Application Guidelines

Copeland™ Stream Semi-Hermetic Compressors for Use with CO_2 in Transcritical & Subcritical Applications

4MTL-05 to 4MTL-50, 4MSL-03 to 4MSL-15

COPELAND

About these guidelines

The purpose of these application guidelines is to provide guidance in the application of Copeland™ Stream semi-hermetic compressors in user's systems operating with CO_2 (R744). 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, contact Application Engineering as other considerations may apply.

1 Safety instructions

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

Copeland Stream CO_2 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. Conformity to local legislation and regulations must also be observed. For relevant standards please refer to the Manufacturer's Declaration, available at www.copeland.com/en-gb.

The Material Safety Datasheet (MSDS) for R744 shall be considered when working with this type of refrigerant – please check the document provided by the gas supplier.

These instructions should 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.		**CAUTION** This icon indicates instructions to avoid property damage and possible personal injury.
	High voltage This icon indicates operations with a danger of electric shock.		**IMPORTANT** This icon indicates instructions to avoid malfunction of the compressor.
	Danger of burning or frostbite This icon indicates operations with a danger of burning or frost burn.	***NOTE***	This word indicates a recommendation for easier operation.
	Explosion hazard This icon indicates operations with a danger of explosion.		

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.**

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 under 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
CO_2 refrigerant! Danger of suffocation! Never release significant volumes of CO_2 or the entire contents of the system into closed rooms. In case of closed room, if possible, keep the room well ventilated and/or install a CO_2 detection device. CO_2 is odourless and colourless, so it cannot be perceived directly in case of emission.

WARNING
High shell temperature! Burning! Do not touch the compressor or 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) or poly-alkylene glycol (PAG) lubricants 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™ Stream semi-hermetic compressors using CO_2 (R744). The series of 4MTL* transcritical models ranges from 5 to 50 hp; the series of 4MSL* subcritical models ranges from 3 to 15 hp. The performance values shown in **Table 1** are valid for 50 Hz supply frequency.

<table>
<tr><th>Compressor</th><th>Displacement (m³/h)</th><th>Cooling capacity Qo* (kW)</th><th>COP</th><th>Net weight (kg)</th><th>Footprint (mm x mm)</th></tr>
<tr><td>4MTL-05</td><td>4.6</td><td>8.83[1)]</td><td>1.62</td><td rowspan="3">124</td><td rowspan="15">368 x 256</td></tr>
<tr><td>4MTL-07</td><td>6.2</td><td>11.85[1)]</td><td>1.66</td></tr>
<tr><td>4MTL-09</td><td>7.4</td><td>14.59[1)]</td><td>1.67</td></tr>
<tr><td>4MTL-12</td><td>9.5</td><td>19.24[1)]</td><td>1.70</td><td rowspan="3">170</td></tr>
<tr><td>4MTL-15</td><td>12.5</td><td>25.16[1)]</td><td>1.75</td></tr>
<tr><td>4MTL-30</td><td>17.9</td><td>36.99[1)]</td><td>1.80</td></tr>
<tr><td>4MTL-35</td><td>22.7</td><td>46.90[1)]</td><td>1.79</td><td rowspan="3">270</td></tr>
<tr><td>4MTL-40</td><td>26.6</td><td>55.90[1)]</td><td>1.84</td></tr>
<tr><td>4MTL-50</td><td>32.0</td><td>67.80[1)]</td><td>1.81</td></tr>
<tr><td>4MSL-03</td><td>4.6</td><td>7.80[2)]</td><td>3.80</td><td rowspan="3">124</td></tr>
<tr><td>4MSL-04</td><td>6.2</td><td>10.40[2)]</td><td>3.80</td></tr>
<tr><td>4MSL-06</td><td>7.4</td><td>12.80[2)]</td><td>3.90</td></tr>
<tr><td>4MSL-08</td><td>9.5</td><td>16.30[2)]</td><td>3.80</td><td rowspan="3">170</td></tr>
<tr><td>4MSL-12</td><td>12.5</td><td>20.70[2)]</td><td>3.90</td></tr>
<tr><td>4MSL-15</td><td>17.9</td><td>31.50[2)]</td><td>3.90</td></tr>
</table>

[1)] *Evaporating -10 °C; gas cooler outlet temp 35 °C; high pressure 90 bar; superheat 10 K; subcooling 0 K*
[2)] *Evaporating -35 °C; condensing -5 °C; superheat 10 K; subcooling 0 K*

Table 1: Stream CO_2 compressors range and performance at full load (100 %)

Table 2 shows the key pressure values that are relevant to the use of Stream CO_2 compressors.

<table>
<tr><th>Compressor</th><th>Motor</th><th>Maximum operating pressure (MOP) (bar(a))</th><th>Standstill pressure (nameplate) PS / PSS (bar(a))</th><th>Burst pressure (bar(a))</th></tr>
<tr><td>4MTL-05</td><td rowspan="3">EWL
FWM/D</td><td rowspan="3">120 / 50.9</td><td rowspan="3">135 / 90</td><td rowspan="3">420 / 330</td></tr>
<tr><td>4MTL-07</td></tr>
<tr><td>4MTL-09</td></tr>
<tr><td>4MTL-12</td><td rowspan="3">AWM/D
EWL</td><td rowspan="2">120 / 50.9</td><td rowspan="3">135 / 90</td><td rowspan="3">420 / 330</td></tr>
<tr><td>4MTL-15</td></tr>
<tr><td>4MTL-30</td><td>120 / 42</td></tr>
<tr><td>4MTL-35</td><td rowspan="3">AWM/D
EWL</td><td rowspan="3">110 / 42</td><td rowspan="3">135 / 90</td><td rowspan="3">420 / 330</td></tr>
<tr><td>4MTL-40</td></tr>
<tr><td>4MTL-50</td></tr>
<tr><td>4MSL-03</td><td rowspan="3">EWL
FWM/D</td><td rowspan="3">60 / 23</td><td rowspan="3">135 / 90</td><td rowspan="3">420 / 330</td></tr>
<tr><td>4MSL-04</td></tr>
<tr><td>4MSL-06</td></tr>
<tr><td>4MSL-08</td><td rowspan="3">AWM/D
EWL</td><td rowspan="3">60 / 23</td><td rowspan="3">135 / 90</td><td rowspan="3">420 / 330</td></tr>
<tr><td>4MSL-12</td></tr>
<tr><td>4MSL-15</td></tr>
</table>

Table 2: Stream CO_2 compressor pressures

The line-up of 4-cylinder Stream semi-hermetic compressors for CO_2 transcritical applications is the ideal solution for the medium temperature section of booster systems. This range is designed for maximum standstill pressures of 135 bar at high side and 90 bar at low side – see **section 3.2.1 "Safety relief valves"**. Refrigerant flow and heat transfer have been optimized for best performance.

NOTE: **The pressure values shown with the bar(a) or bar unit in these guidelines are absolute pressures. For values in relative (gauge) pressure, bar(g) will be used.**

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 Stream semi-hermetic compressors for CO_2 transcritical and subcritical applications with standard equipment and accessories only.**

2.2 Nomenclature

The model designation contains the following technical information about Stream CO_2 compressors:

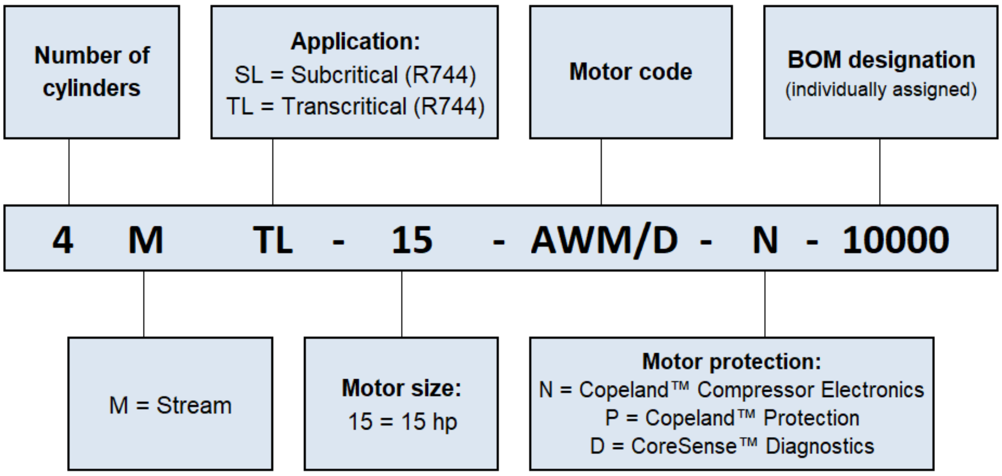


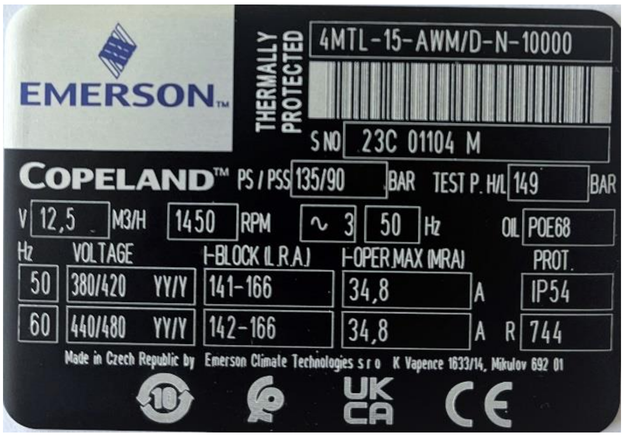
Figure 1: Nomenclature

The oil type is printed on the nameplate – see **section 2.3 "Nameplate information"**. Several oils are qualified – see **section 2.4.1 "Qualified refrigerant and oils"**.

2.3 Nameplate information

All important information for identification of the compressor is printed on the nameplate located below the left cylinder bank:

- the year and month of production are shown as part of the serial number (Jan = A, Feb = B, … Dec = L);
- type of refrigerant (R744);
- type of lubricant: POE or PAG.



23C = Produced in March 2023

POE68 = Oil type

R744 = CO_2 refrigerant

Figure 2: Nameplate information

2.4 Application range

2.4.1 Qualified refrigerant and oils

Stream CO_2 compressors are delivered with POE oil. Large models (4MTL-35 to 4MTL-50) can alternatively be delivered with PAG oil upon request.

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

Qualified refrigerant	R744 (CO_2)				
Copeland standard oils	RL 68 HB (POE 68) RFL 68 EP (PAG 68)				
Qualified servicing oils	RL 68 HB (POE 68) RFL 68 EP (PAG 68)				
Factory oil charge (litres)	Medium temp	Low temp	Medium temp	Low temp	Medium temp
	4MTL-05 4MTL-07 4MTL-09	4MSL-03 4MSL-04 4MSL-06	4MTL-12 4MTL-15 4MTL-30	4MSL-08 4MSL-12 4MSL-15	4MTL-35* 4MTL-40* 4MTL-50*
	1.3		1.8		2.8

** PAG oil qualification in process*

Table 3: Qualified refrigerant and oils & factory oil charges

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 side sight glasses and full in the housing cover sight glass.
- Recommended quality for carbon dioxide purity class: 4.0 [(≥ 99.99 %) H_2O ≤ 10 ppm, O_2 ≤ 10 ppm, N_2 ≤ 50 ppm] or higher.

2.4.2 Application limits

WARNING
Oil dilution due to low superheat! Compressor breakdown! Always operate the system with adequate superheat to avoid oil viscosity decrease. Additional measures in system design will help to avoid inacceptable lubrication conditions.

The operating envelopes of transcritical and subcritical Stream CO_2 compressors are shown below.

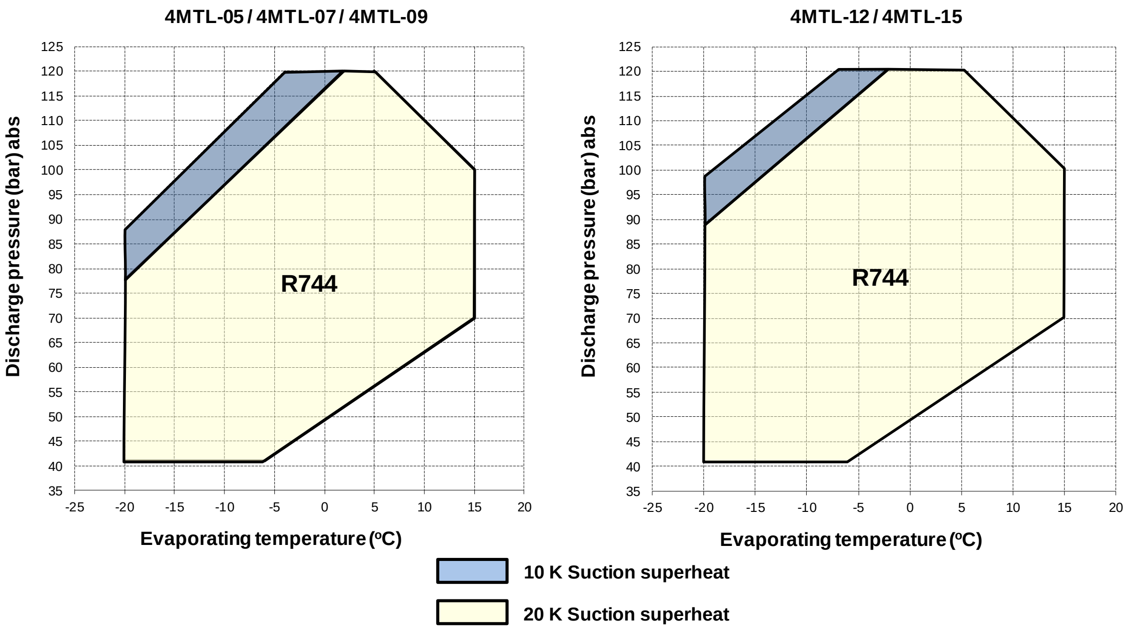


Figure 3: Operating envelopes for transcritical applications with R744 – Models 4MTL-05 to 4MTL-15

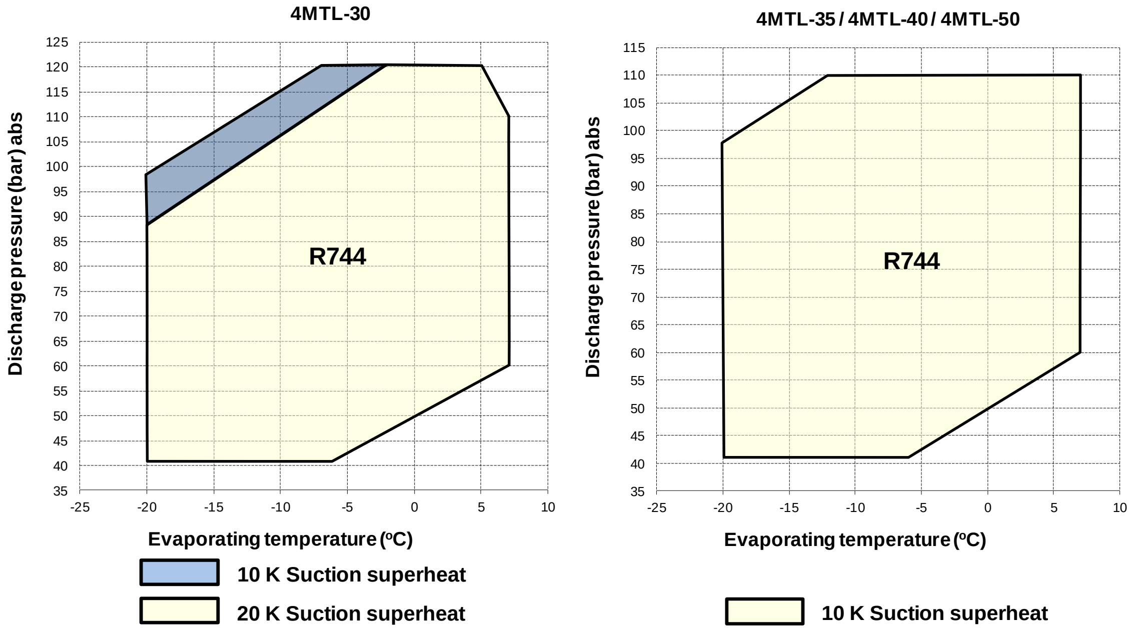


Figure 4: Operating envelopes for transcritical applications with R744 – Models 4MTL-30 to 4MTL-50

