

pompetravaini



OPERATING MANUAL LIQUID RING VACUUM PUMPS AND COMPRESSORS

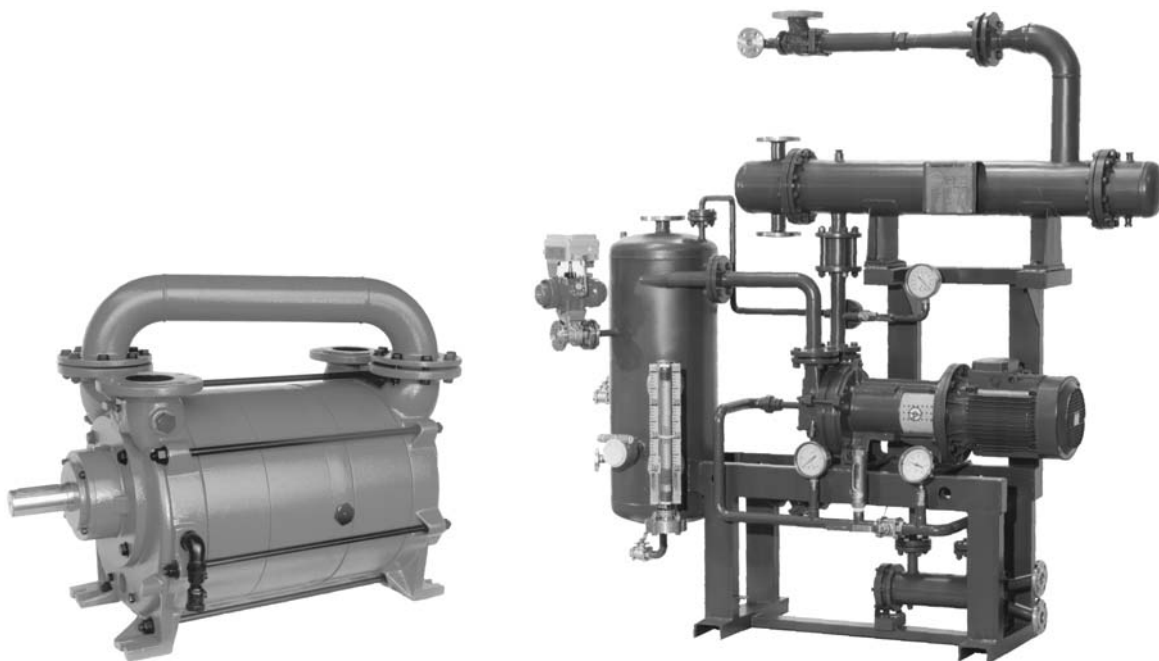
Series

TRH - TRS - TRM - TRV - SA

&

Systems type

HYDROSYS - OILSYS



OPERATING MANUAL FOR INSTALLATION, START-UP AND MAINTENANCE FOR LIQUID RING VACUUM PUMPS AND COMPRESSORS

This manual applies to TRAVAINI liquid ring pumps single stage series **TRM**, **TRS**, **TRV**, double stage series **TRH**, compressors series **SA** and systems series **HYDROSYS** and **OILSYS**, which utilise above pump series. (Please see chapters 18 or 19 for details pertaining to systems).

NOTE: Unless otherwise specified, the term **pump** used throughout this manual means also pump/motor **assembly** or **system** type HYDROSYS and/or OILSYS.

Manufacturer:

POMPETRAVAINI s.p.A.

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WARRANTY: All products manufactured by POMPETRAVAINI are guaranteed to meet the conditions listed on the general terms & conditions of sales and/or conditions listed on the order confirmations.
Failure to strictly adhere to the instructions and recommendations listed in this manual, will void the manufacturer's warranty.

In preparing this manual, every possible effort has been made to help the customer and operator with the proper installation and operation of the pump and/or system. Should you find errors, misunderstandings or discrepancies please do not hesitate to bring them to our attention.

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1 - GENERAL INSTRUCTIONS

This manual is intended to provide reference to:

- application and operating safety
- installation and maintenance for pump or system
- starting, operating and stopping procedures for pump or system

NOTE: All references made to pumps are also applicable to systems that employ these pumps, unless otherwise specified.

Upon receipt of this manual, the operator should complete page 35 with the requested data. The manual should then be read **CAREFULLY** and kept in a safe file for future reference. It should always be available to the qualified operating and maintenance personnel responsible for the safe operation of the pump or system.

(Qualified personnel should be experienced and knowledgeable of Safety Standards, should be recognised by the safety department manager as being capable to effectively act on safety issues, should the need arise.

A knowledge of first aid should also be required).



The pump is to be used only for the applications specified on the confirming order for which POMPETRAVAINI has selected the design, materials of construction and tested the pump to meet the order specifications. Therefore, the pump or system **CANNOT** be used for applications other than those specified on the order confirmation.

In the event the pump is to be used for different applications, please consult POMPETRAVAINI or representative of the manufacturer. POMPETRAVAINI declines to assume any responsibility if the pump is used for different applications without prior written consent.

The user is responsible for the verification of the ambient conditions where the pump will be stored or installed. Extreme low or high temperatures may severely damage the pump or system unless proper precautions are taken.

POMPETRAVAINI does not guarantee repairs or alterations done by user or other unauthorised personnel.

Special designs and constructions may vary from the information given in this manual. Please contact POMPETRAVAINI should you have any difficulty or doubt.

NOTE: Drawings appearing in this manual are only schematics. These drawings are not for construction. For construction drawings contact POMPETRAVAINI or the authorised local representative.

2 - SAFETY INSTRUCTIONS



**CAUTION: CAREFULLY READ FOLLOWING INSTRUCTIONS.
STRICTLY ADHERE TO THE INSTRUCTIONS LISTED BELOW TO PREVENT
PERSONAL INJURIES AND/OR EQUIPMENT DAMAGE.**

- **ALWAYS** apply the pump for the conditions outlined on the confirming order.
- Electrical connections on the motor or accessories must **ALWAYS** be carried out by authorised personnel and in accordance to the local codes.
- Any work on the pump should be carried out by at least 2 people.
- When approaching the pump **ALWAYS** be properly dressed (avoid use of clothes with wide sleeves, neckties, necklaces, etc.) and/or wear safety equipment (hard hat, safety glasses, safety shoes, etc.) adequate for the work to be done.
- **ALWAYS** stop the pump prior to touching it, for whatever the reason.
- **ALWAYS** disconnect the power to the motor prior to working or removing the pump from the installation.
- **NEVER** work on the pump when it is hot.
- After completion of the work **ALWAYS** re-install the safety guards previously removed.
- **ALWAYS** be careful when handling pumps that convey acids or hazardous fluids.
- **ALWAYS** have a fire extinguisher in the vicinity of the pump installation.
- **DO NOT** operate the pump in the wrong direction of rotation.
- **NEVER** put hands or fingers in the pump or system openings or cavities.
- **NEVER** step on pump and/or piping connected to the pump.
- Pump or piping (connected to the pump) must **NEVER** be under pressure or vacuum when maintenance or repair is carried out.

NOTE: There are materials in the pump that may be hazardous to people suffering from allergies. Maintenance and operating personnel should consult the tab. 1 for such materials.

Tab. 1

MATERIAL	USE	POSSIBLE DANGER
Oil and Grease	General lubrication, ball or roller bearings	Skin and eye irritation
Plastic and elastomer components	O-Ring, V-Ring, Splash ring, Oil seals	Release of fumes and vapours when overheated
Teflon & Kevlar fibres	Packing rings	Release of dangerous powders, release of fumes when overheated
Varnishes	Exterior pump surface	Release of powder and fumes in case of rework, flammable
Liquid compound	Gasket between flat surfaces	Skin, eye and breathing organs irritation
Protective liquid	Pump inside surface	Skin and eye rash

3 - IN CASE OF EMERGENCY

Should the pump break down leak gas and/or service liquid, immediately disconnect the electrical power following the instructions given in chapter 11. Alert the maintenance personnel, at least two people should intervene using precautions as it is required for the specific installation: pump may be handling dangerous and/or hazardous fluids. After correction of all the problems that created the emergency situation, it is necessary to carry out all the recommended starting procedures (see chapter 10).

3.1 - BASIC FIRST AID

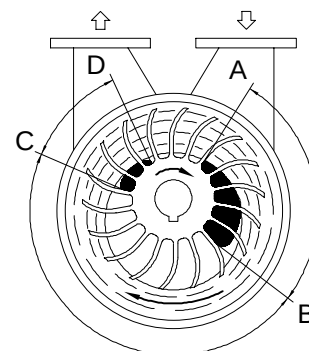
In the event dangerous substances have been inhaled and/or have come in contact with the human body, immediately contact the medical staff and follow the instructions given by the company's internal medical safety procedures.

4 - PUMP OUTLINES

The instructions given in this manual are for liquid ring vacuum pumps and compressors and for systems type HYDROSYS or OILSYS which utilise said pumps.

NOTE: Capacities, vacuum and pressures are nominal and are the maximum attainable values under standard operating conditions. Please contact POMPETRAVINI for data on liquid ring compressors series TR...

TRM	Single stage liquid ring vacuum pumps Capacity to 350 m ³ /h, max vacuum 33 mbar
TRS	Single stage liquid ring vacuum pumps Capacity to 3500 m ³ /h, max vacuum 150 mbar
TRV	Single stage vacuum pumps Capacity to 500 m ³ /h, max vacuum 33 mbar
TRH	Two stage liquid ring vacuum pumps Capacity to 3500 m ³ /h, max vacuum 33 mbar
SA	Double acting liquid ring compressors Capacity to 180 m ³ /h, pressures to 10 bar



4.1 - PRINCIPLE OF OPERATION (See figure at side)

The aspirated gas enters the pump chamber A-B via the pump suction flange. The gas is trapped between 2 impeller vanes. The impeller rotates eccentrically in relation to the centreline of the liquid ring that, by centrifugal force, assumes the shape of the impeller casing. The progressive change of volume between the 2 vanes, the impeller hub and the liquid ring first creates a vacuum and then a compression of the gas in the B-C area till the gas is discharged, together with a portion of the liquid, through the discharge port C-D. The lost liquid must then be replenished.

4.2 - SERVICE LIQUID PROPERTIES

For a good operation the liquid ring pumps must be supplied with a service liquid which is clean, non abrasive and free of any solids.

The service liquid temperature should not exceed 80 °C and the gas handled should be maximum 100 °C; the liquid density should be between 800 and 1200 g/dm³ and the viscosity should be less than 40 cSt (the pump performance will change if the service liquid has properties different than those of water at 15 °C). All engineering data is based on the use of 15 °C as service liquid, see chapter 17 for additional information.

Contact POMPETRAVINI before using liquids with properties outside the ranges listed above.

4.3 - PUMP MODELS AND TABLES FOR MATERIAL OF CONSTRUCTION

On the pump nameplate are printed the pump serial number, the year of manufacture and the pump model. Refer to the following example for understanding the coding of the pump model.

Every letter or number in the pump model designation has a specific meaning relating to the pump design.

Example of pump model number:

T R H C 80 - 750 / C - M / GH			
T	⇒ Manufacturer POMPETRAVAINI	750	⇒ Nominal capacity in m ³ /h
R	⇒ Liquid ring pump	C	⇒ C = Shaft sealing by mechanical seal B = Shaft sealing by stuffing box
M and V	= Single stage pump with high vacuum	M	⇒ Monoblock design with motor flange (upon request)
H	⇒ S = Single stage pump with medium vacuum H = Two stage pump with high vacuum	GH	⇒ Material of construction
C	⇒ Revision of hydraulic design	GH - F - RA - A3 (see following table)	
80	⇒ Ø Flange size (mm)		

STANDARD materials of construction

VDMA	Description	GH	F	RA	A3
106	Suction casing	Cast iron			Stainless steel AISI 316
107	Discharge casing				
137	Intermediate plate				
110	Centre body				
210	Shaft	Stainless steel AISI 420			
147	Manifold	Carbon steel			
357	Bearings & M. S. housing	Cast iron			
230	Impeller	Bronze	Ductile iron	Stainless steel AISI 316	

For additional details regarding standard or special materials contact POMPETRAVAINI.

