-18 UNC 31 - 37 Nm SW 12.6	5/16"-18 UNC 31 - 37 Nm SW 12.7	
Oil pressure switch - OPS2	60 - 75 Nm		

[1)] *Rotalock adapter*

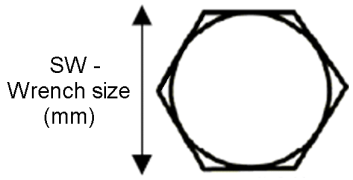
The ranges of torque values given in this specification are assembly torque. Torque after joint relaxation must be within 15 % of the minimum assembly torque unless re-torque is called for and must not be above 10 % of the maximum assembly torque.



	2D* & 3D*	8D*
Magnetic plug	1/8" - 27 NPTF 26 - 32 Nm SW 12.7	1"-16 UNC 87 - 149 Nm SW 25.4
Cylinder head	3/8"-16 UNC 57 - 68 Nm SW 14.2	3/8"-16 UNC 57 - 68 Nm SW 14.2
Bottom plate	3/8"-16 UNC 57 - 68 Nm SW 14.2	3/8"-16 UNC 57 - 68 Nm SW 14.2
Mounting foot	3/8"-16 UNC 57 - 68 Nm SW 14.2	3/8"-16 UNC 57 - 68 Nm SW 14.2
Stator cover	3/8"-16 UNC 57 - 68 Nm SW 14.2	1/2"-13 UNC 68 - 79 Nm SW 18
Housing cover	3/8"-16 UNC 57 - 68 Nm SW 14.2	3/8"-16 UNC 57 - 68 Nm SW 14.2
Mounting plate for terminals	5/16"-18 UNC 32 - 40 Nm SW 12.7	3/8"-16 UNC 57 - 68 Nm SW 14.2
Terminal stud	1/4"-28 UNF 5 - 6.5 Nm SW 10	1/4"-28 UNF 5 - 6.5 Nm SW 10
Terminal stud thermistors	10 - 32 UNF 3.4 - 4 Nm SW 9	10 - 32 UNF 3.4 - 4 Nm SW 9
Bolt for the connecting rod [2)]	1/4"-28 UNF 15 - 18 Nm "Torx"-screw	1/4"-28 UNF 15 - 18 Nm "Torx"-screw

[2)] *In case of replacement of the piston con-rod assemblies, clean the Torx screws and apply Loctite 2701.*

The ranges of torque values given in this specification are assembly torque. Torque after joint relaxation must be within 15 % of the minimum assembly torque unless re-torque is called for and must not be above 10 % of the maximum assembly torque.



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