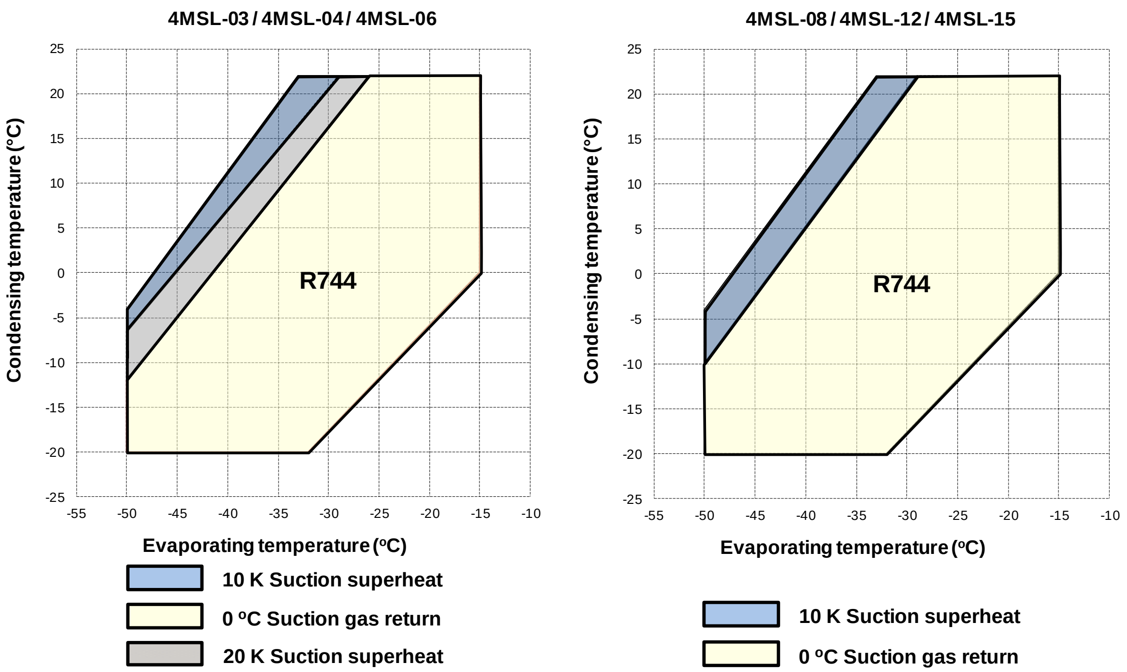


Figure 5: Operating envelopse for subcritical applications with R744 – Models 4MSL-03 to 4MSL-15

2.4.3 Recommendations for minimum suction superheat – Lubrication conditions

The operation of CO_2 compressors at conditions where the viscosity of the oil is low might become very harmful with regard to compressor lifetime expectancy. Indicators like oil temperature and discharge temperature must be observed to judge about the lubrication conditions. Depending on the application (low temp, medium temp, parallel compression, etc.) different minimum suction superheat values have to be respected to secure maximum protection of the compressor. In general, higher superheat on the suction inlet of a compressor provides higher safety, but the limits for the maximum allowable discharge temperature have to be considered as well (superheat has a direct impact on the discharge temperature).

Particular attention should be paid to the following points:

- Measuring the suction superheat becomes more critical with larger diameters on the suction tube. Ensure proper positioning of sensor. Sensor sleeves must be used with large diameters.
- The oil temperature is measured on the bottom (lowest position) of the compressor shell directly between the two sight glasses. The use of sensors for measurements on a plain surface is preferable for best accuracy.

- The discharge temperature can be read through Modbus from the Copeland™ Compressor Electronics module. If an additional sensor is applied to the discharge line (as close as possible to the discharge shut-off valve) the temperature is expected to be 15-20 K lower than inside the cylinder head. This must be taken into account when applying the values in **Table 4** below.

Application	Minimum superheat required	Minimum oil temperature required	Maximum acceptable discharge temperature
Low temp	20 K / 36 °F	30 °C / 86 °F	154.4 °C / 310 °F
Medium temp	10 K / 18 °F	30 °C / 86 °F	154.4 °C / 310 °F
Compressors in parallel or multi-compressors	10 K / 18 °F	30 °C / 86 °F	154.4 °C / 310 °F

Table 4: Superheat recommendations

Caution! The values shown in **Table 4** are maximum temperature values inside the cylinder head. When using a discharge temperature sensor on the discharge line, the temperature drop has to be considered for the high DLT cut-out setpoint.

NOTE: **An additional internal heat exchanger might be required to ensure the recommended suction superheat values on the compressor inlet are achieved.**

2.5 Design features

2.5.1 Compressor construction

Stream CO_2 compressors have a large discharge chamber to eliminate pulsations. The cylinder heads and the discharge plenum are designed to minimize the heat transfer to suction side.

Each cylinder head has a plugged 1/8" - 27 NPTF tapped hole on the high pressure.

Figure 6: Compressor external view

2.5.2 Compressor cooling

Compressor motor cooling must be ensured in all circumstances.

All Stream CO_2 compressors are suction gas-cooled. With suction gas-cooled compressors, the motor is cooled by refrigerant gas that is led through / over the motor. Depending upon the operating conditions, the maximum allowed suction gas superheat shall not exceed the values shown in the envelopes.

2.5.3 Lubrication

For small- and medium-size Stream CO_2 compressors (4MSL-03 to 4MSL-15, 4MTL-05 to 4MTL-30), an oil splasher system ensures proper lubrication at constant or variable speed.

For large models (4MTL-35 to 4MTL-50) an oil pump is used:

- On compressors delivered with Copeland™ Compressor Electronics (-N), the oil pump integrates an electronic switch to ensure the oil pressure safety functionality.
- Compressors with Copeland™ Protection (-P) are designed to accommodate fittings for an OPS2 or a standard oil pressure switch (OPS2 oil sensor included in the oil pump).
- The oil pumps used on these compressors are independent of their rotating direction.

Compressor size	Transcritical mode	Lubrication system	Subcritical mode	Lubrication system
Small	4MTL-05	Splasher	4MSL-03	Splasher
	4MTL-07		4MSL-04	
	4MTL-09		4MSL-06	
Medium	4MTL-12	Splasher	4MSL-08	Splasher
	4MTL-15		4MSL-12	
	4MTL-30		4MSL-15	
Large	4MTL-35	Oil pump	--	--
	4MTL-40			
	4MTL-50			

Table 5: Lubrication system on Stream CO_2 compressors

2.5.4 Oil level

Small- and medium-size models (4MSL-03 to 4MSL-15, 4MTL-05 to 4MTL-30) are equipped with three identical sight glasses, one at each side of the compressor and one at the front.

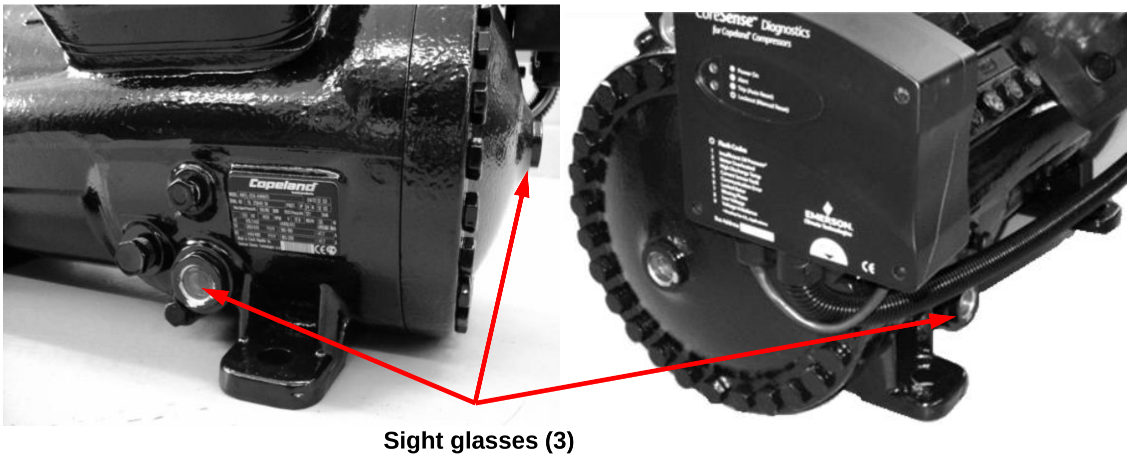


Figure 7: Sight glasses location on small and medium models

Large models (4MTL-35 to 4MTL-50) are equipped with 2 sight glasses, one at each side of the compressor.

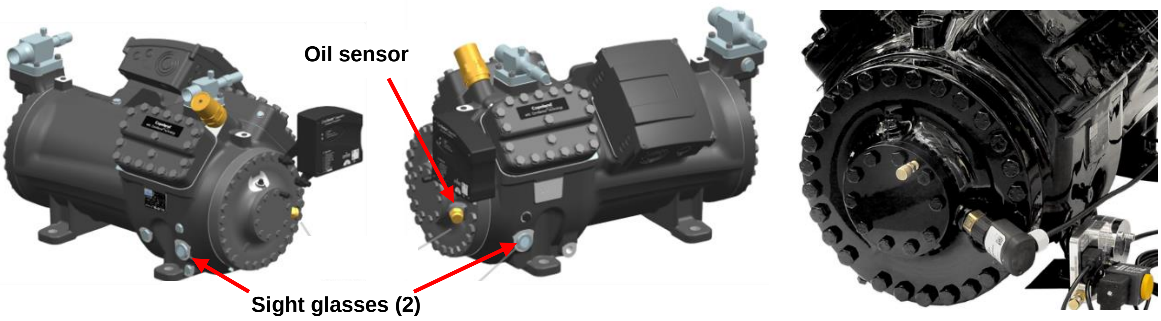


Figure 8: Sight glasses & oil sensor on large models

All 4MTL* & 4MSL* compressors are delivered with sufficient oil for normal operation – see **Table 3**. The optimum oil level should be checked by operating the compressor until the system is stable and then comparing the sight glass reading with the corresponding diagram below. The oil level should be min ¼ and max ¾ of the side sight glasses and full in the housing cover sight glass.

The housing cover sight glass serves only as a means of checking the oil level in the compressor crankcase and cannot be used for its control.

A higher oil level may be accepted if an oil regulator is used, as it will reduce excessive oil circulation. The oil regulator should be fitted in place of one of the side sight glasses. The oil level should be min ¼ and max ¾ of the sight glass. The level can also be checked within 10 seconds of compressor shutdown.

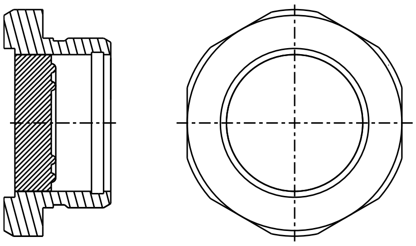


Figure 9: Sight glass design

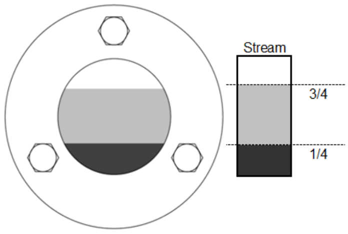


Figure 10: Sight glass reading

The sight glass thread is 1 1/8"-18 UNEF, and the tightening torque is 50 to 60 Nm.

For small- and medium-size compressors, as they do not have an oil pump, an oil pressure safety control cannot be used to protect the compressor against lubrication problems. However, a float level switch for oil can be used to protect the compressor against oil loss.

2.5.4.1 Oil level management device OM5 TraxOil

Active oil level management is a must in order to ensure reliable compressor operation, in particular in refrigeration applications with varying operating conditions and defrost cycles. An additional benefit of active systems is that, in addition to oil balancing, they normally also monitor the oil level and provide alarm capabilities.

Maintaining proper oil level is of primary importance for a long compressor lifetime.

The OM5 TraxOil uses a Hall effect sensor to measure the oil level. A magnetic float changes its position according to the oil level. The Hall sensor converts the magnetic field changes into an equivalent signal, which is used by the internal integrated electronics to evaluate the oil level.

The OM5 TraxOil provides both an oil level monitoring function and an oil level balancing function for active oil level management systems, especially in CO_2 applications.

The OM5 TraxOil has been developed and specially optimized for CO_2 systems where maximum working pressures above 60 bar and up to 130 bar are required.

The OM5 TraxOil is designed to feed oil in subcritical or transcritical CO_2 compressors when necessary.

The oil level control is divided into 3 zones: normal, warning and alarm.

More information about this product can be found at www.copeland.com/en-gb.

Figure 11: TraxOil OM5 with sight glass & coil

2.5.4.2 Oil level monitoring system OW4/OW5 TraxOil

The OW4 and OW5 TraxOil are intended for systems which only require oil level monitoring and alarming and do not need active oil level balancing.

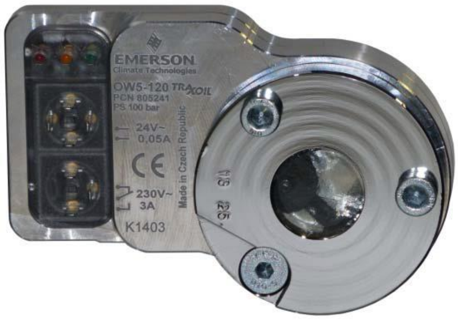


Figure 12: OW4/OW5 TraxOil for oil level monitoring

- OW4 is designed for CO_2 subcritical applications

- OW5 is designed for CO_2 transcritical applications

The level control is divided into 3 zones: normal, warning and alarm.

If the oil level drops into the red zone, the OW4/OW5 generates an alarm signal and the alarm contact (SPDT) changes into alarm state. The alarm contact may be used to shut the compressor down. The alarm will be reset when the oil level goes back to normal.

More information about this product can be found at www.copeland.com/en-gb.

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
- Pressure relief valve on discharge
- Oil charge, oil sight glasses
- Crankcase heater 230 V
- Mounting parts kit (rubber)
- Copeland™ Compressor Electronics or Copeland™ Protection module
- Holding charge up to 2.5 bar(g) (dry air)
- Electrical terminals

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 13**. 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**
- **Storage: n = 1**

Figure 13: Maximum stacking loads for transport and storage

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

Compressors are delivered on pallets. Accessories may be mounted or delivered loose.

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.

For safety reasons two lifting eyes should be fitted before moving a compressor (½" - 13 UNC, ident number 2932854). Otherwise refer to drawing in **Figure 14** to see how to apply another lifting method.

In order to avoid refrigerant leaks or other damage the compressors should never be lifted by the service valves or other accessories.

Figure 14: Compressor lifting

3.1.4 Installation location

Ensure the compressors are installed on a solid level base. Horizontal installation is recommended.

Temperatures around the compressor should not exceed 65 °C in order to avoid suction gas temperature increase and malfunctioning of electronics.

3.1.5 Mounting parts

To minimize vibration and start/stop impulses flexible mounting should be used. For this purpose, one set of rubber mounting parts is delivered with each compressor. The mounting kit can be used for single and parallel operation. Locknuts should be tightened only to surface washer.