Models for systems HYDROSYS and OILSYS are made out of a number which indicates the system size, followed by the pump model number which is fitted in the system.

(ex.: HYDROSYS 5 – TRHB 50-420/C – M / GH).

5 - UNCRATING, LIFTING AND MOVING INSTRUCTIONS

Upon receipt verify that the material received is in exact compliance with that listed on the packing slip.

When uncrating follow the instructions listed below:

- check for visible damages on the crate that could have occurred during transport
- carefully remove the packaging material
- check that pump/or accessories such as tanks, piping, valves, etc. are free from visible markings such as dents and damage which may have occurred during transportation
- in the event of damage, report this immediately to the transport company and to POMPETRAVAINI's customer service department.

Discard through controlled disposals all packaging materials that may constitute personal injury (sharp objects, nails).

The pump or assembly must **ALWAYS** be moved and transported in the horizontal position.

Prior to moving the unit find the following:

- total weight
- centre of gravity
- maximum outside dimensions
- lifting points location.



For safe lifting to prevent material damages and/or personal injuries, it is recommended to use ropes, or belts properly positioned on the pump and/or lifting eyebolts and make correct movements.

Lifting eyebolts fitted on single components of the assembly (pump or motor) should not be used to lift the total assembly.

Avoid lifts whereby the ropes or straps, form a triangle with the top angle over 90°(see fig. 3).

The fig. 4 shows several additional examples of lifting to be avoided.

Prior to moving the unit from an installation, always drain any pumped fluid from the pump, piping and accessories, rinse and plug all openings to prevent spillage. For instructions to remove the unit from installation see chapter 15.

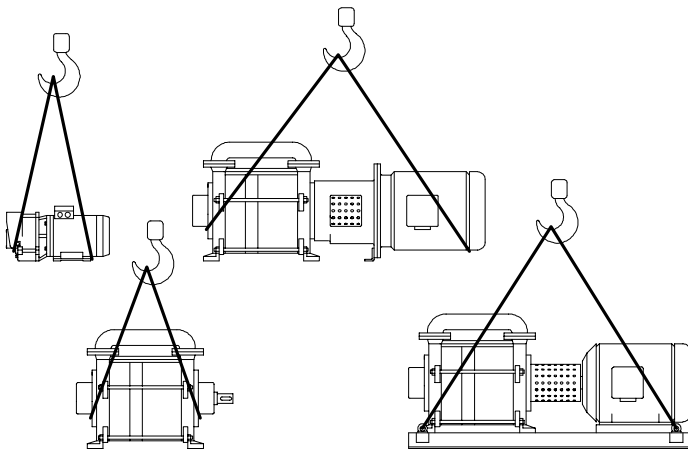


Fig. 1

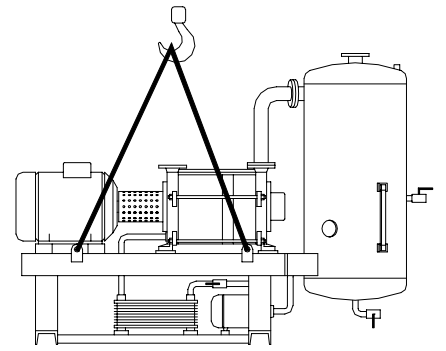
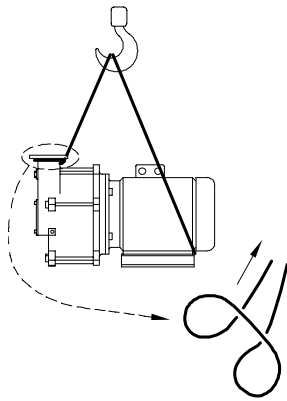


Fig. 2



OK

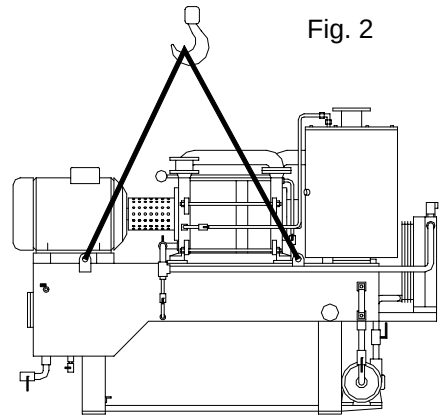
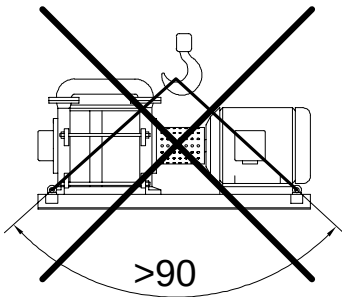


Fig. 3



NO

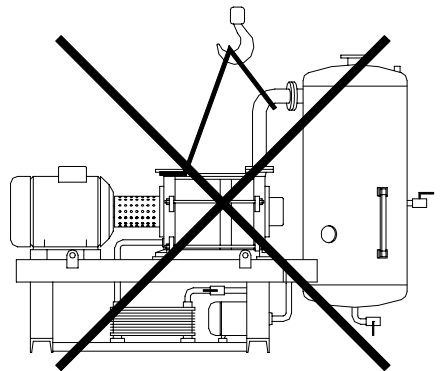
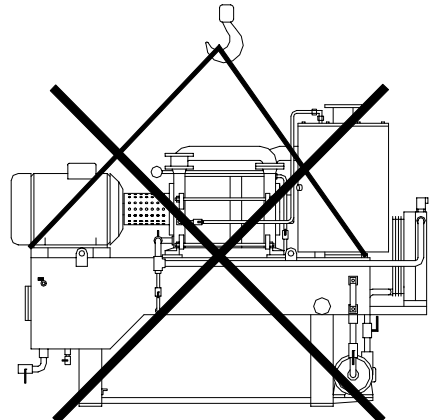
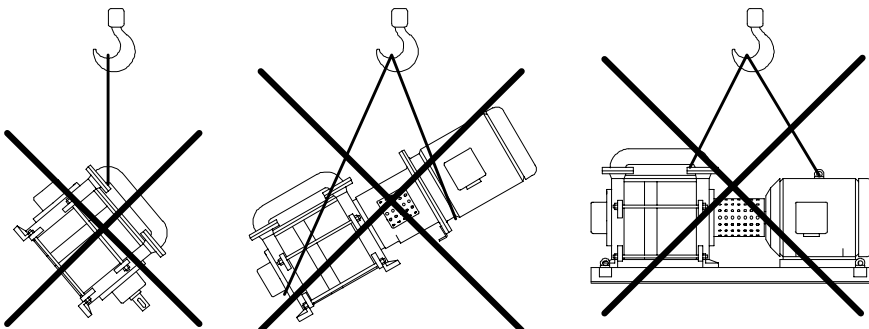


Fig. 4



6 - STORAGE INSTRUCTIONS

After receipt and inspection, if not immediately installed, the unit must be repackaged and stored.

For a proper storage proceed as follows:

- store the pump in a location that is closed, clean, dry and free of vibrations
- do not store in areas with less than 5°C temperature (for lower temperature it is necessary to completely drain the pump of any liquids that are subject to freezing)



FREEZING DANGER!

Where the ambient temperature is less than 5 °C it is recommended to drain the pump, piping, separator, heat exchanger, etc. or add an anti-freeze solution to prevent damage to the equipment.

- fill the pump with a rust-preventative liquid that is compatible with the pump gaskets and elastomers. Rotate the shaft by hand to impregnate all internal surfaces. Drain the excessive liquid from the pump and associated piping (see chapter 11).
Please note that the pumps with cast iron internal parts have been treated at the factory, prior to shipment, with a rust-preventative liquid: this liquid is capable of protecting the pump against rust for a period of 3 to 6 months.
A further solution, for long term storage, is to fill the pump with the rust inhibitor, rotate the pump shaft by hand to eliminate any air pockets (the liquid must be suitable with gasket, elastomers and pump materials).
- plug all openings that connect the pump internals to the atmosphere
- protect all machined surfaces with an anti-rust material (grease, oils, etc.)
- cover the unit with plastic sheet or similar protective material
- rotate pump shaft at least every three months to avoid possible rust build-up or seizing
- pump accessories should be subjected to similar procedure.

7 - MOUNTING AND ALIGNMENT INSTRUCTIONS

7.1 - ASSEMBLY OF BASE MOUNTED PUMP UNIT

If the pump has been purchased with free shaft end, a proper baseplate is required to mount the pump/motor assembly. The baseplate must be properly designed for maximum rigidity to prevent vibrations and distortions. It is recommended the use of a fabricated baseplate manufactured with rigid "U" shaped channel (fig. 16 illustrates an example).

When the pump has been purchased without the electric motor, it is then required to select the proper motor before proceeding to the installation of the unit. Selection of motor must consider the following:

- maximum power absorbed by the pump over the total operating range
- pump operating speed (RPM)
- available power (Hertz, voltage, etc.)
- motor enclosure type (CVE, AD-PE, ODP, TEFC, EX.PR., etc.)
- motor mount (B3, B5, horizontal, vertical, C-flange, D-flange, etc.).

Flexible couplings are selected considering:

- nominal motor horsepower
- motor operating speed
- coupling guard must meet safety standards as dictated by EN 294, OSHA, etc.

Flexible couplings must be properly aligned. Bad alignments will result in coupling failures and damage to pump and motor bearings.

Assembly instructions for MONOBLOCK design are listed on paragraph 7.3 steps 1, 2, 4, 5, 6.

Assembly instructions for PUMP-MOTOR ON BASEPLATE are listed on paragraph 7.3 steps 7, 1, 8, 5, 9, 10, 11.

For pump driven with V-Belt, please consult POMPETRAVAINI for eventual information.

7.2 - ALIGNMENT PROCEDURES FOR MONOBLOCK AND FOR PUMP/MOTOR ASSEMBLY ON BASEPLATE.

The pump/motor assembly is properly aligned by POMPETRAVAINI prior to shipment.

It is however required to verify the alignment prior to the start-up. Misalignment can occur during handling, transportation, grouting of assembly, etc.

For alignment procedures of MONOBLOCK design see paragraph 7.3 steps 3, 4, 5, 6.

For alignment procedure of BASEPLATE design see paragraph 7.3 steps 7, 5, 9, 10, 11.

PLEASE NOTE: Coupling sizes and permissible coupling tolerances listed in this manual are applicable to the particular coupling brand installed by POMPETRAVAINI as a standard. For sizes and tolerances of other type of couplings, follow the instructions given by their respective manufacturer.

7.3 - ALIGNMENT INSTRUCTIONS

NOTICE: Alignment should be done at ambient temperature, obviously with power to the motor disconnected and following the safety procedures to avoid accidental starting (see chapter 2).

Should the pump operate at high temperatures that could upset the coupling alignment, it is necessary to check the alignment to secure proper working operation at such operating temperatures.

It is recommended the use of proper hand protections such as gloves, when carrying out the operations listed below (schematics for various assemblies are shown).

NOTE: The following points must be followed with the sequence stated above and depending upon the type of operation: alignment **assembly** or alignment **verification**.

- 1 - Thoroughly clean motor/pump shaft ends and shaft keys, place the shaft keys in the proper key way slots and fit the coupling halves in line with the shaft ends. The use of rubber hammers and even pre-heating of the metal half couplings may be required (see fig. 5). Lightly tighten the set screws. Verify that both pump and motor shafts rotate freely.

