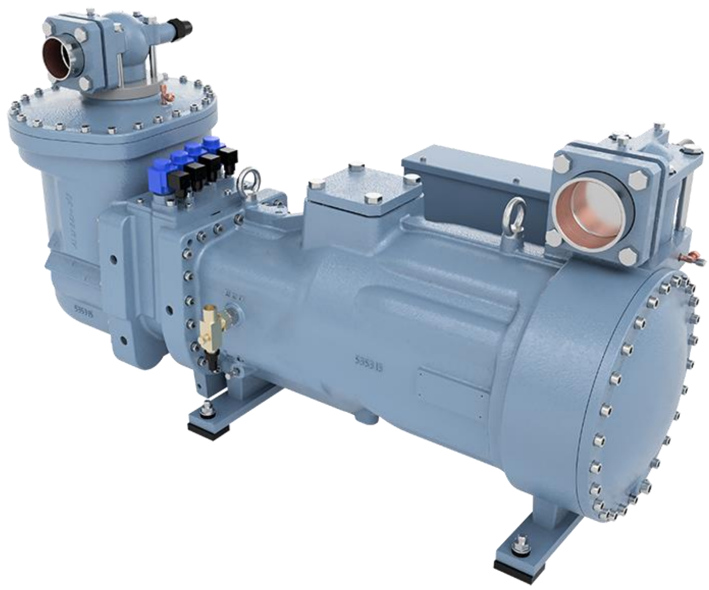
EN

COOL TECHNOLOGY

User and Maintenance Manual

RS5



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Sommario

1 Safety instructions

1.1 Importance of the manual

This manual contains the description of the operation and the necessary instructions to properly execute the main operations of use, ordinary and periodic maintenance of the compressor.

A prerequisite to ensure safe working conditions is compliance with all safety warnings and all instructions contained herein.

It must also ensure compliance with the local safety regulations currently in force in the installation location of the compressor as well as the general safety regulations.

The information contained herein is intended for professional users who must have specific knowledge of how to use the compressor, must be authorized, trained and properly instructed.

We recommend the use of original parts and accessories.

The non-original parts will invalidate the warranty and may also be dangerous, reducing the life and performance of the compressor.

This manual, in case of transfer or sale, must always be delivered with the compressor. If it becomes lost or damaged, you have to ask for a copy to the manufacturer of the compressor or to the previous owner.

The manual is considered an integral part of the sytem.

1.2 Responsibility limitations

All indications and warnings given in this manual have been prepared taking into account the rules and regulations in force, the current state of the art of the technology and the skills and knowledge acquired.

The manufacturer assumes no responsibility for any damage caused by:

- failure to follow instructions contained in this user manual;
- usage outside of the intended purposes;
- use of non-specialized personnel;
- unauthorized modifications;
- technical changes;
- use of non-original spare parts and wearing parts.

If special versions has been requested, additional options have been ordered or technical updates have been applied, it is possible that the components actually supplied are changed with respect to the descriptions and illustrations in this manual. The obligations agreed in the supply contract, the general terms and conditions and the conditions of supply of the manufacturer and the legal provisions in force at the time of signing the contract are intended as valid.

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1.3 Simbols on the manual

The following **symbols** are used in this manual to get your attention how they should behave in all operating situations:

RECOMMENDATIONS: contains advice and recommendations as well as useful information for safe and trouble-free operations.

CAUTION!: indicates a potentially hazardous situation which, if neglected, can lead to material damages.
Carefully follow the instructions and work carefully to avoid accidents, injuries and material damages.

The warnings are accompanied by signal words that identify the severity of the danger.
ADVICE!: indicates a potentially hazardous situation which, if neglected, may cause minor or moderate injury.
WARNING!: indicates a potentially hazardous situation which, if left untreated, can cause death or serious injury.
RISK!: indicates a situation of imminent danger that, if left untreated, can cause serious injury or death. Carefully follow the instructions and work carefully to avoid accidents, injuries and material damages.

MECHANICAL OPERATOR: the indicated steps must be carried out by specialized mechanical operator that operates respecting the rules of national security and any specific rules of the workplace.

ELECTRICAL OPERATOR: the indicated steps must be performed by a specialized electrical operator that operates in compliance with the safety regulations concerning energized equipment.

MAINTENANCE OPERATOR: the indicated steps must be carried out exclusively by the operator in charge of the maintenance of the machinery. As such he has to:

- integrally read and understood the contents of this manual;
- operate respecting the rules of national security and any specific rules of the workplace.

HANDLING OPERATOR: the indicated steps must be carried out exclusively by the operator enabled to handle loads that operates respecting the rules of national security and any specific rules of the workplace.

COMPANY SAFETY MANAGER: the company responsible for safety must be informed of any residual risks present in the machine and has to take care of any application to local safety regulations or specific of workplace and environment.

1.4 Safety signals

On the compressor are affixed pictograms that identify any dangerous areas

It is mandatory of the operator to keep in perfect status and replace them when they are no longer legible.

	**DANGER - VOLTAGE:** indicates hazardous situations due to electrical voltage. In case of failure to follow safety instructions, there is a risk of serious injury or death.
	**DANGER – HIGH TEMPERATURE:** indicates hazardous situations due to compressor parts at high temperature. In case of failure to follow safety instructions, there is a risk of minor injuries and burns.
	**DANGER – RISK OF EXPLOSION:** indicates hazardous situations due to objects in pressure and the possible intervention of the safety valves. In case of failure to follow safety instructions, there is a risk of serious injury or death.
	**DANGER - CRUSHING:** indicates hazardous situations due to parts of the compressor under rotation. In case of failure to follow safety instructions, there is a risk of serious injury.
	**DANGER – MOVING PARTS:** indicates hazardous situations due to parts of the compressor under rotation. In case of failure to follow safety instructions, there is a risk of serious injury.
	**DANGER – EXPLOSIVE AREA:** indicates hazardous situations due to possibility of flammable or explosive area. In case of failure to follow safety instructions, there is a risk of serious injury and death. **The area has to be protected from effective source of ignition.**

Tab. 1 Pictograms

1.5 Machine switched-off status

Defines the condition of safety of the machine, to be applied before any maintenance and/or adjustment operations.

It provides for the compulsory execution of the following steps:

1. Turning off the machine using the stop button.
2. Rotation of the main switch of the compressor to position 0 and padlocked.
3. Main switch turned to position OFF or 0.
4. When performing maintenance work indoors, switch on the room ventilation.
5. Close the valves of the compressor.
6. Use a 2 stage vacuum pump with gas ballast (1.5mbar standing vacuum) for gas recovery.

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1.6 Responsibilities of the operator

The operator of the machine where the compressors is installed is therefore subject to the legal obligations concerning safety in the workplace.
In particular, the operator must:

- identify, through a risk assessment, the possible dangers arising from particular working conditions existing at the place of use of the compressor and of the machine.
- The user commits to comply with the applicable safety standards and regulations as well as with the guidelines given by this technical information.
- The user must provide the operating personnel with all the necessary information on the applicable safety regulations.
- Ensure that all employees who use the machine have read and understood the user manual. Also instruct regularly the personnel on how to use the machine and inform them of the possible dangers;
- implement, trough operating instructions, the behavioral requirements necessary for the operation of the compressor at the place of use;
- establish clear responsibilities for installation, operation, maintenance and cleaning of the compressor;
- check regularly, for all duration of use of the compressor, if the operating instructions correspond to the current version of the regulations;
- adjust, if necessary, the operating instructions to the new rules, regulations and conditions of use.

1.7 Misuse

Below are listed the actions required in order to prevent improper use of the compressor:

- Use the compressor only if it is in perfect technical condition. Promptly repair faults that can compromise security.
- It is not permitted to make changes to the compressor that may compromise its security of the same.
- Disconnect the power supply before performing regular maintenance, cleaning and repair work and ensure that it is an impossible compressor against restarting (disconnect the controls).
- Do not by-pass the safety devices or put them out of order.
- All operations on the compressor and/or on electrical equipment must be carried out by specialized personnel.
- Repairs and maintenance operations must be carried out only when the compressor is off. Make sure that it is impossible an accidental restarting of the machine!
- When performing operations on the compressor, the compressor must not be under pressure. Close the compressor or system valves and recover the gas into the compressor and piping. Observe the indication of the pressure gauge!
- The protective devices of the starter must be removed only when the machine is turned off and must be reassembled correctly at the end of the operations.

Remove the touch guard only when the machine and the pressure line have cooled down.

- The provisions relating to environmental protection require that all fluids handled during the maintenance operations (eg. Oil) are collected and disposed in accordance with current regulations.

1.8 Copyright

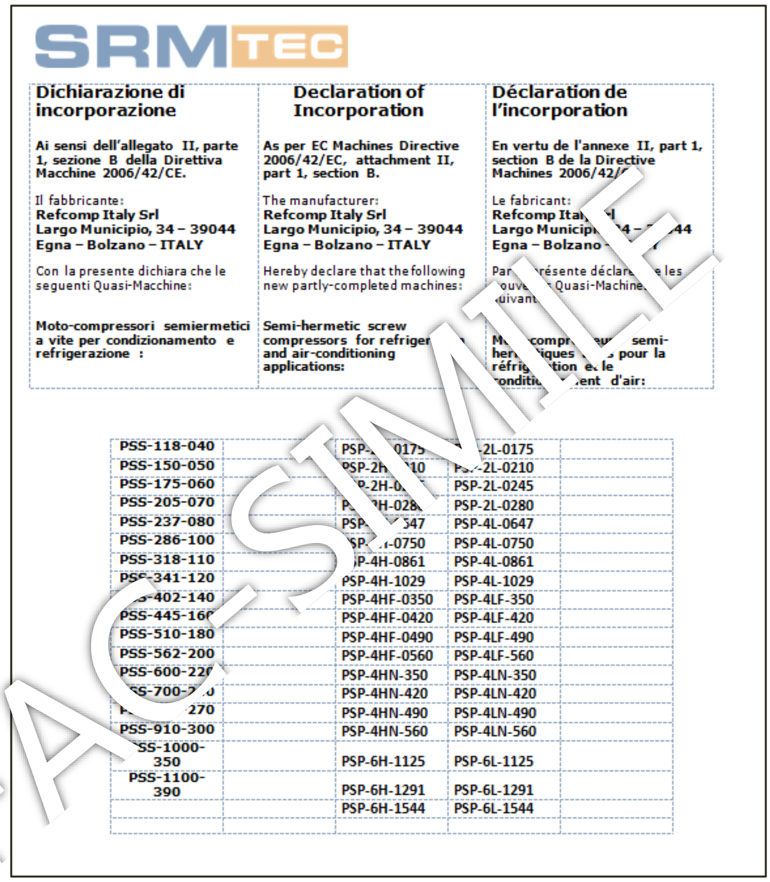
The content, texts, drawings, pictures and any other representation are protected by copyright and trade mark rights. Any violation is punishable.
It is forbidden the reproduction, even partial and by any means, and the use and/or disclosure of the content without prior written declaration by the manufacturer.

1.9 CE Declaration of Incorporation

The following is an example of the conformity declaration and the information contained in it.

As the compressor are dedicated to be installed in a refrigeration system, the CE assessment and certificate have to be produced by the designer and manufacturer of the system.

The original document is delivered in soft copy upon requirement.



Dichiarazione di incorporazione	Declaration of Incorporation	Déclaration de l'incorporation
Ai sensi dell'allegato II, parte 1, sezione B della Direttiva Macchine 2006/42/CE.	As per EC Machines Directive 2006/42/EC, attachment II, part 1, section B.	En vertu de l'annexe II, part 1, section B de la Directive Machines 2006/42/[illegible]
Il fabbricante: **Refcomp Italy Srl** **Largo Municipio, 34 – 39044** **Egna – Bolzano – ITALY**	The manufacturer: **Refcomp Italy Srl** **Largo Municipio, 34 – 39044** **Egna – Bolzano – ITALY**	Le fabricant: **Refcomp Ital[illegible]l** **Largo Municip[illegible]4 – [illegible]44** **Egna – Bolzano [illegible]**
Con la presente dichiara che le seguenti Quasi-Macchine:	Hereby declare that the following new partly-completed machines:	Par [illegible]résente déclar[illegible]e les [illegible]ouve[illegible] Quasi-Machine[illegible] [illegible]uivant[illegible]
Moto-compressori semiermetici a vite per condizionamento e refrigerazione :	**Semi-hermetic screw compressors for refriger[illegible] and air-conditioning applications:**	**M[illegible] compr[illegible]eu[illegible] semi-her[illegible]iques [illegible] pour la réfrig[illegible]tion e[illegible] le [illegible]onditio[illegible]ent d'air:**

PSS-118-040		PSP-[illegible]0175	[illegible]-2L-0175	
PSS-150-050		PSP-2H[illegible]10	P[illegible]-2L-0210	
PSS-175-060		[illegible]P-2H-0[illegible]	PSP-2L-0245	
PSS-205-070		P[illegible]H-028[illegible]	PSP-2L-0280	
PSS-237-080		PSP-[illegible]547	PSP-4L-0647	
PSS-286-100		[illegible]SP-[illegible]-0750	PSP-4L-0750	
PSS-318-110		[illegible]P-4H-0861	PSP-4L-0861	
PS[illegible]-341-120		PSP-4H-1029	PSP-4L-1029	
[illegible]-402-140		PSP-4HF-0350	PSP-4LF-350	
PSS-445-16[illegible]		PSP-4HF-0420	PSP-4LF-420	
PSS-510-180		PSP-4HF-0490	PSP-4LF-490	
PSS-562-200		PSP-4HF-0560	PSP-4LF-560	
PSS-600-22[illegible]		PSP-4HN-350	PSP-4LN-350	
[illegible]S-700-[illegible]		PSP-4HN-420	PSP-4LN-420	
[illegible]270		PSP-4HN-490	PSP-4LN-490	
PSS-910-300		PSP-4HN-560	PSP-4LN-560	
[illegible]SS-1000-350		PSP-6H-1125	PSP-6L-1125	
PSS-1100-390		PSP-6H-1291	PSP-6L-1291	
		PSP-6H-1544	PSP-6L-1544	

2 General

2.1 Identification

The SRMTec RS5 series screw compressors are helical twin screw oil-injected compressors (Fig. 2: Schematic drawing of an RS5 series compact screw compressor
shows an example with all the main parts and assemblies) specifically designed to operate with refrigerants (R134a, R1234yf, R1234ze, R407C, R404A, R450a, R513A) and to be installed in chillers, heat pump and process cooling system.

The identification of the compressor model is possible by the following scheme:

	RS5-	**L**	**140**
RS5- = High efficiency Screw Compressor			
L = System type L = Low temperature; H = High temperature;			
140 = Nominal power [Hp]			

2.2 Intended Use

The **RS5 semi-hermetic rotary screw compressors** have been designed and manufactured exclusively for the installation into a complete system and for the compression of clean refrigerants.
Any whatsoever claim for damages resulting from misuse is excluded. The designer and the operator of the machine where compressor is installed are solely responsible for any damage resulting from misuse.

THE COMPRESSOR USAGE FOR SCOPES DIFFERENT AND NOT INCLUDED IN THE INDICATED EXCLUDES THE MANUFACTURER FROM ANY RESPONSIBILITY FOR THE RISKS THAT SHOULD BE CAUSED AND FOR ANY DAMAGES TO THE MACHINE, PEOPLE OR THINGS.

2.3 Directives and Standards Reference

The compressor in question has been designed and manufactured taking into account the feedback that emerged from a careful analysis of risks and tending to achieve, given the state of the art, the objectives set by the essential requirements of safety and health provided by European Directives.
In the Tab. 2 are listed the referenced European Directives and Standards (EN):

Directive	Description
2006/42/EC	"Machinery Directive on the approximation of the laws of the Member States relating to machinery".
2014/35/EC	"Low Voltage Directive on the approximation of the laws of the Member States relating to electrical equipment designed for use

	within certain voltage limits".
2014/30/EU	"Electromagnetic Compatibility Directive on the approximation of the laws of the Member States relating to electromagnetic compatibility".
EN 1012-1	"Compressors and vacuum pumps. Safety requirements. compressors".
EN 12693:2008	"Refrigerating systems and heat pumps - Safety and environmental requirements - Positive displacement refrigerant compressors"
EN 60204-1	"Safety regulations concerning basic electrical equipment of machines".

Tab. 2 Reference standards and directives

2.4 Residual risks

We inform the authorized operators that, despite the manufacturer has adopted all the measures possible to make the construction of the compressor sure, remain potential residual risks described in Tab. 3**.**

Residual risk n° 1	**DANGER OF BEING EXPOSED TO FLAMMABLE AND EXPLOSIVE GASSES**
Frequency of exposure	Low and accidental. There may be exposure if the required ventilation system is not working properly.
Extent of the damage	Serious lesions (non reversible) and even death.
Solutions adopted	Respect of the correct procedure for maintenance operation. Safety signal.

Tab. 3 Residual risk n° 1

Residual risk n° 2	**DANGER OF BEING AFFECTED BY GAS PRESSURE**
Frequency of exposure	Low and accidental. There may be exposure if the operator decides to perform voluntarily impropriety, prohibited and not reasonably foreseeable.
Extent of the damage	Serious lesions (non reversible).
Solutions adopted	Respect of the correct procedure for maintenance operation. Safety signal.

Tab. 4 Residual risk n° 2

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2.5 Identification of dangerous areas

Dangerous areas of the compressor are identified in the following images.

These areas have to be considered into the risk assessment of the machine were the compressor is installed and appropriate precautions must be taken to reduce residual risks (see chapter 2.4)

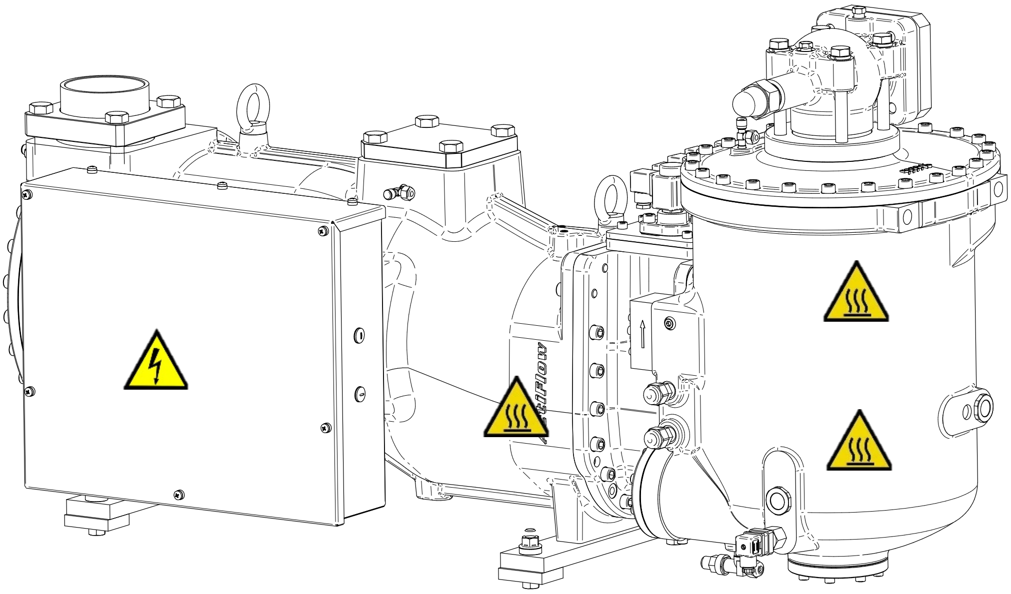

Fig. 1 Dangerous area identification

2.6 Introduction

The compressors feature a semi-hermetic construction, and are fitted with a three-phase asynchronous two-pole motor (2900 rpm at 50 Hz) directly coupled to the male rotor, which in turn drives the female rotor. These compressors are fitted out with a centrifugal oil separator (see chapter 3: "*Lubrication*") and that allows the compressors to be installed in the refrigerant circuit without requiring any additional components. The motor is cooled by the intake gas that flows through special holes and grooves.

For the RS5 series the capacity control is achieved by using a slide valve, which is moved by a hydraulic piston and which ensures part load operation by controlling the suction volume.

The compactness, low noise, efficiency, completeness of the ranges and their simple installation make these series compressors ideal for the construction of a range of high-efficiency and modern flooded evaporator system, water/water and air/water chillers and heat pumps.

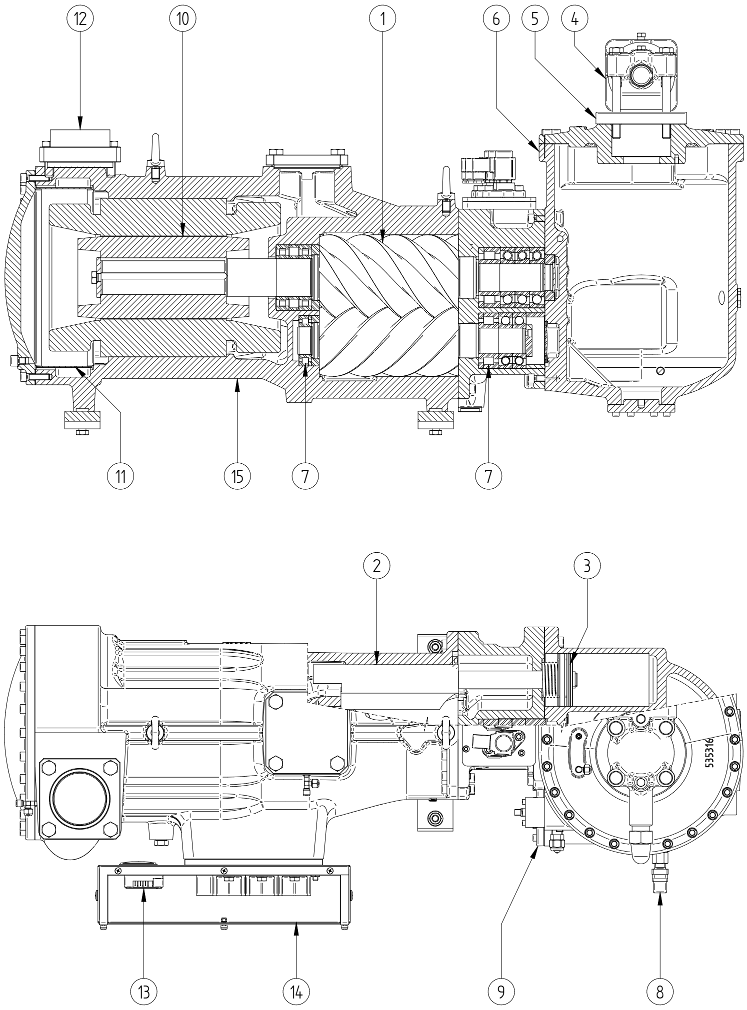

Fig. 2: Schematic drawing of an RS5 series compact screw compressor

1. Rotors;
2. Slide valve for capacity control;
3. Slide valve control piston;
4. Discharge shut off valve;
5. Check valve;
6. Oil reservoir/separator;
7. Rolling bearings;
8. Crankcase heater;
9. Oil filter;
10. Electrical motor;
11. Suction filter;
12. Suction bush;
13. Motor protection device;
14. Terminal box;
15. Rotor housing.

2.7 The compression process

The rotors are housed inside horizontal cylindrical chambers, fitted with a suction port (on the electric motor side) and a discharge port (on the oil separator side). Tightness against leakage through the extremely reduced clearance between the rotors and the chambers is guaranteed by a film of oil that is injected directly onto the screw profile.

The compression process essentially involves the following three phases (for reasons of clarity, the following description is limited to one lobe on the male rotor and one flute on the female rotor):

- Suction

With reference to Fig. 3, when the lobe on the male rotor is unmeshed from the flute on the female rotor, the suction port opens into the compression chamber and, due to the rotation of the screws, the suction volume increases, creating negative pressure that draws in the refrigerant fluid. The suction phase ends when, due to rotation, the suction port is closed.

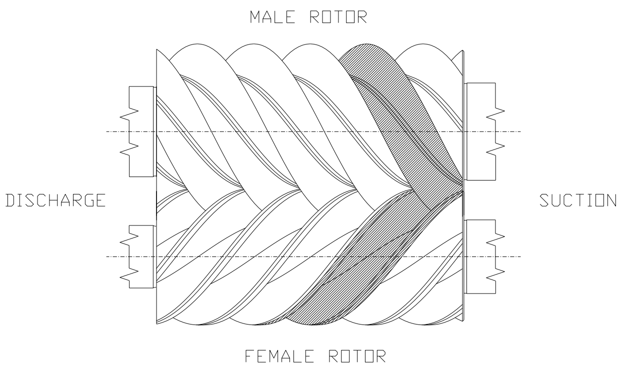

Fig. 3: chamber at the end of the suction phase

- Compression

With reference to Fig. 4, as rotation continues in the compression chamber, both the suction and the discharge ports are closed, the volume inside the chamber progressively decreases and the trapped gas moves in the longitudinal direction of the rotors, towards the discharge port. In other words, the trapped gas is compressed.

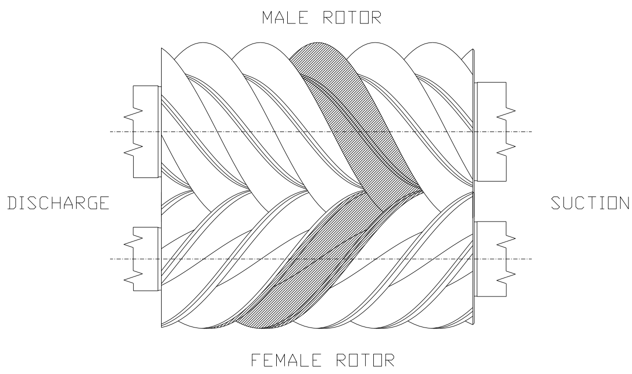

Fig. 4: chamber during the compression phase;

- Discharge

With reference to Fig. 5, the rotation continues until the discharge port opens and the compressed gas is completely expelled, due to the progressive intermeshing of the lobe and the flute. As the gear ratio is 5/6 (5 lobes on the male rotor and 6 flutes on the female rotor) and the rotation speed is around 3000 rpm at 50Hz (asynchronous motor), each minute there will be 3000 x 5 = 15000 discharge cycles, which means an almost complete absence of pulsation at the discharge. A reciprocating compressor operating at 1500 rpm would require 10 cylinders to achieve the same result.