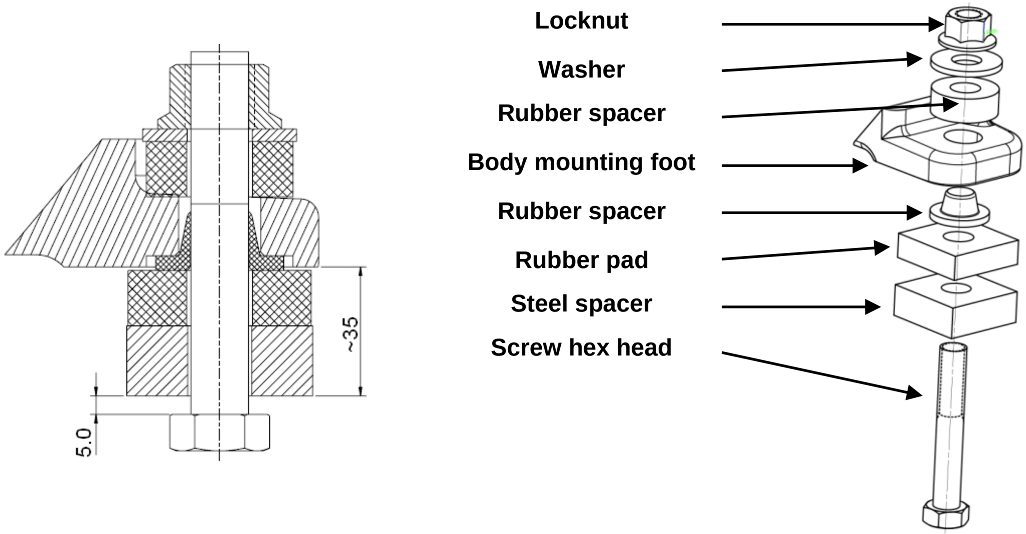


Figure 15: Standard mounting parts for Stream CO_2 compressors

A compressor may be rigidly mounted, ie, without mounting parts. In this case more shock and vibration loading will be transmitted to the frame. Use only the compressor foot for fixation and avoid direct contact of other parts of the compressor housing with bordering components or base frame.

Unevenness in the mounting surface will have to be compensated by the rack and/or the compressor bottom plate/feet. Excessive unevenness can result in too high mechanical stress to the system and could damage the compressor or rack. Therefore, the flatness of the mounting location is essential. In addition, both vibration/shock and mechanical stress to compressor can be avoided by using rubber mounting parts.

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.

3.2 Pressure safety controls

3.2.1 Safety relief valves

CAUTION
High pressure! System leak! In the event that a pressure relief valve activates repeatedly, check and replace it as needed in order to avoid a permanent leak. Always check system for CO_2 loss after activation of the pressure relief valve.

The compressor is fitted with a pressure relief valve on the discharge side (135 bar, factory mounted – **Caution:** left-handed thread). If excessive pressures are reached, the valve opens and prevents further pressure increase. CO_2 is then blown off to the ambient.

An optional pressure relief valve (90 bar) is available for the suction side. Typically the suction side of the system is anyhow protected by an additional pressure relief valve. This system pressure relief valve is also acceptable for compressor protection.

The pressure relief valve does not replace pressure switches or additional safety valves in the system.

- High-pressure side (HP): 135 bar

Pressure relief valves are usually no longer perfectly tight after a blow-off, which is why it is highly recommended to replace them.

The following pictures show the position of the pressure relief valve (high side) and the position of the plug (low side).

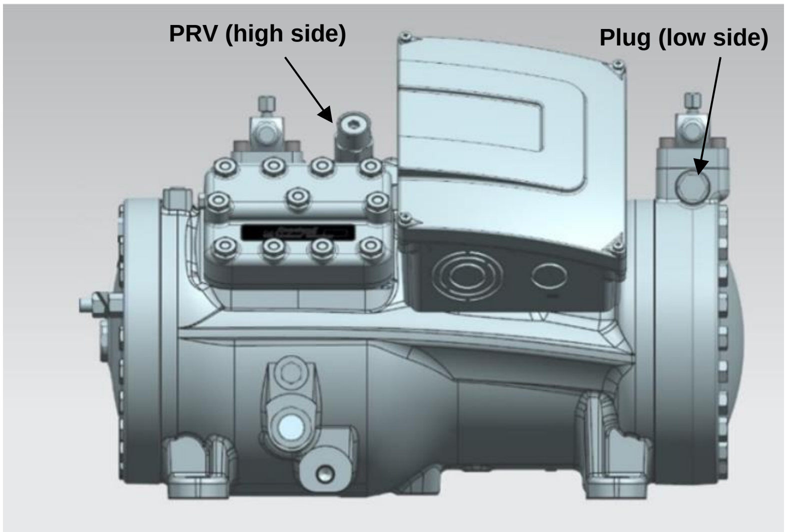


Figure 16: Position of the pressure relief valve – Models 4MTL-05 to 4MTL-09 & 4MSL-03 to 4MSL-06

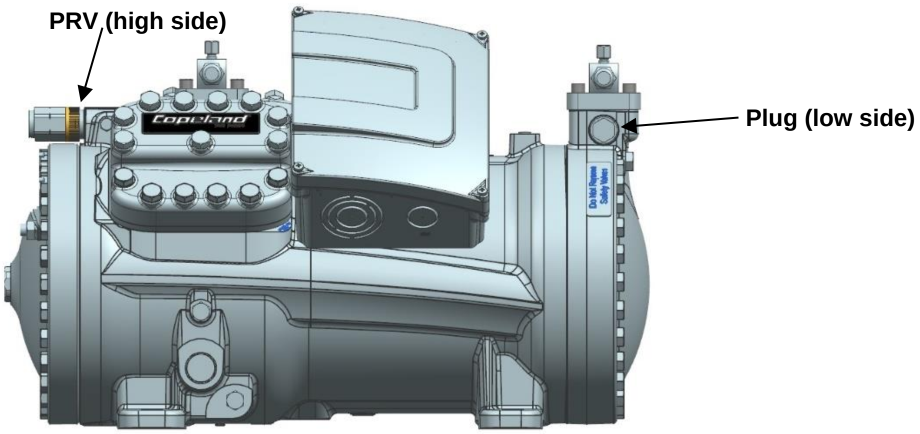


Figure 17: Position of the pressure relief valve – Models 4MTL-12 to 4MTL-30 & 4MSL-08 to 4MSL-15

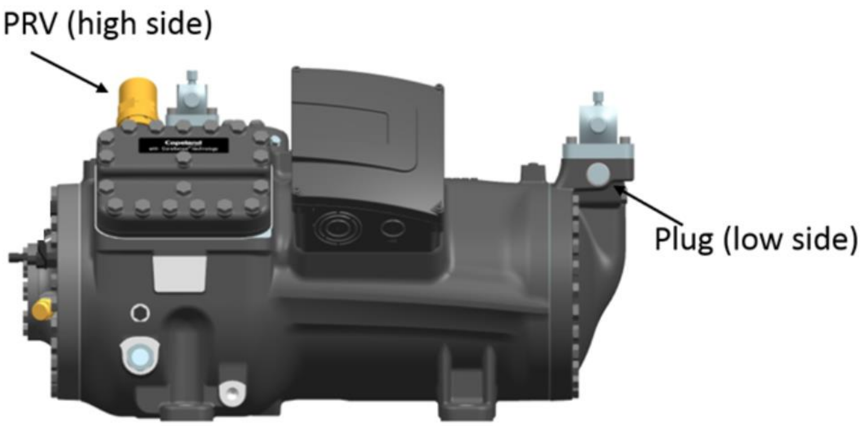


Figure 18: Position of the pressure relief valve – Models 4MTL-35 to 4MTL-50

3.2.2 Maximum allowable pressures PS

The maximum allowable pressures PS according to EN 12693 are shown on the compressor nameplate; they are mandatory and must not be exceeded.

- For transcritical applications: High-pressure side (HP): 135 bar
  Low-pressure side (LP): 90 bar
- For subcritical applications: High-pressure side (HP): 135 bar
  Low-pressure side (LP): 90 bar

All pressures are expressed in bar(a) (absolute pressure).

3.2.3 Maximum operating pressures

The maximum operating pressures according to the envelopes shown in **section 2.4.2 "Application limits"** have to be respected during compressor operation. Running a compressor outside its envelope could lead to compressor breakdown and/or system failure.

The position of the HP and LP connections is shown in **Appendix 1 "Connections of Stream CO_2 compressors"**. It is recommended to connect the pressure cut-out devices directly to the compressor housing. For the high-pressure cut-out switch, one of the connection ports "4" can be used – see **Appendix 1**. For the low-pressure cut-out connection, port "6" is recommended; it is located on the right-hand side of the compressor, ie, the side where the electrical box is installed, above the oil level.

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

3.3 Shut-off valves

Stream CO_2 compressors are factory-equipped with shut-off valves on both the suction and discharge sides. The shut-off valves are suitable for welding and brazing.

Compressor	Displacement (m^3/h)	Flange mountings (mm)	Suction connection			Discharge connection		
			Inner diameter	Drawing number	Description	Inner diameter	Drawing number	Description
4MTL-05	4.60	45 x 45	5/8"	510-0823-00	W22 / ODS 5/8	1/2"	510-0809-00	W17.2 / ODS 1/2
4MTL-07	6.20		5/8"		W22 / ODS 5/8	1/2"		W17.2 / ODS 1/2
4MTL-09	7.40		5/8"		W22 / ODS 5/8	1/2"		W17.2 / ODS 1/2
4MTL-12	9.54	52 x 52	7/8"	510-0844-00	W30 / ODS 7/8	5/8"	510-0842-00	W22 / ODS 5/8
4MTL-15	12.50		7/8"		W30 / ODS 7/8	5/8"		W22 / ODS 5/8
4MTL-30	17.90		7/8"		W30 / ODS 7/8	5/8"		W22 / ODS 5/8
4MTL-35	22.70	70 x 70 & 52 x 52	1 ⅜"	510-0847-00	W42.4 / ODS 1 ⅜	1 ⅛"	510-0845-00	W35 / ODS 1 ⅛
4MTL-40	26.80		1 ⅜"		W42.4 / ODS 1 ⅜	1 ⅛"		W35 / ODS 1 ⅛
4MTL-50	32.00		1 ⅜"		W42.4 / ODS 1 ⅜	1 ⅛"		W35 / ODS 1 ⅛

Table 6: Shut-off valves for transcritical compressors

Compressor	Displacement (m^3/h)	Flange mountings (mm)	Suction connection			Discharge connection		
			Inner diameter	Drawing number	Description	Inner diameter	Drawing number	Description
4MSL-03	4.60	45 x 45	5/8"	510-0823-00	W22 / ODS 5/8	1/2"	510-0809-00	W17.2 / ODS 1/2
4MSL-04	6.20		5/8"		W22 / ODS 5/8	1/2"		W17.2 / ODS 1/2
4MSL-06	7.40		5/8"		W22 / ODS 5/8	1/2"		W17.2 / ODS 1/2
4MSL-08	9.54	52 x 52	7/8"	510-0844-00	W30 / ODS 7/8	5/8"	510-0842-00	W22 / ODS 5/8
4MSL-12	12.50		7/8"		W30 / ODS 7/8	5/8"		W22 / ODS 5/8
4MSL-15	17.90		7/8"		W30 / ODS 7/8	5/8"		W22 / ODS 5/8

Table 7: Shut-off valves for subcritical compressors

3.3.1 Shut-off valves design

The standard shut-off valves on Stream CO_2 compressors are flange valves with one flare connection port (lockable) for service. The service connection port is a 7/16" – 20 UNF, with a blind cap SAE 1/4" (blind cap material: stainless steel 1.4301). The valves are universal, ie, suitable for brazing or welding (butt weld and fillet weld connections are possible).

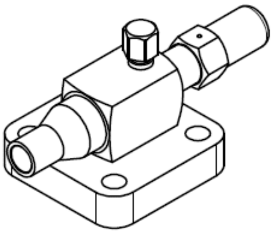


Figure 19: 3-D view of shut-off valve

For proper tightening torques for bolts, spindle cap, blind cap and gland seal, please refer to **Table 18** in **Appendix 2 "Tightening torques in Nm"**.

The spindle is front-seated (close to piping system) when the compressor is delivered.

3.3.2 Explanation of supplier description

W 13.5 / ODS 3/8"

- **Outer diameter tube for brazing**
- **Brazing**
- **Outer diameter tube for welding**
- **Welding**

3.3.3 Additional information about shut-off valves

CAUTION
High operating pressures! Risk of leakage! High operating pressures must be taken into account when welding and brazing connections. Use materials and follow procedures according to the relevant standards in order to prevent any risk of leakage when operating the compressor.

The shut-off valves are made of a fine-grained mild steel (S235JRG2C – EN 10025) suitable for both welding and brazing. Plating is Fe/Cu5Sn5 material.

The use of standard steel tubes (S235, P235, etc) is possible.

When using stainless steel tubes (SS) the welding consumable has to be selected for dissimilar materials (stainless steel to mild steel).

For the brazing of the connection, brazing material with a minimum silver content of 34 % (or higher) in combination with flux material is required, eg, Fontargen A319, A320. The description of the brazing material according to European standard EN 1044 is AG106 and AG104 respectively.

In any case the connection area after welding or brazing has to be cleaned and protected against corrosion.

Valve description PCN	Mounting dimensions (F) (mm)	Inner Ø brazing (d) (inch)	Thickness (Z) (mm)	Dimension (a) (mm)	Outer Ø butt welding (D) (mm)	Depth for tube insertion (h) (mm)
W17.2 / ODS 1/2	45 x 45	1/2"	2.20	3.11	17.2	11.0
W22 / ODS 5/8	45 x 45	5/8"	2.95	4.17	22.0	11.0
W22 / ODS 5/8	52 x 52	5/8"	2.95	4.17	22.0	11.0
W30 / ODS 7/8	52 x 52	7/8"	3.83	5.41	30.0	16.0
W35 / ODS 1 ⅛	52 x 52	1 ⅛"	3.15	4.45	35.0	19.0
W42.4 / ODS 1 ⅜	70 x 70	1 ⅜"	4.20	5.94	42.4	23.0

Table 8: Dimensions for welding and brazing

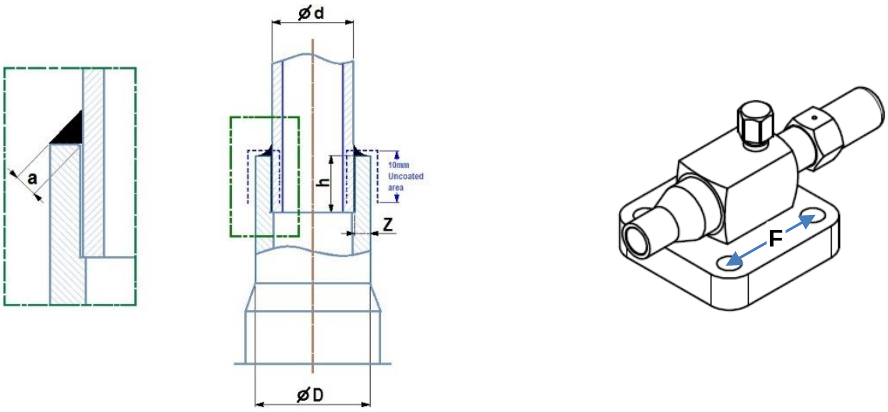


Figure 20: Dimension references for welding and brazing

3.3.4 Variations for shut-off valves

Compressors can be ordered without valves on request. In that case the valves will be removed and a blind flange with gasket will be used for suction and discharge to guarantee the tightness of the compressor during transport.

For Stream CO_2 compressors, Copeland also offers variations for connection sizes – see **Tables 9 & 10** below for details. Additionally, a compression fitting can be used for the discharge part of the compressors. Compressors can be ordered with "variation discharge shut-off valve with Hy-Lok fitting at the discharge part". The tube diameter for the discharge line must be defined by the customer.