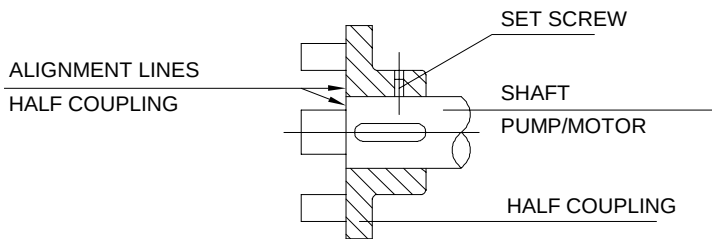


Fig. 5

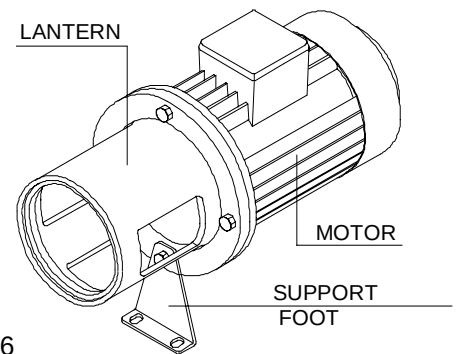


Fig. 6

- 2 - Insert the perforated metal sheet coupling guard inside the lantern so that the coupling is accessible from one of the lateral openings. Couple the electric motor to the pump lantern engaging the two coupling halves, hands may reach the coupling halves through the lateral opening (see fig. 7) tighten the assembly with bolts supplied with the unit and install the supporting foot, when applicable (see fig. 6).

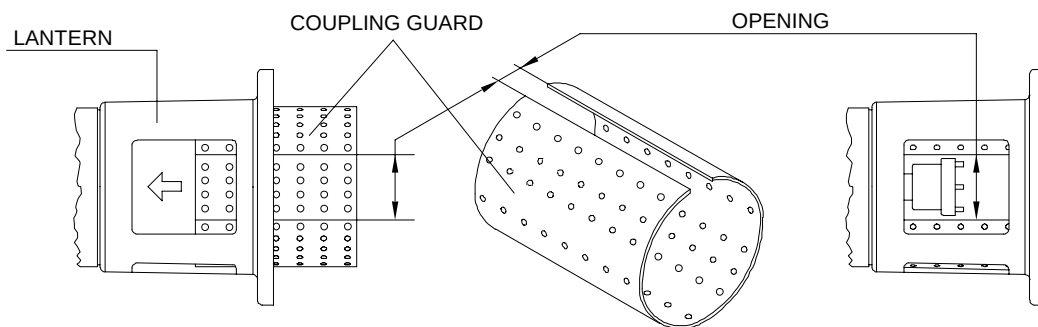


Fig. 7 - PREPARING TO ASSEMBLE THE MONOBLOCK DESIGN

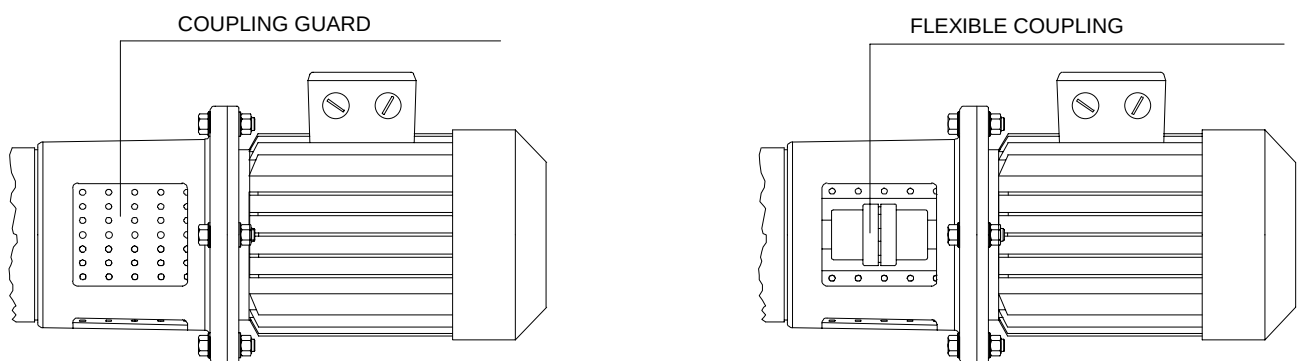


Fig. 8 - CHECKING THE ALIGNMENT ON MONOBLOCK DESIGN

- 3 - Applying slight hand pressure to the coupling guard, rotate it so that one opening of the lantern is accessible (see fig. 8).
- 4 - Rotate by hand the coupling through the lateral opening of the lantern to make sure the pump is free.
- 5 - With a feeler gauge, check the distance between the two coupling halves. The gap value "S" should be as listed on table 2 or as given by the coupling manufacturer.
In the event an adjustment is necessary, loosen the set screws on the coupling half and with a screw driver move the coupling half to attain the gap "S" (see fig. 12). Then tighten the set screw and rotate the rotor by hand to make sure, once more, that there is no obstruction.
- 6 - Rotate back the coupling guard by hand through the two openings of the lantern so that both openings are completely covered. This will complete the alignment verification of the MONOBLOCK design.
- 7 - Remove the coupling guard and its extension (if there is one) attached to the pump, by removing the two locking screws (see fig. 9 and 10).

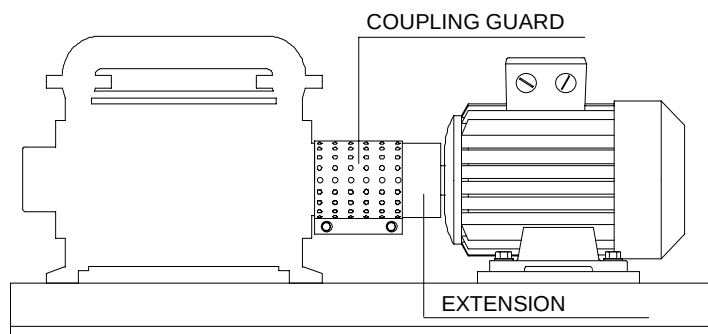


Fig 9 - CHECKING ALIGNMENT ON BASE MOUNTED PUMP DESIGN

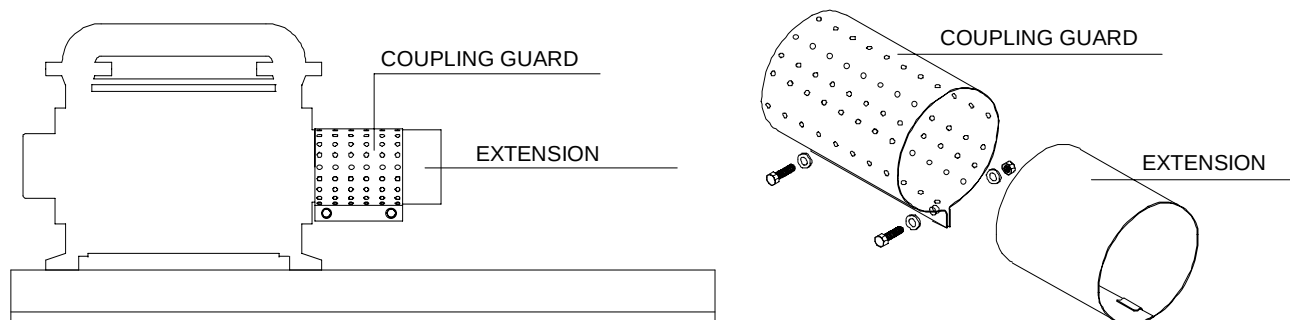


Fig. 10 - ASSEMBLING THE UNIT ON THE BASEPLATE

8 - Place the electric motor on the baseplate and bring the two coupling halves together with approx. 2 mm gap between them keeping the motor axially aligned with the pump shaft. In the event the two shaft heights do not align, proper shimming under the pump or motor feet will be required. Mark the motor and/or pump anchoring bolt holes. Remove motor and/or pump, drill and tap the holes, clean and mount pump and/or motor in place and lightly tighten the bolts (see fig. 11).

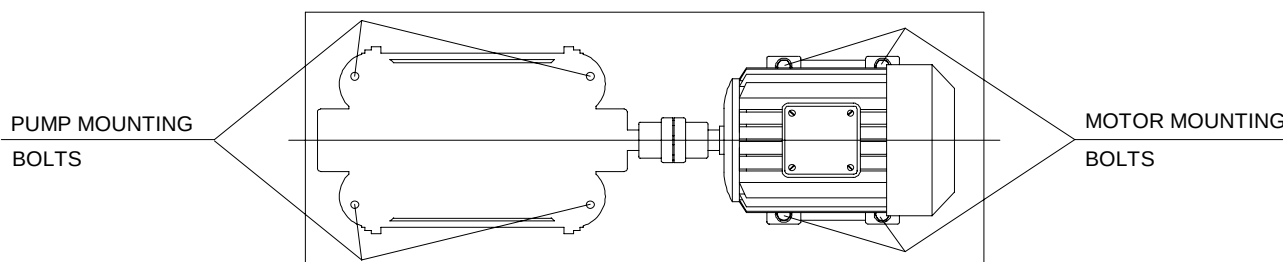


Fig. 11

9 - With a straight edge ruler check the parallelism of the two coupling halves at several points ,90° from each other (see fig. 13).

NOTE: Easier and more accurate readings can be attained with instruments such as Dial Indicators (if readily available).

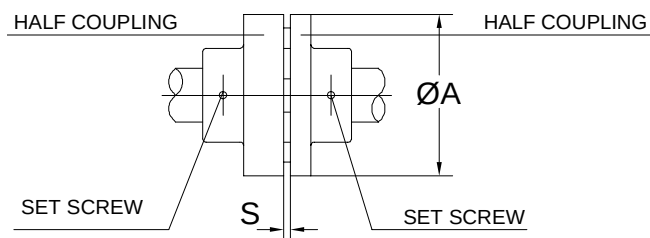


Fig. 12

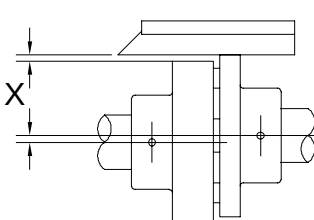


Fig. 13

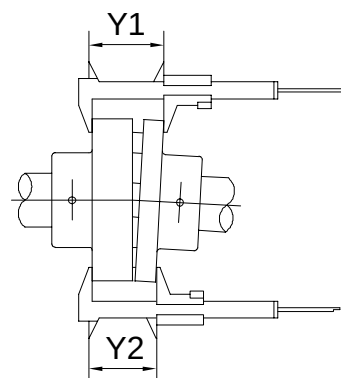


Fig. 14

If the maximum value of "X" is higher than that listed in the tab. 2 (for the given coupling size) it will be required to correct the alignment by using shims under the pump or motor feet.

When the measured values fall within the tolerances, the pump and motor mounting bolts can be tightened.

- 10 - Angular misalignment can be measured with a Calliper. Measure the outside coupling dimension at several points (see fig. 14). Find the minimum and maximum width of the coupling, the difference between these two readings "Y" (Y1-Y2) should no exceed the value listed in tab. 2 for the given coupling size. Should this value be greater it will be necessary to correct the alignment by shimming the pump and/or motor. Following this operation it is recommended to check once more the value "X" to make sure that both values are within the allowed tolerance (see point 9). Make sure that both set screws on the coupling halves are properly secured.