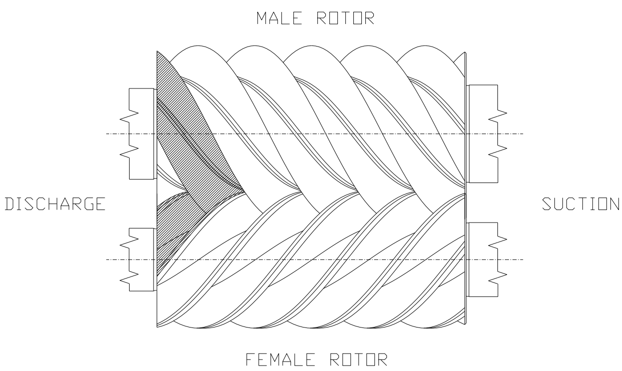

Fig. 5: chamber at the start of the discharge phase;

2.8 The rotors

The rotors, see Fig. 6, have an asymmetrical shape with 5 lobes and 6 flutes, and are made entirely by SRMTec. The perfect intermeshing between the suitably lubricated rotors ensures extremely smooth and silent compressor operation. The picture shows also the correct directions of rotation.

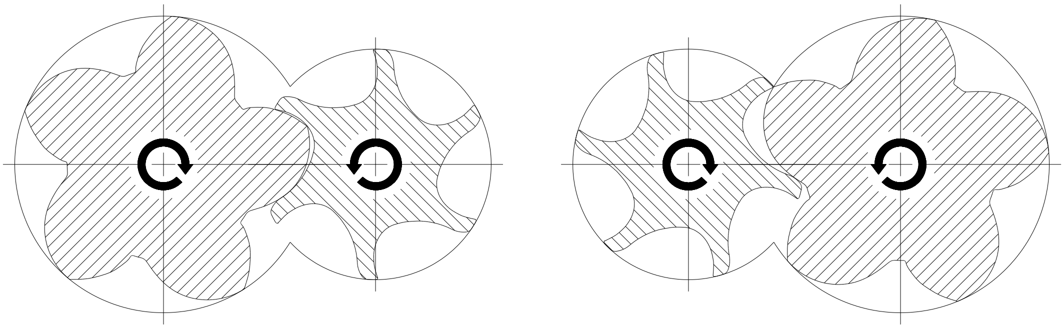

Fig. 6: view of the rotors and correct direction of rotation;

2.9 The Auto-Vi system (patented)

The size and the shape of the discharge port determine the value of the so-called "V_i": the "built in volumetric ratio", defined as the ratio between the volume of the gas at the start and the end of the compression process. This ratio does not depend on the operating conditions, but rather corresponds, according to the type of refrigerant gas, to a precise compression ratio between the compressor discharge pressure and suction pressure. When this compression ratio coincides with the ratio between the condensing pressure and the evaporation pressure, the compression process is running at maximum efficiency. Indeed, the gas discharged from the compression chamber is at the same pressure of the compressor outlet (condensing pressure) and the work required to compress the gas is minimum. When, on the other hand, the pressure at the outlet differs from the discharge pressure of the gas from the rotors, there is over compression or under compression (instantaneous when the discharge port opens), which means a waste of energy, see Fig. 7.
Therefore, the choice of the most appropriate "Vi" ratio to suit the application ensures that energy wastage can be avoided or at least minimized.

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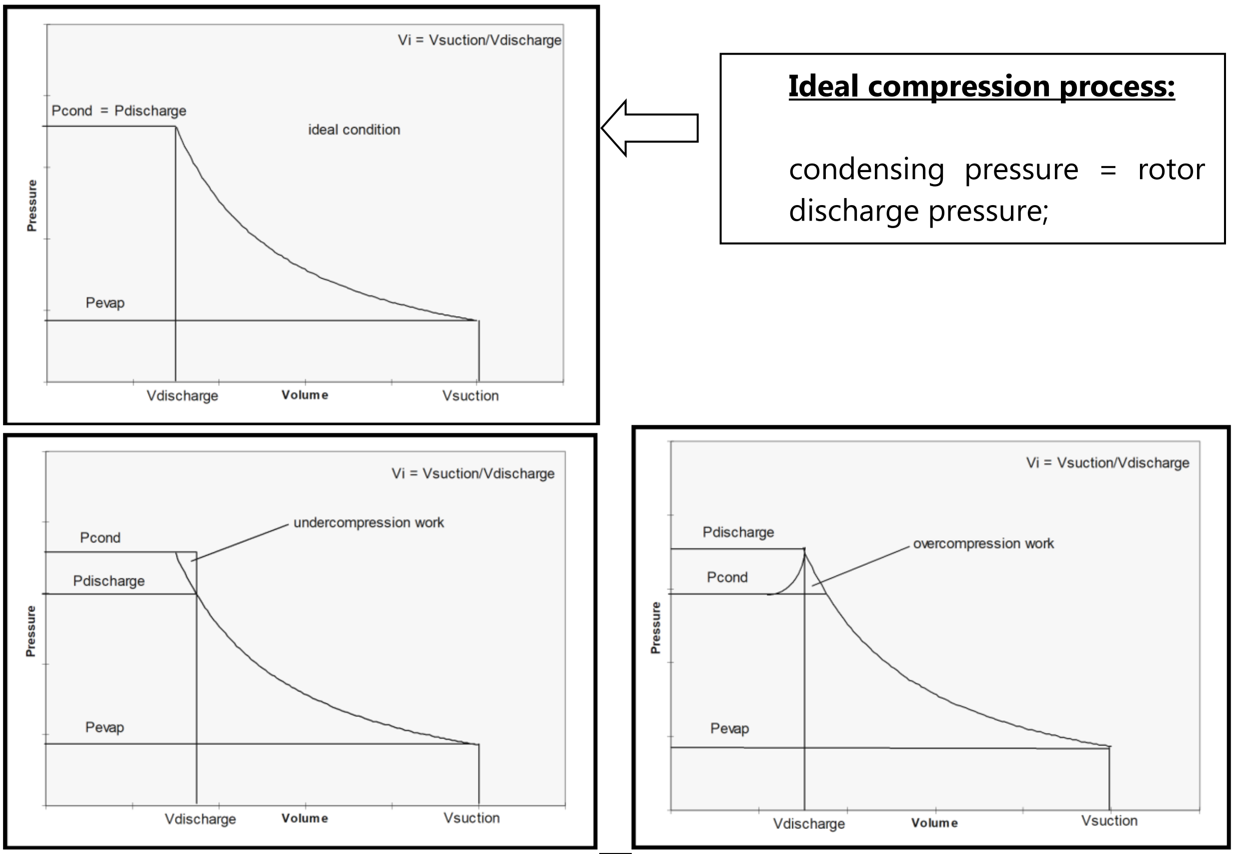

Fig. 7: the compression process on the p-V diagram;

As standard, RS5 compressors are equipped with the innovative and patented **Auto-Vi** system.

Following in real time the variation of the working condition (suction and discharge pressure) the system is able to adjust and optimize the discharge port in order to keep the best compression efficiency as possible: rotor discharge pressure = condensing pressure.

Auto-Vi works independently from the slide valve, and that means it works also at partial load.

The variation range of Auto-Vi is between 2.2 and 3.2 in continuous mode, and that ensure to have always the optimized compressor for each application, water or air cooled, in each season, summer or winter.

The system is totally independent and doesn’t need any signal or control from PLC or any other electronic device.

3 Lubrication

3.1 Oil circuit

The oil carries out the following functions:

- ✓ Dynamic seal between the rotors and the cylindrical chambers;
- ✓ Lubrication of the bearings and the rotors;
- ✓ Control of the slide valve for capacity control;
- ✓ Cooling.

Illustrative examples of the RS5 series internal oil circuits are those shown in the cross sections of the following pictures.

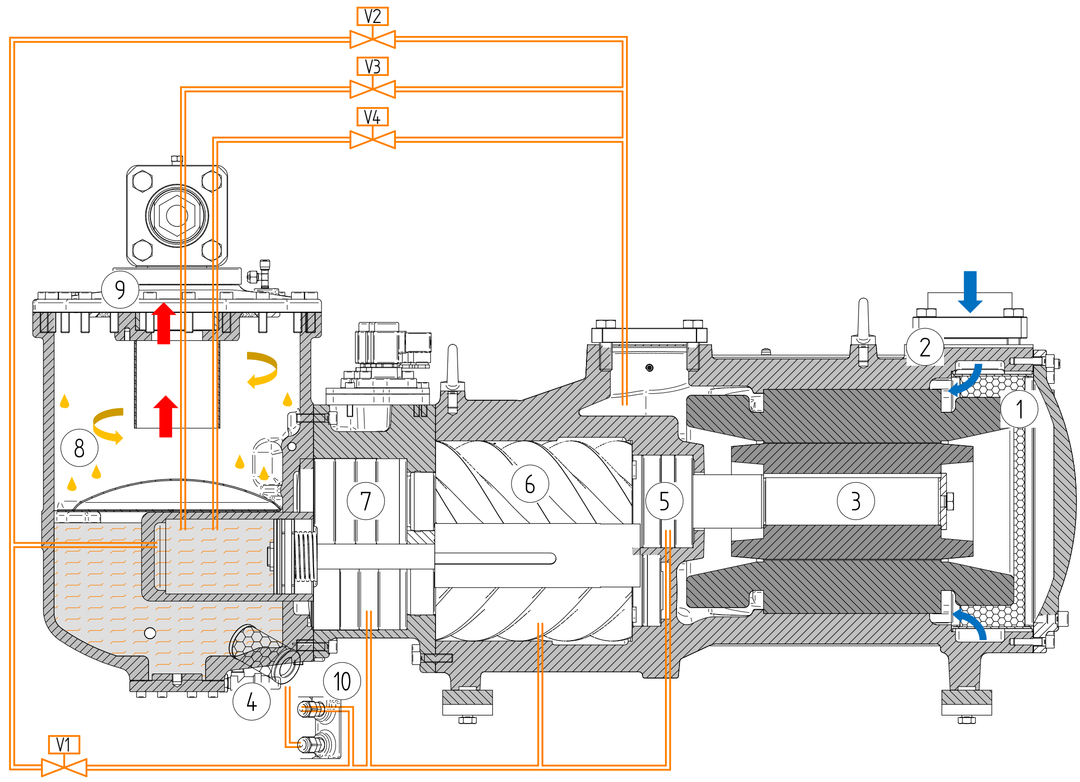

Fig. 8: diagram of the internal oil circuit for lubrication and operation of the slide valve;

1	Suction filter;	6	Rotors;
2	Gas direction;	8	Oil separator;
3	Electrical motor;	9	Discharge side;
4	Oil filter;	10	Oil inlet-outlet for external cooling circuit.
5, 7	rolling bearings;		

The lubricant is held in the bottom of the oil separator.

Warning!

The oil contained in the sump is at the discharge pressure (high pressure).

The oil is circulated by exploiting the pressure difference between the oil separator, at the discharge pressure, and the point of injection, where the pressure is slightly higher than the suction pressure (no oil pump is then necessary).
From the oil separator the oil flows through a filter to the suction bearings, to the injection point on the screw profile and to the discharge bearing chamber.
Then the oil leaving the slide valve control cylinder -whenever present-, the suction bearings and the discharge bearing chamber flows to the suction side of the rotors and it is compressed through the rotors together with the suction gas.
The high-pressure oil-gas mixture undergoes to a separation process, part (8) in Fig. 8 (see paragraph 3.4 'Oil separation'); then the oil is collected at the bottom of the oil separator while the gas leaves the compressor through the discharge shut-off valve located on top of the oil separator.
Downstream the oil filter are two connections (oil outlet/inlet) for the connection to an external cooling system, which could be required by the operating conditions (see chapter 12 "*Additional cooling*").

3.2 Oil flow rate – ActiFlow system

As the circulation of oil is generated by a pressure difference, the oil flow rate depends upon the difference between the discharge and suction pressure, according to the following equation:

$$V_{OLIO} = K \cdot \sqrt{P_S - P_A}$$

Where:

V_{oil} volumetric oil flow-rate through the filter *[l/min]*
K = coefficient, depending on the model of compressor *(see* Table 1*)*
P_S = discharge pressure *[bar]*
P_A = suction pressure *[bar]*

RS5-	**L040 H050**	**L050 H060**	**L060 H070**	**L070 H080**	**L075 H090**	**L080 H100**	**L090 H110**	**L100 H125**	**L110 H140**	**L125 H140**	**L140 H180**	**L160 H210**	**L180 H240**	**L210 H270**	**L240 H300**	**L270 H350**	**L300 H400**
K	n.a.		n.a.		n.a.			n.a.		4,3		5		5,5		6,2	

Table 1: coefficients K for calculating the oil flow-rate;

The minimum oil flow rate required to fulfil all the purposes (lubrication, seal, slide valve control and cooling) is ensured when the compressor works within the established field of operation, as long as the oil filter is normally clean and the oil maintains its characteristics.
During the starting phase, as the pressures are always balanced in the compressor, there is no oil circulation; however the bearings and rotors are designed to tolerate a few seconds of dry operation before the necessary pressure difference is reached.

Warning!
Within 20 seconds from starting, the compressor has to work within the recommended application range (minimum pressure difference, see paragraph 3.8).

In part-load operation and, in general, when the minimum pressure difference is not easily reached, special measures may need to be adopted, such as:

- ✓ delayed start of the condenser fans, on air-cooled units;

- ✓ the use of a water flow-rate control valve on water-cooled units;
- ✓ the use of a pressure regulating valve between the compressor and the condenser (contact SRMTec for further information). At the same time it might be also necessary to keep the time of the compressor part-load operation to the minimum (about 5 seconds).

All RS5 models are equipped with **ActiFlow** system that is able to change the oil flow rate not only based on pressure difference but also according to the discharge temperature.
When the pressure difference is very low, also the discharge temperature is low and the oil flow rate necessary for lubrication and rotor sealing is also very low. Increasing the pressure difference, also the discharge temperature increases and when arrive to 70°C, the automatic valve of ActiFlow system start to open gradually, increasing the oil flow rate and keeping always under control the discharge temperature.
The system is fully automatic and doesn't need any external signal or control.

3.3 Lubricants

The lubricants have been selected mainly based on the following requirements:

- ✓ Seal against leaks along the rotor profile;
- ✓ Correct lubrication of the bearings;
- ✓ Good viscosity characteristics at high temperature;
- ✓ Good miscibility with the refrigerant fluid at low temperature.

Warning!
Do not use lubricants other than those recommended. All the oils approved by SRMTec must not come into contact with the humidity in the air.

Depending on the kind of refrigerant fluid, below are the oils recommended by SRMTec for the RS5 series compressors.

3.3.1 Lubricant for HFC, HFO

Supplier	Type	Chemical comp.	Density at 15°C [g/ml]	Viscosity at 40°C [cSt]	Flash point [°C]	Pour point [°C]
CPI	Emkarate RL170H	POE	0.968	170	290	-25
Shrieve	Zerol Ester 170	POE	0,968	170	270	-33
CPI	Solest 170	POE	0.951	170	265	-22

Table 2: properties of oil for HFC and HFO refrigerant

3.4 Oil separation

The separation of the oil is required for the following reasons:

- ✓ to ensure the accumulation of oil in the compressor crankcase so that it can continuously be delivered to the bearings and the rotors;
- ✓ to prevent the migration of oil from the compressor into the refrigerant circuit.

SRMTec has developed a high efficiency centrifugal oil separator with low space requirements.

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The process of oil separation is made in three phases:

- ✓ speed variation inside specific gas passages designed with different volume.
- ✓ centrifugal effect
- ✓ sudden change of flow direction

The pictures here below give a general overview of the position of the oil separator and how it's work.

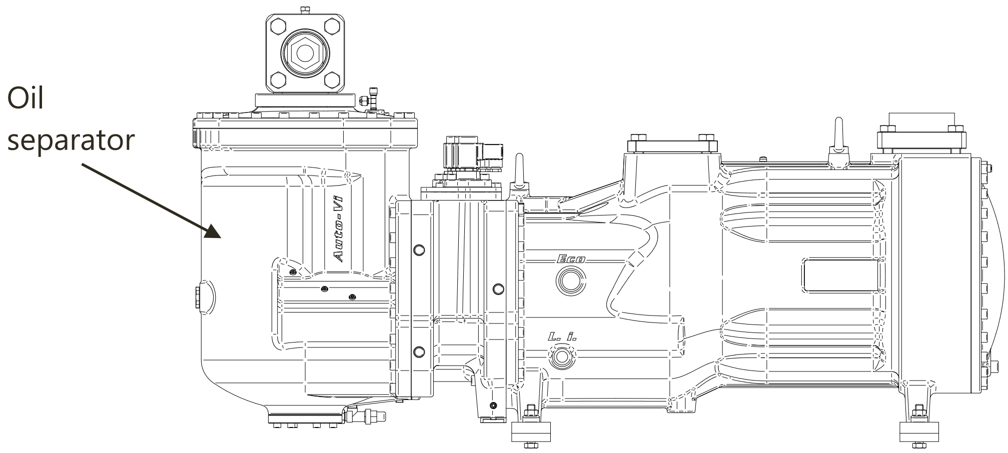

Fig. 9: specific position of the oil separator RS5 series;

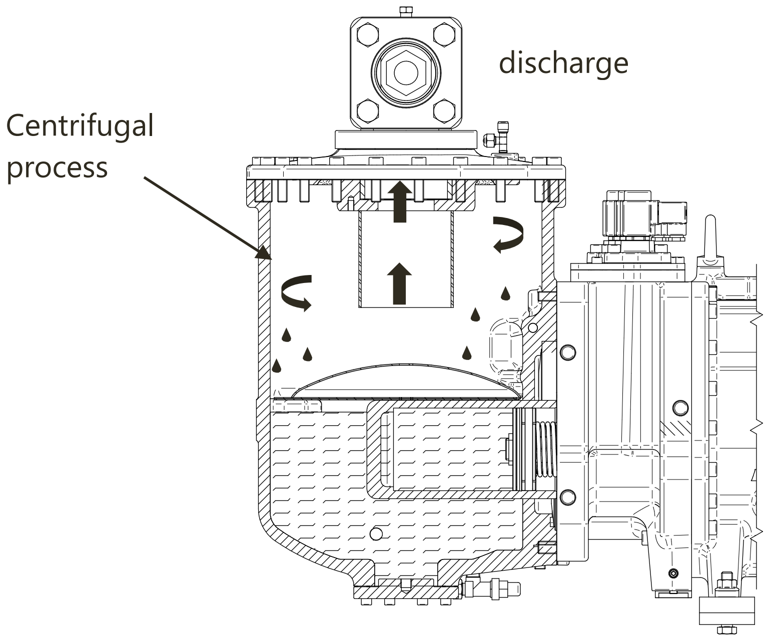

Fig. 10: separation process of the oil-refrigerant mixture;

The high pressure oil-gas mixture leaving the rotors is subjected to an initial separation due to the different velocity between the gas and oil droplets. The mixture pass through channels with different volume and the effect is an alternance of increase/decrease of the speed which help the oil separation.

The mixture goes inside the centrifugal oil separator and thanks to the high speed rotation, the oil droplets are splashed all around the internal wall and then drop down. The oil is collected in the bottom part of the oil separator, and a shield avoid that the refrigerant
Last separation phase is due to the sudden change of flow direction. The “clean” refrigerant is forced to flow through the internal pipe from the bottom to the top where is located the discharge valve.
The system, tested in the all working conditions, show that the oil carry over rate is always between 0,1% and 0,5% of the refrigerant mass.

3.5 Oil filter

The compressors are fitted with a high efficiency oil filter. In all models of the RS5 series, the oil filter is positioned on the bottom of the oil separator, as shown in Fig.11, and it is easily accessible from the outside of the compressor.
The oil filter must always be clean to ensure correct lubrication. The cleanness condition of the filter can be checked by the pressure drop through the filter itself. Under normal conditions and with a new filter the pressure drop is lower than 0.8 bar.
When first starting the compressor, the oil filter may become clogged quite quickly if the refrigerant circuit has not been carefully cleaned.

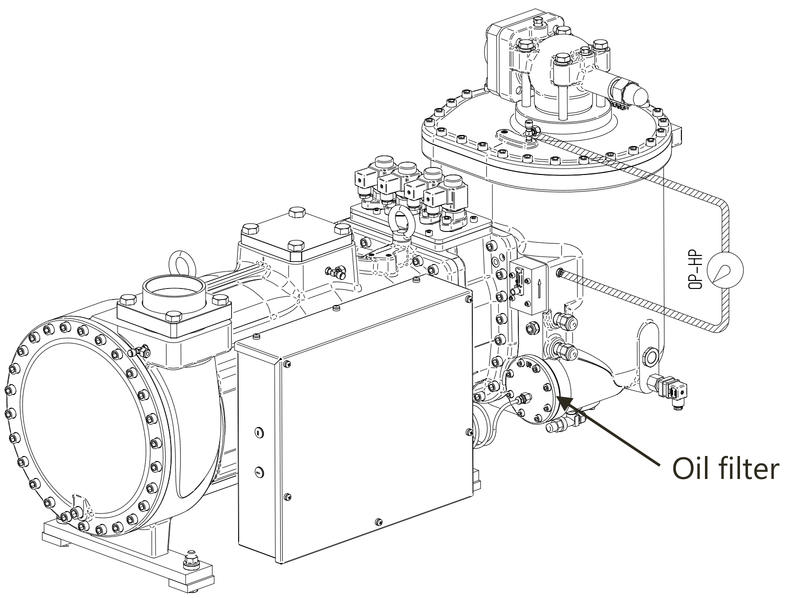

Fig. 11: position of the oil filter in the RS5 series compressors and definition of the HP-OP pressure drop across the filter;

Considering HP as the high pressure -discharge side and OP the pressure of the oil leaving the filter, the pressure difference **HP-OP** represents the pressure drop across the filter.

Warning!
For the limit value of the pressure drop HP-OP across the oil filter at which the filter needs to be replaced, see paragraph 3.8: “lubrication monitoring”.

When the pressure drop across the filter exceeds the values indicated in paragraph 3.8, the filter is dirty and must be replaced. The compressors are fitted with a fine mesh oil filter: in some cases, then, the filter may even need to be replaced after just a few hours of operation, and in any case when the pressure drop exceeds the values shown in the above-

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mentioned paragraph (consequently, a spare filter should be ordered together with the compressor).

3.6 Oil heater

The oil heater is designed to prevent the excessive dilution of refrigerant in the oil when in standstill, and must be on when the compressor is off. The heater is a tubular heating element, see Fig. 13. In all RS5 models it is inserted in a socket made in the oil separator, see Fig. 12. For further details on the position, see chapter 8.1 “Dimensional drawings and packaging”.
The socket could be in the shape of a sleeve in the oil separator. Refer to Table 3 for details related to specific model.

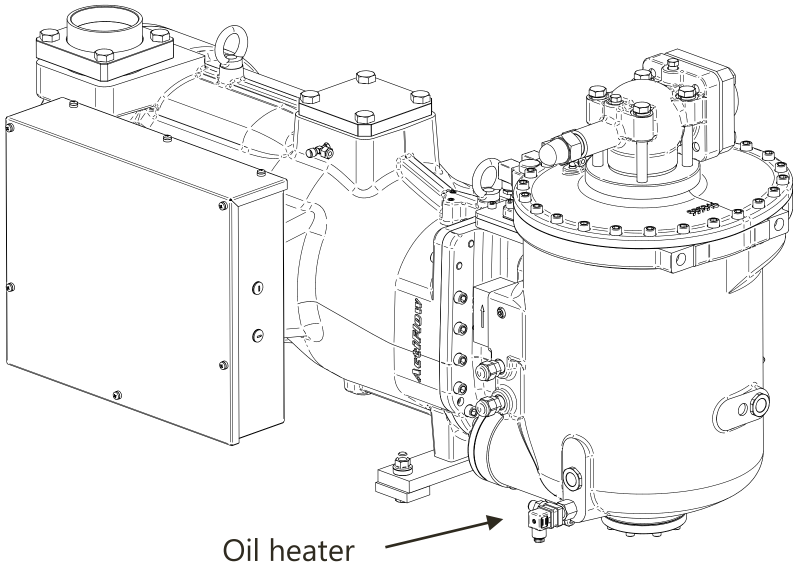

Fig. 12: position of the oil heater;

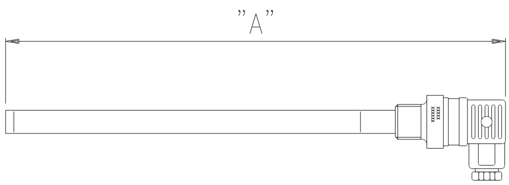

Fig. 13: Oil heater;

The characteristics of the crankcase heater are reported on table below.

RS5-	**L040 H050**	**L050 H060**	**L060 H070**	**L070 H080**	**L075 H090**	**L080 H100**	**L090 H110**	**L100 H125**	**L110 H140**	**L125 H160**	**L140 H180**
Socket shape								Sleeve			
Lenght “A”								302			
Nominal power [W]								200			
Voltage supply [V-Hz]	220-50/60**										
Tightening torque [Nm]	30										

RS5-	L160 H210	L180 H240	L210 H270	L240 H300	L270 H350	L300 H400
Socket shape	Sleeve					
Lenght "A"	302					
Nominal power [W]	275					
Voltage supply [V-Hz]	220-50/60**					
Tightening torque [Nm]	30					

Table 3: characteristics of the crankcase heater;

** : other voltages on request (110V-50/60Hz, 24V-50/60Hz)

The oil heater must be used when the compressor is off, and in the following situations:

- ✓ when the compressor is installed outdoors (if necessary, the oil separator should be insulated);
- ✓ extended standstill periods;
- ✓ high refrigerant charge;
- ✓ risk of the refrigerant condensing inside the compressor. During standstill the compressor crankcase must have the highest temperature in the entire refrigerant circuit.