<table>
<tr><th colspan="2" rowspan="2">Compressor</th><th rowspan="3">Displ. (m³/h)</th><th rowspan="3">Flange mountings (mm)</th><th colspan="4">Variation bigger Ø</th></tr>
<tr><th colspan="2">Suction connection</th><th colspan="2">Discharge connection</th></tr>
<tr><th>Transcritical</th><th>Subcritical</th><th>Inner Ø brazing</th><th>Valve description</th><th>Inner Ø brazing</th><th>Valve description</th></tr>
<tr><td>4MTL-05</td><td>4MSL-03</td><td>4.60</td><td rowspan="3">45 x 45</td><td rowspan="3">3/4"</td><td rowspan="3">W25.4 / ODS 3/4</td><td rowspan="3">5/8"</td><td rowspan="3">W22 / ODS 5/8</td></tr>
<tr><td>4MTL-07</td><td>4MSL-04</td><td>6.20</td></tr>
<tr><td>4MTL-09</td><td>4MSL-06</td><td>7.40</td></tr>
<tr><td>4MTL-12</td><td>4MSL-08</td><td>9.54</td><td rowspan="3">52 x 52</td><td rowspan="3">1 ⅛"</td><td rowspan="3">W35 / ODS 1 ⅛</td><td rowspan="3">3/4"</td><td rowspan="3">W25.4 / ODS 3/4</td></tr>
<tr><td>4MTL-15</td><td>4MSL-12</td><td>12.50</td></tr>
<tr><td>4MTL-30</td><td>4MSL-15</td><td>17.90</td></tr>
<tr><td>4MTL-35</td><td>--</td><td>22.70</td><td rowspan="3">70 x 70 & 52 x 52</td><td rowspan="3">1 ⅝"</td><td rowspan="3">W48.3 / ODS 1 ⅝</td><td colspan="2" rowspan="3">Not available</td></tr>
<tr><td>4MTL-40</td><td>--</td><td>26.80</td></tr>
<tr><td>4MTL-50</td><td>--</td><td>32.00</td></tr>
</table>

Table 9: Variations with larger tube connections

				Variation smaller Ø			
Compressor		**Displ. (m^3/h)**	**Flange mountings (mm)**	**Suction connection**		**Discharge connection**	
Transcritical	**Subcritical**			**Inner Ø brazing**	**Valve description**	**Inner Ø brazing**	**Valve description**
4MTL-05	4MSL-03	4.60	45 x 45	1/2"	W17.2 / ODS 1/2	1/2"	W17.2 / ODS 1/2
4MTL-07	4MSL-04	6.20					
4MTL-09	4MSL-06	7.40					
4MTL-12	4MSL-08	9.54	52 x 52	5/8"	W22 / ODS 5/8	1/2"	W17.2 / ODS 1/2
4MTL-15	4MSL-12	12.50					
4MTL-30	4MSL-15	17.90					
4MTL-35	--	22.70	70 x 70 & 52 x 52	1 ⅛"	W35 / ODS 1 ⅛"	7/8"	W30 / ODS 7/8
4MTL-40	--	26.80					
4MTL-50	--	32.00					

Table 10: Variations with smaller tube connections

3.4 Screens

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

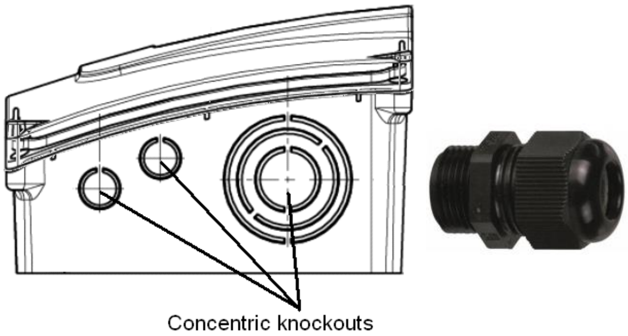
The use of screens finer than 30 x 30 meshes (0.6 mm openings) anywhere in the system should be avoided with these compressors. Field experience has shown that finer mesh screens used to protect thermal expansion valves, capillary tubes or accumulators can become temporarily or permanently plugged with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

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 that the supply voltage, the phases and the frequency match the nameplate data.

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



Twist driller

Figure 21: Terminal box knockouts

4.2 Electrical installation

All compressors can be started Direct-On-Line.

The position of bridges required for Direct-On-Line start (depending on the type of motor and/or mains voltage) is shown in **section 4.2.4 "Terminal box isolators and jumpers position"**.

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

A part-winding motor contains two separate windings (2/3 + 1/3) which are internally connected in star and operated in parallel. The voltage cannot be modified by changing the electrical connections as the motor is only suitable for one voltage.

The first part-winding, ie, the 2/3 winding on terminals 1-2-3, can be used for part-winding start (remove 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 Part-winding motors (YY/Y) – Code F

Part-winding motors contain two separate windings (code F motors always split by 1/2 + 1/2) which are internally connected in star and operated in parallel. The voltage cannot be modified by changing the electrical connections as the motor is only suitable for one voltage.

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

4.2.3 Star / Delta motors (Y/∆) – Code E

On this three-phase motor, the 6 ends of the three windings are led into the terminal box of the compressor via cable bushings.

The star or delta connection as required is achieved by means of connection bars in the terminal box or via controlled contactors. Thus, the motor can be run at the operating voltage.

The voltage version L (motor code EWL) of this motor allows operation at two voltages, a lower voltage, eg, 230 V in delta connection, and a higher voltage, eg, 400 V in star connection.

4.2.4 Terminal box isolators and jumpers position

4.2.4.1 Part-winding motors (AW… or FW…)

Part-winding motors can be connected Direct-On-Line or part-winding start.

Make sure that the 2 wires (L2) which are guided through the current sensor are in the same direction. The black wire (voltage sensing) from the sensor module must be connected to the same terminal as the wires that are guided through the current sensor.

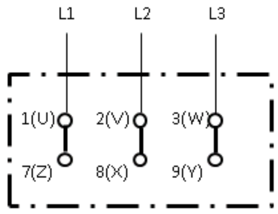
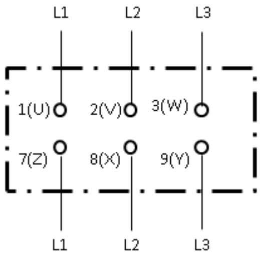
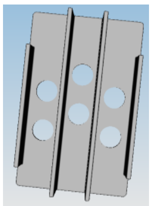
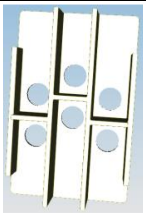
	Direct-On-Line start YY - Y	Part-winding start YY – Y First start step 1–2-3
Part-winding motor: YY – Y **Code A** **Code F**		
Recommended isolator (packed in T-Box)		

Figure 22: Terminal box isolators & jumpers position for part-winding motors

NOTE: **The isolators are not factory-mounted; they are packed and shipped loose in the terminal box.**

NOTE: **Assembly instructions with an exploded view are provided in Appendix 3.**

4.2.4.2 Star/Delta motors (EW…)

Star/Delta motors can be connected Direct-On-Line or Star/Delta start.

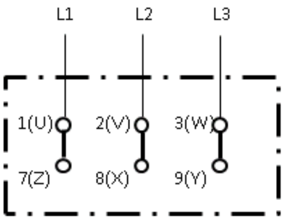
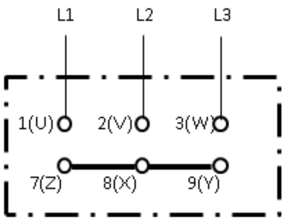
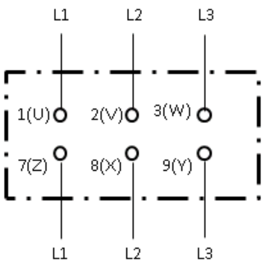
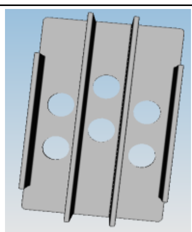
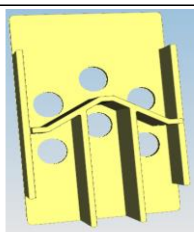
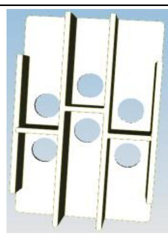
	Direct-On-Line start Δ	Direct-On-Line start Y	Star/Delta start *Y - Δ*
Star/Delta motor Y - Δ **Code E**			
Recommended isolator (packed in T-Box)			

Figure 23: Terminal box isolators & jumpers position for Star/Delta motors

NOTE: **The isolators are not factory-mounted; they are packed and shipped loose in the terminal box.**

NOTE: **Assembly instructions with an exploded view are provided in Appendix 3: T-Plate isolators depending on motor version & power supply.**

4.3 Electrical protection (fuses)

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.

4.4 Compressor protection

All Stream 4MTL* and 4MSL* models are factory-fitted with a compressor protection. The standard scope of delivery contains the Copeland™ Compressor Electronics extended and advanced compressor protection system.

Alternatively the compressors can be ordered with Copeland™ Protection (formerly CoreSense Protection), a less advanced protection system.

Protection system		Examples of designation	
Copeland Compressor Electronics	"-N"	4MTL-35-AWM/D-**N**-10000	From S/N 21E59371 (May 2021) onwards
Copeland Protection	"-P"	4MTL-35-AWM/D-**P**-10000	Optional version
Next Generation CoreSense	"-N"	4MTL-35X-AWM/D-**N**	From S/N 19L55XXX (Dec 2019) to 21E59371M (May 2021)
CoreSense Diagnostics	"-D"	4MTL-35X-AWM/D-**D**	From S/N 10A52XXX (Jan 2010) to 20L30XX (Dec 2020)

Table 11: Overview of protection systems on Stream CO_2 compressors

4.4.1 Compressors with Copeland™ Compressor Electronics

Copeland Compressor Electronics (formerly Next Generation CoreSense) is standard in all Stream CO_2 compressors. With active protection, advanced algorithms and features like fault history and LED indicators, Copeland Compressor Electronics enables technicians to diagnose the past and recent state of the system, allowing for quicker, more accurate diagnostics and less downtime.

The Copeland Compressor Electronics module has a compact design with a base board and optional plug-in modules with advanced functionalities. The base board with current, discharge temperature and oil sensor, provides advanced diagnostics and protection against faults such as high discharge temperature, locked rotor, single/missing phase, voltage imbalance, low voltage, etc... An external overload protection is not necessary. The module is capable of communication via Modbus and Bluetooth (optional) protocol. The optional plug-in modules on the base board will bring additional functionalities.

Figure 24: Copeland Compressor Electronics module

Figure 25: Module location inside the terminal box

4.4.1.1 Copeland Compressor Electronics – Specifications

The Copeland Compressor Electronics module is located and prewired in the terminal box. All required parameter are flashed during the production of the compressor.

The power supply for the control module can be 115 or 230 V AC.

Operating ambient temperature	-30 to 70 °C
Storage temperature	-30 to 80 °C
Voltage requirements	115-230 V AC - 50/60 Hz
Protection class	IP00

Table 12: Copeland Compressor Electronics specifications

4.4.1.2 Copeland Compressor Electronics – Features

Copeland Compressor Electronics is a modular system. This modular design gives the customers the flexibility to choose individual protection and/or control levels. It is possible to extend the compressor protection from just basic functions to a high tier protection to enlarge the lifetime of the compressor.

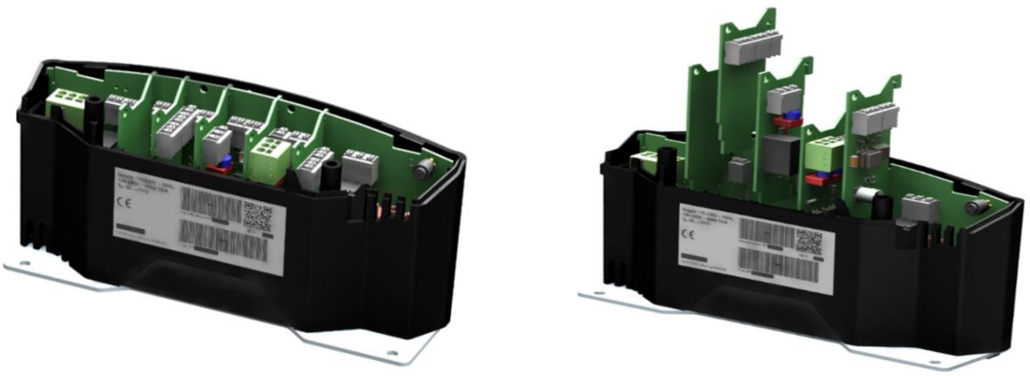


Figure 26: Inside view of the Copeland Compressor Electronics module, with the modular boards

Basic features	
Motor overheat protection	High discharge temperature protection
Insufficient oil pressure protection	Oil level protection (in combination with TraxOil)
Current protection	Phase failure protection
Voltage imbalance protection	Undervoltage and overvoltage protection
Power consumption measurement	Part-winding protection
Crankcase heater control	Welded contactor protection
Switching frequency overstepping protection	Connection with computer, Android or iOS device
LEDs on the terminal box cover	Reset button for manual reset

Table 13: List of basic features

NOTE: **More information about Copeland Compressor Electronics and available functions and protections can be found in the following Technical Information:**

- **TI_Stream_NGCS_01_E "Copeland™ Compressor Electronics for Copeland™ Stream Compressors.**
- **TI_Stream_NGCS_04_E "Copeland™ Compressor Electronics for Copeland™ Stream Compressors – Quick Installation Guide".**
- **TI_Stream_NGCS_05 "Next Generation CoreSense™ for Copeland™ Stream Compressors – Guide for the Replacement of CoreSense™ Diagnostics".**

4.4.1.3 Copeland Compressor Electronics – Electrical connections

The Copeland Compressor Electronics standard version is originally delivered with the basic modules preconnected.

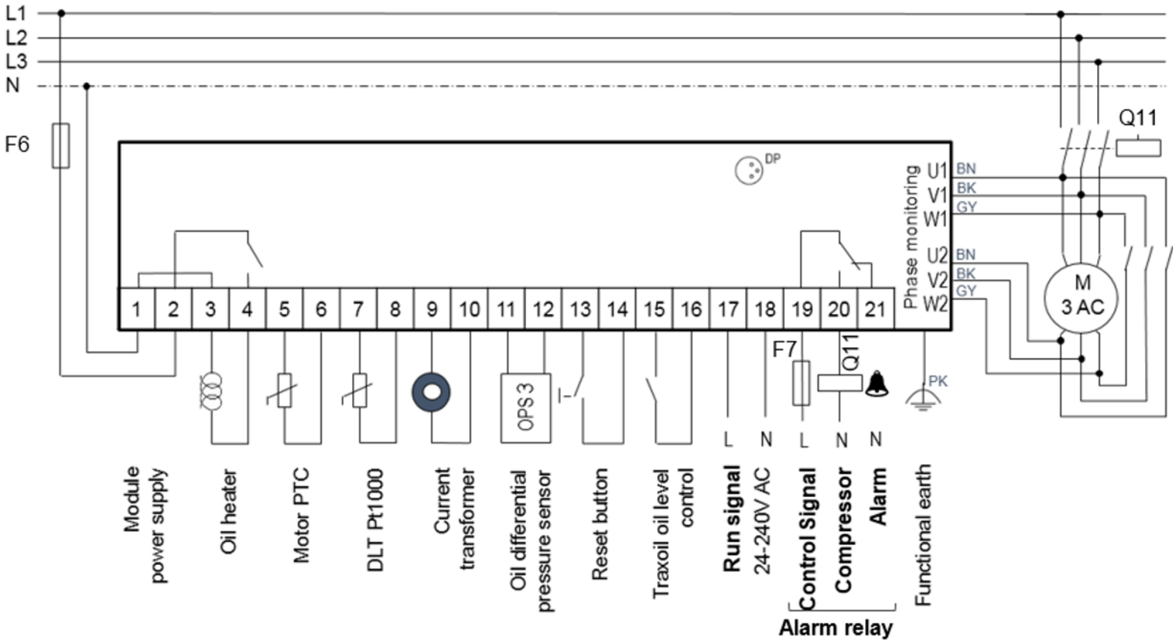


Figure 27: Basic modules connections

4.4.1.4 Copeland Compressor Electronics – Wiring diagrams

IMPORTANT
For small and medium compressor models (4MTL-05 to 4MTL-30 & 4MSL-03 to 4MSL-15), the blue positions 1U, 2V, 3W, 7Z, 8X, 9Y in diagrams below must be considered. The position of the terminals in large models (4MTL-35 to 4MTL-50) is inverted and corresponds to the black positions. The factory delivery is correct, DO NOT reverse the connections.