Tab. 2

COUPLING "Ø A" mm	GAP "S" mm	PARALLEL "X" mm	ANGULAR "Y" mm
60	2 to 2,50	0,10	0,20
80	2 to 2,50	0,10	0,20
100	2 to 2,50	0,15	0,25
130	2 to 2,50	0,15	0,25
150	3 to 3,75	0,15	0,30
180	3 to 3,75	0,15	0,30
200	3 to 3,75	0,15	0,30

- 11 - Install the coupling guard and its extension (if applicable) on the pump, secure the two locking bolts. The gap between motor frame and the guard should not be greater than 2 to 3 mm (see fig. 15).

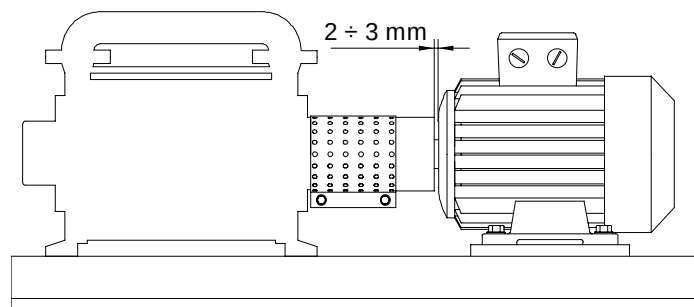


Fig. 15

8 - ELECTRICAL CONNECTIONS



Electrical connections must be made exclusively by qualified personnel in accordance with the instructions from the manufacturer of the motor or other electrical components and must adhere to the local National Electrical Code.



**FOLLOW ALL SAFETY PRECAUTIONS AS LISTED IN CHAPTER 2.
BEFORE DOING ANY WORK TO THE INSTALLATION DISCONNECT ALL POWER SUPPLIES.**

It is recommended that electric motors be protected against overloading by means of circuit breakers and/or fuses. Circuit breakers and fuses must be sized in accordance with the full load amperage appearing on the motor nameplate. It is advisable to have an electrical switch near the pump for emergency situations. Prior to connecting the electrical wiring, turn the pump shaft by hand to make sure that it rotates freely. Connect the electrical wiring in accordance with local electrical codes and be sure to ground the motor.

Motor connection should be as indicated on the motor tag (frequency and voltage) and as discussed in the motor instruction manual. It is recommended that motors over 5,5 kW be wired for Star-Delta start-up, to avoid electrical overloads to the motor and mechanical overloads to the pump.

Be sure to replace all safety guards before switching on the electrical power.

If possible check the direction of rotation before the motor is coupled to the pump but protect the motor shaft to prevent any accidents. When this is not possible briefly jog the pump to check its direction of rotation(see arrow on pump for correct rotation). If the direction must be changed two of the three electrical wire leads must be alternated with each other (at the terminal box or at the motor starter).

Please be aware that rotation in the wrong direction and/or pump running dry may cause severe pump damage.

Electrical instrumentation such as solenoid valves, level switches, temperature switches, etc. which are supplied with the pump or systems must be connected and handled in accordance with the instructions supplied by their respective manufacturers.

9 - INSTALLATION INSTRUCTIONS

Information to determine the piping sizes and floor space requirements can be obtained from dimension drawings and other engineering data. The information required is:

- size and location of suction and discharge flanges
- size and location of service liquid connection and connections for cooling, heating, flushing, draining, etc.
- location and size for mounting bolts for monoblock pump and/or baseplate and/or frame.

In the event additional accessories are required to complete the installation such as separators, piping, valves, etc. refer to chapters 9.2 to 9.8.

Proper lifting devices should be available for installation and repair operations.

Pump assembly should be installed in an accessible location with adequate clear and clean space all around for maintenance, so that an efficient and proper installation can be made.

It is important to have proper room around the unit for ventilation of motor and air cooled radiator, if applicable. Avoid installing the unit in hidden locations, dusty and lacking of ventilation.

Select a mounting pad that will minimise vibrations or torsion of the pump baseplate or frame. It is generally preferred to have a concrete base or sturdy steel beams.

It is important to provide adequate anchor bolting for the pump frame or baseplate to be firmly attached to the foundations (see fig. 16).

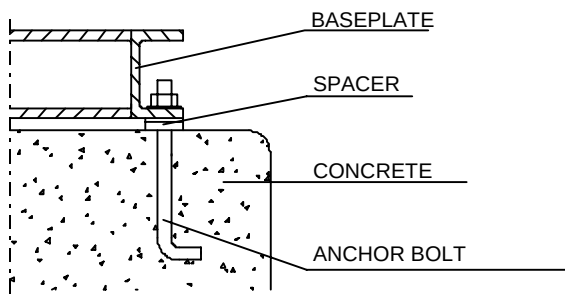
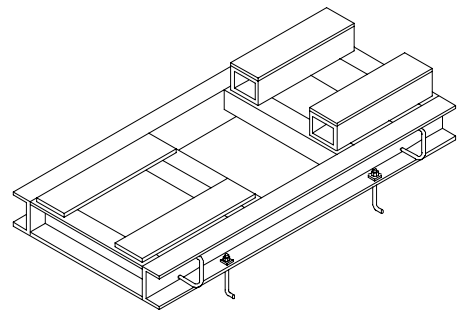


Fig. 16



Concrete pads and other concrete works must be aged, dry and clean before the pump assembly can be positioned in place. Complete all the work relating to the foundations and grouting of the pump assembly, before proceeding with the mechanical and electrical portion of the installation.

9.1 - PIPING CONNECTIONS

Identify first locations and dimensions of all connections required to interconnect the pump with the installation, then proceed with the actual piping: connect the pump suction and discharge flanges, the service liquid line and all other service connections (see fig. 17 to 26).



BE SURE TO PIPE THE CORRECT CONNECTION FROM THE INSTALLATION TO THE RESPECTIVE PUMP CONNECTION !

To prevent foreign matters from entering the pump during installation, do not remove protection cap from flanges or cover from openings until the piping is ready for hook-up.

Verify that all foreign objects such as welding bits, bolts, nuts, rags and dirt are removed from piping, separators, etc. before these are connected to the pump.

Flanges should be connected parallel with each other, without stress and with bolt holes lined up.

The flange gaskets should not interfere with the inside diameter of piping and/or flange.

All piping must be independently supported, easily located and must not transmit forces or torque to the pump due to the weight or to thermal expansions.

Piping size must never be less than the respective connection on the pump.

Suction and discharge flanges are vertical and identified with arrows.

To minimise friction losses and back-pressures, the discharge piping should be one size larger than the pump connection size. To avoid back-pressure and possibility of flooding the pump when it stops, it is recommended to limit the rise of the discharge piping to approximately 50 cm above the pump discharge flange.

Upon completion piping and connections should be tested for leakage under vacuum.

9.2 - ACCESSORIES

Listed below are common accessories that may be supplied with the pump or added at a later date. See fig. 17 to 26 for locations and connection sizes on the pumps.

Non return valve, (check valve)

Prevent back-flow of gas and liquid in the suction piping and/or discharge piping when the pump stops.

Is installed on the pump suction flange in the case of vacuum service or on the pump discharge flange in the case of compressor service.

Vacuum relief valve

It is used to protect the pump from cavitation or to regulate the suction minimum pressure (or max vacuum). When the pump capacity exceeds the system load at a given vacuum, the relief valve opens letting in atmospheric air or gas (if connected to the discharge separator) keeping constant the pre-set vacuum.

Automatic draining valve

It is used to drain the pump to the shaft centreline when the pump stops so to prevent that the pump has excessive liquid for the next start-up. Starting the pump full or with too much liquid could severely damage the pump.

Vacuum gauge

Usually installed under the pump suction flange, will provide an indication of the pump operating vacuum (pressure).

Discharge reservoir separator

It separates the service liquid from the gases at the pump discharge.

It can be mounted on the pump discharge flange (type HSF) or on the pump baseplate (type HSP).

It is required when the system is with partial or total recovery of the service liquid.

Heat exchanger

It cools the service liquid for those systems with total liquid recovery: it can be plate and frame type, shell and tube type or radiator type, depending upon the application.

Filter

Required to stop solids from entering the pump suction. Sizing of the filter is very important as it could create excessive pressure drops which would affect the pump performance.

9.3 - INSTALLATION SCHEMATICS FOR LIQUID RING VACUUM PUMPS

The working principle of the vacuum pump requires a continuous flow of fresh and clean liquid that enters the pump at the service liquid connection identified by the letter **Z** (see chapter 9.11). The liquid is discharged together with the handled gas through the pump discharge flange.

The quantity of said liquid will vary with pump size and degree of working vacuum (see performance curves and/or tab. 3).

The service liquid absorbs the compression heat generated by the pump compression therefore its temperature will rise by some 3-4 °C (for additional information see chapter 17).

There are three basic installation schematics listed below that may be considered, depending upon the quantity of service liquid that is desired and possible to be recycled.

9.3.1 - Service liquid: Once-through system (no recovery)

All the service liquid is supplied from an external source. The liquid is separated from the incoming gas in the discharge separator and is totally drained.

This is a popular installation and is used where there is an abundant supply of fresh liquid and/or there is no contamination of the same. The service liquid should be supplied at the pump connection with a pressure of 0.4 bar maximum to avoid flooding the pump with too much liquid. If this is not possible it is recommended to install a reservoir fitted with a float valve, this tank is supplied with the liquid that is then pulled by the pump as required by the operating conditions.

The liquid level in the reservoir should be approximately at the pump shaft centreline.

Schematic fig. 17 illustrates the once-through system.

9.3.2 - Service liquid: Partial recovery system

This type of installation is used where it is desired to minimise the use of fresh service liquid (for calculations see chapter 17).

The service liquid enters and leaves the pump same as the once through system, however part of the liquid is recycled from the discharge separator and the balance is continuously supplied from an external source. The excessive liquid is drained through the separator overflow connection.

The temperature of the mixed liquid supplied to the pump will be higher than the temperature of the make-up liquid. Its final temperature will depend upon the amount of the recycled liquid.

It is important to remember that with higher service liquid temperature the pump performance will decrease (see chapter 17) with the possibility of operating the pump in the cavitation area.

When the separator/reservoir is installed along side of the pump (type HSP), its liquid level should not be above the pump shaft centreline.

When flanged separators (type HSF) are mounted on the pump discharge flange, the liquid level is automatically maintained by the location of the connections. Schematic fig. 18 illustrates the system with partial recovery of the service liquid.

9.3.3 - Service liquid: Total recovery system

This system has total recycle of the service liquid without fresh liquid make-up from an outside source.

A heat exchanger is required to lower and control the temperature of the recycled service liquid: for sizing and calculations of heat loads see chapter 17.

A circulating pump will be required for those applications where the vacuum pump operates for extended period of times in the pressure ranges above 500/600 mbar or when there are high pressure drops in the closed loop including the heat exchanger (over approximately 1,5 m).

The liquid level in the separator/reservoir should not be above the pump shaft centreline.

Losses of liquid from the closed loop must be compensated with an equal amount from an outside source.

Schematic fig. 19 illustrates the system with total recovery of the service liquid.

9.4 - INSTALLATION SCHEMATICS FOR LIQUID RING COMPRESSORS

The liquid ring vacuum pump can also operate as a compressor up to a maximum differential pressure, depending upon the models, of about 2 bar. The compressors series SA are specifically engineered to perform with differential pressures of up to 10 bar, depending on models.

The principle of operation is same as given in previous paragraph (9.3 for vacuum pumps) and there are three possible type of installations: once-through service liquid, partial recovery service liquid and total recovery service liquid.

The service liquid entering the compressor connection should have a pressure of minimum 0,4 bar above the compressor operating inlet pressure. A booster pump will be required if the service liquid is available at lower pressures.