Warning!
Before starting up for the working season, the heater must be on for at least 24 hours before starting the compressor.

3.7 Oil level

The standard oil charge is indicated in the table of technical data reported in chapter 7.2.

Warning!
The compressor is delivered with a nitrogen charge of about 1 bar to prevent contamination of external air.
It is responsibility if the customer to extract the nitrogen charge of the compressor and produce a deep vacuum.

The oil level can be checked through two sight glasses according to the model type (for the position on the compressor, see chapter 8)

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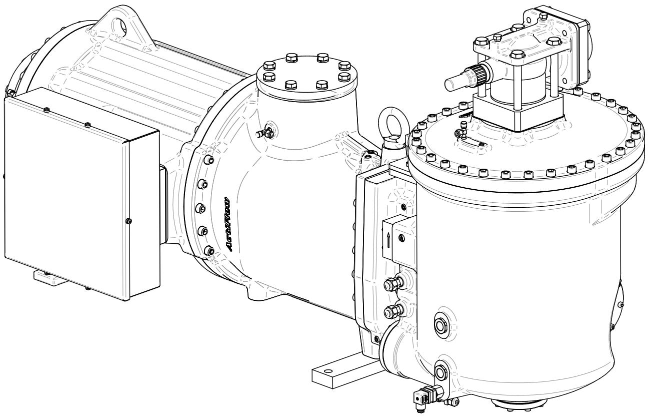
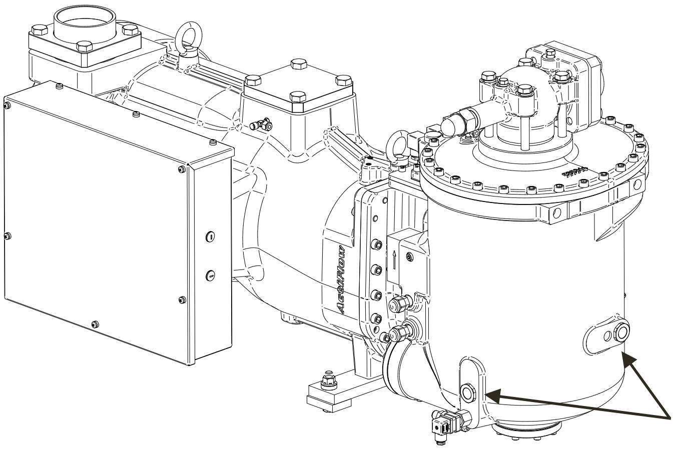


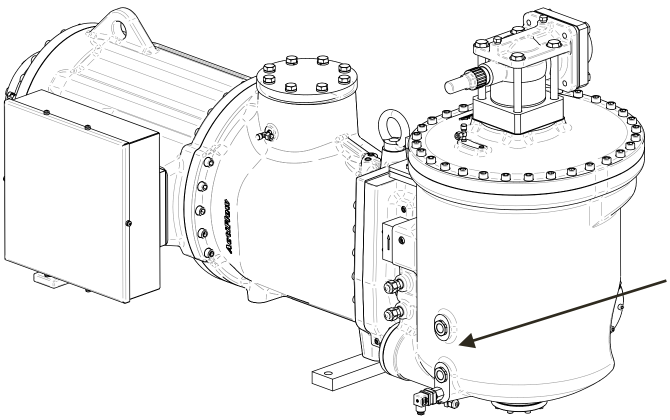
Fig. 14): the top sight glass indicates the optimum level for the correct operation of the compressor, while the lower one indicates the minimum level, below the which the compressor cannot operate.

RS5-L100/H125 – L110/H140 – L125/H160 – L140/H180 – L160/H210 – L180/H240



Oil sight

RS5-L210/H270 – L240/H300 – L270/H350 – L300/H400



Oil sight

Fig. 14: position of the two oil sight glasses and model identification;

During operation a certain quantity of oil may migrate into the refrigerant circuit. Moreover for the RS5 compressors a variation in the load entails also a variation in the amount of oil contained in the hydraulic cylinder which control the slide valve; consequently there may

be fluctuations in the oil level due to its flowing from and to the slide valve control cylinder. In any case, during operation the level of oil must remain visible within the sight glass.
These sight glasses also show if there is too much refrigerant diluted in the oil. In fact, this problem is highlighted by the continuous presence of foam and is caused by an excessive cooling of the oil when the additional cooling is obtained by the liquid injection (see chapter 12: ***"Additional cooling"***).

Warning!

- ✓ According to the type of installation and the operating conditions of the compressor (whether the oil cooling circuit is used or not, see chapter 12: *'Additional cooling'*), some extra oil may be needed.
- ✓ The oil level in the sight glass should be checked when the compressor is on.

3.8 Lubrication monitoring

3.8.1 Oil temperature monitoring

Normally the lubrication can be indirectly monitored by checking the discharge temperature of the oil: lack of lubrication leads to an increase of that value.
Hence a temperature sensor is available to monitor the oil temperature and can be connected to INT 69 SNY module.
Whenever this accessory is not used, a safety thermostat should be installed on the discharge pipe to switch off the compressor as the temperature reaches 120°C.

Warning!
The additional cooling of the oil (chapter 12) does not guarantee the indirect monitoring of the lubrication through the oil temperature value.

Depending on the operating conditions, however, the discharge temperature may be quite different from the alarm condition of the above-mentioned device (120°C).
Consequently, the delay in the increase and in reaching the critical temperature of 120°C, corresponding to insufficient lubrication, must be considered, as the correct operation of the compressor may be affected in this period. As a result, SRMTec suggests further alternative methods for monitoring correct lubrication. They are described below.

3.8.2 Static pressure control

The correct circulation of the oil is guaranteed by the fact that both the filter is clean and the compressor operates in the admissible field of operation (see chapter "*Application range*"; Fig. 16 shows an example).
With reference to Fig. 15, to protect the compressor against insufficient lubrication, the following three pressure values need to be measured:

- ✓ The high pressure "HP";
- ✓ The oil pressure "OP";
- ✓ The low pressure "LP";

and make sure that:

- ✓ The compressor works inside the application range, within 20 sec. from the starting;
- ✓ HP – OP < 2,5 bar

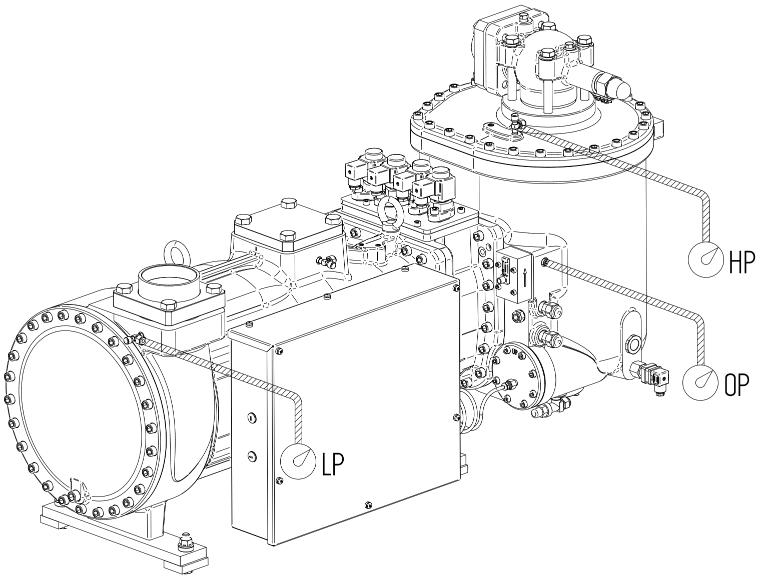


Fig. 15: measuring the HP, OP and LP pressure values in the RS5 series

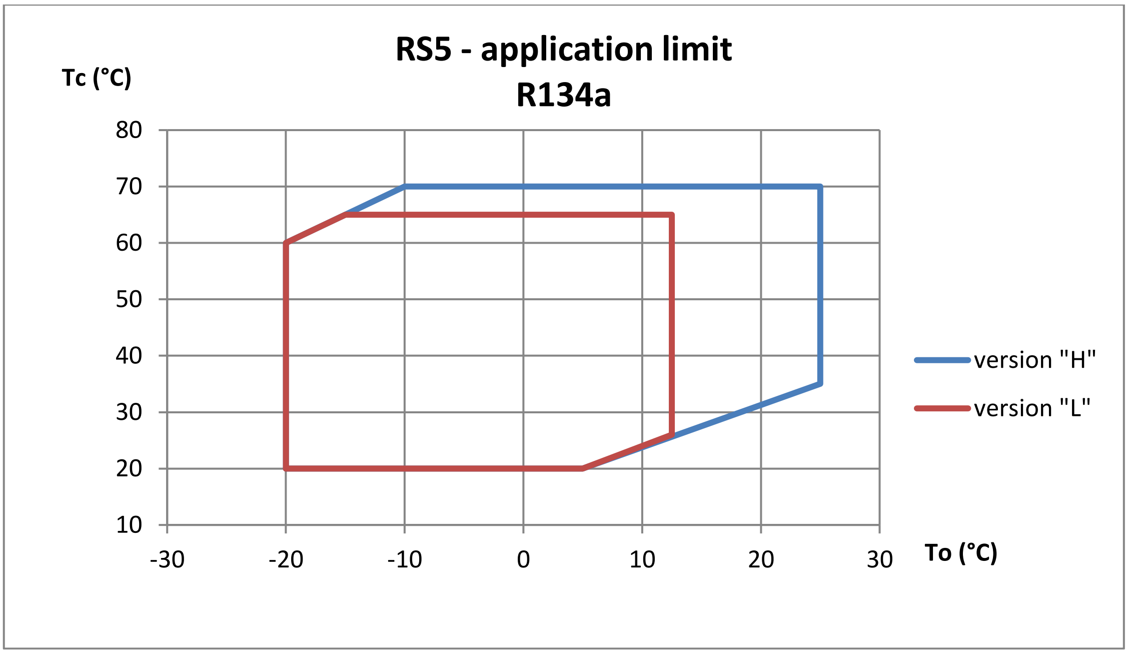


Fig. 16: generic application limit for series RS5 compressors;

Warning!

- ✓ The compressor cannot operate for more than 20 seconds outside of the conditions required by the application limits and with the oil filter dirty. After such time, the protection system has to be activated to stop the compressor;
- ✓ The differential pressure switch for monitoring the status of the oil filter must be suitable for high pressure.

3.8.3 Flow control.

The monitoring of oil flow through the compressor could be done with a flow switch kit (see chapter 5: “*Components)*
This device is a dynamic type control cause , setting aside how much oil is in the crankcase , shows its effective flow inside the circuit made on the body of compressor. This circulation is granted only by the difference of pressure between discharge and suction line and is hindered by concentrated pressure drops as for instance the oil filter.
The oil flow switch (optional) is directly connected to the compressor body. Is provided by a reed contact with M12 connection cable, that is a “normally open” free contact.
During the normal operation and when the oil flow is above the minimum level to guaranty the lubrication, the contact will be close.

If will happen that the difference between discharge and suction pressure couldn’t assure the flow of oil it is bearded a delay of intervention of oil flow switch.
The statements recommended by SRMTec for this delay are:

- 120 seconds during start-up procedure;
- 60 seconds during normal working.

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4 Capacity control

4.1 Operating principle and oil control circuit

The SRMTec screw compressors can operate both at full load and part load.
The cylindrical chambers that house the screw rotors are fitted with a longitudinal port, whose connection with the suction side is regulated by the position of the slide valve (17), see Fig. 18.
When the slide valve completely closes the above mentioned port, the effective compression length is maximum and coincides with the entire length of the rotors; when, on the other hand, the valve moves towards the discharge and the opening expands longitudinally, the effective working length of the rotors is reduced and as a consequence a smaller quantity of gas is processed. As a result, adjusting the volume taken in by the rotors make it possible to control the mass flow processed and definitely the cooling capacity generated by the compressor.

The following paragraphs describe the operating principle of the oil circuit in the step and stepless configurations and, as you can see, this principle is the same in both the RS5 series compressor types.

4.1.1 Layout and identification of solenoid valves

RS5 compressors are equipped as standard, with a 4 solenoid valves that control the movement of the slide valve.
The compressor capacity can be managed at 4-steps or stepless, without any mechanical modification. Only the activation sequence of the solenoid valves must be reset.

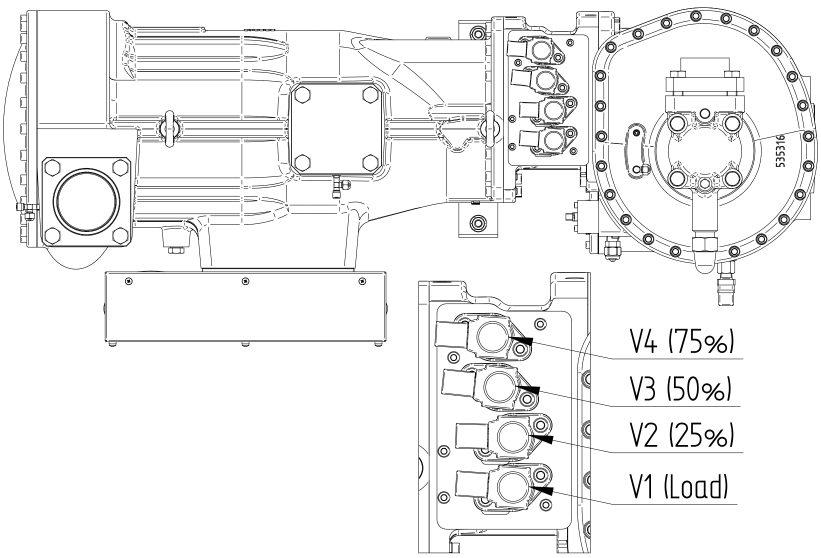

Fig. 17: solenoid valves position

4.2 STEP capacity control

The slide valve is controlled by a hydraulic piston that can have four distinct positions, corresponding to the capacity steps: 100 - 75 - 50% - minimum step (note: the effective capacity steps may differ from the rated values, according to the normal operating conditions and from compressor to compressor).

As you can see from the picture, for all the compressors the oil circuit is characterized by the four normally-closed solenoid valves V1, V2, V3 and V4 which respectively allow to control the four capacity steps: minimum capacity, 50, 75 and 100%.
Below is a brief description of the operation of the oil circuit in the four compressor capacity steps.

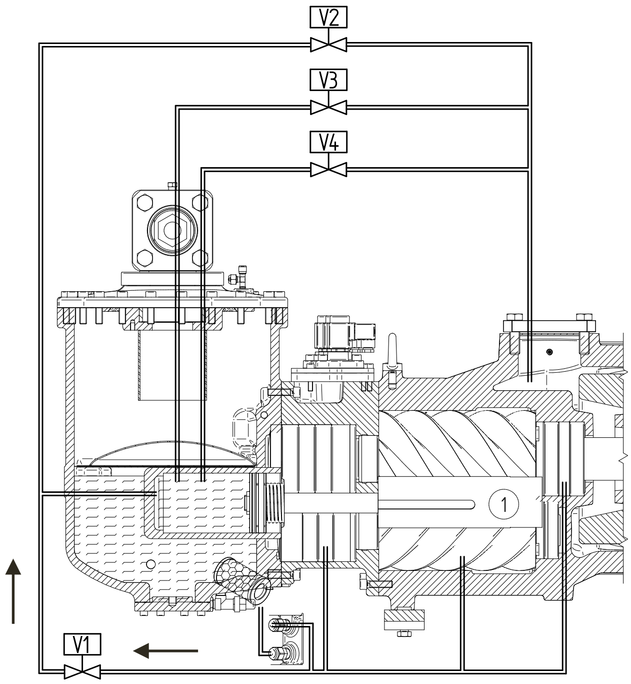

Fig. 18: step capacity control oil circuit
V1, V2, V3, V4: capacity control solenoid valves;
1: capacity control slide valve and operation piston;

4.2.1 Minimum capacity step (compressor step for start up and stop)

The picture below shows how the oil runs inside the control circuit. At the minimum step the solenoid valve V2 is opened, while the valves V1, V3 and V4 are closed. Therefore the oil, coming from the control cylinder, flows through the opened port to the suction side. Consequently, the piston is pushed to the end stroke, the longitudinal port is completely opened on the suction side and the length along which the rotors are working is the shortest.

Caution!
Concerning the step capacity control mode (4 steps), the minimum capacity step can be used only to start and stop the compressor; it cannot be used for continuous running operations.

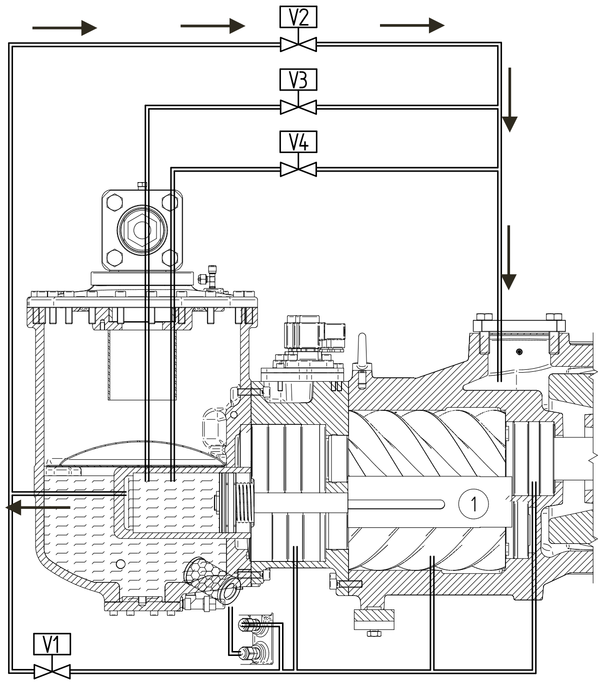

Fig. 19: Minimum capacity control oil circuit

4.2.2 50% CAPACITY

With reference to Fig. 20 at 50% capacity, the solenoid valve V1 and V3 are open while the valves V2 and V4 are closed; the oil enters the cylinder (through the 1st hole on the left) and drives the piston to the position corresponding to the 2nd hole, where the oil flows to the suction side. The slide valve also moves and partially closes the longitudinal opening, thus increasing the effective working length of the rotors.

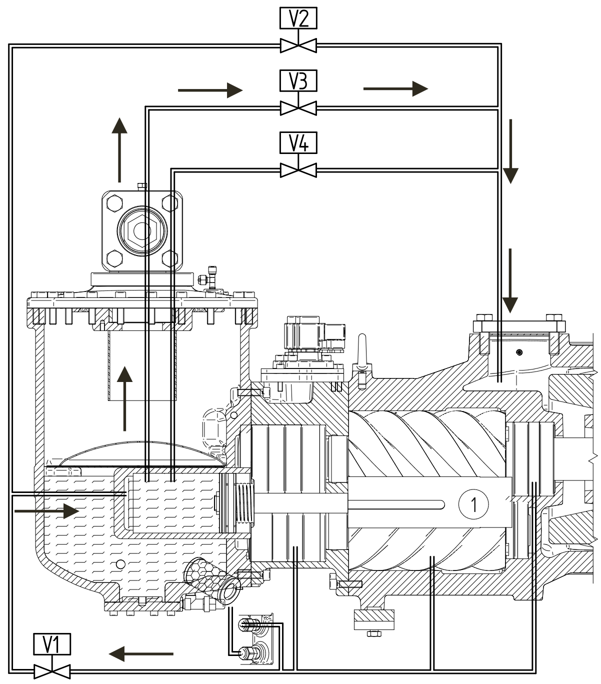

Fig. 20: capacity control at 50% step

4.2.3 75% CAPACITY

At 75 % capacity, see Fig. 21, the situation is similar to the previous one, but now the solenoid valves V1 and V4 are open while the valves V2 and V3 are closed; the control piston is thus positioned corresponding to the 3rd hole, the slide valve closes the opening further and increases the working length of the rotors.

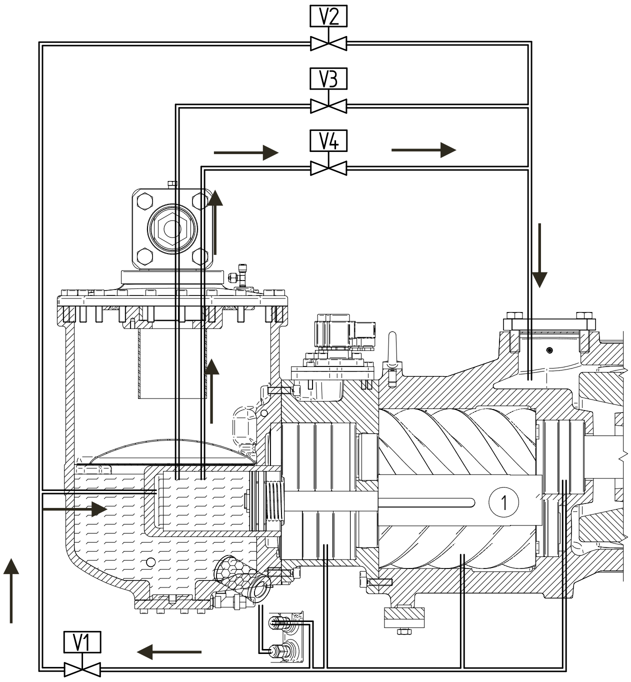

Fig. 21: capacity control at 75% step;

4.2.4 100% CAPACITY

At 100% capacity, see Fig. 22, only the solenoid valve V1 is opened; the oil can no longer leave the cylinder and pushes the piston to the limit on the right side and the slide valve completely closes the longitudinal opening, meaning that the compression occurs along the entire length of the rotors.

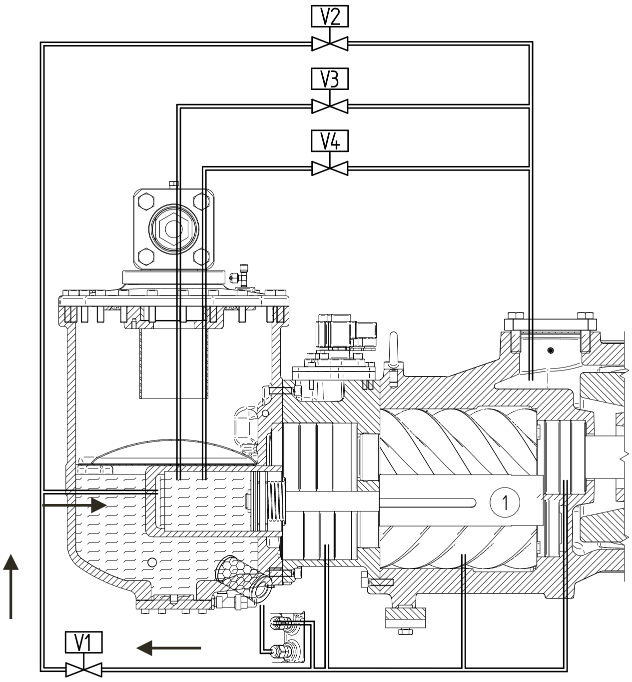

Fig. 22: capacity control at 100% step

4.2.5 Control sequence: step configuration

The oil flow is controlled by the four solenoid valves, normally-closed, positioned on the compressor casing according to the layout defined in Table 4**Errore. L'origine riferimento non è stata trovata.**. For all the compressors series RS5 these valves are energized according to the logic shown in Table 4.

	Solenoid valves			
Capacity steps	V1	V2	V3	V4
Start / Stop	Off	**On**	Off	Off
25%	Off	**On**	Off	Off
50%	**On**	Off	**On**	Off
75%	**On**	Off	Off	**On**
100%	**On**	Off	Off	Off

"Off"= solenoid not energized;
"On"= solenoid energized;

Table 4: operating logic of the solenoid valves for step capacity control;

4.3 Infinity capacity control: STEPLESS

Infinite capacity control is recommended whenever the cooling capacity of the system has to be controlled with a high degree of precision, while it is not very useful in systems featuring high inertia, where step capacity control is more suitable.
The cooling capacity is therefore controlled by using the normally-closed solenoid valves V1, V2 and V3 with the following logic:

- ✓ V1: fill the hydraulic cylinder for increasing the cooling capacity required by the users;
- ✓ V2 or V3: empty the hydraulic cylinder, until the minimum step or 50%, to decrease the cooling capacity required by the users.

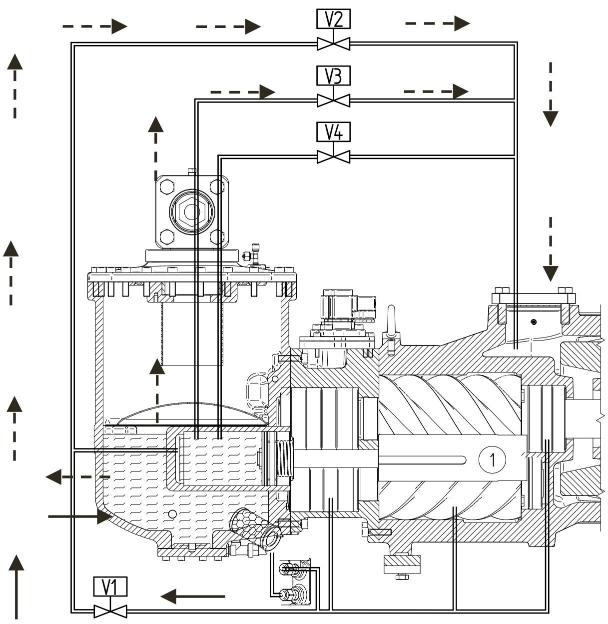

Fig. 23: infinite capacity control oil circuit (step less configuration)

4.3.1 Control sequence: stepless configuration

Stepless control can be managed following the below activation sequence.