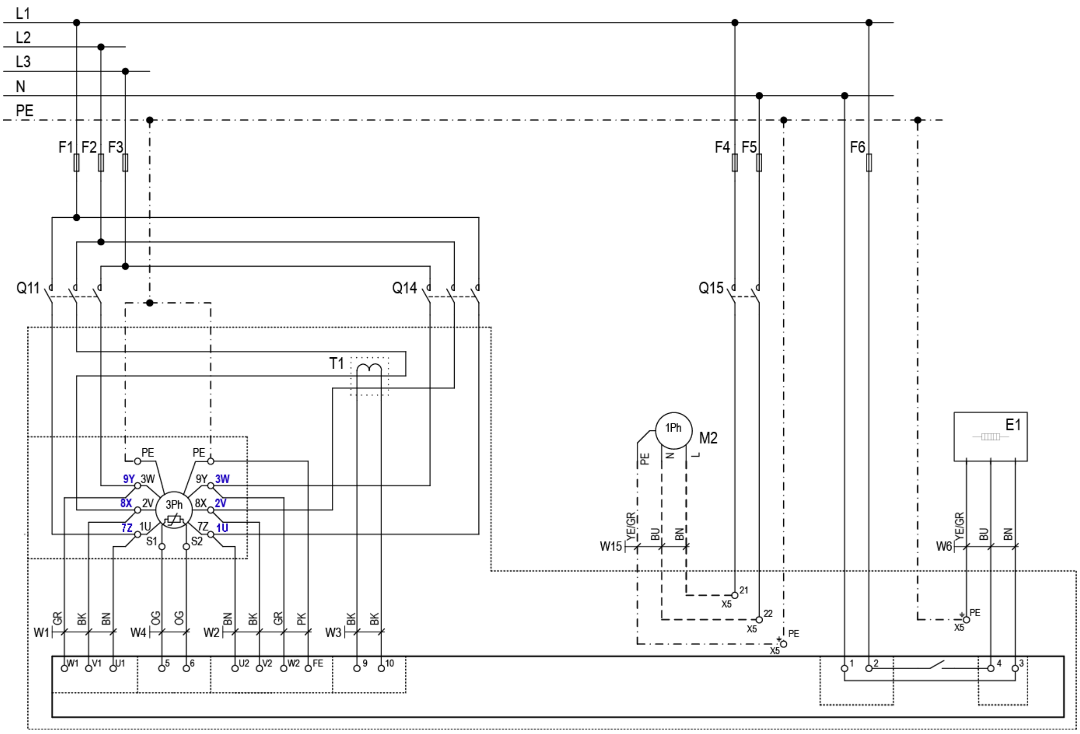


Figure 28: Wiring diagram (1st part) for part-winding motors (AW…, FW…)

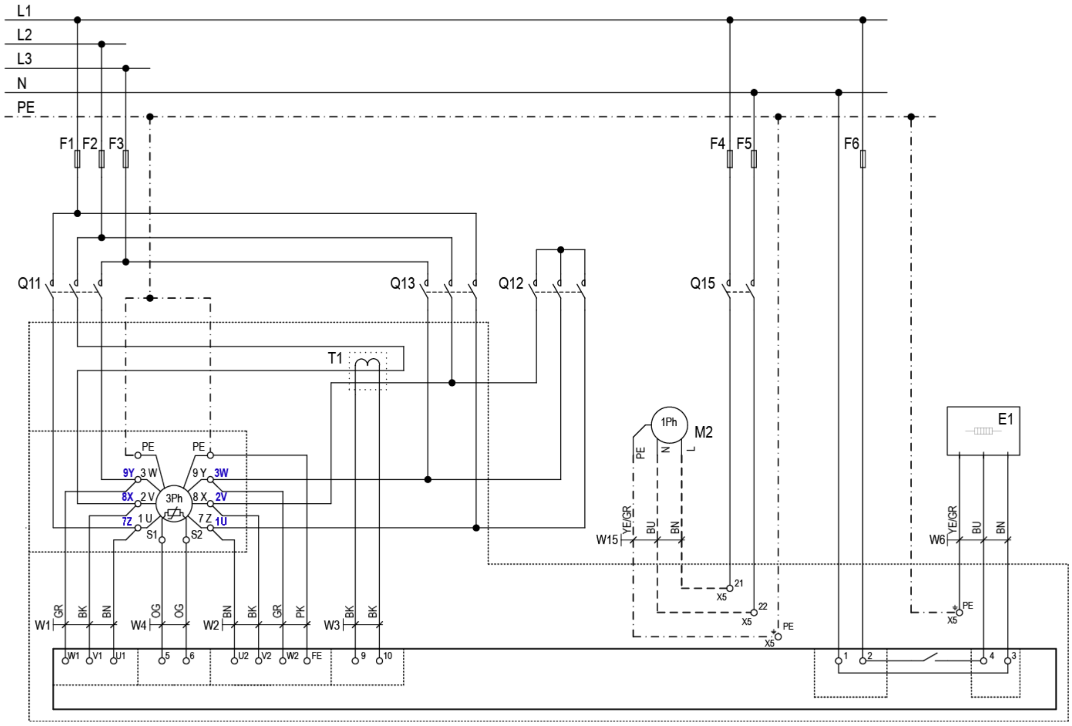


Figure 29: Wiring diagram (1st part) for Star/Delta motors (EW…)

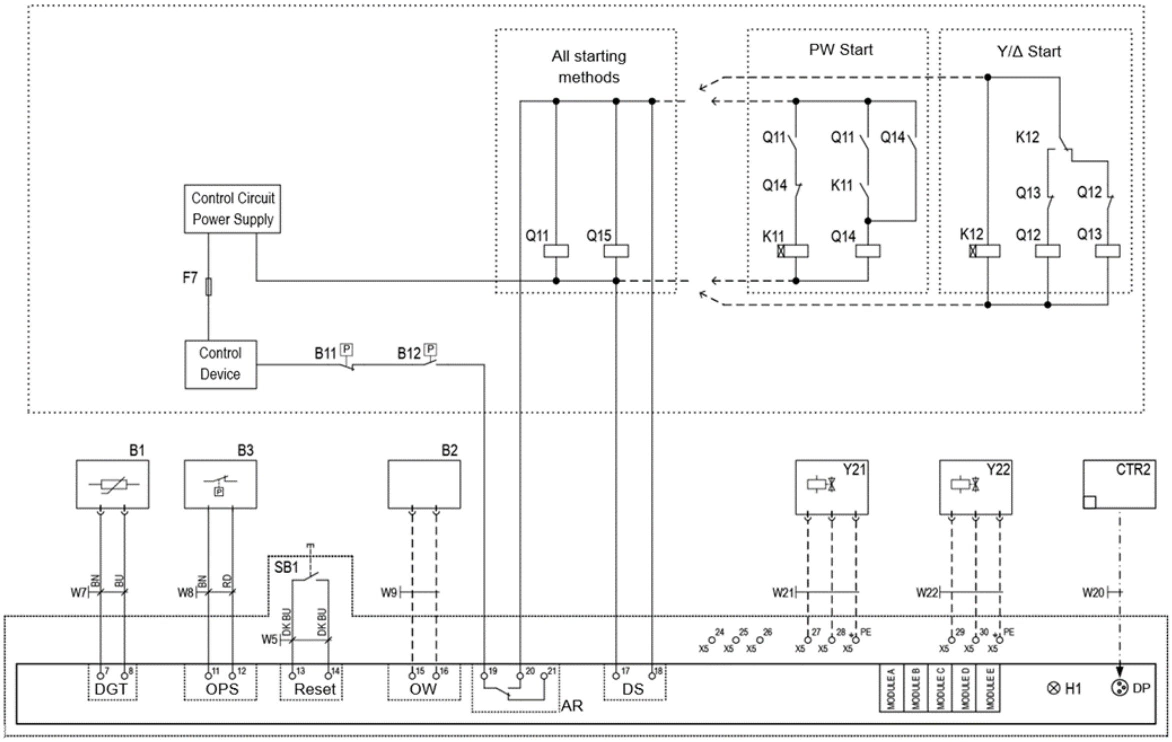


Figure 30: Wiring diagram (2nd part) for part-winding and Star/Delta motors (AW… & EW…)

Legend

B1 .... Discharge gas sensor
B2 .... Oil level watch (TraxOil)
B3 .... Oil differential pressure switch (OPS)
B11 .... High-pressure switch
B12 .... Low-pressure switch
CTR2 ...... DP Gateway
E1 .... Heater
F1,F2,F3 Compressor fuses
F4, F5 ..... Fan fuses
F6 .... Module and heater fuse
F7 .... Control circuit fuse
H1 .... Diagnosis LED
M2 .... Fan motor
Q11 .... Compressor contactor
Q12 .... Compressor contactor Y (if Y/Δ start)
Q14 .... Compr. contactor 2nd part-winding (if used)
SB1 .... Reset button
T1 .... Current sensor

DGT .. Discharge gas temperature monitoring
OW.... Digital oil level watch
OPS .. Oil differential pressure protection
AR..... Alarm relay
DS..... Demand signal

CH..... Control oil heater
PTC... Motor thermal protection
PM .... Phase monitoring
PS..... Power supply

K11 ... Time relay for part-winding (if used)

Q15 ... Fan contactor
Q13 ... Compressor contactor Δ (if Y/Δ start)
Y21 ... Solenoid valve capacity control 1 (not used)
Y22 ... Solenoid valve capacity control 2 (not used)
CM .... Current monitoring

4.4.2 Copeland™ Protection

As an alternative to the advanced Copeland Compressor Electronics, the compressors can also be equipped with Copeland Protection, a more basic compressor protection system. This compressor variation is available as an option in compressor production and must be ordered accordingly.

4.4.2.1 Copeland Protection – Electrical connections

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

Stream compressors with "-P" at the end of the description are equipped with a Copeland Protection device. The temperature-dependent resistance of the thermistor (PTC-resistance) is used to sense the winding temperature. Two chains of three thermistors, 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 Copeland protection module switches a control relay depending on the thermistor resistance. It is installed in the terminal box to which the thermistors are connected.

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.

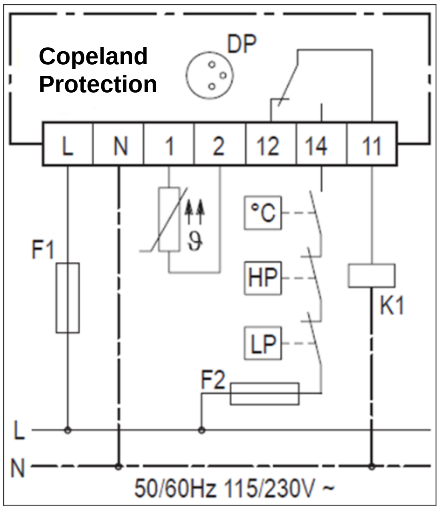
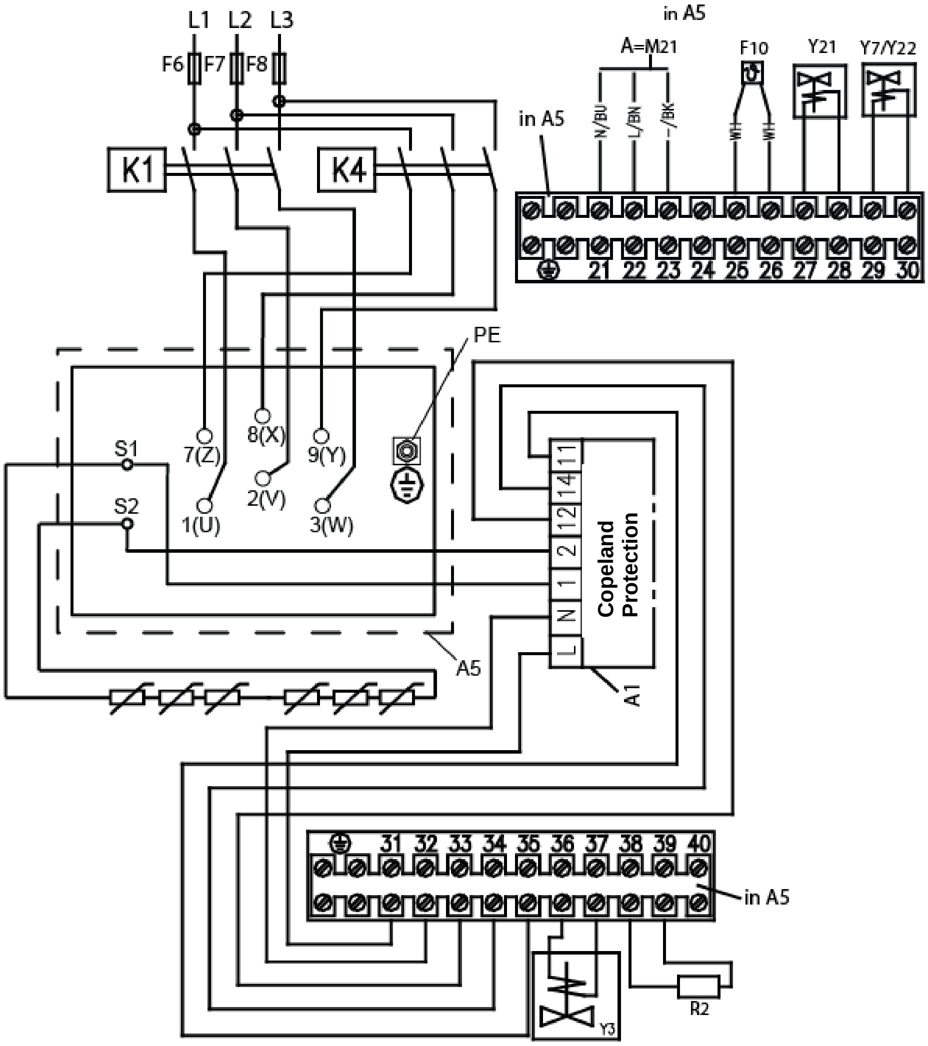


Figure 31: Wiring diagram

Protection class of the module: IP20.