Separator/reservoir is considered a pressure vessel and as such it must be engineered and built to the applicable codes (ISPEL, ASME, etc.). Accessories such as pressure relief valve, check valve(non-return valve), automatic float type drain valve(water trap), etc. are required in a compressor system.

fig. 20, 21 and 22 illustrate the three possible types of installations.

9.5 - INSTALLATION OF "HYDROSYS" SYSTEMS

HYDROSYS systems are factory assembled and piped including discharge separator/reservoir, heat exchanger (air/liquid or air/air), circulating pump, and all required accessories mounted on a common compact baseplate/frame. See chapter 18 for additional details.

Installation of HYDROSYS system is similar to that of a vacuum pump or a compressor with partial recovery or total recovery of service liquid depending upon the application (see chapter 9.3 or 9.4).

It is important to properly engineer the connecting piping to the system suction and discharge, cooling lines, flushing lines, and draining lines.

The used heat exchanger is designed with service liquid being cooled approximately 4 to 6 °C over the available cooling media temperature. The cooling liquid flow is approximately same as the service liquid flow needed by the pump at the operating conditions (see chapter 9.7 or 9.8).

Schematics for once-through, partial and total service liquid recovery are shown in fig. 18 - 19 - 21 - 22.

9.6 - INSTALLATION OF "OILSYS" SYSTEMS

OILSYS are factory packaged systems including liquid ring vacuum pump using oil for service liquid. For additional details see chapter 19. The system is complete with oil circulating pump, heat exchanger, oil demister, cyclone for removal of dust (optional) and other accessories upon request.

Installation is simple and does not require additional details other than those already discussed in the previous chapter.

Suction and discharge piping should be connected to the respective pump flanges. When locating the discharge piping it should be noted that although the system is fitted with oil demister, there may still be traces of oil fumes carried by the vented gas. Make sure therefore, that the selected area for vacuum pump discharge is suitable for such purpose.

All other connections, (heat exchanger, draining, etc.) must be properly done. See fig. 37 for location of connections.



ATTENTION: HOT SURFACES, DO NOT TOUCH TO AVOID POSSIBLE BURNS!

During operation the temperature of pump, frame, separator and piping can reach values over 60 °C. Therefore take all precautions necessary to comply with the safety regulations.

9.7 - SERVICE LIQUID (H₂O at 15 °C) FLOW (in m³/h) FOR VACUUM PUMPS

The listed values are referred to the system with "Once-through" service liquid, handling dry air at 20 °C (for more specific data see the pump's performance curve).

To reduce the amount of service liquid flow read the information given in chapter 17.

If the pump is handling saturated or condensable gases at relatively high temperatures, there will be condensation inside the pump. In those cases the service liquid flow listed below can be increased up to 25% to reduce the discharge temperature and minimise the danger of pump cavitation at high vacuum.

Tab. 3

PUMP MODEL	SUCTION PRESSURE (in mbar)			PUMP MODEL	SUCTION PRESSURE (in mbar)	
	33 - 200	> 200 - 600	> 600		200 - 600	> 600
TRH 32-4	0,20	0,20	0,16	TRS 32-20	0,34	0,24
TRH 32-20	0,36	0,30	0,28	TRS 32-50		
TRH 32-45				TRS 40-55	0,78	0,44
TRH 32-60	0,90	0,70	0,60	TRS 40-80		
TRH 40-110				TRS 40-100	0,96	0,57
TRH 40-140				TRS 40-150	1,17	0,72
TRH 40-190	1,00	0,85	0,70	TRS 50-220	2,40	1,29
TRH 50-280	2,40	1,70	0,90	TRS 100-550	2,90	1,74
TRH 50-340	3,00	2,22	1,20	TRS 100-700	3,30	2,10
TRH 50-420	3,60	2,76	1,60	TRS 100-980	9,00	5,40
TRH 80-600	2,50	1,98	1,30	TRS 125-1250	8,70	4,20
TRH 80-750	3,00	2,40	1,60	TRS 125-1550	9,90	4,50
TRH 100-870	7,40	5,70	3,80	TRS 200-1950	18,00	11,40
TRH 100-1260				TRS 200-2500	20,10	11,70
TRH 100-1600				TRS 200-3100	25,80	17,40
TRH 150-2000	12,00	9,60	6,00			
TRH 150-2600	13,20	11,10	6,60			
TRH 150-3100	16,20	14,10	8,70			

PUMP MODEL	SUCTION PRESSURE (in mbar)		
	33 - 200	> 200 - 600	> 600
TRM 25-30	0,24	0,18	0,12
TRM 32-50	0,48	0,24	0,15
TRM 32-75	0,72	0,41	0,34
TRM/V 40-110	1,20	0,80	0,50
TRM/V 40-150			0,54
TRM/V 40-200	1,30	0,90	0,60
TRM/V 50-300	1,60	1,20	0,80
TRV 65-300			
TRV 65-450	2,40	1,68	0,90

For the above pumps running as compressors without the specific performance curves, please contact POMPETRAVAINI.

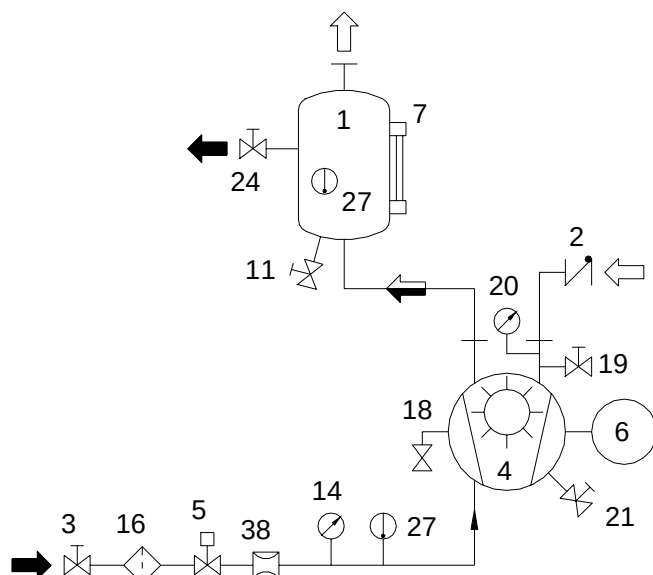
9.8 - SERVICE LIQUID FLOW (H₂O at 15 °C) AND PRESSURE FOR COMPRESSORS SERIES "SA"

Values are applicable when the compressor suction is barometric pressure (1013 mbar) and the gas is air at 20 °C. The indicated flow and pressure requirements are valid for the compressor total performance curve.

SA0E3U = 0,90 m³/h at minimum pressure of 2,5 to 3 bar
SA0G2D = 1,00 m³/h at minimum pressure of 2 to 3,5 bar
SA0G2G = 1,50 m³/h at minimum pressure of 2 to 3,5 bar

9.9 - TYPICAL INSTALLATION SCHEMATICS FOR VACUUM PUMPS

Fig. 17



- 1 Separator/reservoir
- 2 Non return valve
- 3 Shut off valve
- 4 Liquid ring vacuum pump
- 5 Solenoid valve
- 6 Electric motor
- 7 Level gauge glass
- 8 Float valve
- 9 Heat exchanger
- 10 Make-up solenoid valve
- 11 Drain valve
- 13 Flow control valve
- 13A By-pass valve
- 14 Compound gauge
- 15 Level switch
- 16 Filter (y-strainer)
- 18 Automatic drain valve (check valve)

Fig. 18

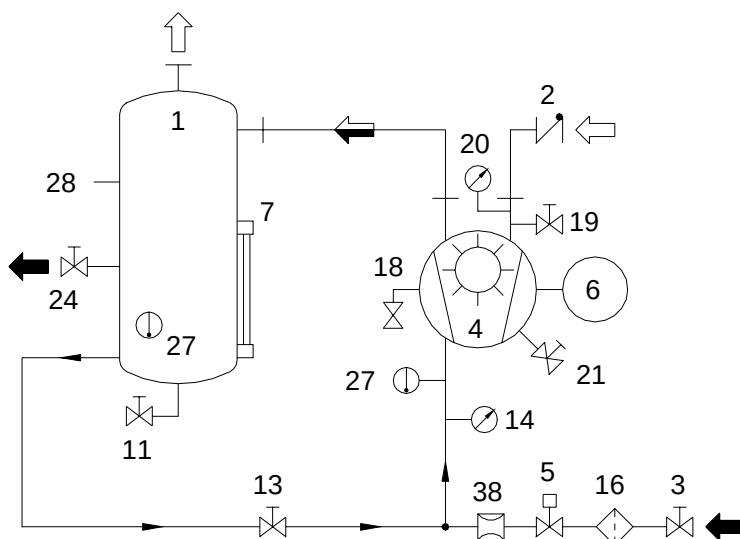
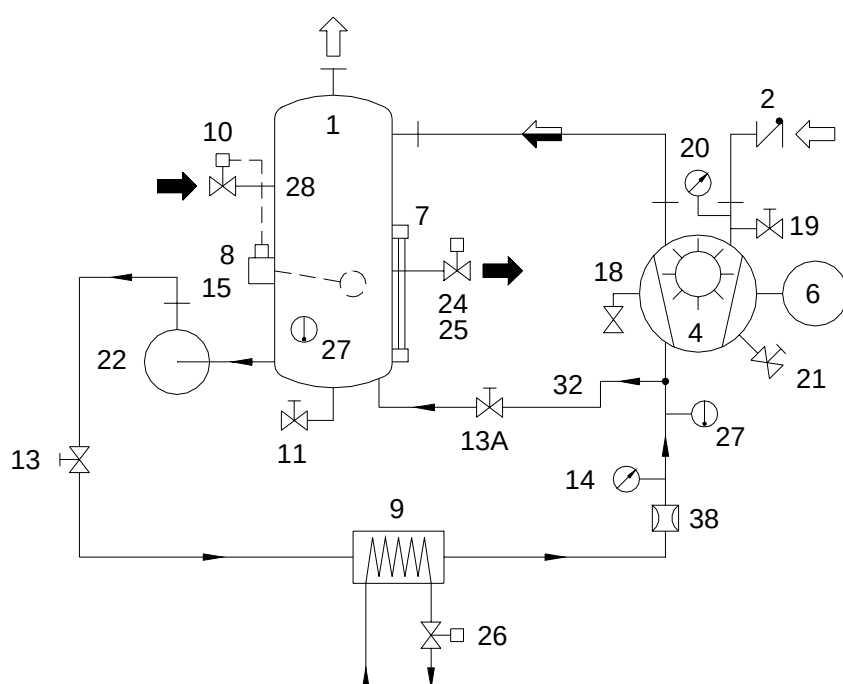
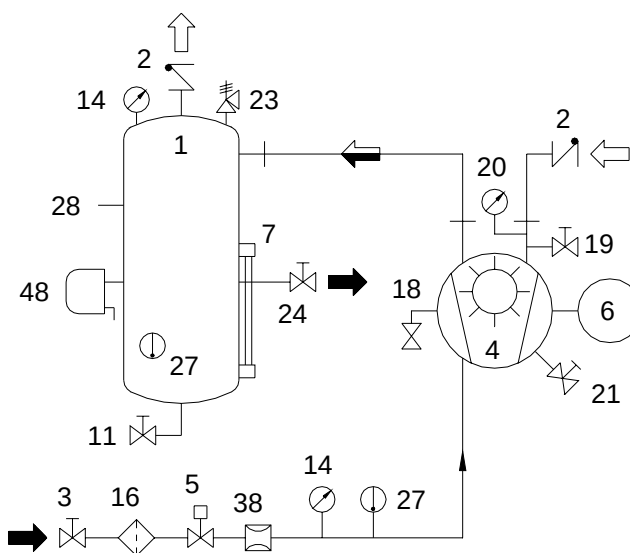