Pulse time depend of working condition. Refer to the Table 5 to <u>Stepless control from 50% to 100% (standard configuration).</u>

	Solenoid valves			
Capacity steps	V1	V2	V3	V4
Start / Stop	Off	**On**	Off	Off
Up ↑	**Pulse**	Off	Off	Off
Down ↓ (min 50%)	Off	Off	**Pulse**	Off
Constant ↔	Off	Off	Off	Off

"Off"= solenoid not energized;
"On"= solenoid energized;

Table 5: Control sequence of solenoid valves from 50% to 100% configuration.

Refer to the Table 6 to <u>Stepless control from 25% to 100% (valid only in some working condition).</u>

	Solenoid valves			
Capacity steps	V1	V2	V3	V4
Start / Stop	Off	**On**	Off	Off
Up ↑	**Pulse**	Off	Off	Off
Down ↓ (min 25%)	Off	**Pulse**	Off	Off
Constant ↔	Off	Off	Off	Off

"Off"= solenoid not energized;
"On"= solenoid energized;

Table 6: Control sequence of solenoid valves from 25% to 100% configuration.

Attention !

The working at partial load condition is allowed according to the application limits reported in the chapter: "*Application limit*".

Particularly, the compressor can work at the minimum capacity step only during the start up phase, the stop phase and in any case for short period of time (see previous page).

At any rate the part load operation requires specific actions to prevent:

- ✓ The insufficient return of oil due to the reduced speed of the gas;

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- ✓ Higher temperatures on the discharge side, caused by the compression lower efficiency and by the lower refrigerant mass flow;
- ✓ An overheating of the electrical motor that might occur whenever the tension value is out of the given range.

Thorough and extensive testing is recommended.

4.4 Variable speed control

RECOMMENDATIONS:
Usage of frequency converter to control the load of the compressor and of the system is strongly recommended.
Usage of frequency converter in combination of compressor internal load control is discouraged.

The usage of a frequency converter allow the speed control with conventional asynchronous motors, reaching the highest efficiency control method for compressors.

In the variable-frequency control mode, the operating frequency of the motor can be adjusted automatically to greatly reduce the reactive loss of the motor.

All the SRMTec compressor are designed to operate in the frequency range 25Hz-60Hz, and the motor have to be connected according to the Fig. 24.

When using frequency converter for capacity control, several basic factor has to be taken into account:

- positive displacemente compressors have a practically contant torque requirement over the entire speed range;
- to grant the constant torque operation of the compressor, the voltage and frequency must be changed proportionally;
- the speed of the asycronous motor is affected by the slippering of the motor.

This mean that, as conventional inverters cannot supply motor overating voltages higher than supply voltage, when the motor is driven at frequency higher than the nominal speed (>50Hz) it will be supplied with "under voltage" conditions. The selection of a special winding motor voltage (380V-3-60Hz) could avoid this situation but the sizing of the inverter is affected by the larger current drawn.
For details on motor size and electrical data please refer to Table 8; for special motor voltage please check the data on SRMTec selection software or contact SRMTec.
When the driving frequency instead is much lower than the nominal, the refrigerant flow could be not sufficient to cool down the motor.
It is so necessary to check in the SRMTec selection software the application envelope limitations according to the rotating frequency.

Caution!
Due to the high oil solubility the acceleration and deceleration ramps have to be reduced in order to prevent foaming in oil separator.

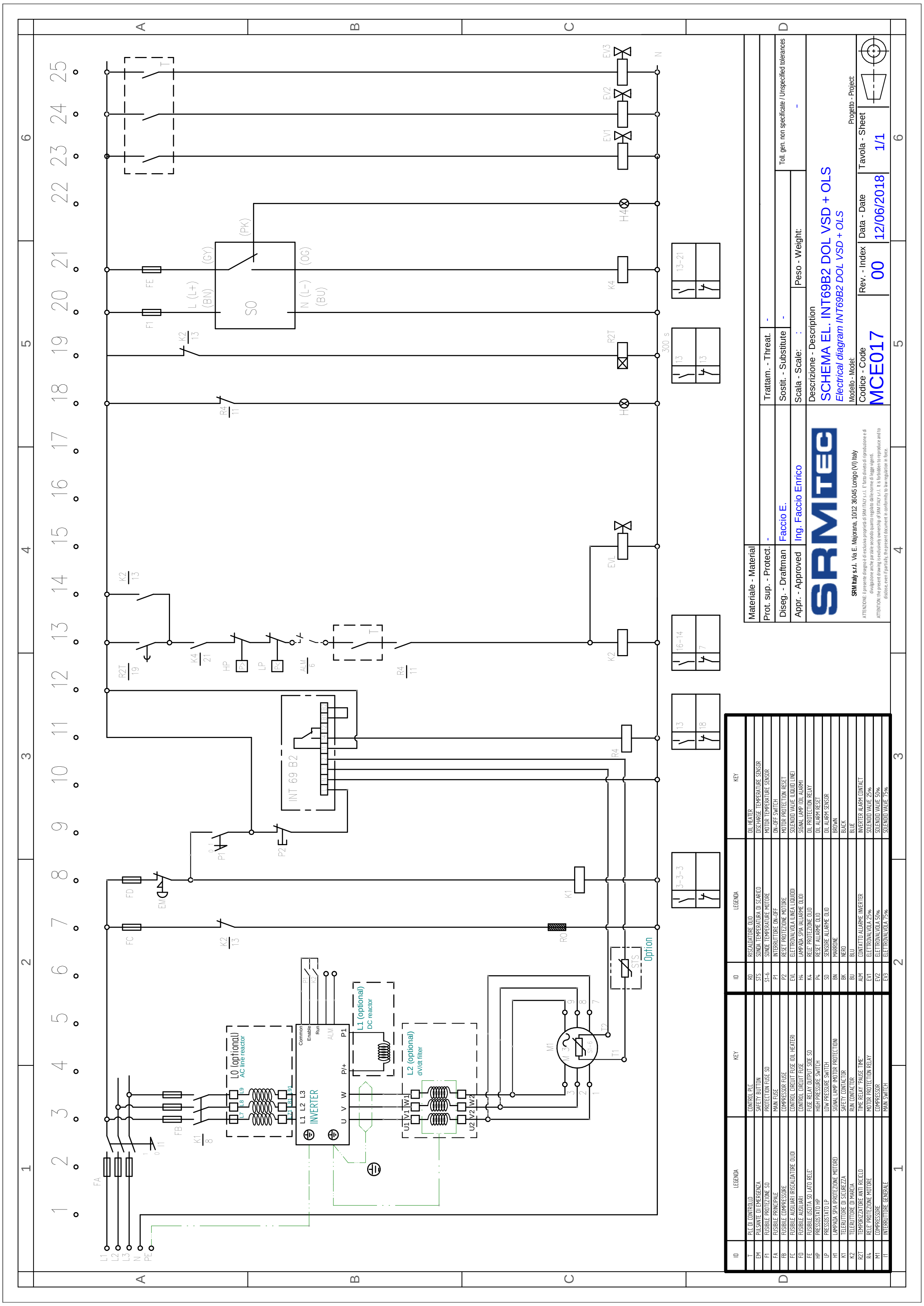

Fig. 24 Electrical connection for Variable frequency drive

The motor speed control has to be regulated between minimum and maximum speed with smooth and reduced variation of load. Refer to the picture below for a reference of time and speed variation.

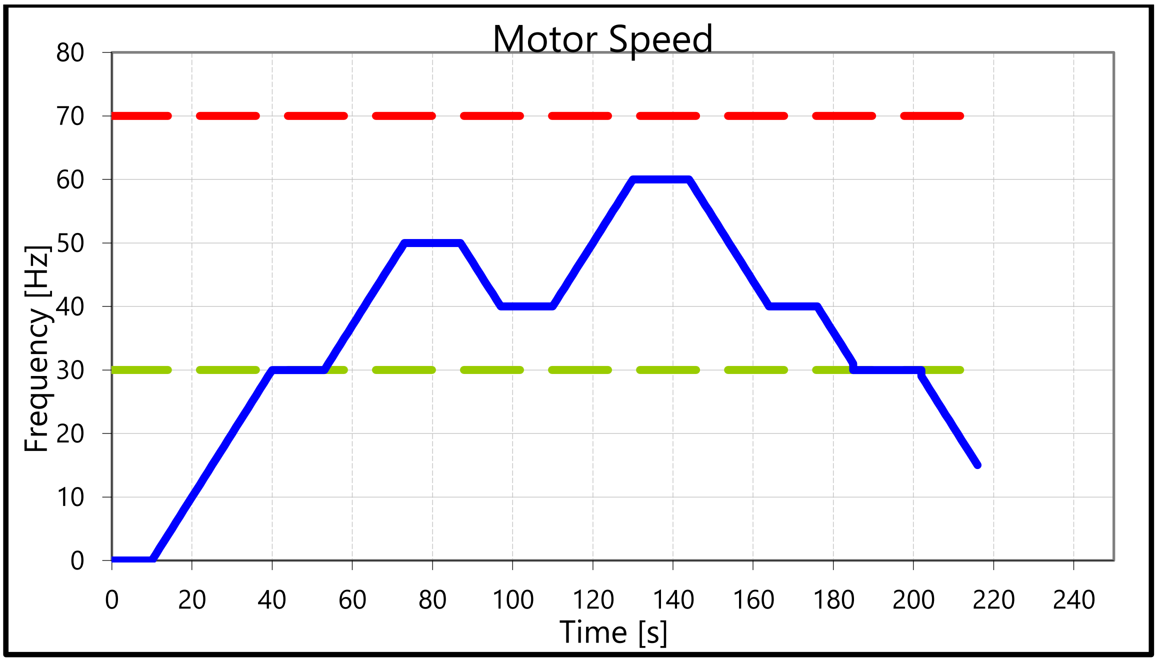

Fig. 25 Speed vs Time variation example

4.5 Procedure for starting and stopping the compressor

To limit the peak current when starting, the electric motors are started in the part-winding configuration, or alternatively with the windings connected in the star configuration (see chapter 6: 'Electrical devices'). This, however, means also a drop in the starting torque, and as a result the resisting torque needs to be reduced in order to start the compressor without excessively overloading the electric motor. For this purpose, SRMTec recommends to start the compressors at the minimum capacity step, see Fig. 26.
In the configuration with 4 steps or stepless, the slide valve automatically returns to the position of minimum capacity after the compressor stops, if V2 valve is ON.
In fact due to the pressure difference, the oil can flow out of the cylinder to the crankcase through the pipe, see Fig. 18. Therefore the compressor can start again at the minimum capacity.
In order to re-start the compressor at the minimum capacity step, the valve V2 must be energized for around 25 seconds before switching ON and switching OFF the compressor, see Fig. 26. Moreover the valve V2 should be kept energized during the compressor standstill periods.
The starting and stopping procedure indicated in Fig. 26 has to be followed for all the screw compressors, both in the step and in the stepless version, as this avoids noisy stopping due to the temporary reverse rotation with high mass flow.

Attention!
If it is necessary to shutdown for an emergency, the compressor will stop at the current capacity step. Before restarting the unit, make sure that the compressor is at the minimum capacity step.

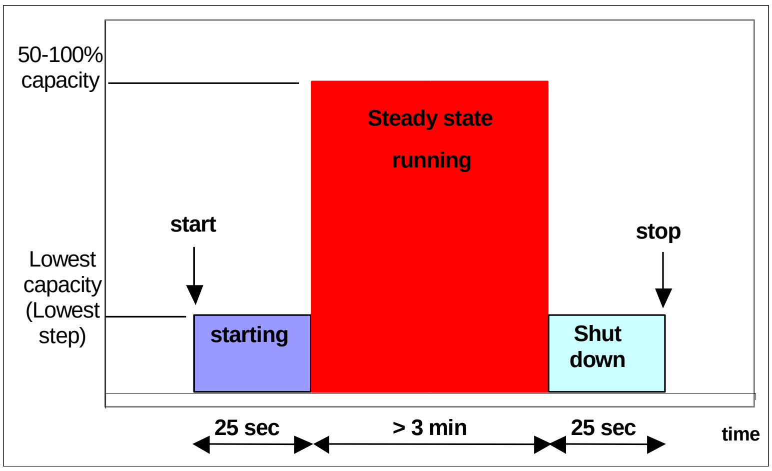

Fig. 26: starting and stopping the compressor;

Operation at part load increases the discharge temperature (it is recommended not to exceed 110° C) and has a slightly lower efficiency than at full load.
In particular, the discharge temperature increases if:

- The condensing pressure increases;
- The evaporation pressure decreases;
- The temperature of the suction gas (superheat) increases.

To define the operating limits at part load, see chapter 11: "*Application range*".

5 Components

5.1 Suction filter (standard)

The suction filters of the RS5 compressor range is illustrated below:

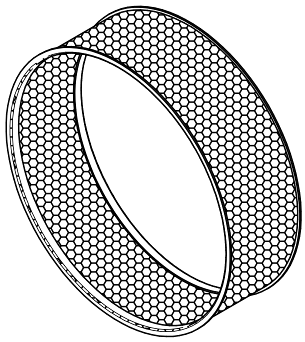

Fig. 27 Suction filter.

All models give the possibility to inspect and clean without disassembling the suction valve. Only suction cover is necessary to be disassembled.

Attention!

- Apply maximum cleanliness for pipelines and components.
- Braze under a protective gas (use dry nitrogen).
- Follow cleanliness requirements according DIN 8964 or comparable standards
- Apply suction side cleaning filter in case of widely extended systems.

5.2 Safety valve (standard)

The compressors are fitted with a safety valve that when necessary opens a passage way between the high and low pressure sections, see Fig. 28. The valve is sized in accordance with the European standard EN 700-24035-2-34. The safety valve opens when the pressure differential, between discharge and suction, exceeds 30 bar, and closes again automatically.

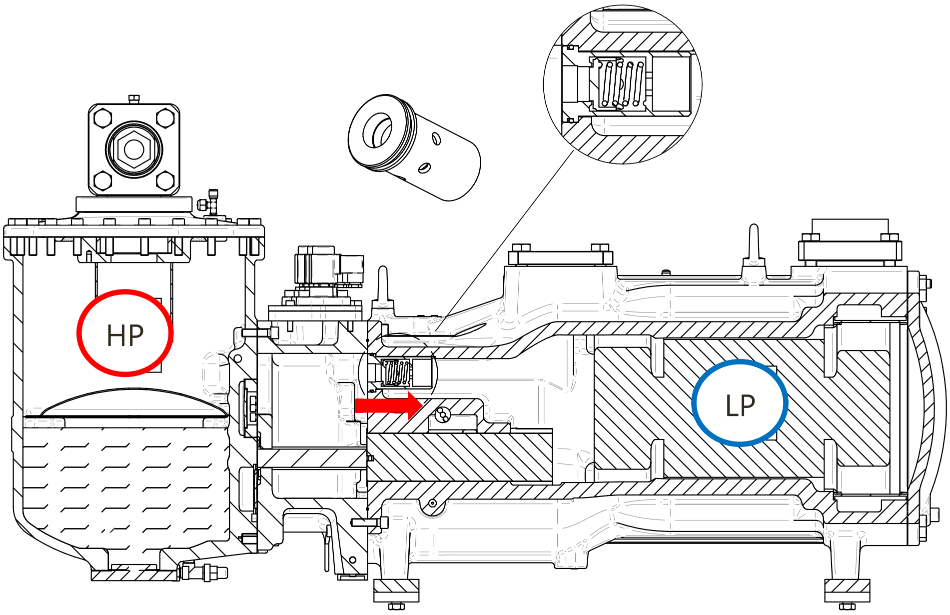

Fig. 28: safety valve shape and position

5.3 Check valve (standard)

To avoid the backflow of the gas when the compressor stops, due to the pressure difference, the compressor is fitted with a check valve installed immediately upstream of the discharge shut-off valve, see Fig. 29.

Attention!
When the compressor stops, following the balancing of the pressure, there is a temporary reverse rotation of the rotors, which produces a typical noise. If this noise lasts more than 3 seconds, check and if necessary replace the check valve.

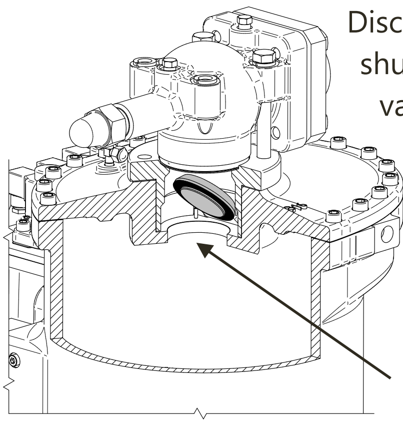

Fig. 29: check valve

5.4 Rubber vibration damper (standard)

The compressor are delivered with as standard with a vibration dampers kit, inserted only for shipment in the electrical box.
Fig. 30 below shows the location of the rubber vibration dampers underneath the 4 feet of the RS5 compressor.

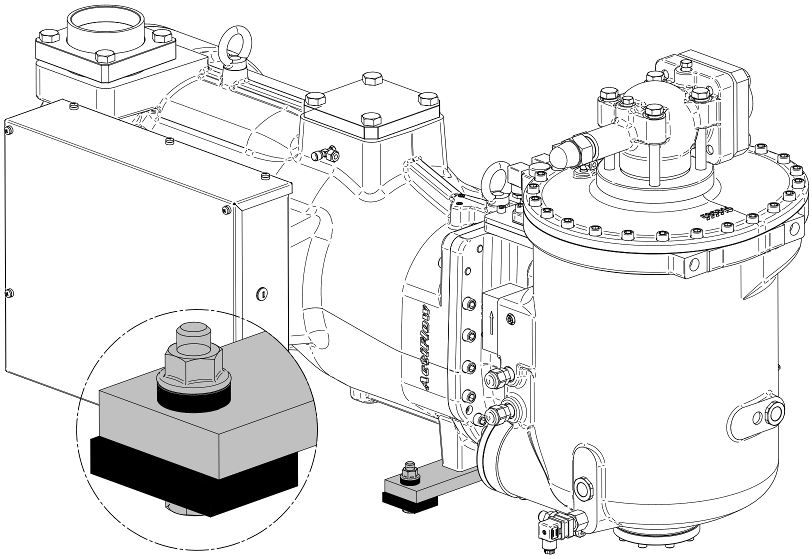

Fig. 30: position of the rubber vibration damper underneath the 4 feet of the compressors;

In order to completely fulfil their purposes, the vibration dampers must be compressed as little as possible and the exact tightness of the self-locking bolt is achieved when the deformation of the vibration damper bushing is around 0.5 mm less than its size when relaxed.

Fig. 31 and Fig. 32 respectively show the correct assembly of the vibration damper, and the assembly diagram for all the components included in the kit.

Below are the codes of the vibration damper kit for all the series models.

RS5-	**L040 H050**	**L050 H060**	**L060 H070**	**L070 H080**	**L075 H090**	**L080 H100**	**L090 H110**	**L100 H125**	**L110 H140**	**L125 H140**	**L140 H180**	**L160 H210**	**L180 H240**	**L210 H270**	**L240 H300**	**L270 H350**	**L300 H400**
Vibration damper kit	303243							303321									

Fig. 31: correct assembly of the vibration dampers;

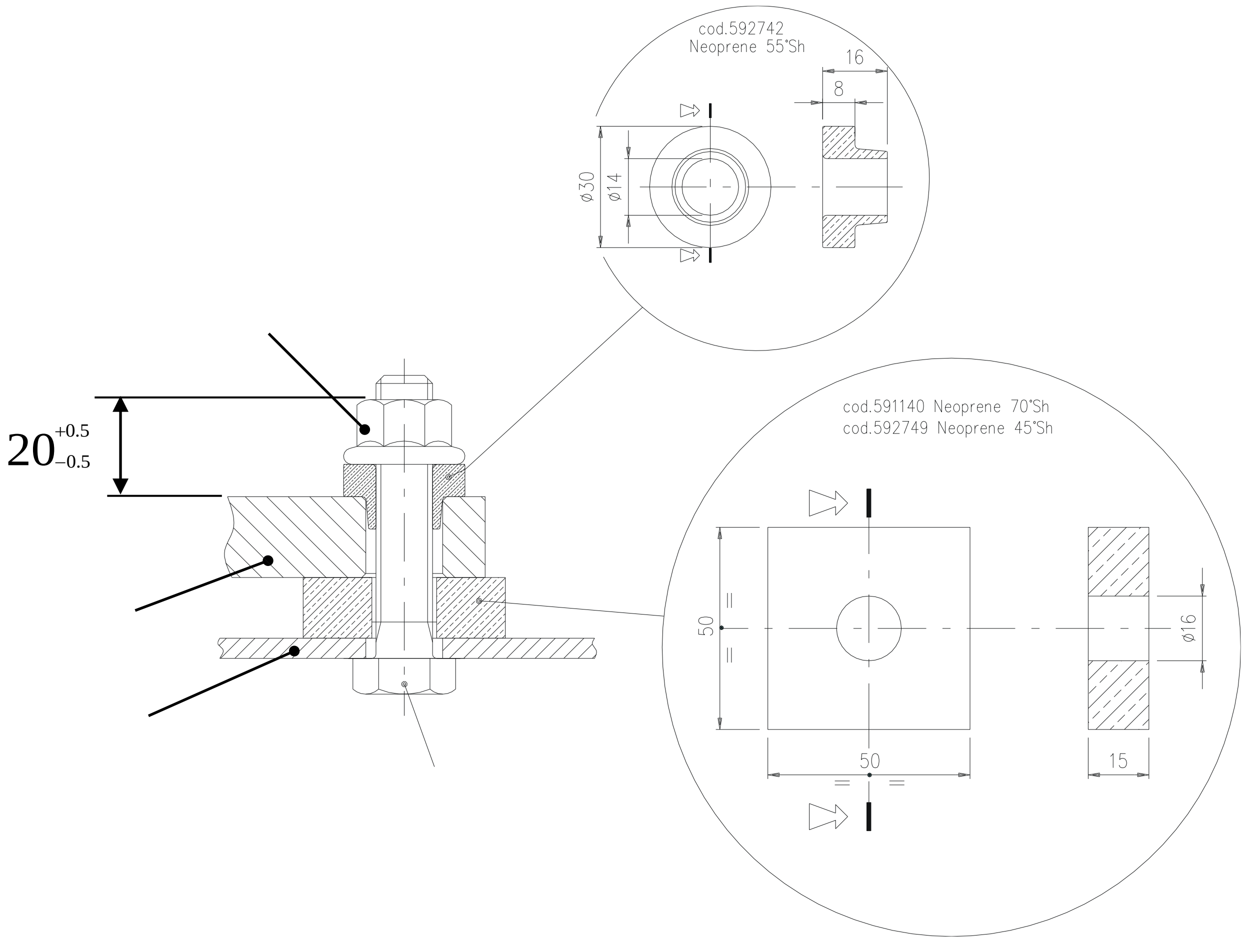

Fig. 32: assembly diagram for the rubber vibration dampers;

5.5 Oil flow switch (optional)

The flow switch kit is available upon request to check the correct circulation of the oil in the compressor.
The oil flow switch is directly installed on compressor body without any external pipe.

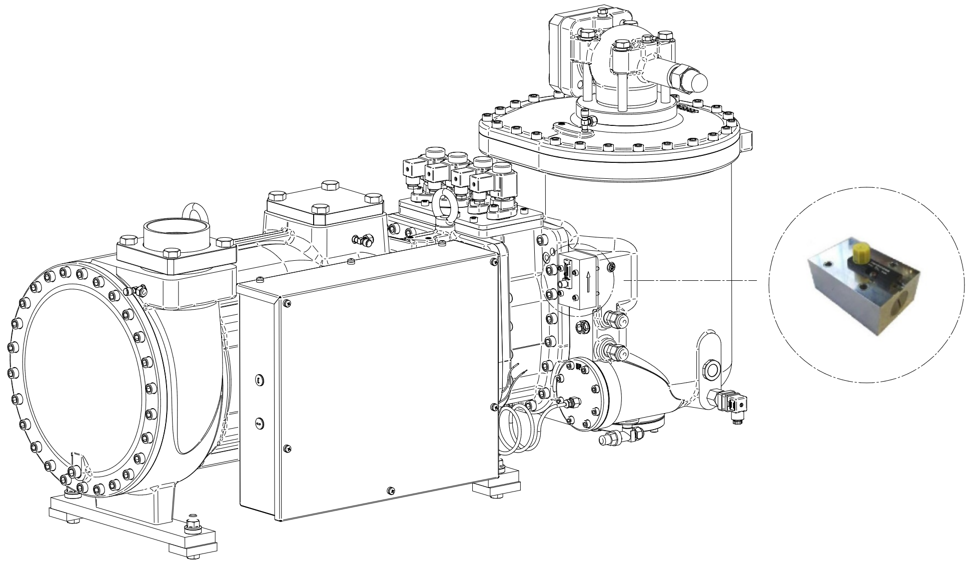

Fig. 33: Oil flow switch;

The same can be ordered and installed by the customer even if the compressor is already installed on the system.
Please contact SRM Italy Srl for more details on the components of the oil flow switch kit and technical details.

Technical specifications of the flow switch:

Switch value: 6 l/min H_2O (N. 680015);

Type	MF2-020JA-41	Pressure limit	100 bar
Medium temperature	-40..+100°C	O-ring dimension	Ø31*Ø1.5
Voltage	Max. 24 V DC	Current	Max. 0.5 A
Power	Max. 10 W	IP grade	IP 67
Electrical cable type	K04PU-02SG	Cable parameter	Length : 2m; Connector output: straight; Number of pins:4-pin

Cable blue (pin 1) and brown (pin 3) can be directly connected to the PLC.
When the oil flow rate is higher than calibrated set value, reed contact will be closed.