4.4.2.2 Copeland Protection – Wiring diagrams

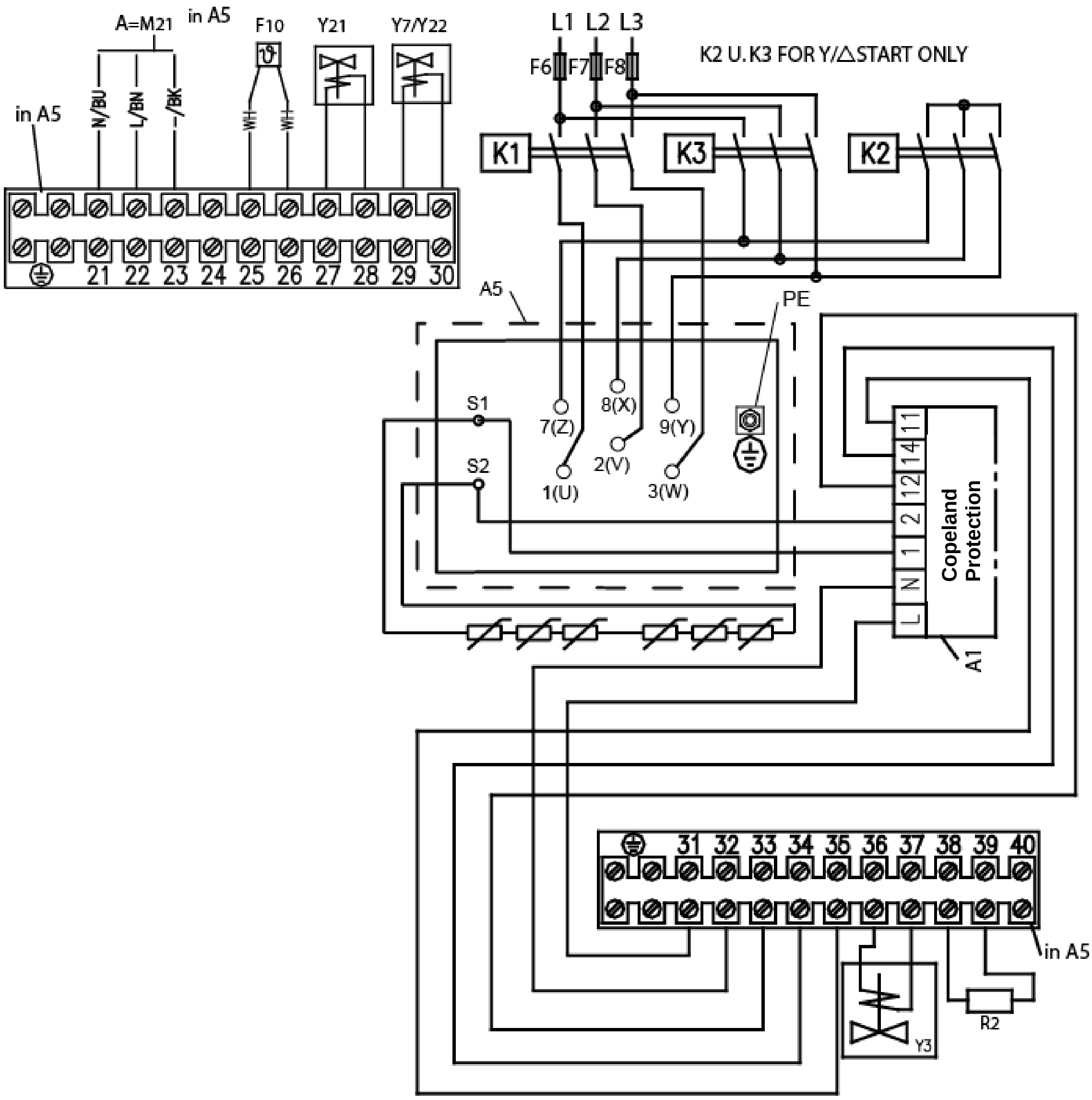


Legend

A1 .... Protection module
A5 .... Terminal box compressor
F6 .... Fuse for control circuit
F7 .... Fuse for control circuit
F8 .... Fuse for control circuit
F10 ..... Thermal protection switch M21

K1........Contactor M1
K4........Contactor M1 for 2nd part-winding
M21 .....Fan motor / condenser
R2........Crankcase heater
S1........Thermistor chain motor temperature
S2........Thermistor chain motor temperature
Y3........Solenoid valve unloaded start

Figure 32: Wiring diagram – Part-winding motors (AW…, FW…)



Legend

A1 .... Protection module
A5 .... Terminal box compressor
F6 .... Fuse for control circuit
F7 .... Fuse for control circuit
F8 .... Fuse for control circuit
F10 ..... Thermal protection switch M21
K1 .... Contactor M1

K2........Contactor M1 Y-connection
K3........Contactor M1 Δ-connection
M21 .....Fan motor / condenser
R2........Crankcase heater
S1........Thermistor chain motor temperature
S2........Thermistor chain motor temperature
Y3........Solenoid valve unloaded start

Figure 33: Wiring diagram – Direct-On-Line (EW…) motors

4.4.3 Compressors with CoreSense Diagnostics (until December 2019)

CoreSense Diagnostics was the standard protection system for Stream 4MTL* and 4MSL* compressors until December 2019 included. Stream compressors with "-D" at the end of the description are equipped with a CoreSense Diagnostics device.

CoreSense Diagnostics provides advanced protection against faults such as high discharge temperature, locked rotor, single/missing phase, voltage imbalance and low voltage. It also provides oil pressure protection on models 4MTL-35 to 4MTL-50 only. The module is capable of communication via Modbus protocol. An external overload protection is not necessary.

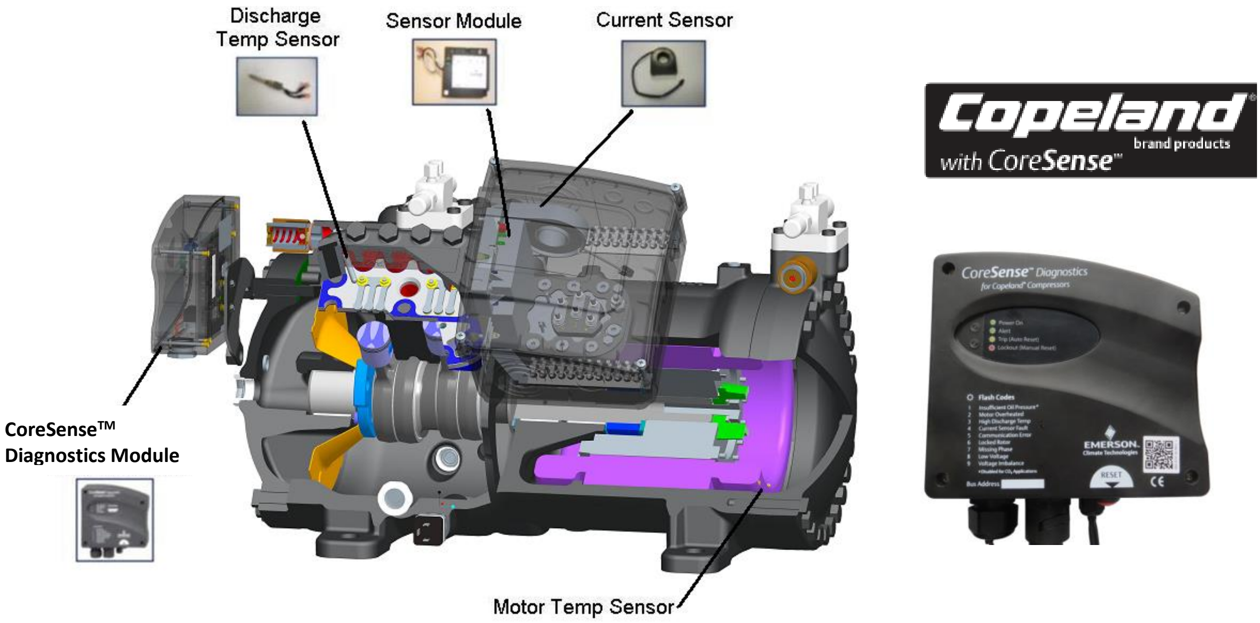


Figure 34: Compressor internal view with sensors and CoreSense Diagnostics module

4.4.3.1 CoreSense Diagnostics – Electrical connections

For the electrical connection of the CoreSense Diagnostics module, refer to the wiring diagram in **Figure 35** below:

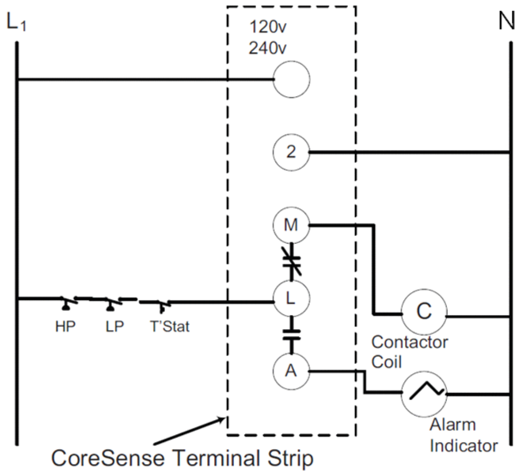
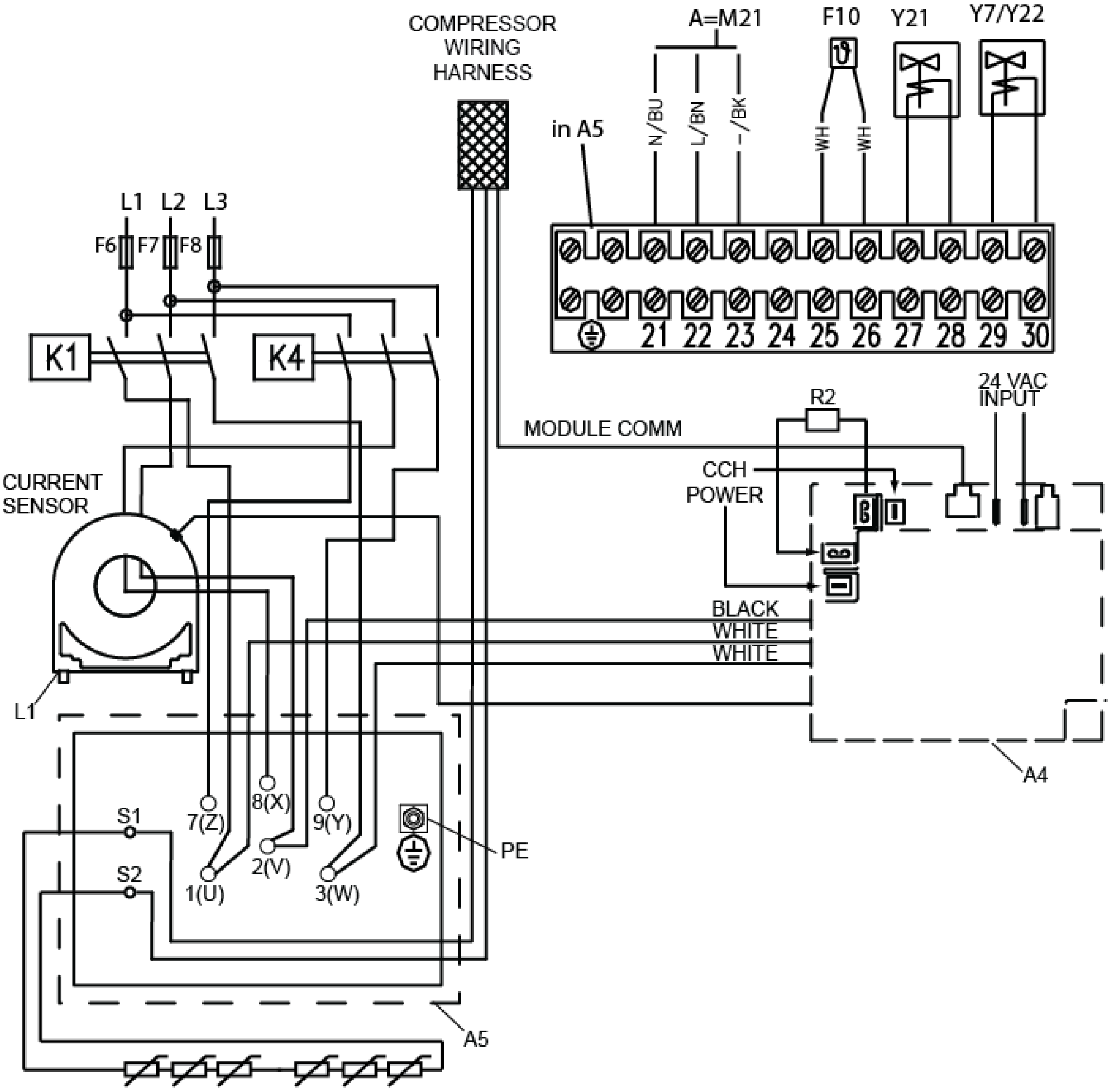


Figure 35: CoreSense Diagnostics module wiring diagram

NOTE: **For more information please refer to Technical Information D7.8.4 "CoreSense™ Diagnostics for Stream refrigeration compressors".**

4.4.3.2 CoreSense Diagnostics – Wiring diagrams

Wiring diagram for part-winding motors (AW…, FW…)



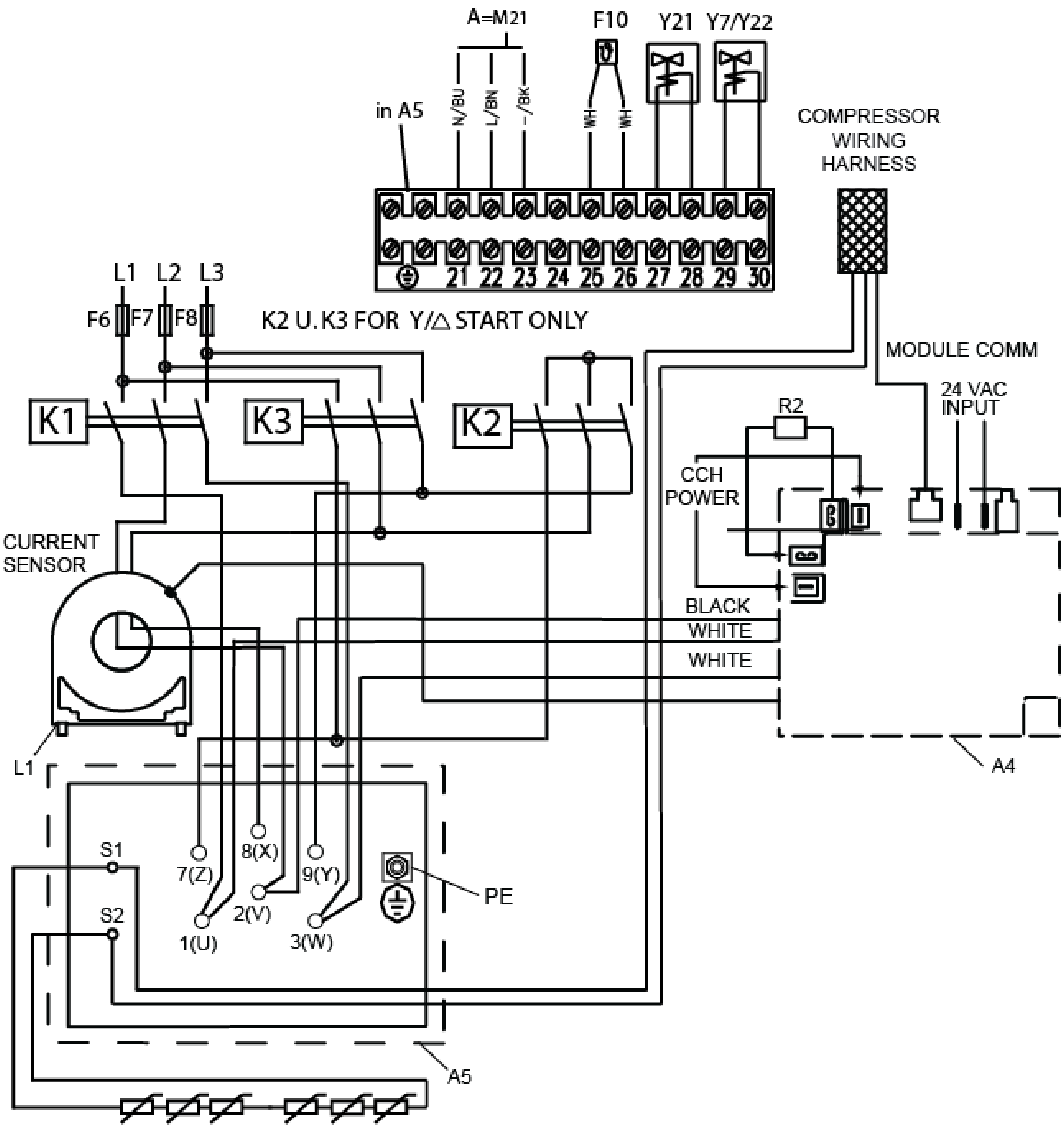
Legend

A4 .... Sensor module
A5 .... Compressor terminal box
CCH.... Crankcase heater
F6 .... Fuse for control circuit
F7 .... Fuse for control circuit
F8 .... Fuse for control circuit
F10 ..... Thermal protection switch M21
K1........Contactor M1 Y-connection
K4........Contactor M1 YY-connection
L1 ....Current transducer CoreSense
M21 .....Fan motor / condenser
R2........Crankcase heater
S1........Thermistor chain motor temperature
S2........Thermistor chain motor temperature

Figure 36: Wiring diagram – Part-winding motors (AW…, FW…)

***NOTE*: The sensor module inside the terminal box requires a separate 24 V AC power supply.**

Wiring diagrams for Star/Delta motors (EW…)



Legend

A4 .... Sensor module
A5 .... Compressor terminal box
F6 .... Fuse for control circuit
F7 .... Fuse for control circuit
F8 .... Fuse for control circuit
F10 ..... Thermal protection switch M21
K1 .... Contactor M1
K2 .... Contactor M1 Y-connection
K3 .... Contactor M1 Δ-connection

L1 .... Current transducer CoreSense
M21 ..... Fan motor / condenser
R2........ Crankcase heater
Y7........ Solenoid valve pumpdown
Y21...... Solenoid valve
Y22...... Solenoid valve
S1........ Thermistor chain motor temperature
S2........ Thermistor chain motor temperature

Figure 37: Wiring diagram – Direct-On-Line (EW…)

***NOTE*: The sensor module inside the terminal box requires a separate 24 V AC power supply.**

4.5 Crankcase heater

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 compressor shell during standstill periods. It is always required for Stream 4MTL* and 4MSL* compressors.