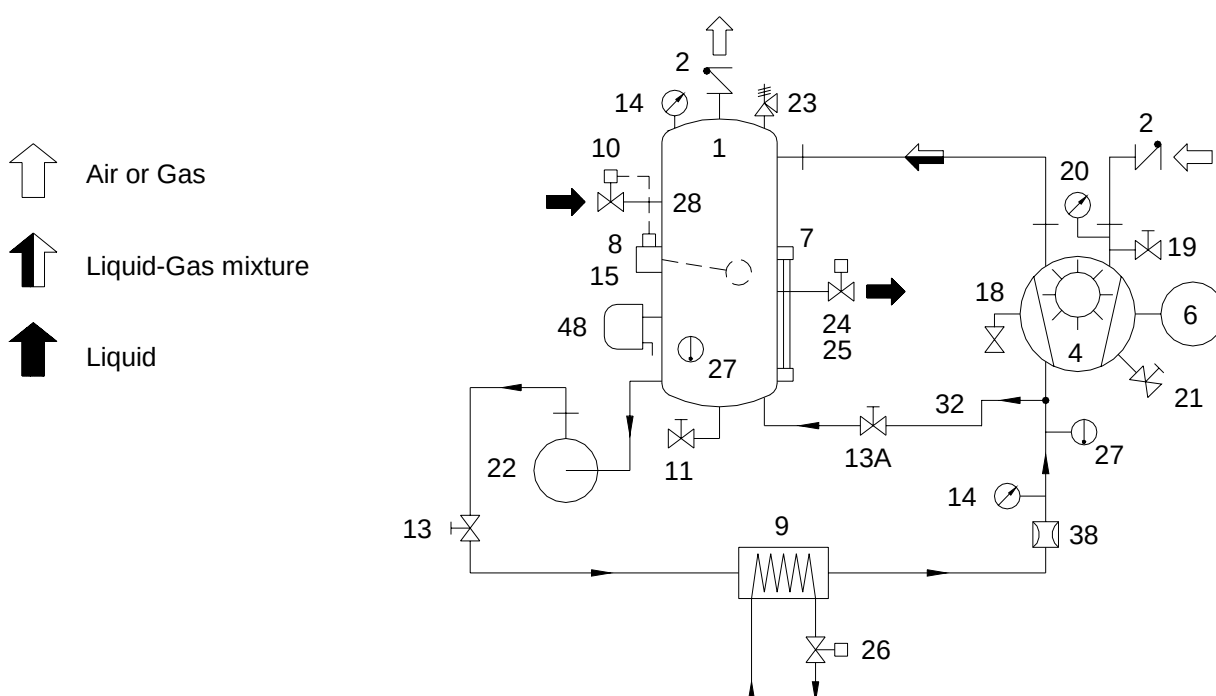
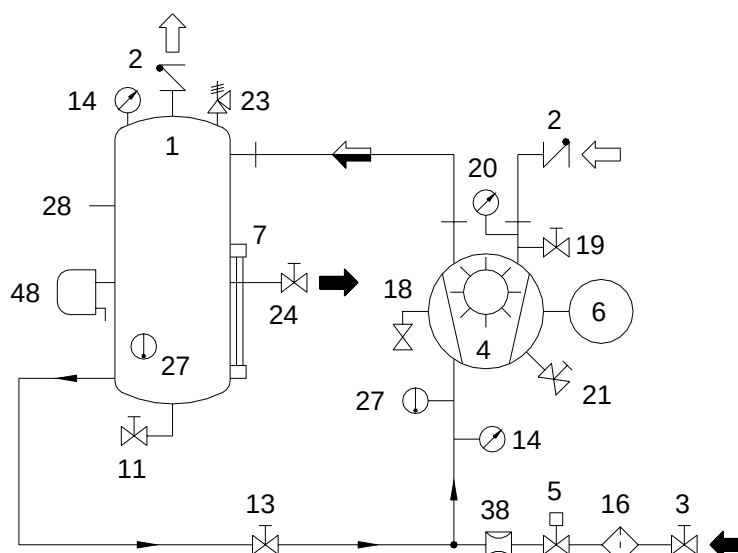
Fig. 19



9.10 - TYPICAL INSTALLATION SCHEMATICS FOR COMPRESSORS



- 19 Valve for spare vacuum connection
- 20 Vacuum gauge
- 21 Anti-cavitation valve
- 22 Circulating pump
- 23 Pressure relief valve
- 24 Overflow valve
- 25 Draining solenoid valve
- 26 Solenoid valve for heat exchanger cooling liquid
- 27 Temperature gauge
- 28 Fill-up connection
- 32 By-pass piping
- 38 Orifice flow
- 48 Automatic drain valve or water trap



9.11 - CONNECTIONS LOCATION

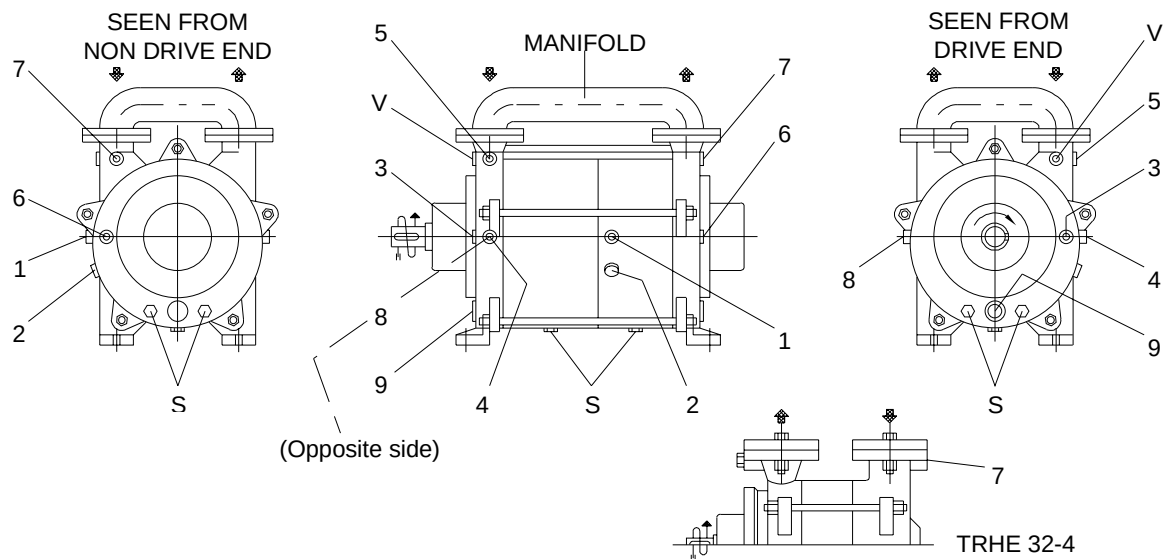


Fig. 23 - Pump series TRH (for details see tab. 4)

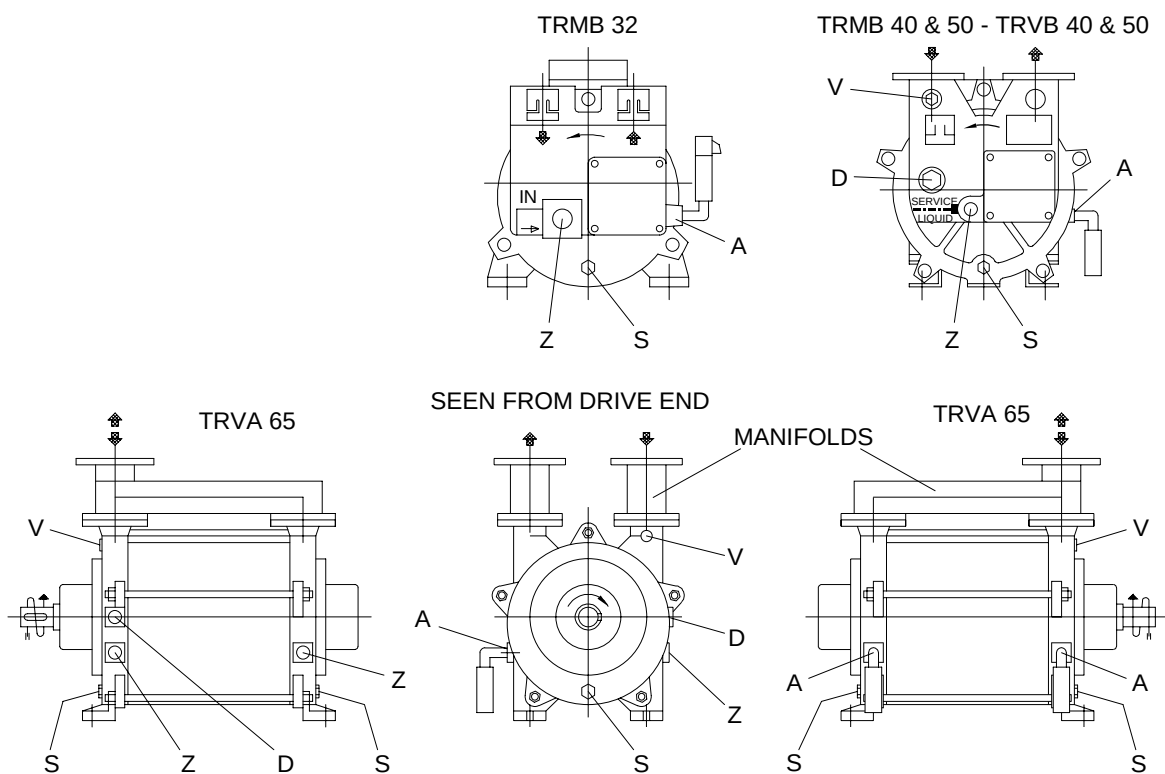


Fig. 24 - Pump series TRM - TRV (for details see tab. 5)

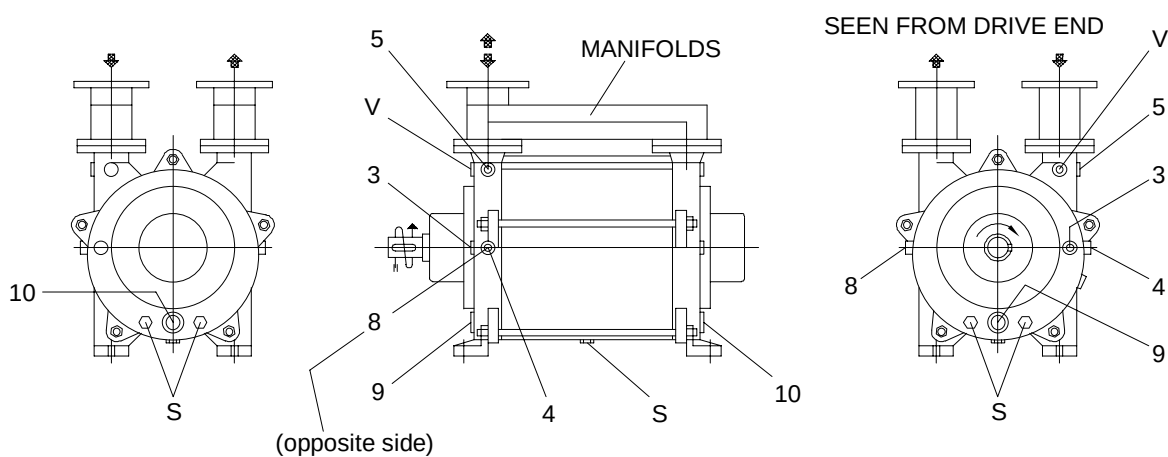


Fig. 25 - Pump series TRS (for details see tab. 6)