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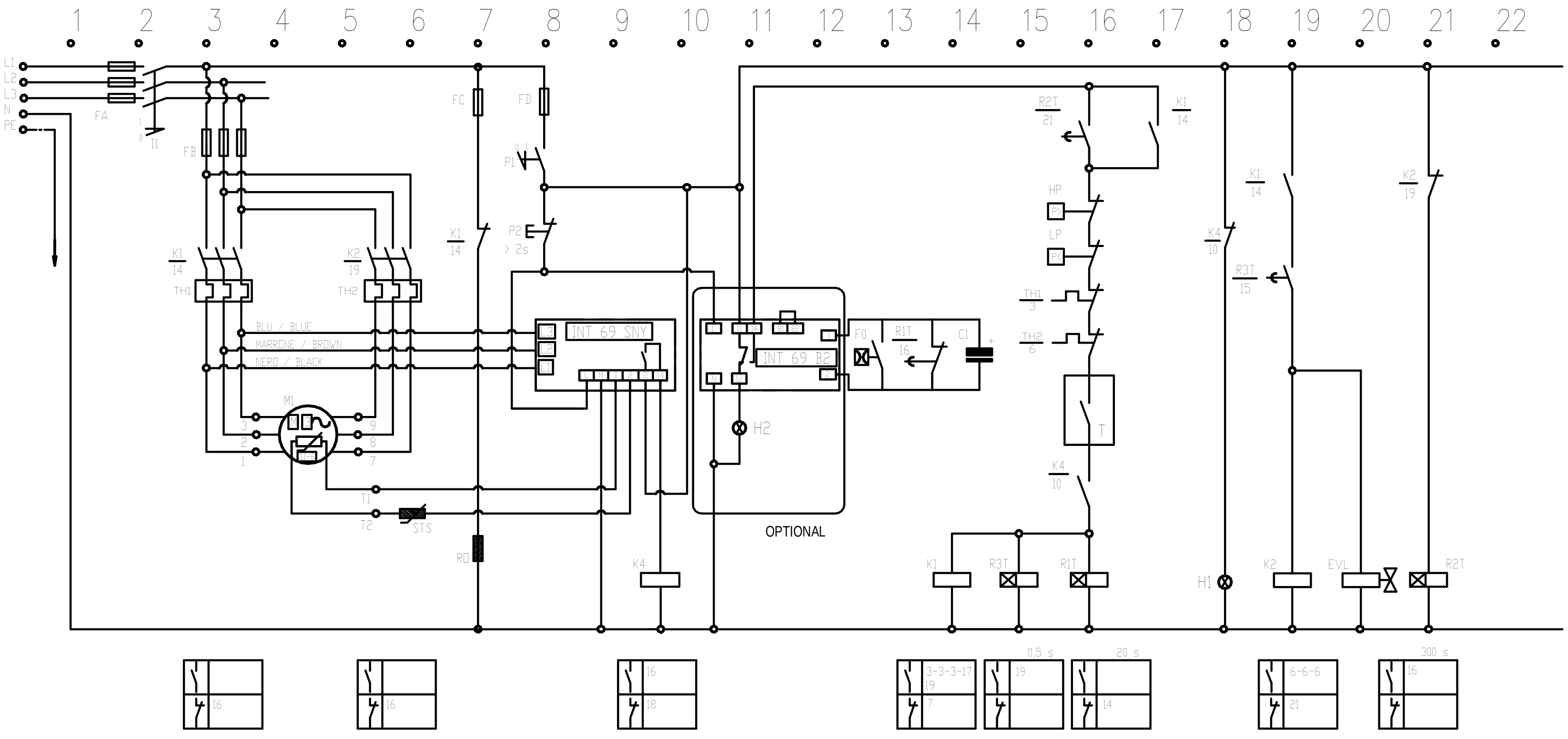
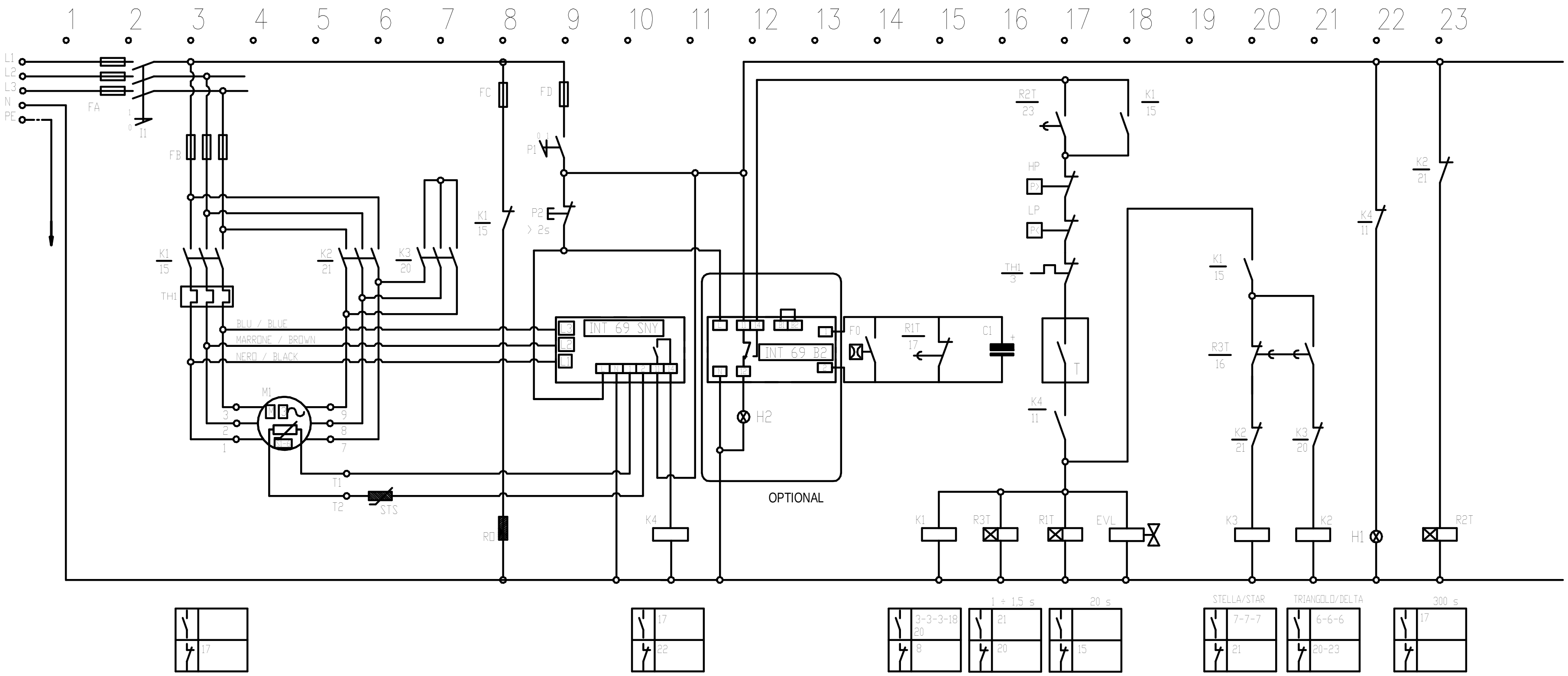


KEY:

T CONTROL THERMOSTAT
FA MAIN FUSE
FB COMPRESSOR FUSE
FC CONTROL CIRCUIT FUSE (OIL HEATER)
FD CONTROL CIRCUIT FUSE
HP HIGH PRESSURE SWITCH
LP LOW PRESSURE SWITCH
H1 SIGNAL LAMP (MOTOR PROTECTION)
K1 START CONTACTOR
K2 RUN CONTACTOR
R2T TIME RELAY "PAUSE TIME"
R3T TIME RELAY START - RUN
K4 MOTOR PROTECTION RELAY
M1 COMPRESSOR

I1 MAIN SWITCH
RO OIL HEATER
STS DISCHARGE TEMPERATURE SENSOR
S1-6 MOTOR TEMPERATURE SENSOR
P1 ON-OFF SWITCH
P2 MOTOR PROTECTION RESET
EVL SOLENOID VALVE (LIQUID LINE)
H2 SIGNAL LAMP (OIL FLOW FAULT)
R1T TIME RELAY (OIL FLOW CONTROL)
C1 ELECTROLYTIC CAPACITOR
FO OIL FLOW SWITCH
TH1 RELAY OVERCHARGE FIRST WINDING
TH2 RELAY OVERCHARGE SECOND WINDING

Fig. 34: wiring diagram for the connection of the flow switch; electric motor with part-winding configuration PW (MCE007$2);
Note 1: INT 69 B2 and electrolytic capacitor included only in appropriate kits.



KEY:

- T CONTROL THERMOSTAT
- FA MAIN FUSE
- FB COMPRESSOR FUSE
- FC CONTROL CIRCUIT FUSE (OIL HEATER)
- FD CONTROL CIRCUIT FUSE
- HP HIGH PRESSURE SWITCH
- LP LOW PRESSURE SWITCH
- H1 SIGNAL LAMP (MOTOR PROTECTION)
- K1 START CONTACTOR
- K2 RUN CONTACTOR
- K3 WYE CONTACTOR
- R2T TIME RELAY "PAUSE TIME"
- R3T TIME RELAY START - RUN
- K4 MOTOR PROTECTION RELAY
- M1 COMPRESSOR
- I1 MAIN SWITCH
- RO OIL HEATER
- STS DISCHARGE TEMPERATURE SENSOR
- S1-6 MOTOR TEMPERATURE SENSOR
- P1 ON-OFF SWITCH
- P2 MOTOR PROTECTION RESET
- EVL SOLENOID VALVE (LIQUID LINE)
- H2 SIGNAL LAMP (OIL FLOW FAULT)
- R1T TIME RELAY (OIL FLOW CONTROL)
- C1 ELECTROLYTIC CAPACITOR
- FO OIL FLOW SWITCH
- TH1 RELAY OVERCHARGE MOTOR

Fig. 35: wiring diagram for the connection of the flow switch; electric motor with star-delta configuration YΔ (MCE008$2);
Note 1: INT 69 B2 and electrolytic capacitor included only in kit appropriate.

6 Electrical motor

The electrical connection of the machine to the network line must be carried out by the customer at its own expense and responsibility, by use of specialized personnel and in accordance with safety standard EN 60204.

It is mandatory to install upstream of the power supply line a suitable isolating device with residual current protection coordinated with the earth system.

Each connection must be performed under the conditions described in par. 1.5

6.1 General

The motor stator is secured to the compressor casing by using a screw and a key. Hence no special tools are required to replace the motor.
The electrical motors are designed and tested in compliance with the European standard EN 700-24035-2-34.
The electric motors are three-phase asynchronous two-pole motors (2900 rpm at 50 Hz). To reduce the peak current, they are available in the part-winding (PW) or star/delta (Y/Δ) version; for the standard supply see chapter: "Electrical data".
Depending on the compressor model there are two different types of PW motors which differ from each other for the connection of the three phases: star or delta type. In any case at the compressor starting only a part of the windings is powered, while in normal operation all are powered. The PW versions can be:

- ✓ Double star (Y-YY);
- ✓ Double delta (Δ–ΔΔ).

As regards the mains connections, there is no difference between the two PW motor configurations. Fig. 36 and Fig. 37 below show the internal connections of the phases, depending on the configuration of the electrical motor.

- **PART-WINDING CONFIGURATION**

  Important note:
  The two above-mentioned part-winding types of motors can be distinguished by measuring the electrical resistance between terminals 1-2-3 and 7-8-9.
  With reference to Fig. 36:
  - ✓ in the Y-YY configuration there is continuity between terminals 1 and 2, 1 and 3, 2 and 3, 7 and 8, 7 and 9, 8 and 9; while there is insulation between terminals 1 and 7/8/9, 2 and 7/8/9, 3 and 7/8/9.
  - ✓ in the Δ-ΔΔ configuration there is continuity between each pair of terminals and there is not reciprocal insulation between any of them.

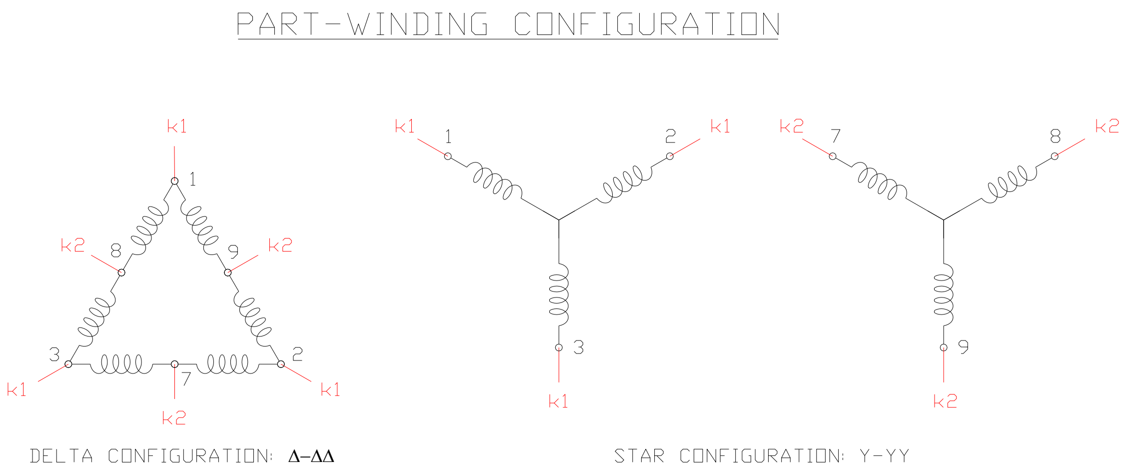


Fig. 36: internal winding connections for the motors with part-winding configuration

- **STAR-DELTA CONFIGURATION**

Important note:
With reference to Fig. 37, measuring the electrical resistance between terminals 1-2-3 and 7-8-9, the star-delta version has the following values: continuity between terminals 1 and 8, 3 and 7, 2 and 9, and insulation between terminals 1 and 2/3/7/9, 2 and 1/3/7/8, 3 and 1/2/8/9, 7 and 1/2/8/9, 8 and 2/3/7/9, 9 and 1/3/7/8.

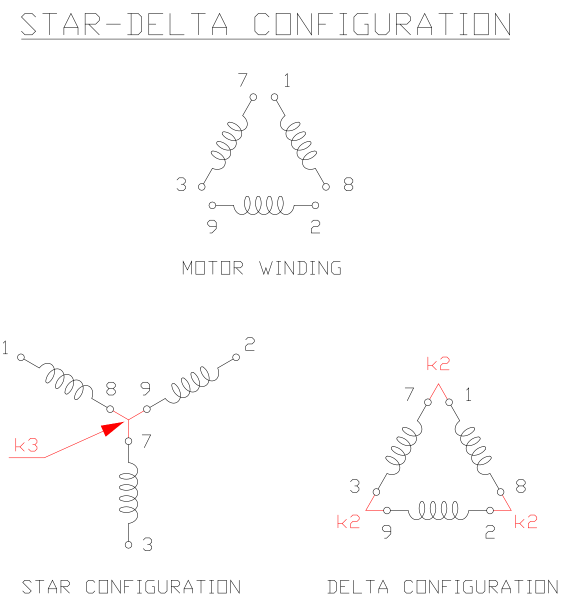


Fig. 37: internal winding connections for the motors with star-delta configuration

By starting the electrical motor either in part-winding configuration or with the windings in star connection for the electrical motor in star-delta configuration there is a reduction in the starting current LRA and starting torque. To achieve a reduction in the resisting torque and consequently start the motor without overloading it, the compressor needs to be started at the minimum capacity step, see chapters 4: "*Capacity control*" and 0: "*Operating instructions*".

Note:
Then with the screw compressors no by-pass system between the high and low pressure is required for reducing the resisting torque on starting.

Fig. 38 shows how to connect the electrical motor to the three-phase line, both for the star-delta configuration and the part-winding one. It also gives the time sequence for the contactors. The compressor therefore starts as follows:

- ✓ In the PW motors, the delay in closing the run contactor K2 from when the starting contactor K1 closes must be 1 second maximum (recommended value 0.6 sec), see Fig. 38.
- ✓ In the star-delta configuration, on the other hand, the starting duration in star configuration (closing of contactors K1-K3) must not exceed 1.5 sec (recommended value 0.8/1 sec); while when switching to delta configuration (closing of contactors K1-K2), contactor K2 must be closed with a delay of 35-50 msec from the instant when contactor K3 is opened, see Fig. 38 again.

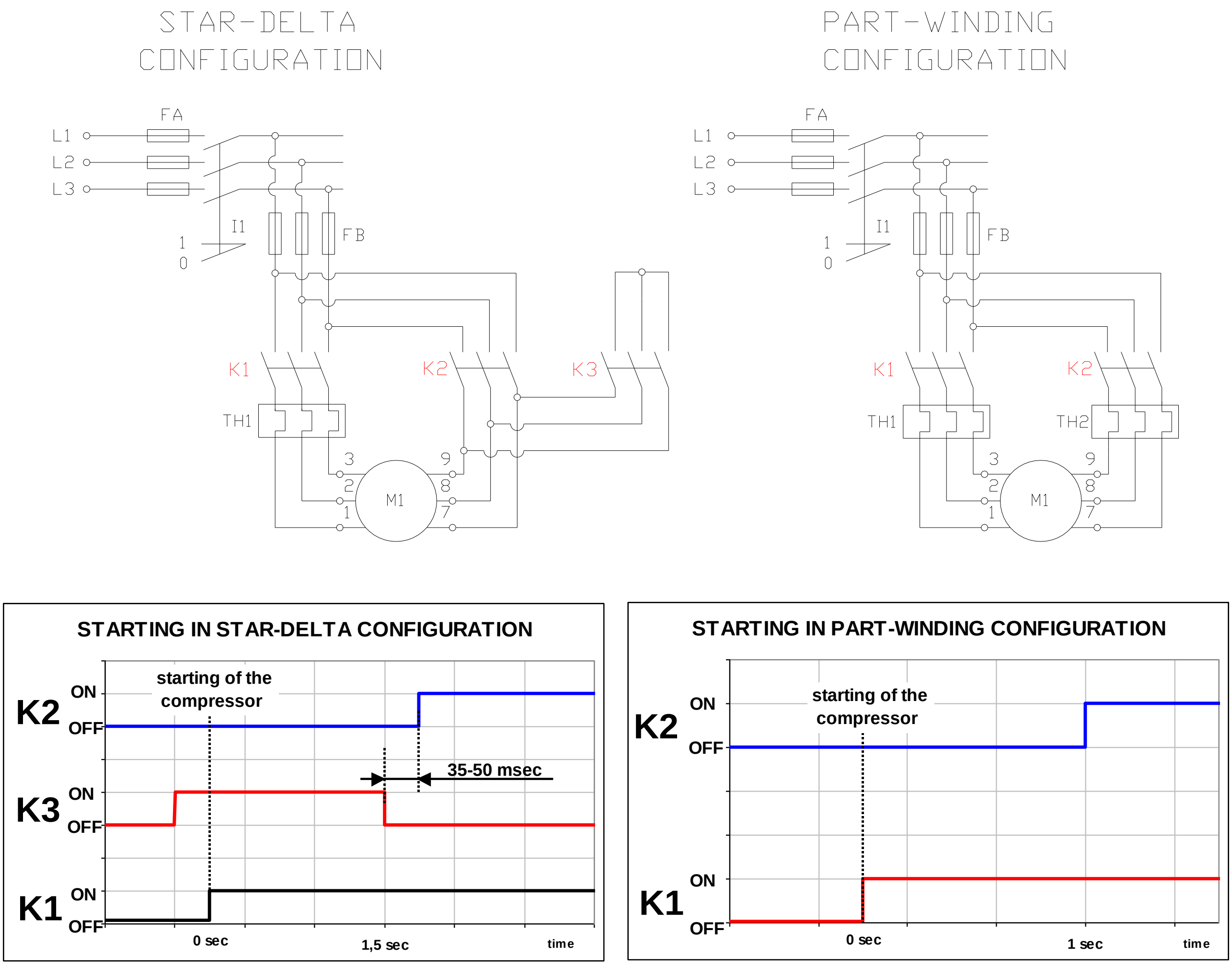


Fig. 38: connection diagrams to the three-phase network and time charts for the activation of contactors K1,K2 and K3 in the two compressor starting modes: star-delta and part-winding;
FA, FB: main fuses and compressor's fuses

6.2 Protection devices

6.2.1 Motor thermistors (standard)

To protect the motor against high temperatures six PTC thermistors connected in series are inserted in the motor windings. Three thermistors are positioned on the intake side of the motor (suction side) and have an activation temperature of 100°C, while the other three are positioned on the opposite side of the motor (discharge side) and have an activation temperature of 120°C.

The resistance of the chain of thermistors when cold (temperature less than 40°C) must be less than 1800 Ohm; but even if just one of the thermistors reaches the critical temperature, the resistance of the chain will increase exponentially, with the consequent activation of the INT 69 SNY electronic module, which cut off the power supply to the motor. The resistance can be measured between terminals T1 and T2 on the terminal block.

Attention !

When measuring the resistance of the thermistors' chain, never apply a voltage higher than 3V.

6.2.2 INT 69 SNY

The INT 69 SNY module is available as standard. This module carries out the following functions:

- ✓ monitors the temperature of the electrical motor and the oil;
- ✓ monitors the direction of rotation of the motor;
- ✓ monitors for a missing phase.

The electrical connections on the INT 69 SNY protection module are shown in Fig. 41 (PW and Star/Delta). For the technical specifications of the module see in the following pages.

Monitoring the temperature

The temperature of the motor and the oil are monitored by the PTC sensors. The oil temperature sensor is connected in series to the chain of thermistors in the electrical motor (for its position of the sensor on the compressor see Fig. 39).

Manual reset of alarm through disconnection of power supply for at least 5 seconds .

The temperature is monitored through its value (static control) and through the swiftness of its increase (dynamic control).

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Only when the alarm is given by the temperature static control, and only if the reset level has been reached, the motor protector will perform an automatic reset after 5 minutes from the alarm detection.

Attention!

Following an alarm and after the motor has cooled down, an internal lockout prevents the compressor from starting again.

1. Reset the INT 69 SNY module by briefly disconnecting the power supply through the main switch or by pressing a specific button that can be installed for this purpose in the power supply line.
2. Never apply power to the module terminals 1-2, B1-B2, nor to terminals T1 and T2 of the terminal plate.

TAKE NOTE: Before re-starting the compressor following an alarm, the operator must check the temperature of the motor and the oil temperature, making sure that the resistance of the PTC chain is less than 2,9 kΩ.

Monitoring the direction of rotation of the motor

The correct direction of rotation of the motor is monitored by measuring the sequence of the phases at the compressor terminals.

The function has a manual reset and requires the power supply to be disconnected for at least 5s . The check is performed in the first 5 seconds at each starting.

Attention!

Following an alarm for wrong rotation, an internal lockout prevents the compressor from starting again.

1. Put the system in the Machine switched-off status
2. Reset the INT 69 SNY module by briefly disconnecting the power supply through the main switch or by pressing a specific button that can be installed for this purpose in the power supply line.
3. Before re-starting the compressor check the correct sequence of the phases

Monitoring for a missing phase

The phases are monitored during the start-up and. The alarm causes the stop of compressor and it could not start before 5 minutes.

So the reset is automatic till maximum 10 consecutive restarts (in the first 24 hours of working) with a missing phase the compressor is stopped definitively. After this, it must be reset manually by disconnecting the power supply for at least 2 seconds.

Attention!

Following a repeated alarm for missing, an internal lockout prevents the compressor from starting again.

4. Put the system in the Machine switched-off status
5. Reset the INT 69 SNY module by briefly disconnecting the power supply through the main switch or by pressing a specific button that can be installed for this purpose in the power supply line.
6. Before re-starting the compressor check the power supply of the compressor.