4MTL* and 4MSL* compressors use a 100-Watt crankcase heater available in 115 or 230 V. The crankcase heater is delivered as a kit together with the compressor. This "easy-to-install" kit consists of 3 parts:

- 1 crankcase heater;
- 1 heat-conductive paste tube;
- 1 mounting ring.

The operation of 115 V and 230 V crankcase heaters can be controlled by the Copeland Compressor Electronics module.

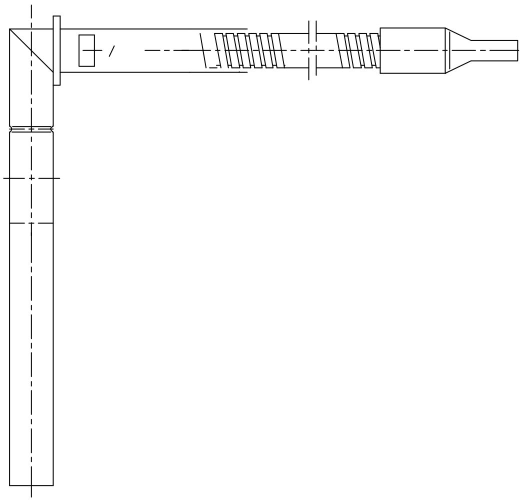
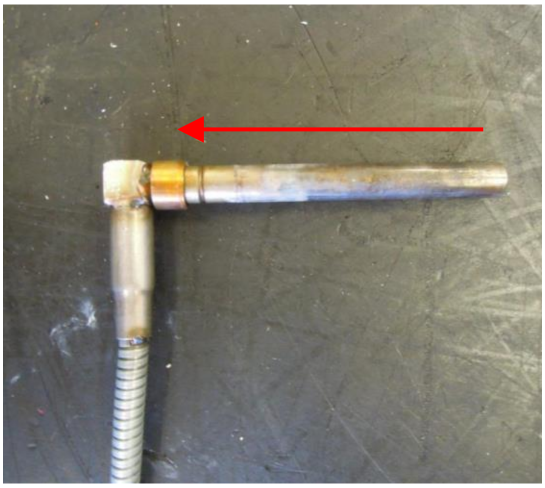


Figure 38: 100-Watt crankcase heater element

Figure 39: Crankcase heater kit

The crankcase heater has to be inserted in a special chamber.

Assembly instructions

	
Insert the mounting ring along the heating part until it blocks.	Spread a thick layer of conductive paste around the heating part.

	
Remove the plug before heater installation. Insert the heater in the hole. The mounting ring (preassembled on the heater before insertion) has to be pressed into the hole.	The crankcase heater is secured into position. It is also possible to secure the heater more firmly by using a rubber hammer on the flat surface.

Table 14: Crankcase heater installation procedure

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.

5.1 Leak test

As a general rule, the reduction of leaks is a legal obligation. Refrigeration systems must be checked for leakage before they get into operation. The rules for tightness tests when building a CO_2 system are the same as for systems using other refrigerants. Usually leakage tests are performed by means of inert gases, eg, dried nitrogen or helium.

Leak test frequency is covered by legislation. CO_2 is not in the scope of the F-gas Regulation (EU) No 517/2014. In principle refrigeration equipment with a refrigerant charge of 3 kg or more shall be subject to tightness inspection at least once per year. Repeated inspection might be required.

Leak detection spray and electronic leak detectors can be used. Electronic leak detectors shall have specific sensitivity according to local standards and need to be checked regularly.

Fluorescent additives must be approved by the equipment manufacturer.

Copeland brand compressors are leak-tested during manufacturing. Never apply pressures higher than the maximum allowable pressure PS to the compressor. If the pressure / tightness test of the connected piping system requires higher pressures, the compressor shut-off valves must remain closed during the test. It is legally allowed to test parts of the system separately.

5.2 System evacuation

Before commissioning, remove the holding charge then evacuate with a vacuum pump. Proper evacuation reduces residual moisture to 50 ppm. The installation of adequately sized access valves at the furthest point from the compressor in the suction and liquid lines is advisable. To achieve undisturbed operation the compressor valves are closed and the system is evacuated down to 3 mbar / 0.225 Torr or lower. Pressure must be measured using a vacuum pressure (Torr) 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. Then the compressor must be evacuated.

Due to the factory holding charge of dry air the compressor is under pressure (about 1 to 2.5 bar); this is to indicate that the compressor does not leak.

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

5.3 Preliminary checks – Pre-starting

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

- visual check of the electrics, wiring, fuses etc;
- visual check of the plant for leaks, loose fittings such as TXV bulbs etc;
- compressor oil level;
- calibration 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;
- compressor pre-charged with refrigerant;
- compressor electrical auxiliary switch location & position.

5.4 Charging procedure

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 without enough system charge to maintain at least 6 bar absolute suction pressure. Allowing the absolute pressure to drop below 6 bar for more than a few seconds might cause CO_2 solidification which would block valves or pipes.

CAUTION
Low moisture content! Corrosive impact on refrigeration system! Use only high-dried CO_2 quality.

Charge the system with vapour CO_2 up to a minimum absolute pressure of 6 bar to prevent dry ice formation. A gaseous pre-charge of 10 bar in the whole system is common practice. Then continue charging with liquid CO_2. The system should be charged through the liquid-receiver shut-off valve or through a valve in the liquid line. The use of a filter-dryer in the charging line is highly recommended.

As there may be several valves in the system it is recommended to charge on both the high and low sides simultaneously to ensure a sufficient pressure is present in the compressor before it runs. The majority of the charge should be placed in the high side of the system to prevent bearing washout during first-time start.

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.

The compressor must be equipped according to our technical documentation considering the application intended. Make sure this requirement is met before start-up.

For brazing connections where dissimilar or ferric metals are joined a silver alloy rod with a minimum silver content of 34 % shall be used being either flux-coated or with a separate flux.

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

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

NOTE: **A compressor should never be operated outside its approved application range! Check the corresponding 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

Copeland 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.

5.7 Inverter operation

Stream compressors are released for inverter applications with inverters from Nidec or other brands available on the market.

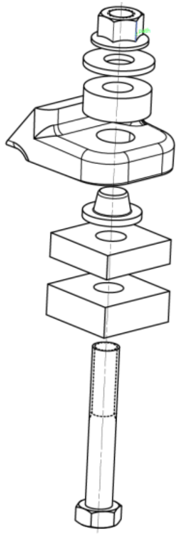
Compressor		Nominal power	Displacement m³/h @ 50 Hz	Approved frequency ranges	Recommended mounting parts
Subcritical	4MSL-03	3 hp	4.6	25 - 70 Hz	Hard rubber kit # 3189744 
	4MSL-04	4 hp	6.2		
	4MSL-06	6 hp	7.4		
	4MSL-08	8 hp	9.5	25 - 70 Hz	
	4MSL-12	12 hp	12.5		
	4MSL-15	15 hp	17.9		
Transcritical	4MTL-05	5 hp	4.6	30 - 70 Hz	
	4MTL-07	7 hp	6.2		
	4MTL-09	9 hp	7.4		
	4MTL-12	12 hp	9.5	25 - 70 Hz	
	4MTL-15	15 hp	12.5		
	4MTL-30	30 hp	17.9		
	4MTL-35	35 hp	22.7	30 - 70 Hz (check approved application envelope)	
	4MTL-40	40 hp	26.6		
	4MTL-50	50 hp	32.0		

Table 15: Inverter operation – Approved frequency ranges

NOTE: **The frequency range depends on the operating conditions. For approved application envelope please contact Application Engineering or refer to Copeland Select software at www.copeland.com/en-gb.**

5.7.1 Maximum Operating Current – Models 4MTL-35 to 4MTL-50

Large Stream CO_2 compressors from 35 to 50 hp have a different MOC in operation with frequency drives. **Table 16** below shows the values for both types of operation.

Compressor	MOC (A)	MOC_{VS} (A)
4MTL-35	59.6	67.1
4MTL-40	67.4	75.8
4MTL-50	82.7	90.6

Table 16: Maximum operating current for large Stream CO_2 compressors

5.7.2 Recommendations for use with an inverter

Running the Stream CO_2 compressor with an inverter is a reliable application. Nevertheless resonances might occur in the lower frequency ranges. This phenomenon strongly depends on the system design and operating conditions.

Copeland conducted extensive tests to investigate compressor behaviour in terms of resonances. The testing indicates that the following hardware variables have a significant impact on possible resonances:

- **Mounting parts:** The rubber mounting parts supplied with Stream compressors are suitable for the whole frequency range from 25 to 70 Hz.
- **Piping design:** It is recommended to pay particular attention to the discharge line design. A discharge pipe parallel to the compressor axis normally gives a positive effect to reduce resonances at low frequencies.
- **Base frame design:** The framework structure should be stiff enough to ensure that its resonance frequencies are above the maximum 70 Hz frequency. A design with natural frequencies below the minimum 25 Hz speed may lead to high vibrations during start-up.

NOTE: **Performance data and envelopes are published in Copeland Select software available at www.copeland.com/en-gb/tools-resources.**

6 Maintenance & repair

6.1 Exchanging the refrigerant

Stream 4MTL* and 4MSL* compressors are released for use with CO_2 refrigerant only. The replacement of CO_2 with any other refrigerant is not allowed.

In the event that the refrigerant needs replacing, the CO_2 charge does not need to be recovered and can be blown off into the environment. Ensure that no oil is blown off (use a filter-dryer). It is essential to ensure good ventilation or evacuation of the CO_2 refrigerant to avoid a risk of suffocation.

6.2 Replacing a compressor

CAUTION
Inadequate lubrication! Bearing destruction! 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.

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-dryers. A 100 % activated alumina suction line filter-dryer is recommended but must be removed after 72 hours. **It is highly recommended that the suction accumulator be replaced if the system contains one.** This is because the accumulator oil-return orifice or screen may be plugged with debris or may become plugged shortly after a compressor failure. This will result in starvation of oil to the replacement compressor and a second failure. When a single compressor or tandem 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.

6.3 Lubrication and oil removal

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 of Stream CO_2 compressors for use with R744 refrigerant is a polyolester (POE) lubricant Emkarate RL 68 HB. Large models (4MTL-35 to 4MTL-50) can alternatively be delivered with PAG oil upon request.

Both PAG and POE oils are far more hygroscopic than mineral oil. Only brief exposure to ambient air is needed for POE to absorb and retain sufficient moisture to make it unacceptable for use in a refrigeration system. It is even more so for PAG oil. It is also more difficult to remove moisture through the use of vacuum. The measures taken in POE systems to prevent moisture ingress and to remove moisture (for example, minimizing the contact with air, using appropriate vacuuming methods, using a filter-dryer, etc.) can similarly be used in PAG systems.

The compressors supplied by Copeland contain oil with low moisture level, but it may rise during the system assembling process. Therefore, it is recommended that a properly sized filter-dryer be installed in all systems, which will maintain the moisture level in the oil to less than 50 ppm. If POE or PAG oil is charged into a system, it is recommended that its moisture content be no higher than 50 ppm.

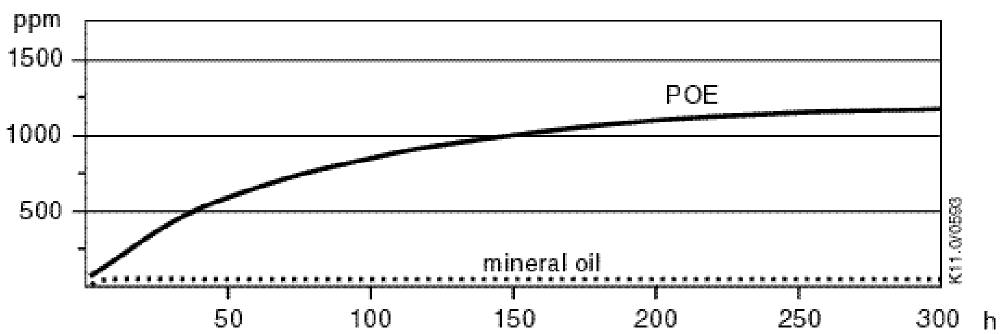


Figure 40: Absorption of moisture in ester oil vs mineral oil in ppm by weight (h=hours)

The diagram in **Figure 40** compares the hygroscopic characteristics of POE oil with mineral oil (moisture absorption in ppm at 25 °C and 50 % relative humidity).

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 an absolute pressure of 3 mbar or lower. Sight glass/moisture indicators currently available can be used with natural refrigerants and lubricants. However, the moisture indicator will only show the moisture content of the refrigerant. The actual moisture level in the oil is likely to be higher than indicated by the sight glass. This is due to the high hygroscopicity of POE and PAG oils. Therefore, if there is uncertainty as to the moisture content in the system, or to measure the actual moisture level, oil samples should be taken and analysed.

Use the plug (1/4"-18 NPTF) shown in **Figure 41** below for oil removal.

Figure 41: Oil removal plug location

6.4 Oil additives

Although Copeland 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 components.

6.5 Unbrazing system components

WARNING
Explosive flame! Fire hazard! Oil/refrigerant mixtures are highly flammable. Remove all of the 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 of the refrigerant from both the high and low sides of the system. If a brazing torch is 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.

6.6 Replacing a pressure relief valve (PRV)

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 under vacuum and has no refrigerant charge, when it has a holding charge of nitrogen, or when the compressor service valves are closed.

In case a pressure relief valve has to be replaced, it is recommended to follow the steps below:

- Connect manifolds that are applicable with high pressures to the suction and discharge shut-off valves on the compressor.

- Close compressor shut-off valves and make sure that the compressor cannot start (electrically lock it out).
- Release the remaining CO_2 refrigerant to the atmosphere through the manifold. A filter-dryer in the flexible hose of the compressor helps to separate oil from the released gas to protect the environment.
- Make sure that there is no more pressure in the compressor.
- Replace the 135 bar pressure relief valve (caution: left-handed thread!). Torque to 90-110 Nm.
- Check all screwed / thread connections for tightness and proper torque.
- Use a vacuum pump to remove any air that may have entered the compressor.
- Do a quick tightness test with CO_2.
- Put the compressor back to operational conditions (open valves).
- Restart the compressor.
- Add missing refrigerant if required.

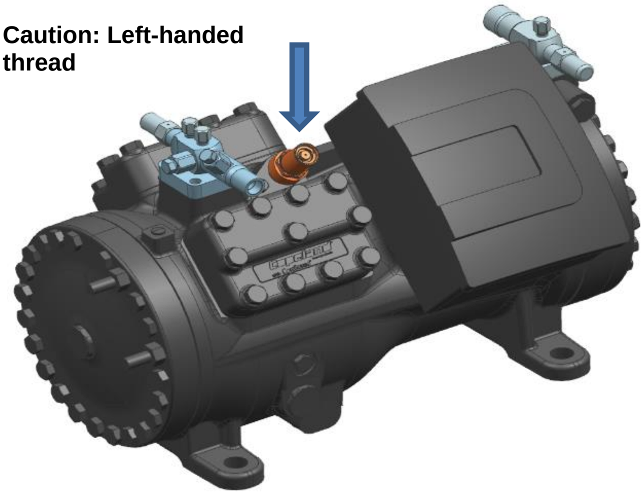
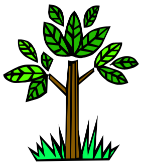


Figure 42: PRV location (example)

7 Dismantling & disposal



Removing oil and refrigerant:

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

Dispose of compressor in compliance with national legislation and regulations.