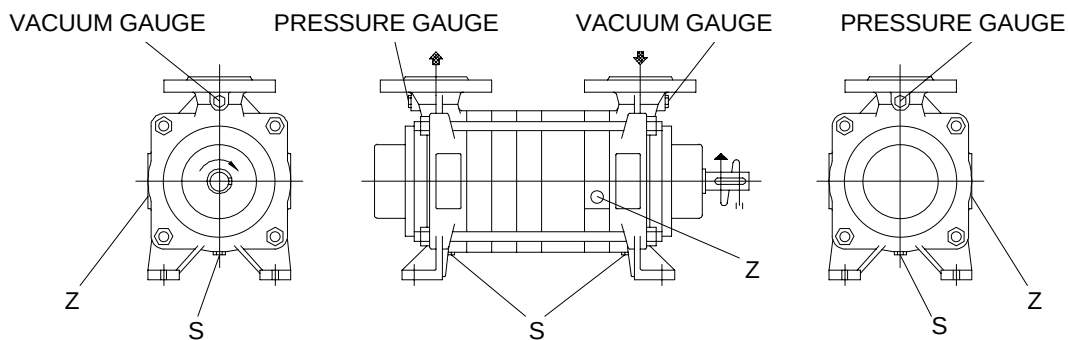


Fig. 26 - Pump series SA (for details see tab. 7)

Tab. 4 - Pump series TRH

PUMP MODEL	A		D		Z		Qty. Manifolds
	Location	Dimension	Location	Dimension	Location	Dimension	
TRHE 32-4	-	-	-	-	7	1/4" GAS	-
TRHE 32-20 & 45	1	1/4" GAS			8	3/8" GAS	
TRHC 32-20 & 45					4	1/2" GAS	
TRHE & TRHC 32-60							
TRHE 40-110	2		1/4" GAS	4	1/2" GAS	9	3/4" GAS
TRHC 40-110		4		1/2" GAS			
TRHE 40-140 & 190		3		3/4" GAS			1
TRHC 40-140 & 190		4		1/2" GAS			
TRHB 50	7	3	1" GAS				
TRHC 80	6	3/8" GAS	4	1" GAS	1 1/4" GAS		
TRHE 100		1/2" GAS	1 1/2" GAS				
TRHA 150	7	3/4" GAS	4 - 5		2 1/2" GAS		

Tab. 5
Pump series
TRM - TRV

PUMP MODEL	Dimension				Qty. Manifolds
	A	D	S	Z	
TRMB 25-30 & 32-50	1/8" GAS	-	1/8" GAS	1/4" GAS	-
TRMB 32-75				3/8" GAS	
TRMB & TRVB 40		1/2" GAS	1/4" GAS	1/2" GAS	
TRMB & TRVB 50		3/4" GAS		3/4" GAS	2
TRVA 65		1/2" GAS		1/2" GAS	

Tab. 6
Pump series TRS

PUMP MODEL	D		Z		Qty. Manifolds
	Location	Dimension	Location	Dimension	
TRSE 32	-	-	8	3/8" GAS	-
TRSC 32			4		
TRSE 40-55 to 150			9	3/4" GAS	
TRSC 40-55 to 100	4	1/2" GAS		1	
TRSC 40-150		1/2" GAS	9 - 10	3/4" GAS	2
TRSE 50-220	3			1/2" GAS	
TRSC 50-220	4			1 1/4" GAS	
TRSB & TRSC 100				1 1/2" GAS	
TRSE 125				2 1/2" GAS	
TRSA 200	4 - 5				

Tab. 7 - Pump series SA

COMPRESSOR MODEL	Dimension	
	S	Z
SA0E3U	1/4" GAS	3/8" GAS
SA0G2D		1/2" GAS
SA0G2G		

GAS = Straight pipe thread

A = Connection anti-cavitation valve

D = Auxiliary connection for automatic draining valve,
connection valve for spare vacuum pick-up, vacuum relief valve

S = Connection for draining plugs or valves

V = Connection for vacuum gauge 1/4" GAS (series 32 excluded)

Z = Connection for service liquid

All drawings are general and schematics (for additional details see the specific pump catalogue).

9.12 - PUMP ENGINEERING DATA

Tab. 8

PUMP MODEL	Noise level dB(A)	Weight, Bare pump kg	Weight ass.ly Monoblock (B5 design) kg	Weight ass.ly with baseplate kg	Operating Speed		Installed Motor size		Electric Motor Frame size		Weight of Electric Motor	
					RPM		kW				Kg	
					50 Hz	60 Hz	50 Hz	60 Hz	50 Hz	60 Hz	50 Hz	60 Hz
TRHE 32-4	67	14	19	32	1450	1750	0,55	0,75	80 A	80 B	9	9
TRHC 32-20	66	25	31	41	2900	3500	1,1	1,5	80 B	90 S	9	12,5
TRHE 32-20	66	18	22,5	34	2900	3500	1,1	1,5	80 B	90 S	9	12,5
TRHC 32-45	66	28	34	44	2900	3500	1,5	2,2	90 S	90 L	12,5	14,5
TRHE 32-45	66	21	25,5	37	2900	3500	1,5	2,2	90 S	90 L	12,5	14,5
TRHC 32-60	66	30	36	47	2900	3500	2,2	3	90 L	100 LA	14,5	19
TRHE 32-60	66	26	31	43	2900	3500	2,2	3	90 L	100 LA	14,5	19
TRHC 40-110	65	67	79	92	1450	1750	4	5,5	112 M	132 SB	27	38
TRHE 40-110	65	49	61	74	1450	1750	4	5,5	112 M	132 SB	27	38
TRHC 40-140	65	79	88	119	1450	1750	4	5,5	112 M	132 SB	27	38
TRHE 40-140	65	67	76	100	1450	1750	4	5,5	112 M	132 SB	27	38
TRHC 40-190	65	87	105	137	1450	1750	5,5	7,5	132 SB	132 MA	38	46
TRHE 40-190	65	75	93	118	1450	1750	5,5	7,5	132 SB	132 MA	38	46
TRHB 50-280	70	130	146	195	1450	1750	9	15	132 MB	160 L	46	100
TRHB 50-340	70	140	170	212	1450	1750	11	15	160 M	160 L	80	100
TRHB 50-420	71	145	178	220	1450	1750	15	18,5	160 L	180 M	100	140
TRHC 80-600	76	220	245	360	1450	1750	22	30	180 L	200 L	148	225
TRHC 80-750	76	240	280	377	1450	1750	30	37	200 L	225 S	225	250
TRHE 100-870	79	412	---	574	960	1150	30	37	225 M	250 M	280	440
TRHE 100-1260	79	485	---	652	960	1150	37	45	250 M	280 S	440	500
TRHE 100-1600	79	518	---	690	960	1150	45	75	280 S	315 S	500	710
TRHA 150-2000	83	1330	---	1805	730	880	75	90	315 MA	315 MB	750	750
TRHA 150-2600	84	1480	---	2095	730	880	90	110	315 MB	355 S	750	1225
TRHA 150-3100	84	1630	---	2245	730	880	110	160	355 S	355 MB	1225	1530

PUMP MODEL	Noise level dB(A)	Weight, Bare pump kg	Weight ass.ly Monoblock (B5 design) kg	Weight ass.ly with baseplate kg	Operating Speed		Installed Motor size		Electric Motor Frame size		Weight of Electric Motor	
					RPM		kW				Kg	
					50 Hz	60 Hz	50 Hz	60 Hz	50 Hz	60 Hz	50 Hz	60 Hz
TRSC 32-20	69	19	25	39	2900	3500	1,1	1,5	80 B	90 S	9	12,5
TRSE 32-20	69	15	19,5	31	2900	3500	1,1	1,5	80 B	90 S	9	12,5
TRSC 32-50	69	20	26	40	2900	3500	1,5	2,2	90 S	90 L	12,5	14,5
TRSE 32-50	69	17	21,5	33	2900	3500	1,5	2,2	90 S	90 L	12,5	14,5
TRSC 40-55	66	54	67	79	1450	1750	2,2	3	100 LA	100 LB	19	19
TRSE 40-55	66	34	47	59	1450	1750	2,2	3	100 LA	100 LB	19	19
TRSC 40-80	66	57	70	82	1450	1750	3	4	100 LB	112 M	19	27
TRSE 40-80	66	37	50	62	1450	1750	3	4	100 LB	112 M	19	27
TRSC 40-100	67	60	72	85	1450	1750	3	4	100 LB	112 M	19	27
TRSE 40-100	67	39	52	64	1450	1750	3	4	100 LB	112 M	19	27
TRSC 40-150	67	71	88	96	1450	1750	4	5,5	112 M	132 SB	27	38
TRSE 40-150	67	44	57	69	1450	1750	4	5,5	112 M	132 SB	27	38
TRSC 50-220	67	87	104	122	1450	1750	5,5	7,5	132 SB	132 MA	38	46
TRSE 50-220	67	74	92	109	1450	1750	5,5	7,5	132 SB	132 MA	38	46
TRSC 100-550	76	200	225	327	1450	1750	15	18,5	160 L	180 M	100	140
TRSC 100-700	76	230	255	380	1450	1750	18,5	30	180 M	200 L	140	225
TRSB 100-980	78	250	290	385	1450	1750	30	37	200 L	225 S	225	250
TRSE 125-1250	79	436	---	596	960	1150	37	45	250 M	280 S	440	500
TRSE 125-1550	79	462	---	634	960	1150	45	75	280 S	315 S	500	750
TRSA 200-1950	83	1125	---	1600	730	880	75	90	315 MA	315 MB	750	750
TRSA 200-2500	84	1225	---	1700	730	880	75	110	315 MA	355 S	750	1225
TRSA 200-3100	84	1325	---	1800	730	880	110	160	355 S	355 MB	1225	1530

Tab. 8 (continued)

PUMP MODEL	Noise level	Weight ass.ly Monoblock 50 Hz motor	Weight ass.ly Monoblock 60 Hz motor	Operating Speed		Installed Motor size		Electric Motor Frame size	
				RPM		kW			
				50 Hz	60 Hz	50 Hz	60 Hz	50 Hz	60 Hz
TRMB 25-30	69	17	18	2900	3500	0,75	1,1	80 A	80 B
TRMB 32-50	69	24	26	2900	3500	1,5	2,2	90 S	90 L
TRMB 32-75	70	37	41,5	2900	3500	3	4	100 LA	112 M
TRMB 40-110	68	66	71	1450	1750	3	4	100 LB	112 M
TRMB 40-150	69	76	106	1450	1750	4	5,5	112 M	132 SB
TRMB 40-200	72	103	111	1450	1750	5,5	7,5	132 SB	132 MA
TRMB 50-300	72	126	---	1450	---	7,5	---	132 MA	---

PUMP MODEL	Noise level	Weight, Bare pump	Weight ass.ly Monoblock (B5 design)	Weight ass.ly with baseplate	Operating Speed		Installed Motor size		Electric Motor Frame size		Weight of Electric Motor	
					RPM		kW				Kg	
					50 Hz	60 Hz	50 Hz	60 Hz	50 Hz	60 Hz	50 Hz	60 Hz
TRVB 40-110	68	---	62	---	1450	1750	3	4	100 LB	112 M	19	27
TRVB 40-150	69	---	64	---	1450	1750	4	5,5	112 M	132 SB	27	38
TRVB 40-200	72	---	78	---	1450	1750	5,5	7,5	132 SB	132 MA	38	46
TRVB 50-300	72	---	88	---	1450	1750	7,5	11	132 MA	160 M	46	80
TRVA 65-300	70	133	155	161	1450	1750	7,5	11	132 MA	160 M	46	80
TRVA 65-450	70	146	176	201	1450	1750	11	15	160 M	160 L	80	100

PUMP MODEL	Noise level	Weight, Bare pump	Weight ass.ly with baseplate	Operating Speed		Installed Motor size		Electric Motor Frame size		Weight of Electric Motor	
				RPM		kW				kg	
				50 Hz	60 Hz	50 Hz	60 Hz	50 Hz	60 Hz	50 Hz	60 Hz
SA0E3U	67	56	110	2900	3500	11 15	15 22	160 MA 160 MB	160 MB 180 M	100 114	114 156
SA0G2D	69	83	135	2900	3500	11 18,5	18,5 37	160 MA 160 L	160 L 200 LB	100 126	126 230
SA0G2G	69	87	139 157	2900	3500	15 22	22 45	160 MB 180 M	180 M 225 M	114 156	156 275

NOTES:

- Noise level (measured at 1 m distance, without motor, with pump installed in the system) for pump series TRH, TRM, TRV when operating at 80 mbar and pump series TRS when operating at 250 mbar. Noise level test to ISO 3746 standards and with pumps at 50 Hz operating speeds.
- Weights are for pumps fitted with Mechanical Seals and in Cast Iron materials (tolerance $\pm 10\%$).
- The assemblies, Monoblock and with Baseplate, are suitable for 50 Hz motors, except where otherwise noted. Indicated total weights for the assemblies are without motors.
- The installed motor size cover the whole performance curve when operating as vacuum pump.
- The electric motors over the frame size 315 M are not unified.
- The motor weights are for type CVE and are only approximate values. For exact weights refer to the specific motor manufacturer data.