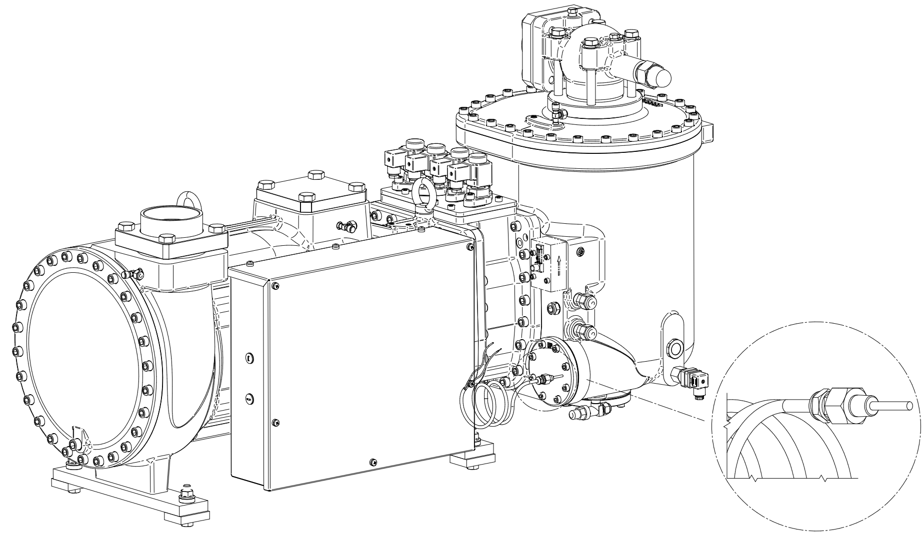


Fig. 39: position on compressor for oil temperature monitoring sensor ;

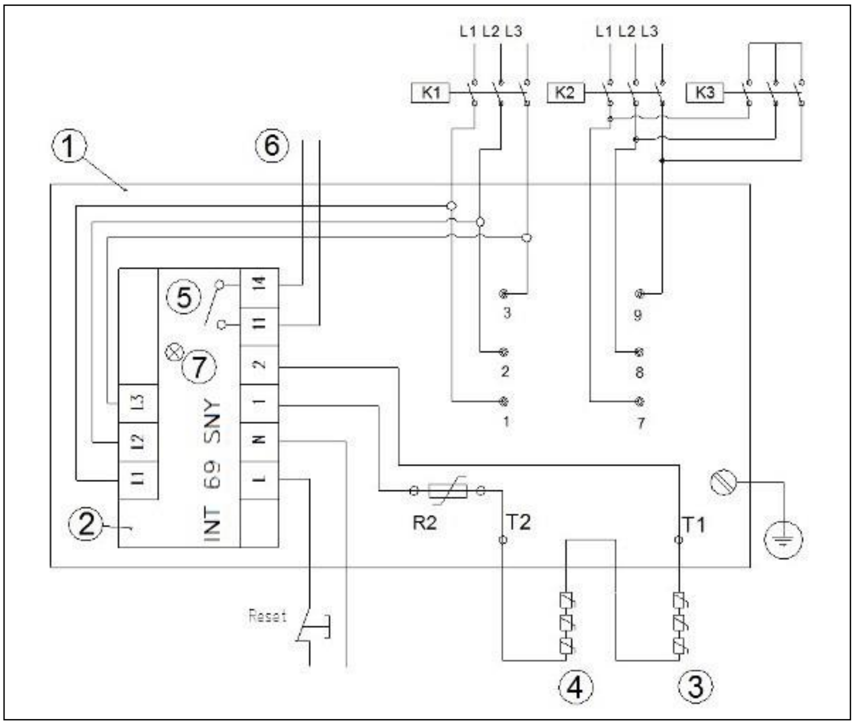


Fig. 40: electrical connections to the INT 69 SNY module (part-winding and star delta)

1) Terminal box
2) Motor protection device INT 69 SNY
3-4) Motor thermistors PTC
R2) Discharge gas temperature sensor
L1-L2-L3) Power supply
PW motor: K1 PW contactor 50%
K2 PW contactor 50%,
Y/D ·motor: K1-K3 start contactors (Y)
K1-K2 run contactors (D)

L/N) Phase + neutral 230V-50/60Hz
6) Control circuit
1/2) Connection cables to thermistors
5) Relay
7) Led

Trip value	4500±20% Ohm
Reset value	2750±20% Ohm
Power supply	115/120 V or 230/240 V –15/+10%, 50/60 Hz, Absorbed power : 3VA
Output relay	AC, 240 V, 2,5A max continuous current, C300 Potential-free normally open contact (NOC)
Ambient working conditions (temp.)	-30°C...+70°C
Required fuse	4 A, fast type
Motor supply	200...690V AC ±10%, 3 AC , 50/60 Hz

Table 7: INT 69 SNY technical specifications;

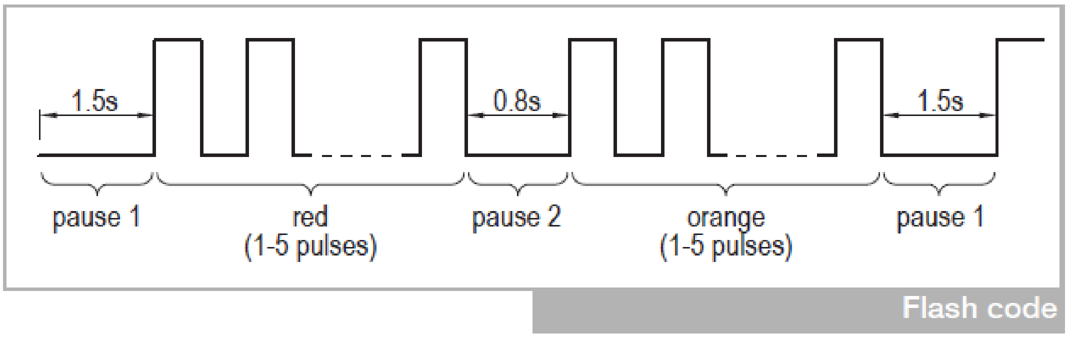
The INT 69 SNY has to be fitted in a main control box far away from the compressor according to the following indications:

- ✓ The connection cables to the motor terminals must be connected following the specified sequence: L1 to terminal 1, L2 to terminal 2 and L3 to terminal 3; check the direction of rotation with an indicator;
- ✓ To connect the module to the PTC sensors, only use shielded cables or a twisted pair (danger of induction);

Alarm signals

The motor protector INT 69 SNY is equipped on its box with a led for displaying the kind of the alarm occurred. The kind of optic signal identifies the motor protector status and in case of alarm also its cause.

Through the cyclical sequence of the red blinks it is possible to identify both the category and the type of the detected alarm.
Specifically, with reference to the table and examples reported below, the blinking cycle can be divided onto two subsequent sequences: at first that of the alarm category and afterwards that of the alarm type.
All alarms are recorded in an internal memory of the device and can be downloaded through the interface connection.



Green lit	Compressor operational
Green flashing	Compressor running
Red/Orange flashing	Error, compressor is switched off; for description see table below

1st flashing sequence (LED red)	2nd flashing sequence (LED orange)	Description
1	1	Motor temperature: Static switch-off, Permissible winding temperature exceeded
	3	Motor temperature: Reset delay after static switch-off
	4	Motor temperature: Sensor input detected open circuit or short circuit
2	1	Motor voltage: Incorrect phase sequence
	2	Motor voltage: Phase failure/asymmetry
	4	Motor voltage: Reset delay after "Motor voltage" error
3	1	General: Supply voltage too low
	5	General: Reset delay after "General" error

6.3 Power supply

Warning!

For the direction of rotation of the rotors see chapter 2: "*General*". If the motor turns in the opposite direction the compressor can be seriously damaged.

- Motor power supply for standard version (part-winding and star-delta):

  400 V - 3 phases - 50 Hz / 460 V - 3 phases - 60 Hz (other power supply on request);
- Permissible voltage range: ± 10 % of rated voltage;
- Permissible voltage unbalance between L1 - L2 - L3: ± 2 %;
- Maximum voltage drop during the starting phase: 10 % of rated voltage;
- Permissible frequency range: ± 2 % of rated frequency;
- Permissible current unbalance: 5 /12 % calculated as follows:

  Currents on the first contactor: I_1 - I_2 - I_3

Currents on the second contactor: I_7 - I_8 - I_9

Currents of each supply phase

$$I_R = I_1 + I_7$$

$$I_S = I_2 + I_8$$

$$I_T = I_3 + I_9$$

Unbalance of the three R - S - T currents:

$$I_M = \frac{I_R + I_S + I_T}{3}$$

$$SB_3^{\%} = \frac{MAX\left|\left(I_R, I_S, I_T\right) - I_M\right|}{I_M} \cdot 100$$

$$SB_3^{\%} < 5\%$$

Unbalance of the six 1 - 2 - 3 - 7 - 8 - 9 currents:

$$I_M = \frac{I_1 + I_2 + I_3 + I_7 + I_8 + I_9}{6}$$

$$SB_6^{\%} = \frac{MAX\left|\left(I_1, I_2, I_3, I_7, I_8, I_9\right) - I_M\right|}{I_M} \cdot 100$$

$$SB_6^{\%} < 12\%$$

6.4 Selection of electrical components

The various electrical components: cables, fuses etc. must be sized considering the maximum current that can be absorbed by the electrical motor during normal operation, i.e. the FLA.

Specifically, erring on the side of safety, in Part-Winding configuration the contacts on the motor contactors must be sized for a current equal to at least 65% of the maximum operating current (FLA). On the other hand, for the star-delta configuration the contacts must be sized for a current equal to at least 75% of the FLA.

7 Data

7.1 Electrical data

Mod. **RS5-**			L040 H050	L050 H060	L060 H070	L070 H080	L075 H090	L080 H100	L090 H110	L100 H125	L110 H140	L125 H160	L140 H180	L160 H210	L180 H240	L210 H270	L240 H300	L270 H350	L300 H400
Nominal motor power		HP/kW	40/30 50/37	50/37 60/45	60/45 70/52	70/52 80/59	75/55 90/66	80/59 100/75	90/66 110/80	100/75 125/90	110/80 140/103	125/90 160/118	140/103 180/132	160/118 210/154	180/132 240/176	210/154 270/199	240/176 300/221	270/199 350/257	300/221 400/294
Nominal Voltage (V)		V	400/3/50Hz - 460/3/60Hz																
PW L version	Starting current (A)	LRA Y	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	-	-	-	-	-	-	-	-	-	-
		LRA YY	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	-	-	-	-	-	-	-	-	-	-
	Max running current (A)	FLA	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	-	-	-	-	-	-	-	-	-	-
PW H version	Starting current (A)	LRA Y	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	-	-	-	-	-	-	-	-	-	-
		LRA YY	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	-	-	-	-	-	-	-	-	-	-
	Max running current (A)	FLA	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	-	-	-	-	-	-	-	-	-	-
Y / Δ L version	Starting current (A)	LRA Y	-	-	-	-	-	-	-	n.a.	n.a.	368	368	402	445	551	703	703	783
		LRA Δ	-	-	-	-	-	-	-	n.a.	n.a.	1176	1176	1283	1421	1667	2109	2109	2348
	Max running current (A)	FLA	-	-	-	-	-	-	-	n.a.	n.a.	227	243	264	302	353	395	433	488
Y / Δ H version	Starting current (A)	LRA Y	-	-	-	-	-	-	-	n.a.	n.a.	402	445	481	528	703	783	876	1062
		LRA Δ	-	-	-	-	-	-	-	n.a.	n.a.	1283	1421	1535	1686	2109	2348	2627	3186
	Max running current (A)	FLA	-	-	-	-	-	-	-	n.a.	n.a.	267	308	335	383	447	501	549	619
(green)	Standard Delivery - Fornitura standard																		

Table 8: electrical data of the compressors;

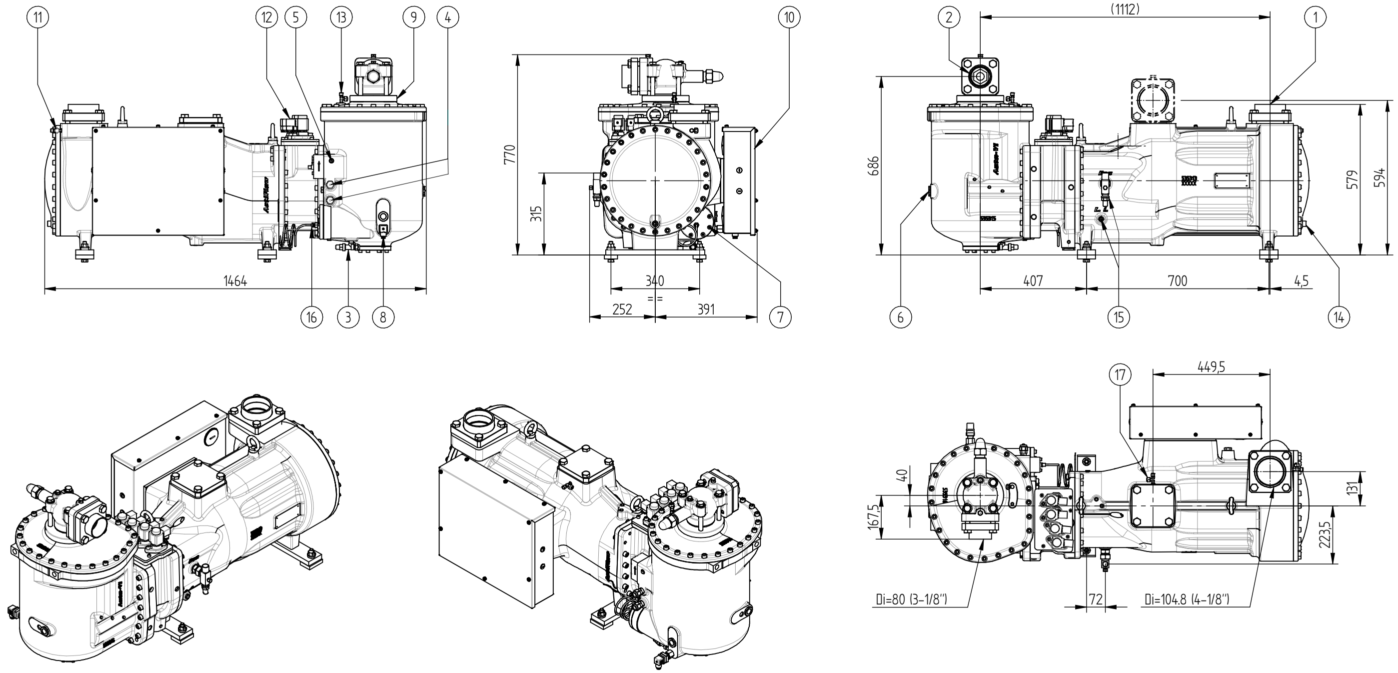
7.2 Technical data

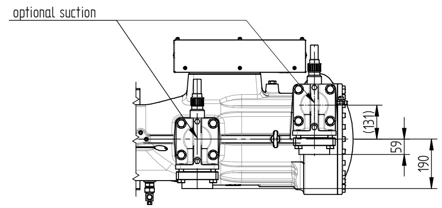
Mod. **RS5-**		L040 H050	L050 H060	L060 H070	L070 H080	L075 H090	L080 H100	L090 H110	L100 H125	L110 H140	L125 H160	L140 H180	L160 H210	L180 H240	L210 H270	L240 H300	L270 H350	L300 H400
Nominal motor power	HP/kW	40/30 50/37	50/37 60/45	60/45 70/52	70/52 80/59	75/55 90/66	80/59 100/75	90/66 110/80	100/75 125/90	110/80 140/103	125/90 160/118	140/103 180/132	160/118 210/154	180/132 240/176	210/154 270/199	240/176 300/221	270/199 350/257	300/221 400/294
Displacement at 50/ 60Hz	m3/h	140/ 168	175/ 210	200/ 240	240/ 288	270/ 324	300/ 360	330/ 396	365/ 438	415/ 498	480/ 576	550/ 660	620/ 744	710/ 852	830/ 996	930/ 1116	1020/ 1224	1150/ 1380
Weight "L version/ H version"	Kg	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	820/ 830	850/ 860	950/ 963	980/ 993	1120/ 1135	1150/ 1165	n.a.	n.a.
Oil charge	dm3	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	14	14	25	25	25	25	30	30
Crankcase heater									230V-200W-50/60Hz				230V-275W-50/60Hz					
Discharge line, internal Ø	mm/ "	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	80 / 3 1/8"	80 / 3 1/8"	80 / 3 1/8"	80 / 3 1/8"	104,8 / 4 1/8"	104,8 / 4 1/8"	104,8 / 4"1/8	104,8 / 4"1/8
Suction line, internal Ø	mm/ "	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	104,8 / 4 1/8"	104,8 / 4 1/8"	104,8 / 4 1/8"	104,8 / 4 1/8"	133 / 5 1/4"	133 / 5 1/4"	133 / 5 1/4"	133 / 5 1/4"
Capacity control steps		STEP: 100,75,50%, minimum capacity; STEPLESS: from minimum capacity to 100% or from 50 to 100% "Vi" control																
Protection devices		INT 69 SNY																
Lubricant		POE 170																

Table 9: technical data

8 Dimensional drawings and packaging

8.1 Dimensional drawings

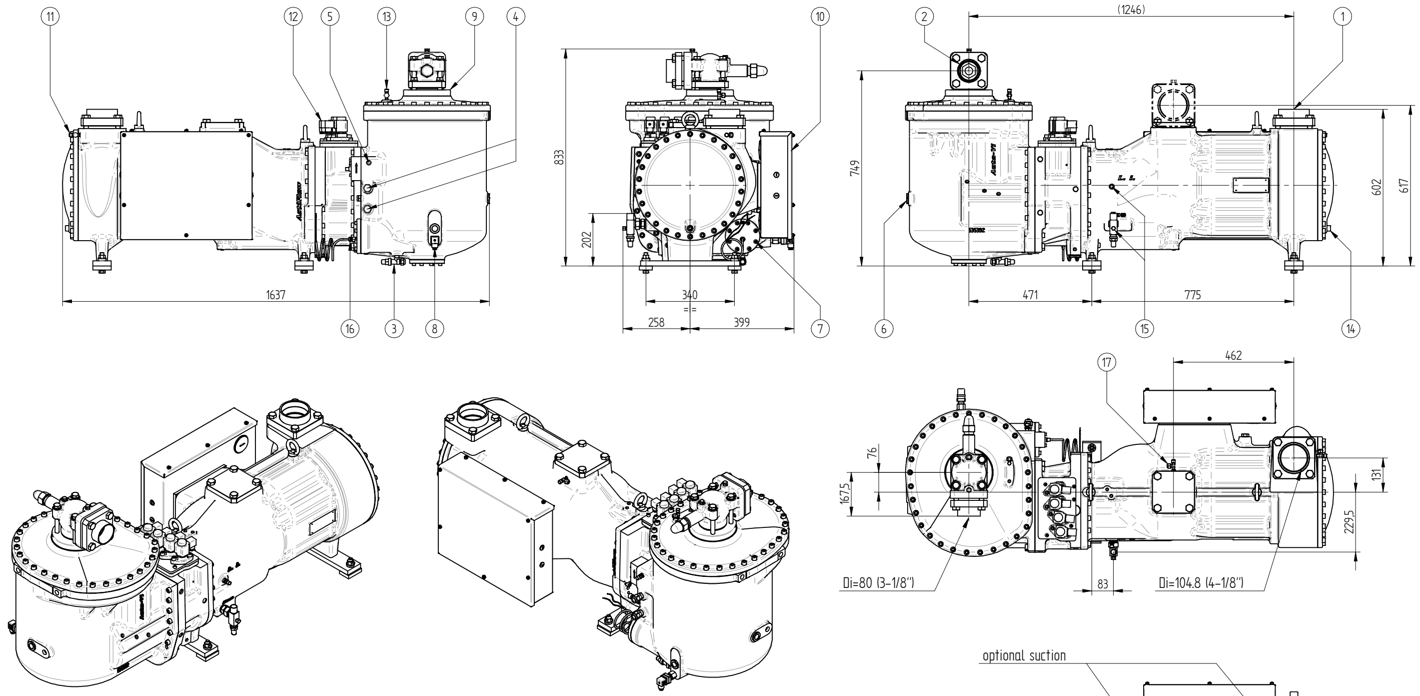


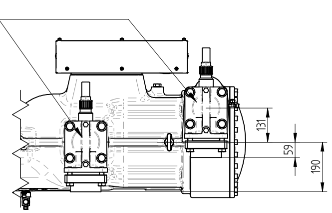


LEGENDA
1 - Manicotto aspirazione
2 - Rubinetto mandata
3 - Rubinetto carico/scarico olio 3/8" SAE-FLARE
4 - Connessione raffredamento olio 1/2" SAE-FLARE
5 - Pressione olio 1/4" SAE-FLARE
6 - Spia olio
7 - Filtro olio
8 - Resistenza carter
9 - Valvola di non ritorno
10 - Scattola morsettiera
11 - Bassa pressione 1/4" SAE-FLARE
12 - Solenoidi di parzializzazione
13 - Alta pressione 1/4" SAE-FLARE
14 - Scarico olio lato motore
15 - Iniezione di liquido/economizzatore (opzionale)
16 - Sensore temperatura di scarico 1/8"NPT (opzionale)
17 - Bassa pressione 1/4" SAE-FLARE (con aspirazione opzionale)

KEY
1 - Suction bush
2 - Discharge shut-off valve
3 - Oil charge/drain valve 3/8" SAE-FLARE
4 - Oil cooling connection 1/2" SAE-FLARE
5 - Oil pressure connection 1/4" SAE-FLARE
6 - Oil sight glass
7 - Oil filter
8 - Crankase heater
9 - Check valve
10 - Electrical box
11 - Low pressure 1/4" SAE-FLARE
12 - Capacity control solenoid valves
13 - High pressure 1/4" SAE-FLARE
14 - Oil drain motor side
15 - Liquid injection/Eco connection (option)
16 - Discharge temperature sensor 1/8"NPT (option)
17 - Low pressure 1/4" SAE-FLARE (with optional suction)

Fig. 41: dimensional drawing of the models: RS5-L125/L140/H160/H180 (drawing code: MSI305-AC);

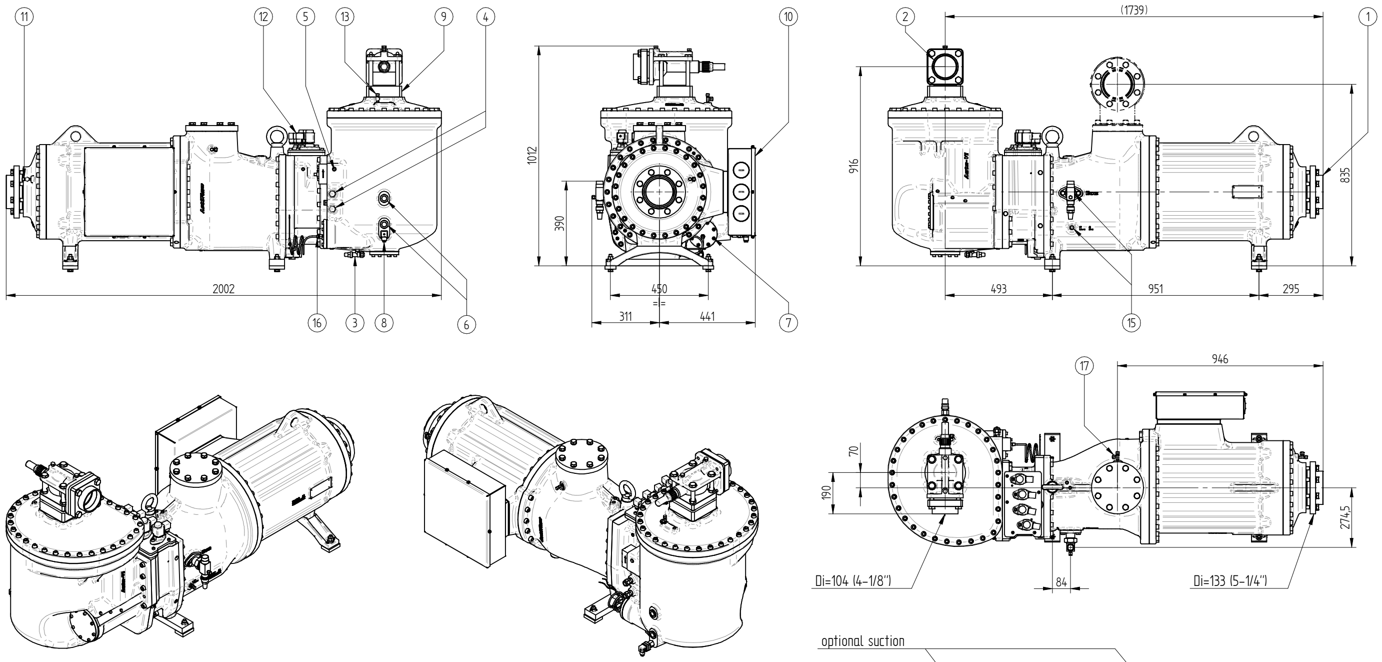


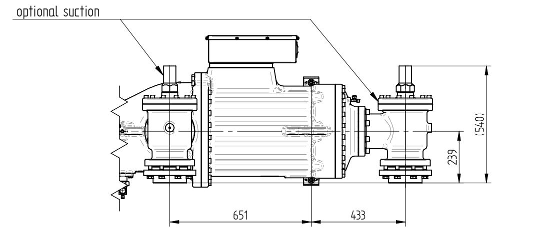


LEGENDA
1 - Manicotto aspirazione
2 - Rubinetto mandata
3 - Rubinetto carico/scarico olio 3/8" SAE-FLARE
4 - Connessione raffredamento olio 1/2" SAE-FLARE
5 - Pressione olio 1/4" SAE-FLARE
6 - Spia olio
7 - Filtro olio
8 - Resistenza carter
9 - Valvola di non ritorno
10 - Scattola morsettiera
11 - Bassa pressione 1/4" SAE-FLARE
12 - Solenoidi di parzializzazione
13 - Alta pressione 1/4" SAE-FLARE
14 - Scarico olio lato motore
15 - Iniezione di liquido/economizzatore (opzionale)
16 - Sensore temperatura di scarico 1/8"NPT (opzionale)
17 - Bassa pressione 1/4" SAE-FLARE (con aspirazione opzionale)

KEY
1 - Suction bush
2 - Discharge shut-off valve
3 - Oil charge/drain valve 3/8" SAE-FLARE
4 - Oil cooling connection 1/2" SAE-FLARE
5 - Oil pressure connection 1/4" SAE-FLARE
6 - Oil sight glass
7 - Oil filter
8 - Crankase heater
9 - Check valve
10 - Electrical box
11 - Low pressure 1/4" SAE-FLARE
12 - Capacity control solenoid valves
13 - High pressure 1/4" SAE-FLARE
14 - Oil drain motor side
15 - Liquid injection/Eco connection (option)
16 - Discharge temperature sensor 1/8"NPT (option)
17 - Low pressure 1/4" SAE-FLARE (with optional suction)

Fig. 42: dimensional drawing of the models: RS5-L160/L180/H210/H240 (drawing code: MSI388-AB);