Appendix 1: Connections of Stream CO_2 compressors

4MTL*			**4MSL***		
4MTL-05	4MTL-07	4MTL-09	4MSL-03	4MSL-04	4MSL-06
4MTL-12	4MTL-15	4MTL-30	4MSL-08	4MSL-12	4MSL-15
4MTL-35	4MTL-40	4MTL-50			

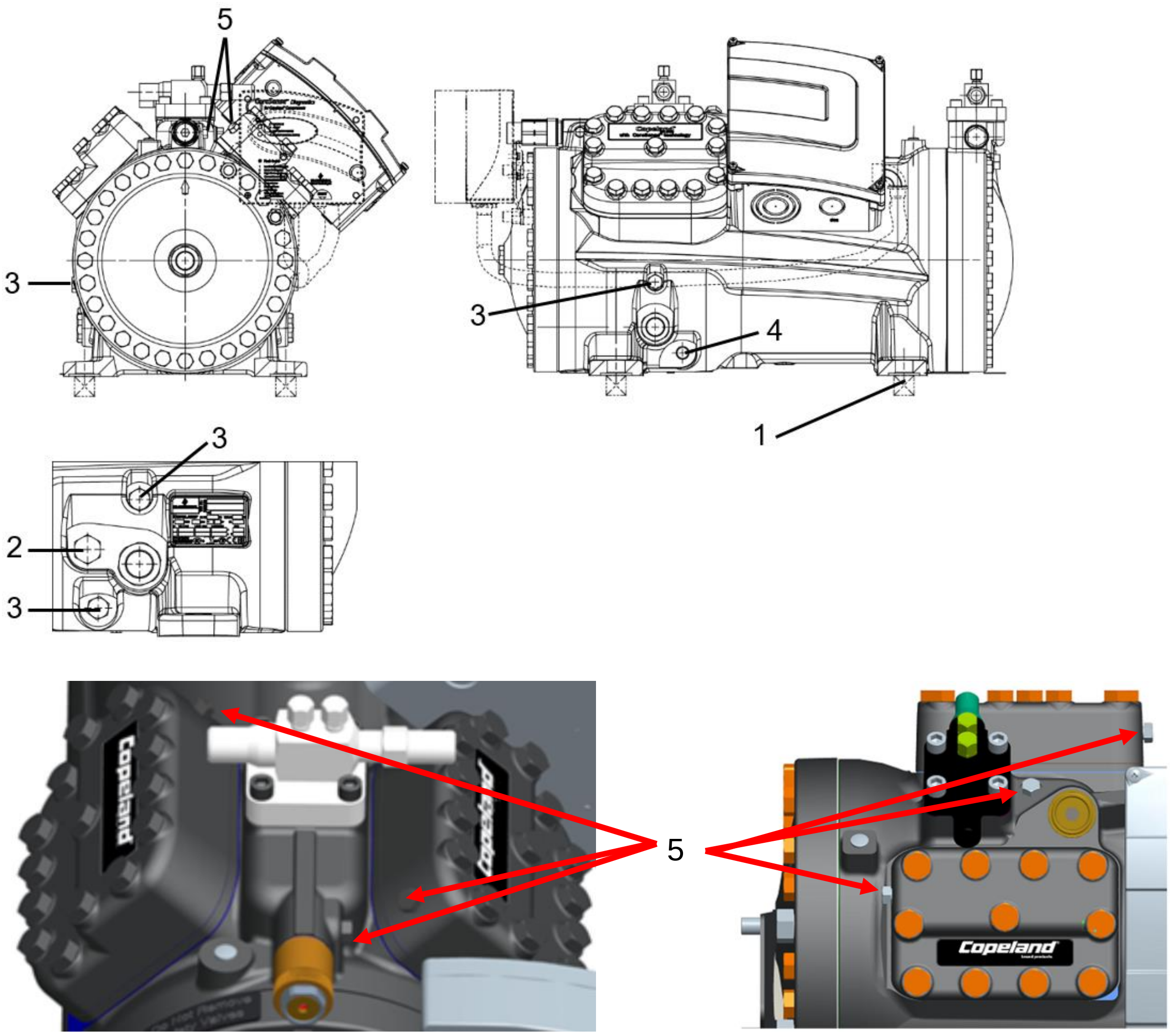


Figure 43

SL	Suction line size (sweat) 4MSL-03, 4MSL-04, 4MSL-06 4MTL-05, 4MTL-07, 4MTL-09	ID: 5/8" Tube OD: 16.15 mm	DL	Discharge line size (sweat) 4MSL-03, 4MSL-04, 4MSL-06 4MTL-05, 4MTL-07, 4MTL-09	ID: 1/2" Tube OD: 12.85 mm
SL	Suction line size (sweat) 4MSL-08, 4MSL-12, 4MSL-15 4MTL-12, 4MTL-15, 4MTL-30	ID: 7/8" Tube OD: 22.40 mm	DL	Discharge line size (sweat) 4MSL-08, 4MSL-12, 4MSL-15 4MTL-12, 4MTL-15, 4MTL-30	ID: 5/8" Tube OD: 16.15 mm
SL	Suction line size (sweat) 4MTL-35, 4MTL-40, 4MTL-50	ID: 1 3/8" Tube OD: 35.25 mm	DL	Discharge line size (sweat) 4MTL-35, 4MTL-40, 4MTL-50	ID: 1 1/8" Tube OD: 28.75 mm
1	Base mountings	Ø 22 mm	4	Crankcase heater	No thread
2	Plug low-pressure connection	1/2" 14 NPTF	5	Plug high-pressure connection	1/8" 27 NPTF
3	Plug low-pressure connection / Oil drain plug	1/4" 18 NPTF			

Table 17: Legend

Appendix 2: Tightening torques in Nm

Pressure relief valve LP/HP side	M24 X 1.5 90 - 110 Nm SW 24 mm	Shut-off valve screws Discharge and suction	3/8" - 16 UNC 36 - 44 Nm SA 8 mm
Shut-off valve cap (spindle)	3/4" - 16 UNF 4 - 5 Nm	Shut-off valve pressure cap	7/16" - 20 UNF 24 - 35 Nm
Plugs for low-pressure connection (position 3 in **Table 17**)	1/4" - 18 NPTF 30 - 40 Nm SW	Plugs for low-pressure connection (position 2 in **Table 17**)	1/2" - 14 NPTF 50 - 60 Nm SW
Plugs for high-pressure connection	1/8" - 27 NPTF 35 - 40 Nm SW	Cylinder head	1/2" - 13 UNC 102 - 138 Nm SW 19 mm
Discharge temperature sensor	1/8" - 27 NPTF 30 - 35 Nm	Terminal studs	M5 8.5 - 9.6 Nm SW 8
Mounting plate for terminals*	3/8" - 16 UNC 36 - 44 Nm SA 3/16"	Mounting plate for terminals**	3/8" - 16 UNC 70 - 75 Nm
Stator cover	1/2" - 13 UNC 119 - 159 Nm SW 19 mm	Housing cover	1/2" - 13 UNC 119 - 159 Nm SW 19 mm
Screws for oil pump cover**	3/8" - 16 UNC-2A 52 - 64 Nm SW 9/16"	Schraeder valve in oil pump cover	1/8" - 27 NPTF 11 - 13.5 Nm SW 11 mm
OPS3 Oil differential pressure sensor**	3/4" - 16 UNF-2A 60 - 75 Nm SW 1 1/16"	Oil relief valve screw	3/8" - 16 UNC-2A 38 - 46 Nm Torx E12
Oil sight glass	1 1/8" - 18 UNEF 50 - 60 Nm SW 35 mm	Oil drain plug	1/4" - 18 NPTF 30 - 40 Nm
Magnetic plug fitting	1/8" - 27 NPTF 35 - 40 Nm SW 7/16"		

* *For small & medium models: 4MTL-05 to 4MTL-30 & 4MSL-03 to 4MSL-15*
** *For large models: 4MTL-35 to 4MTL-50*

Table 18: Tightening torques for main components

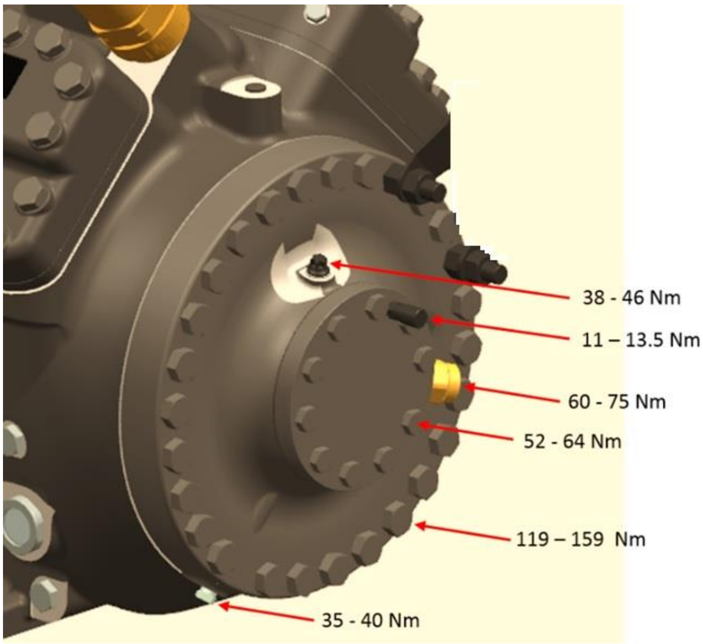


Figure 44: Tightening torques around oil pump

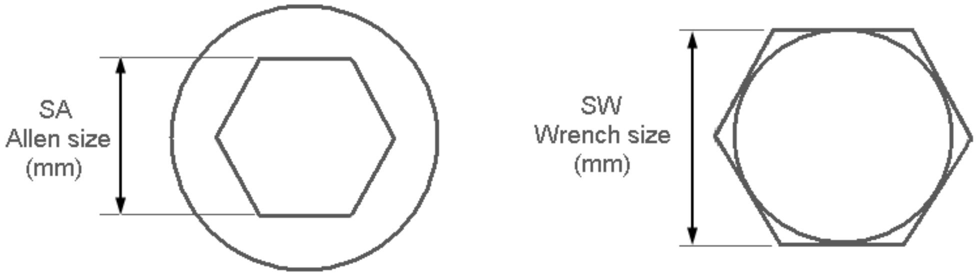
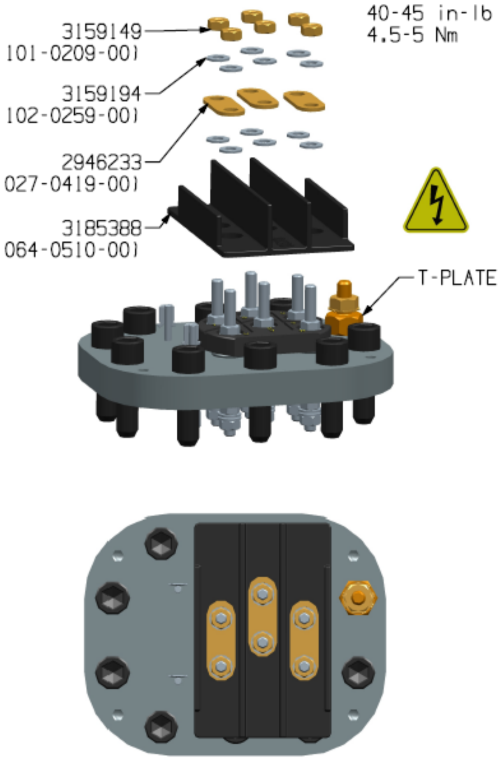


Figure 45: Hexagon socket screws (Allen / Inbus) & hexagon heads (Wrench)

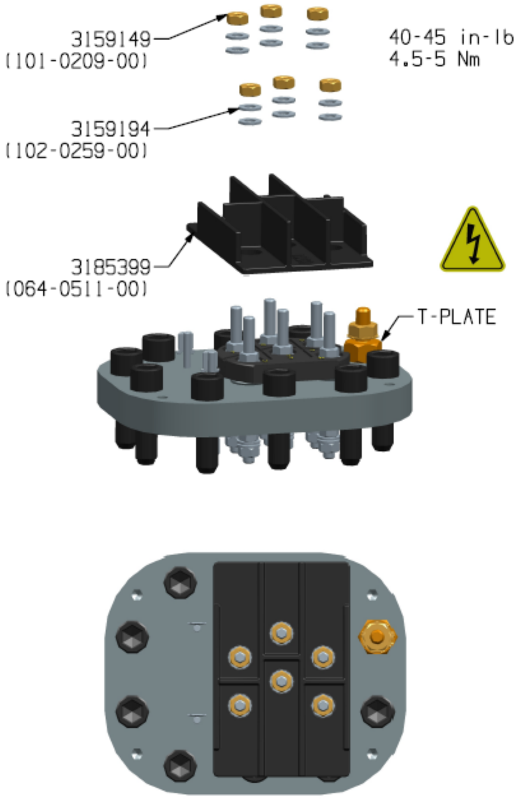
The ranges of torque values given in this specification are assembly torques. Torque after joint relaxation must be within 15 % of the minimum assembly torque unless re-torque is called for and must not be above 10 % of the maximum assembly torque.

Appendix 3: T-Plate isolators depending on motor version & power supply

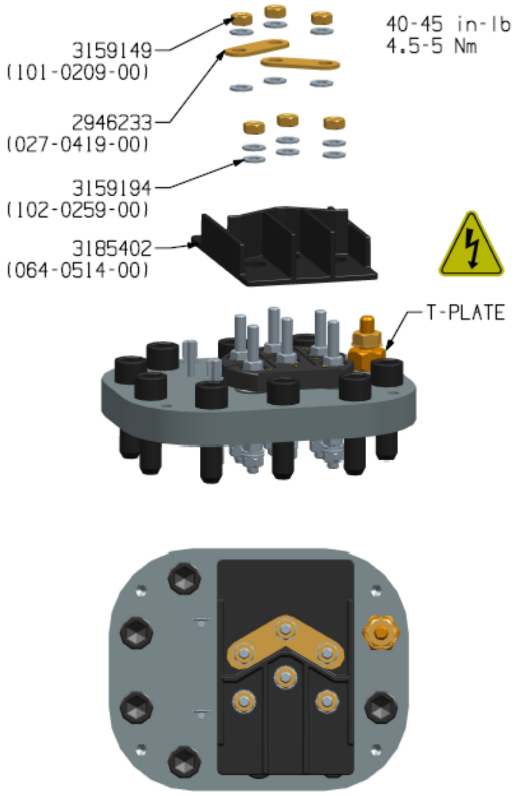
FWM - Direct on line in Y/Y-connection
FWD - Direct on line in Y/Y-connection
EWL - Direct on line in Δ-connection
EWK - Direct on line in Δ-connection
EWM - Direct on line in Δ-connection
EWD - Direct on line in Δ-connection
AWM - Direct on line in YY/Y-connection
AWD - Direct on line in YY/Y-connection
AWC - Direct on line in YY/Y-connection
AWX - Direct on line in YY/Y-connection
FSC - Direct on line in YY/Y-connection
FSD - Direct on line in YY/Y-connection
TSE - Direct on line in YY/Y-connection



FWM - Part-winding start in Y/Y-connection
FWD - Part-winding start in Y/Y-connection
EWM - Star-Delta start in Y-Δ-connection
EWD - Star-Delta start in Y-Δ-connection
AWM - Part-winding start in YY/Y-connection
AWD - Part-winding start in YY/Y-connection
AWC - Part-winding start in YY/Y-connection
AWX - Part-winding start in YY/Y-connection
FSC - Part-winding start in YY/Y-connection
FSD - Part-winding start in YY/Y-connection
TSE - Part-winding start in YY/Y-connection



EWL - Direct on line in Y-connection
EWK - Direct on line in Y-connection



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