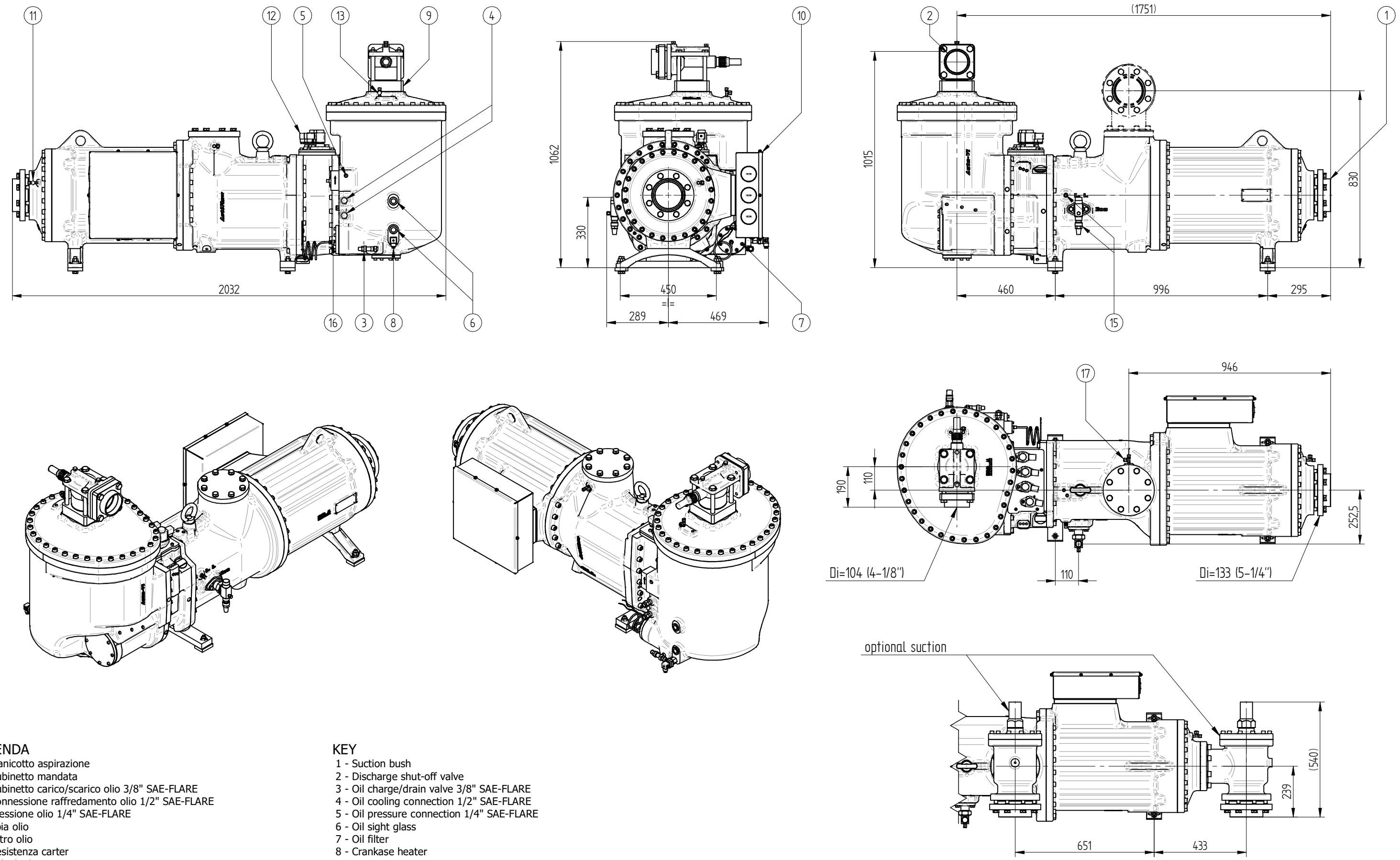




LEGENDA
1 - Manicotto aspirazione
2 - Rubinetto mandata
3 - Rubinetto carico/scarico olio 3/8" SAE-FLARE
4 - Connessione raffredamento olio 1/2" SAE-FLARE
5 - Pressione olio 1/4" SAE-FLARE
6 - Spia olio
7 - Filtro olio
8 - Resistenza carter
9 - Valvola di non ritorno
10 - Scattola morsettiera
11 - Bassa pressione 1/4" SAE-FLARE
12 - Solenoidi di parzializzazione
13 - Alta pressione 1/4" SAE-FLARE
14 - Scarico olio lato motore
15 - Iniezione di liquido/economizzatore (opzionale)
16 - Sensore temperatura di scarico 1/8"NPT (opzionale)
17 - Bassa pressione 1/4" SAE-FLARE (con aspirazione opzionale)

KEY
1 - Suction bush
2 - Discharge shut-off valve
3 - Oil charge/drain valve 3/8" SAE-FLARE
4 - Oil cooling connection 1/2" SAE-FLARE
5 - Oil pressure connection 1/4" SAE-FLARE
6 - Oil sight glass
7 - Oil filter
8 - Crankase heater
9 - Check valve
10 - Electrical box
11 - Low pressure 1/4" SAE-FLARE
12 - Capacity control solenoid valves
13 - High pressure 1/4" SAE-FLARE
14 - Oil drain motor side
15 - Liquid injection/Eco connection (option)
16 - Discharge temperature sensor 1/8"NPT (option)
17 - Low pressure 1/4" SAE-FLARE (with optional suction)

Fig. 43: dimensional drawing of the models: RS5-L210/L240/H270/H300 (drawing code: MSI386-AA);



LEGENDA
1 - Manicotto aspirazione
2 - Rubinetto mandata
3 - Rubinetto carico/scarico olio 3/8" SAE-FLARE
4 - Connessione raffredamento olio 1/2" SAE-FLARE
5 - Pressione olio 1/4" SAE-FLARE
6 - Spia olio
7 - Filtro olio
8 - Resistenza carter
9 - Valvola di non ritorno
10 - Scattola morsettiera
11 - Bassa pressione 1/4" SAE-FLARE
12 - Solenoidi di parzializzazione
13 - Alta pressione 1/4" SAE-FLARE
14 - Scarico olio lato motore
15 - Iniezione di liquido/economizzatore (opzionale)
16 - Sensore temperatura di scarico 1/8"NPT (opzionale)
17 - Bassa pressione 1/4" SAE-FLARE (con aspirazione opzionale)

KEY
1 - Suction bush
2 - Discharge shut-off valve
3 - Oil charge/drain valve 3/8" SAE-FLARE
4 - Oil cooling connection 1/2" SAE-FLARE
5 - Oil pressure connection 1/4" SAE-FLARE
6 - Oil sight glass
7 - Oil filter
8 - Crankase heater
9 - Check valve
10 - Electrical box
11 - Low pressure 1/4" SAE-FLARE
12 - Capacity control solenoid valves
13 - High pressure 1/4" SAE-FLARE
14 - Oil drain motor side
15 - Liquid injection/Eco connection (option)
16 - Discharge temperature sensor 1/8"NPT (option)
17 - Low pressure 1/4" SAE-FLARE (with optional suction)

Fig. 44: dimensional drawing of the models: RS5-L270/L300/H350/H400 (drawing code: MSIXXX-XX);

9 Transport, Handling and Storage

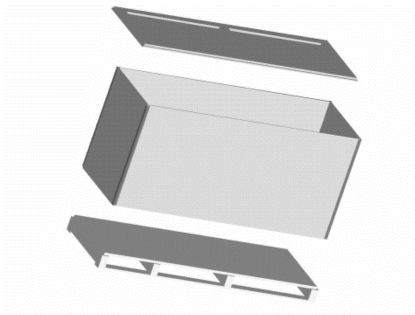
9.1 Receiving and unpacking

In order to protect and avoid damages during transport, the compressor is usually placed on a wooden pallet, fixed by screws, and a cardboard cover.
All the informations/pictograms required for shipping are printed on the package.
Upon receipt of the compressor, after removing the upper part of the package, make sure that no damage occurred during transport. If you notice damage due to transport, please provide to make a written complaint, possibly accompanied with photos of the damaged parts, to your insurance company and send copies to the Manufacturer and transporter. For the entire period that the compressor is not used, before unpacking it, store in a dry place at a temperature between + 5 ° C and + 45 ° C and in position to avoid contact with atmospheric agents.
For the entire period that the compressor is not used, after being unpacked, before first start-up or for long period unused, you need to change the oil and check the operation.
If the compressor is not used for long periods, you need to change the oil and check the operation.

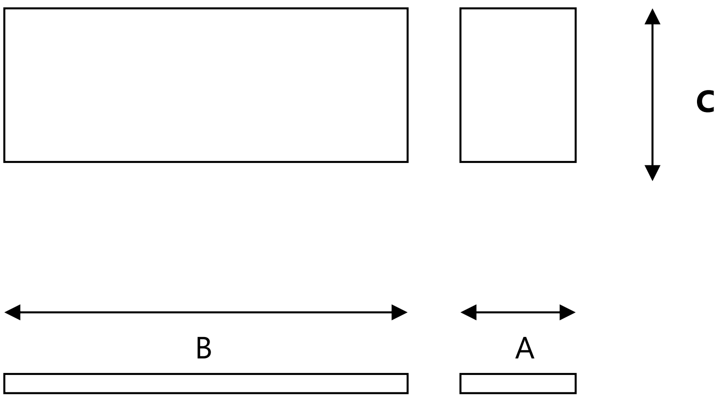
Please dispose of the packaging according to the different types of material in full compliance with the legislation in force in the country of use.

9.2 Package dimensions:

Internal packaging structure with cardboard walls;



Packaging with wooden wall;



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Models	A [mm]	B [mm]	C [mm] Wooden packing	C [mm] Carton packing
RS5–L125/L140/H160/H180	900	1860	1010	1063
RS5–L160/L180/H210/H240	900	1860	1010	1063

Table 10: Packing dimensions (mm);

9.3 Transport & Handling

The transport of the packed compressor must be operated by qualified personnel using a forklift truck.

ATTENTION : before making any transport operation, make sure that the lift capacity is suitable for the load to be lifted.

Place the forks exclusively in the pallet bottom. After positioning the forks at the points indicated, lift slowly without sudden movements.

With the usage of a forklift, bring the compressor as close as possible to the place to install, then carefully remove the protective packing, paying attention not to damage it, and follow the instructions below:

- Remove the carton.
- Remove the screws that fix compressor to the wooden pallet.

Please dispose of the packaging according to the different types of material in full compliance with current legislation in the country of utilization.

It is mandatory to install the compressor in a ventilated area with proper ventilation to keep the room temperature between +2°C to +40°C, with humidity level between 5 to 95%.
It is mandatory to contact the manufacturer or authorized dealer in the event of an inadequate exhaust of hot air from the place of installation of the compressor.
It is mandatory that the air introduced into the compressor installation site is clean and free of dust, fumes and flammable vapors.

9.4 Compressor lifting

The compressor has to be lifted using the eyebolts of the same.

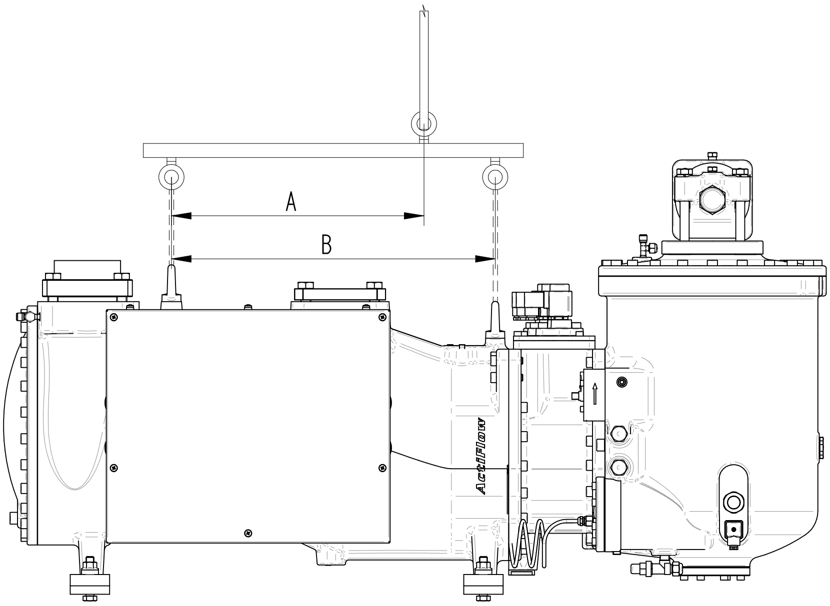

Fig. 45: anchor points for lifting the compressor;

The compressor can be transported by securing it to a pallet or alternatively lifting it with a suitable cross-beam, using the anchor points highlighted in Fig. 45.

RS5-	L040 H050	L050 H060	L060 H070	L070 H080	L075 H090	L080 H100	L090 H110	L100 H125	L110 H140	L125 H160	L140 H180	L160 H210	L180 H240	L210 H270	L240 H300	L270 H350	L300 H400
A										450		472		724		714	
B										575		639		927		854	

Table 11: Compressor position

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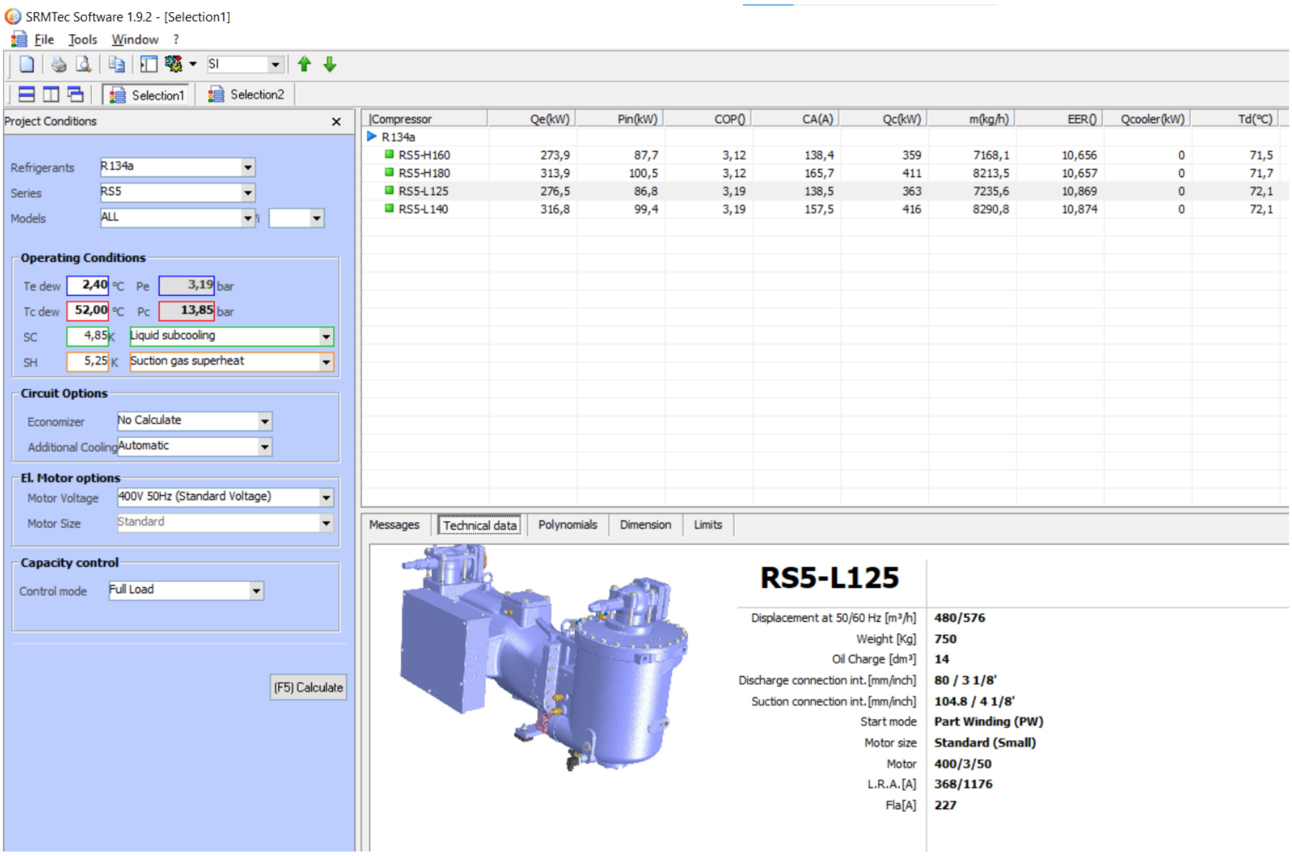
10 **Performance data for the RS5 series compressors**

In order to have performance data for all working conditions allowed, use SRMTec selection program (contact SRMTec to have the updated software version):



Performance data are obtained through measurements made at the suction and discharge connection. See chapter 8:"*Dimensional drawing and packaging*" for connection positions on each models.

According to the chapter 11: "*Application range*", the following tables highlight the working condition which require the monitoring of the filter lodgment (see chapter 3) or the additional cooling (see chapter 12);

For all the refrigerant mixtures the above mentioned temperatures are the DEW point.

The performances are optimized for the following working conditions:

- Gas suction overheating: SH=10K;
- Liquid sub-cooling: SC=5K;
- Three-phase electrical net frequency: f=50Hz;
- Nominal voltage: V=400V;
- Refrigerant fluid: HFC, HFO

Key:

Te:	Evaporating temperature [° C];
Tc:	Condensing temperature [° C];
Qe:	Refrigerant power [kW];
Pta:	Absorbed power [kW];

11 Application range

11.1 General

The normal admissible operating conditions for the RS5 series compressors, with changes in evaporation and condensing temperature, are defined by a polygon, as highlighted in Fig. 46.

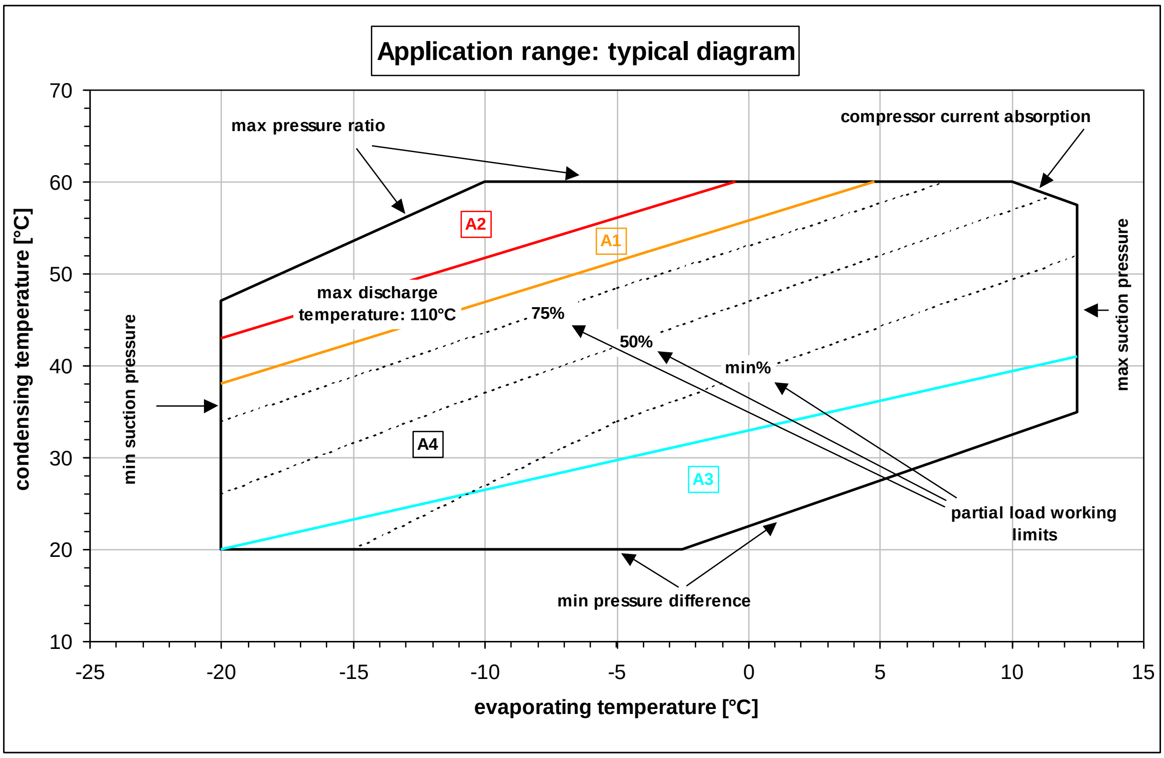


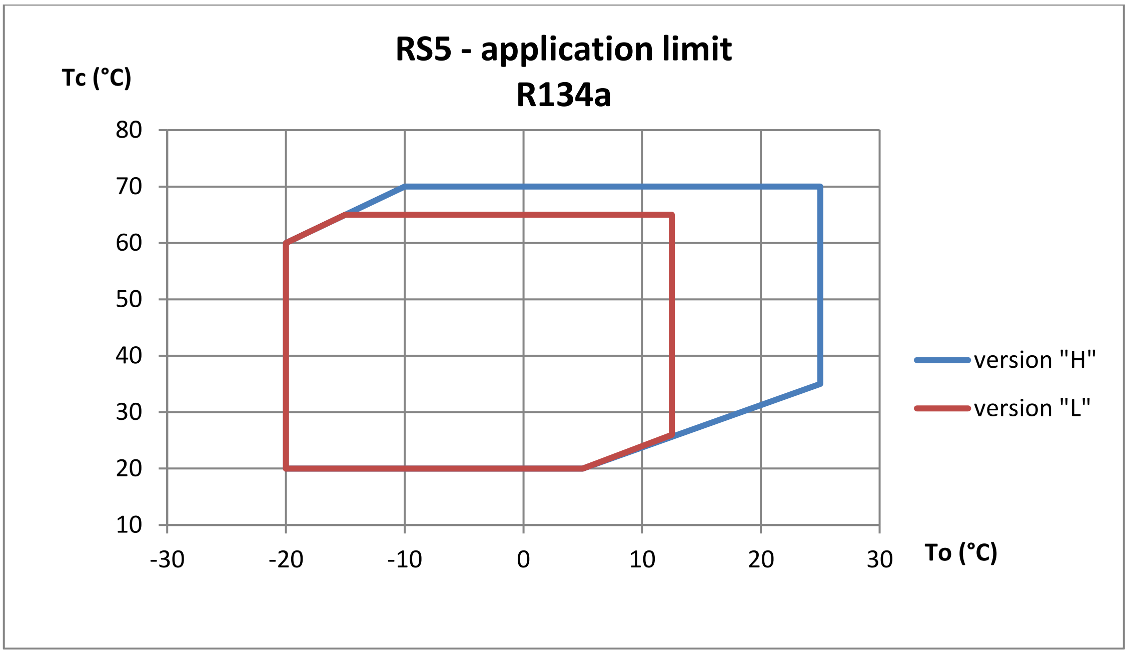
Fig. 46: typical application range;

The entire field of operation of the compressor is divided into four areas, featuring special precautions that must be adopted so as to ensure correct operation; specifically:

- Area A1: area in which the correct operation of the compressor requires additional cooling by the injection of liquid (refrigerant) or cooling of the oil in an external circuit (air-oil, water-oil and refrigerant-oil heat exchangers), see chapter: "*Additional cooling*";
- Area A2: area in which additional cooling must be provided only by cooling the oil. Use air-oil or water-oil exchangers (the injection of liquid into the compressor is not allowed), see chapter: "*Additional cooling*";
- Area A3: area in which the status of the oil filter needs to be monitored: the pressure drop allowed across the filter must be less than 1.5 bar; if the pressure drop across the filter is greater than 1.5 bar, the compressor must be stopped and the filter replaced. When the filter has been replaced, check the condition of the new filter after around 200-300 hours of operation. The pressure drop across a clean filter is less than 0.8 bar, see chapter 3: "*Lubrication*";
- Area A4: area of standard compressor operation;

In addition to the above given areas, the diagram gives also, as dotted lines, the working limits on partial load: 75%, 50% and min%. For each partial load, these lines limits the maximum possible condensation temperature in relation to the evaporation temperature.

Here below the application limit for RS5 series with R134a. In the selection software is possible to see for each refrigerant allowed the relative application limit.



12 Additional Cooling

12.1 Admissible compressor discharge temperature

The value of the discharge temperature is determined by the following factors:

- ✓ power input of the compressor and any part-load conditions, which determine a drop in the cooling capacity of the electric motor;
- ✓ actual cycle working compression ratio;
- ✓ superheating of the refrigerant fluid on the suction side;
- ✓ characteristics of the refrigerant gas, such as the thermal capacity;
- ✓ characteristics of the oil mixed with the refrigerant.

An excessive discharge temperature can cause:

- ✓ the carbonization and permanent alteration of the oil;
- ✓ a reduction in the oil cinematic viscosity, with a consequent drop in the lubrication capacity and reduction in the volumetric efficiency of the compressor;

Excessive cooling of the oil, on the other hand, may cause, as well as a high pressure drop in the oil circuit, the excessive dilution of the oil by the refrigerant, and consequently:

- ✓ an alteration in the flow of lubricant inside the compressor;
- ✓ a reduction in the lubricating properties;
- ✓ the bypass of refrigerant fluid to the suction side (through the oil circuit), which has undergone the compression process but will not produce the cooling effect.

The maximum admissible discharge temperature is 110 °C while, when the compressor is off, the minimum temperature of the oil before starting is 40°C.

Below is described how to evaluate the additional cooling capacity when the oil needs to be cooled, and the possible ways to provide it. As regards the heating of the oil, on the other hand, see paragraph 3.6: 'Oil heater ' in chapter 3: "*Lubrication*".

12.2 Evaluating the additional cooling capacity

When the discharge temperature exceeds 110°C, an additional cooling system is required. The additional cooling capacity required to perform such cooling can be calculated by multiplying the mass flow in the evaporator by the difference between the enthalpy at the discharge without additional cooling and the enthalpy at the discharge pressure when the temperature is 110°C (the enthalpy values should be read on the refrigerant chart).

When calculating the required cooling capacity, the most critical normal operating conditions should be considered (minimum evaporation temperature, maximum condensing temperature, maximum superheat).

Alternatively, the calculation can be performed automatically using the SRMTec selection program.

As a result, depending on the additional cooling capacity to be provided, there are two possible methods to limit the compressor discharge temperature:

- ✓ Cooling by injection of refrigerant (liquid) onto the rotors. It is taken from the condenser outlet and subsequently expanded;
- ✓ Cooling of the oil in a circuit external to the compressor. It can be used either an oil-air, or an oil-water, or an oil-refrigerant heat exchanger.

The following pages describe the two above-mentioned methods of cooling.

12.3 Injection of liquid by thermostatic expansion valve

A relatively simple and economical system for additional cooling consists in the injection of refrigerant (saturated liquid) at intermediate pressure onto the rotors, as seen in the diagram of Fig. 47[1]. The liquid is injected through the economizer port and allows the operating limits to be extended, see chapter 11: '*Application range*.

When the required additional cooling capacity exceeds a certain percentage of the compressor cooling capacity, the use of this method would entail an excessive quantity of refrigerant and bring about its dilution in the oil, with a consequent loss in the oil lubricating properties, as well as an excessive overloading of the motor. In this situation, the oil should be cooled in an external circuit with a heat exchanger, see the following paragraph. The operating limits shown in chapter 11 highlight the normal operating conditions in which cooling by injection is admissible, and the conditions where an external oil cooler is required.

[1] This is simply a schematic drawing; refer to the dimensional drawing for each individual compressor to identify the actual position of the liquid injection port and the high and low pressure connections.

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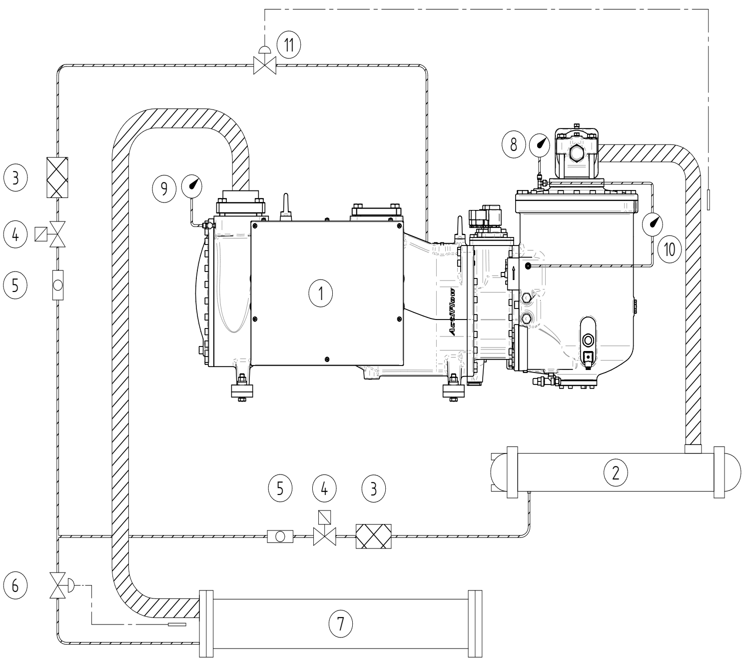

1 Compressor;
2 Condenser;
3 Filter;
4 Solenoid valve;
5 Sight glass;
6 Thermostatic expansion valve;
7 Evaporator;
8 HP pressure gauge (high pressure);
9 LP pressure gauge (Low pressure);
10 Differential pressure gauge on the oil filter;
11 Thermostatic injection valve.

Fig. 47: injection of refrigerant (saturated liquid) via thermostatic expansion valve;

To inject the refrigerant into the compressor, an expansion device must be installed; this may be:

✓ a thermostatic expansion valve;
✓ a calibrated nozzle;
✓ a capillary tube.

If a thermostatic valve is used, the expansion can be controlled accurately. In this case, the quantity of refrigerant injected varies according to the actual temperature measured at the discharge side of the compressor.
The thermostatic valve should be set to be activated at discharge temperatures of 100-110°C (manufacturers such as Danfoss, Alco and Sporlan provide such products).

Note:

✓ **for the correct sizing of the thermostatic valve according to the specific application, contact your valve supplier;**
✓ the use of liquid injection is not recommended when the required additional cooling capacity reaches values of around 10% of the cooling capacity of the compressor;
✓ the use of liquid injection together with the ECOnomizer circuit is strongly not recommended.

The thermostatic valve bulb must be positioned on the discharge line around 10-20 cm from the discharge shut-off valve; it must be thermally insulated so as to not be affected by the outside temperature, and the contact with the discharge pipe must be improved by using conductive paste. Attach the bulb securely.

Make sure only saturated liquid or sub-cooled liquid is tapped from the line. Once the injection circuit has been constructed, check that there are no dangerous vibrations in the section of pipe that runs from the valve to the point of injection.
To prevent the migration of oil and protect the components against liquid-oil slugging, the injection pipe must initially run vertically, starting from the point of injection, see the picture Fig. 48[2].

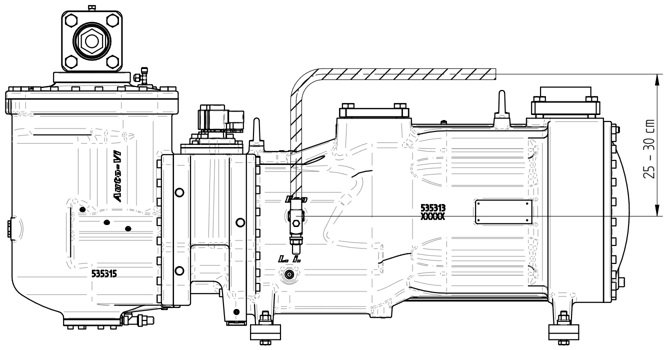

Fig. 48: layout of the liquid injection line;

The valve should not be oversized, so as to avoid the injection of an excessive quantity of liquid. When sizing, the injection pressure must be considered, intermediate between the evaporation and condensing pressure. This can be determined using the SRMTec selection program.

Together with the expansion device, the injection circuit must be fitted with a solenoid valve, a thermostat (or equivalent device) positioned on the discharge, a sight glass and a fine mesh filter (max 25 μm) to avoid the injection of metallic particles onto the rotors that may affect the correct operation and the life of the compressor.
The thermostat on the discharge line will activate the injection circuit when the discharge temperature exceeds the value of 110°C, while it will be de-activated when the discharge temperature drops below 100-105°C.

12.4 Oil cooling via external heat exchanger

In comparison with the previous cooling method this one allows a further extension of the application limits of the compressor (see chapter 11: '*Application limits*') and a more efficient operation. In fact, cooling improves the volumetric and isoentropic efficiency of the compression, thus increasing the coefficient of performance of the refrigerating cycle.
For this purpose, the compressor has special oil outlet and inlet fittings (on the internal oil circuit) for connection to the external cooling circuit, see paragraph 12.5. The diameter of the pipes in the circuit is 16 mm for all models in the RS5 series.
Using an external circuit increases the compressor oil requirement. In this case, the oil charge in the compressor must be suitably increased according to the type of cooling circuit used. Specifically, you must consider:

---

[2] This is just a schematic drawing: please refer to the specific compressor dimensional drawing in order to locate the actual position for the liquid injection port.

TOTAL OIL CHARGE = COMPRESSOR CHARGE
+ HEAT EXCHANGER CHARGE
+ VOLUME OF OIL PIPES
+1% OF REFRIGERANT CHARGE

i	**ATTENTION!** the pressure drop in the external oil cooling circuit must not exceed 0.5 bar.

- Air cooled oil cooler

  The oil cooler (finned coil) must be installed as near as possible to the compressor, so that the pressure drop in the circuit does not exceed 0.5 bar in normal conditions. The cooling system with fans must be controlled by a temperature sensor positioned on the compressor discharge line, set at 110°C; the control logic may be ON-OFF or variable speed.
  To ensure the rapid heating of the oil when starting (so as to reduce the high pressure drop with cold oil), the cooler should be heated during standstill periods, or the cooler can be bypassed using a modulating 3 way valve until the discharge temperature reaches 100°C. This is especially recommended when the temperature of the cooler, during standstill periods, may drop below 40°C, or when the volume of oil in the cooler and in the pipes exceeds 25 dm^3

- Water cooled oil cooler

  The oil-water heat exchanger can be supplied with condensed water or chilled water. The water supply can be modulated by a two-way valve with the temperature sensor on the compressor discharge pipe (set at 110°C) or alternatively, as highlighted in picture11-C3, a modulating three-way valve can be used, with the temperature sensor positioned on the oil pipe leaving the compressor.

[3] This is simply a schematic drawing; refer to the drawings of each compressor shown in the paragraph 11-5 for details on the oil fittings.

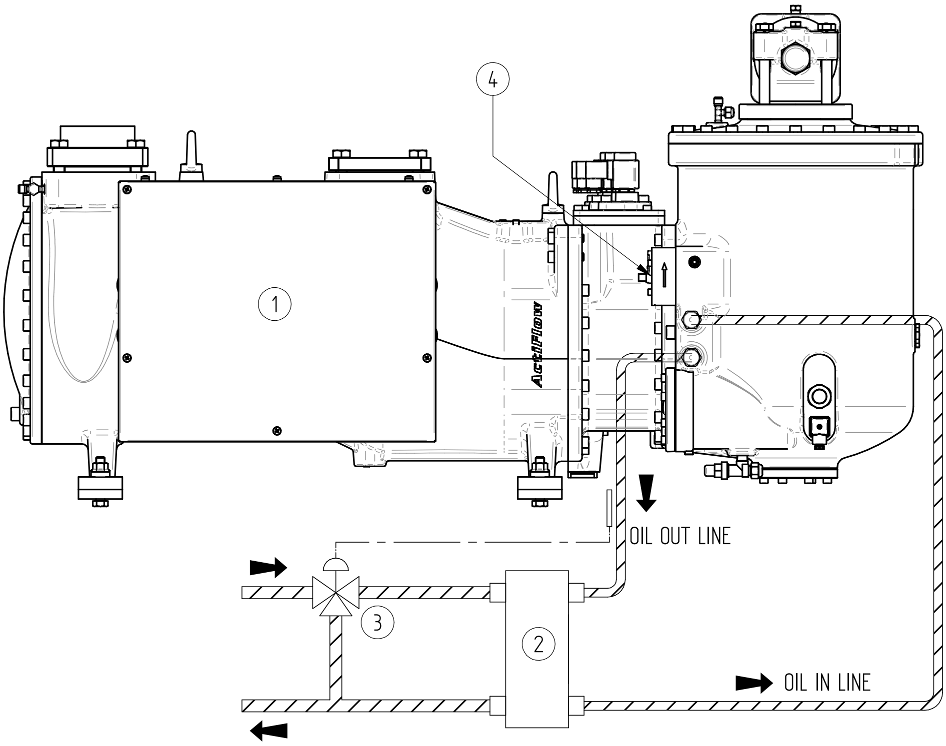

Fig. 49: oil cooling with oil/water heat exchanger

1. Compressor;
2. Oil/water heat exchanger;
3. Thermostatic valve;
4. Oil flow switch;

For any further information about this oil cooling method, please contact SRMTec.

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12.5 Position of the oil inlet-outlet connections.

To connect the oil cooler, the internal lubrication circuit needs to be modified, changing some parts of the compressor, as shown in Fig. 50 below.

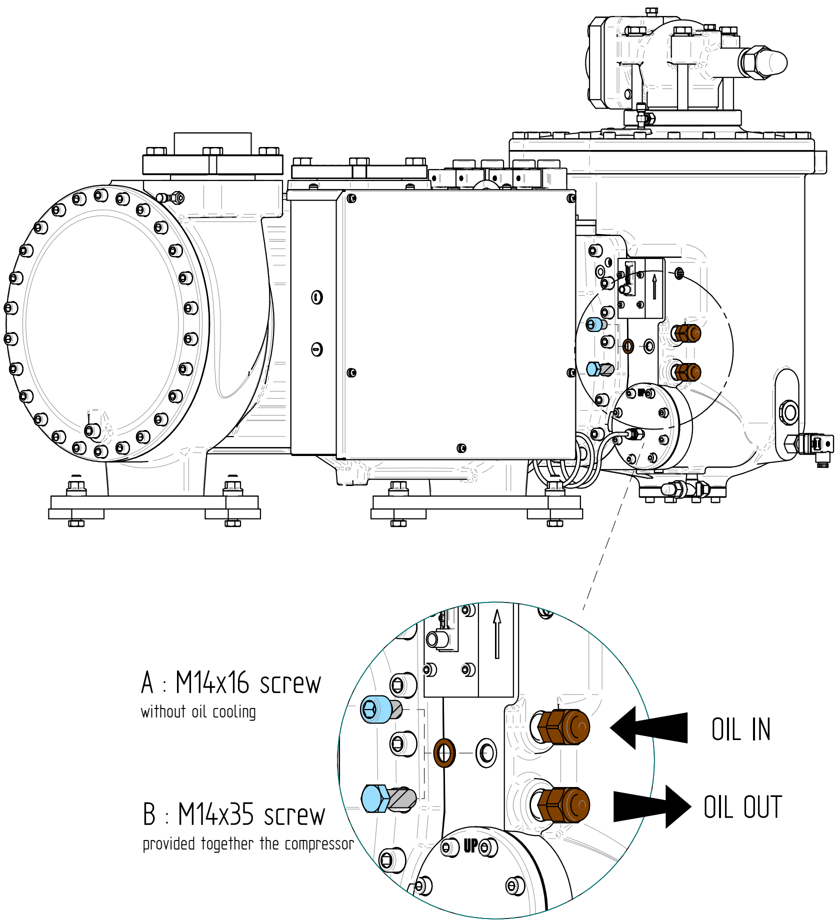

Fig. 50: oil inlet/outlet connection location for the external oil cooling circuit;

In Fig. 50the part subjected to modification is shown.
The compressor is delivered, in the standard version, with screw A: M14 x 16 fitted on the compressor; in this configuration, the compressor works without the oil cooler. Screw B: M14 x 35 is sent with the compressor, is not fitted and is placed in the electrical box.
To fit the oil cooler simply replace screw A with screw B and connect the pipes.

13 **Operative instruction**

13.1 Suction superheat

For all refrigerants allowed, suction superheat must be included between 2K (for flooded evaporator systems) and 20K. It's very important to control the superheat in order to do not exceed the max discharge temperature.
Discharge temperature must be 20K higher than condensing temperature.

Low or insufficient superheat in operation and insufficient heating or the oil sump during shut-off periods lead to a substantial reduction of the oil viscosity in the compressor.
This results in reduced performance, heavy wear on drive gear parts, increased oil carryover and foaming into the oil separator.
Secure the compressor against wet operations and guarantee a sufficiently high suction gas temperature.

13.2 Pressure specifications

The compressor has the following pressure specifications:

- ✓ Maximum operating pressure: 25 bar high pressure side;
- ✓ Maximum balanced pressure: 19 bar high and low pressure sides.

Never operate the compressor at a higher pressure than the maximum operating pressure specified by SRMTec and indicated on its plate. The user must ensure also that the balanced pressure does not exceed the maximum value specified by SRMTec.
To test the tightness of the compressor, proceed as follows:

- ✓ Test the tightness on low pressure side at 19 bar;
- ✓ Test the tightness on high pressure side at 25 bar.

13.3 Balanced pressure when starting

In order to generate a starting torque greater than the resisting one, the balanced system pressure (pressure inside the compressor during standstill periods) must not exceed 19 bar.

Attention!
The compressor has to start at minimum capacity step.

13.4 Maximum ambient temperature

During operation, the temperature of the environment where the compressor is working must be kept below the maximum value of 55°C.
If the compressor is installed in a soundproofed cabinet, suitable ventilation and temperature monitoring systems must be provided.

13.5 Number of start-ups

The compressor can be started a maximum of 6 times per hour (1 start every 10 minutes).

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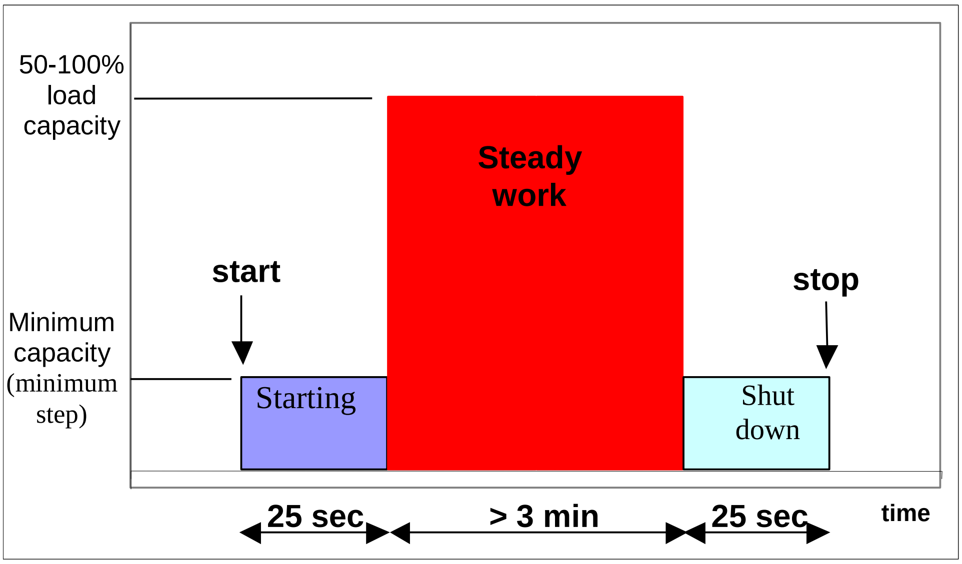
Attention!
A number of starts higher than the one suggested may damage the electrical motor and affect the theoretical compressor working life.

13.6 Starting, stopping and minimum running time

The compressor must operate for a minimum time of three minutes. In addition, it must be started and stopped at minimum capacity (minimum step). The transients at minimum load must last 25 seconds at least.



13.7 Installation

The compressor must be installed horizontally. To prevent the compressor from transmitting vibrations to the structure, the vibration damper kit should be used. It is supplied as an option. Flexible pipes are not required on the suction or discharge lines. Only minimum flexibility of the lines is required, so that these do not exert any force on the compressor.
Please use pipes and components that are extremely clean and dry inside, without slag, swarf, rust and phosphate coating.
When operating in extreme conditions, such as low ambient temperatures or aggressive atmospheres, suitable measures should be adopted. Please contact SRMTec.

13.8 Heat pumps

⚠	Warning! Reverse cycle systems or hot gas defrosts require suitable measures to protect the compressor against: ✓ Liquid slugging; ✓ Increase in oil carry over, which determines a consequent decrease in the oil level inside the compressor; ✓ Operation with a reduced Δp (HP-LP), and a consequent reduction in lubrication.

To protect the compressor against liquid slugging, a suction accumulator should be installed. To prevent excessive oil carry over (due to a rapid decrease in pressure in the oil separator), make sure that the temperature of the oil during the reverse cycle procedure is at least 30-40 K above the condensing temperature. It may be necessary to install a pressure regulating valve downstream the compressor to limit the drop in pressure during reverse cycle and defrost operation. The compressor can also be stopped just before reversing the cycle and then started again after the pressure has balanced. In any case the compressor should work within the specified range of pressures and within the operating limits, as well as with the recommended protectors, within a maximum of 20 seconds from starting (see chapter 3: "*Lubrication*").

13.9 Testing

13.9.1 Leak testing/evacuation/oil charge

⚠	**Note:** The compressors are supplied with a protective nitrogen charge (0.5-1 bar above atmospheric pressure) to prevent air from entering inside.

Perform the leak test on the refrigerant circuit with dry nitrogen; if the circuit is tested with dry air, the compressor must be bypassed. Empty the entire circuit, including the compressor and the sections isolated by the valves, both on the suction side and on the discharge side. The vacuum required is at least 1.5 mbar (with isolated vacuum pump); if necessary, repeat the operation more than once. After emptying, add the oil to the compressor, if the oil charge is supplied separately, and switch on the oil heater.
As regards the compressor, this has already been tested for leaks under pressure, and therefore this test does not need to be performed by the user. If the leak test does need to be repeated by the user, make sure the design pressures reported on the compressor rating plate are never exceeded (see paragraph 13.2: "Pressure specifications").

⚠	**Warning!** ➢ Never subject the compressor to pressure higher than the design values indicated on the rating plate; ➢ Never start the compressor under vacuum.

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13.9.2 Refrigerant charge

Charge the liquid refrigerant directly into the receiver and into the condenser, and complete the charge on the suction side during operation.
To avoid liquid backflow when the refrigerant is charged in the liquid phase (verify that the discharge temperature is around 20K above the condensing temperature.
An insufficient charge causes a low suction pressure and a high superheat (observe the chapter 11: "*Application limits*").

To identify the correct discharge temperature, use the SRMTec SRMTEC selection software.

13.10 Starting

STARTING:

- ✓ After discharging the protective nitrogen charge, connect the compressor to the plant, making sure that the shut-off valves are closed. This avoids contact between the humidity of the air and the oil. However, if the oil comes into contact with the humidity, it must be for not longer than 30 min;
- ✓ Make all the electrical connections as given in the wiring diagram on chapter 6.1
- ✓ Perform the following preliminary checks:
  - Correct setting of the start timers;
  - Oil level;
  - Correct safety and protection devices setting and functioning;
  - Correct functioning of the high and low pressure switches;
  - Look for leakage along the piping and system components;
- ✓ Turn on the oil heater at least 24 hours before each first seasonal start-up. The oil inside the separator must have a temperature at least 15K higher than the ambient temperature;
- ✓ Charge the condenser with the minimum refrigerant charge;
- ✓ Open the suction and discharge shut off valves and start the compressor while checking the correct motor rotation in the following way (even if some protection electronic device is used):
  - Connect a manometer on the suction port;
  - Start for 1 second max;
  - If the compressor screws rotate correctly, the suction pressure will drop promptly. The electronic protection intervention or a suction pressure increase

implies the wrong rotors rotation. In this case, switch two of the power supply phases in the terminal plate.

⚠	**Warning!** To prevent severe damage of the compressor, a contingent screw inverse rotation should lasts for less than 3 sec.

START:

- ✓ Fill up the plant with the necessary amount of refrigerant;
- ✓ Re-start the compressor and open slowly the suction shut-off valve;
- ✓ Make sure that the oil level is visible through the sight glass. Presence of foam is normal as long as the working conditions are not stable. The discharge temperature must be about 20K higher than the condensing temperature;
- ✓ Check the correct intervention for the pressure switches;
- ✓ Check the working parameters (data logging is recommended):
    - Evaporating pressure;
    - Condensing temperature;
    - Suction gas temperature;
    - Discharge temperature;
    - Pressure drop through the oil filter;
    - Contingent unbalanced electrical absorbed currents on all the 6 wires connected to the electricity grid.
- ✓ Change the oil filter if dirty (see chapter 3: "*Lubrication*").

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13.11 Protection devices intervention and trouble shooting

Failure	Protection devices	Why it is necessary	Delivery
Incorrect phase sequence	Phase monitor	The compressor should not work with inverse rotation	INT 69 SNY (optional)
High discharge pressure	Manual pressure switch	To avoid an excessive pressure increase in the compressor	necessary, not included
high temperature of motor windings	thermistors embedded in the motor windings (cut out 100/130° C)	To protect the motor from high temperatures	standard
too high motor current	Thermal Relay	To protect motor from electrical overload	necessary, not included
low suction pressure	pressure switch	insufficient refrigerant charge (high pressure ratio, high disch.temp.)	necessary, not included
low differential pressure HP/LP	HP/LP differential pressure switch (cut out 4 bar min)	To grant a sufficient oil flow	necessary, not included
high oil discharge temperature	Additional cooling (liquid injection / oil cooling)	To ensure a long bearing life	mandatory if required by the working conditions
lack of lubrication	discharge gas temperature sensor (cut out 120° C)	To protect the compressor from lack of lubrication	temperature sensor: optional with INT 69 VS and standard with INT 69 SNY
too high pressure drop in the oil filter	differential pressure switch (cut out 1.5 or 3.5 bar, see chapter 3 and 11)	To ensure cleanness of oil filter	necessary, not included
too frequent compressor starts	limit of starts (max 6 per hour)	To protect the electrical motor	necessary, not included

14 Maintenance

14.1 LUBRICANTS.

The lubricants have high thermal and chemical stability: if installation is performed correctly, the oil normally does not need to be changed. Periodically test the acidity of the oil to prevent damage to the motor or the compressor and, if necessary, perform the following operations:

- ✓ clean the circuit placing an acid filter in the suction line;
- ✓ change the oil and the oil filter;
- ✓ purge the system from the highest point on the discharge side.

The oil can be drained through the service valve and the plug on the bottom of the suction cover (see chapter 3: "*Lubrication*"). The oil can be recharged through the service valve, creating a vacuum inside the compressor.

14.2 BEARINGS.

The bearings in the compressor are designed to ensure 40,000 hours of operation with correct lubrication (oil filter clean and oil pressure within the limits, see paragraph 3: '*Lubrication*') and continuous load within23 the limits specified in chapter 11: "*Application range*". Any alteration of the above-mentioned conditions and excessive changeability of the load may bring a drastic reduction in the effective working life. The bearings must be replaced by qualified personnel in a specially equipped workshop.

14.3 ROTORS ROTATION DIRECTION.

If the reverse rotation, which occurs when the compressor stops to balance the pressure, lasts more than 3 seconds, the check valve located underneath the discharge shut-off valve may be damaged, and consequently must be replaced. In any case, the reverse rotation must not last more than 5 seconds to avoid damage to the compressor and the unwanted activation of the INT 69 SNY protection module.
On the table below, necessary check outs and maintenance operations are listed:

Time (h)	50-100	1000	10000	20000	30000	40000
Oil filter	I/R		I/R	I/R	I/R	R
Oil	I	I	I	I	I	R
Suction filter		I	I/R	I/R	I/R	I/R
Solenoid valves		I	I	I	I	I
Bearings						R
Check valve		I	I	I	I	I
INT module		I	I	I	I	I
Feeding voltage	I	I	I	I	I	I
Motor contactors		I	I	I	I	I

Table 12: maintenance plan: R = replace I = Inspect

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