10 - CHECK LIST PRIOR TO START-UP



All questions listed below must have **POSITIVE** answers prior to proceeding to the pump start-up. Please note that the following is a partial list. Special installations may require further precautions therefore, additional safety steps must be taken as the cases dictate.

- This manual has been completely read, including the following chapters, and is understood in its entirety?
- The piping system has been flushed of any foreign particles, welding impurities, etc.?
- Have all piping and pump obstruction been removed?
- All connections and piping are leak proof and there are no external forces or moments applied to the piping or pump flanges?
- Pump and motor are properly lubricated, per instructions?
- Pump/motor alignment has been checked?
- Mechanical seal flushing line has been connected, where required?
- All valves in the installation are in the correct position?
- All safety guards are in place?
- Pump direction of rotation has been checked by jogging the motor?
- The pump Stop switch is clear and visible?
- Pump as well as installation are ready for start-up?

11 - STARTING, OPERATING AND STOPPING PROCEDURES

Upon receipt and/or completion of installation, before turning on the power to the electric motor, rotate the pump shaft by hand to make sure that the pump rotor is free. In the event the shaft does not turn, try to free it up by applying a torque to the pump coupling with a pipe wrench. To free the rotor of a monoblock style pump (without coupling) introduce a bolt (or similar tool) at the motor shaft end that has a threaded connection and apply the torque by hand.

In the event the pump does not become free with the above procedures, fill up the pump with a suitable solvent or lubricating liquid, let it rest for several hours to allow softening of the rust build-up inside the pump, drain the pump and apply torque to the pump shaft as described above to finally free the rotor.

NOTE: The selected solvent or lubricating fluid must be compatible with the pump, seals and gasketing materials.



CHECK PUMP-MOTOR COUPLING ALIGNMENT!

This must be done prior to the first start-up and before every start-up if pump or motor has been removed from the installation for maintenance or other reasons. See chapter 7.2.

Prior to starting the pump verify that all auxiliary components are available, ready for use and, where required, they are in the open position (i.e.: double mechanical seals are pressurised with buffer liquid, cooling liquid to heat exchanger is open, etc.) and the pump bearings are lubricated.

If the gas and/or service liquid temperatures are in the dangerous levels, it is recommended to insulate the pump, piping and separator to avoid direct contact with their surface, avoid freezing, thermal shock or losing heat energy.

NOTE: See chapters 11.4 to 11.6 for **OILSYS** systems start-up, operation and shut-down.

11.1 - START-UP

(In the following, reference is made to certain ITEM numbers which appear on fig. 17 to 22 of chapters 9 and 18).

Open valve at gas discharge if installed and partially open the valve at the suction side.

When operating the pump as compressor there must be a check valve ITEM 2 fitted at the discharge side.

When pump ITEM 4 is fitted in a partial recovery or total recovery or HYDROSYS systems, as built by POMPETRAVAINI, it is required to have drain valve ITEM 11 at separator ITEM 1 in the closed position, flow regulating valve ITEM 13 and overflow valve ITEM 24 in the open positions. Separator overflow valve ITEM 24 should be piped to drain (or collecting container). Before start-up fill the pump to the shaft centreline, separator and piping of system with service liquid through pump inlet flange or fill connection ITEM 28. Check all components for leakage.

If the automatic drain valve ITEM 48 is installed, the overflow valve ITEM 24 must be closed after the filling.

Start all accessories (temperature switches, level switches, pressure switches, etc.) open cooling and flushing lines. Start the pump and open the service liquid valve ITEM 3 (if applicable), soon after start the circulating pump ITEM 22 (if applicable) and adjust the service liquid flow (see tab. 3).

Gradually open the valve at gas suction side till the required vacuum level is reached.

Check the system for abnormal conditions (see chapters 12 and 14).

If the system is fitted with a circulating pump and/or the service liquid has an excessive pressure the by-pass valve ITEM 13A (if available) or valve ITEM 13 can be adjusted to reduce the service liquid flow to the vacuum pump and/or optimise the thermodynamic efficiency of the heat exchanger ITEM 9.

NOTE: HYDROSYS systems engineered with multiple pumps are fitted with isolating valves at suction, discharge, and service liquid lines of each pump. When one or more pumps are not operating it is required to isolate the idle pump(s) by closing these valves. When the pumps are put back into service the said valves (at suction and discharge) must be opened.

11.2 - OPERATION

After starting the vacuum pump check the following:

- the vacuum level is as desired or adjust the flow regulating valve to the required vacuum
- flow and temperature of service liquid and/or cooling liquid are as expected (within 25% tolerance)
- motor does not draw more amperage than shown on its nameplate
- the pump-motor assembly does not have abnormal vibrations and noises such as cavitation
- the operating temperature at full load, does not exceed approximately 85 °C
- there are no leaks from mechanical seals, joints and flushing or cooling liquid lines
- liquid level in separator is between the minimum and the maximum.



NEVER OPERATE THE PUMP DRY!

If the gas discharge is not open to the immediate atmosphere but it is piped to other locations, the pump discharge should be checked for back-pressures that could cause higher power consumption and loss of pump capacity.

11.3 - SHUT DOWN

First close the service liquid flow and cooling liquid flow (if applicable) then shut down the circulating pump ITEM 22 (if there is one).

Where possible, gradually decrease the vacuum level to 400/900 mbar in about 10 seconds max or, if compressor, decrease the discharge pressure. The discharged service liquid from pump ITEM 4 helps producing a slow deceleration rather than sudden stop.

Turn off the power to motor ITEM 6 and close any accessories and flushing lines.

Make sure the non return valves ITEM 2, or similar, at suction and discharge lines are leak tight.

Should the system be idle for an extended period of time it is recommended to disconnect the electricity to the motor panel, drain all liquids from pump, separator and piping. Refer to chapter 6 for storage procedures.

11.4 - START UP OF "OILSYS" SYSTEMS

(In the following, reference is made to certain ITEM numbers which are listed in the figures and legend of chapters 12.1 and 19).

Open the valve at the gas discharge, if applicable, and partially close the valve at the suction side.

Close draining valve ITEM 11 and valves for condensate recovery ITEMS 13F and 13L which are on the frame separator ITEM 1B; open the valve ITEM 13D which is between the circulating pump ITEM 22 and the frame separator ITEM 1B, then partially open flow regulating valve ITEM 13 between the discharge of circulating pump ITEM 22 and the heat exchanger ITEM 9 and the by-pass valve ITEM 13A.

If the system is fitted with a separator cyclone ITEM 1D and the adjacent collecting tank ITEM 1E, it is required to close valves ITEM 11A and 12 and open valve ITEM 13E.

Fill frame separator with service oil through the filling plug ITEM 28. Proper oil level can be seen on sight glass ITEM 7. Refer to tab. 12 and 13 for the required oil quantity.

Start and/or open applicable accessories (temperature switches, level switches, etc.) and circuitry for cooling and flushing.

Start vacuum pump ITEM 4 and soon after start the circulating pump ITEM 22. Adjust the circulating pump capacity with valve ITEM 13.

Gradually open the system suction valve till the desired vacuum is achieved. Check the systems for abnormal noises or vibrations (see chapters 12 and 14).

Adjust by-pass valve ITEM 13A to regulate the oil flow to the vacuum pump or to improve the thermodynamic efficiency of the heat exchanger.

NOTE: OILSYS systems engineered with multiple pumps are fitted with isolating valves at suction, discharge, and service liquid lines of each pump. When one or more pumps are not operating it is required to isolate the idle pump(s) by closing these valves. When the pumps are put back into service the said valves (at suction and discharge) must be opened.

11.5 - OPERATION OF "OILSYS" SYSTEMS

After starting the vacuum pump check the following:

- the vacuum level is as desired or adjust the flow regulating valve to the required vacuum
- the oil temperature is between 60 and 80 °C. If required, adjust the thermostat on the radiator or in case of water/oil heat exchanger adjust the cooling water flow
- motor does not draw more amperage than shown on its nameplate
- the pump-motor assembly does not have abnormal vibrations or noises such as cavitation
- the frame temperature at full load, does not exceed approximately 85 °C
- that there are no leaks from mechanical seals, joints, flushing or cooling liquid lines
- liquid level in separator and frame is between the minimum and the maximum
- the pressure gauge of the oil demister separator does not read more than 0,3 bar. When this value is exceeded it will be required to change the filter element.

If the gas discharge is not open to the immediate atmosphere but it is piped to other locations, the pump discharge should be checked for back-pressures that could cause higher power consumption and loss of pump capacity.

11.6 - SHUT DOWN OF "OILSYS" SYSTEMS

Close, if applicable, the cooling water to the water/oil heat exchanger ITEM 9, then turn off the power to the circulating pump ITEM 22.

Where possible, gradually decrease the vacuum level to 400/900 mbar in about 10 seconds max. The discharged service liquid from pump ITEM 4 helps producing a slow deceleration rather than sudden stop.

Turn off motor ITEM 6, radiator ITEM 9 and any accessories and flushing circuitry.

Make sure the non return valves ITEM 2, or similar, at suction and discharge lines are leak tight.

Should the system be idle for an extended period of time it is recommended to disconnect the electricity to the motor panel, drain all liquids from pump, separator and piping. Refer to chapter 6 for storage procedures.

12 - OPERATING MAINTENANCE

Periodically check the working conditions of the system by means of the instrumentation on the installation (pressure gauges, vacuum gauges, temperature gauges, ammeters, etc.) and if the pump is consistently handling the application for which it was selected.

The operation of the pump should be without abnormal vibrations or noises, if any of these problems is noticed, the pump should be stopped immediately, search for the cause and make the necessary corrections.

It is good practice to check the pump/motor alignment, the running conditions of the bearings and of the mechanical seals (see chapter 13) at least once a year, even if no abnormalities have been noticed.

If there is a deterioration of the pump performance, which is not attributable to changes in system demands, the pump must be stopped and proceed with necessary repairs or replacement.

If the mechanical seals are fitted with external flushing and/or quenching lines their pressures, temperatures and flows must be checked constantly.



NEVER ALLOW THE PUMP TO OPERATE IN THE CAVITATION AREA!

Cavitation has the characteristic metallic sound, like if gravel was rotating inside the pump, and it causes also high pump vibrations. This happens when the pump is running at absolute pressures close to the vapour tension of the service liquid at the running conditions.

This is a damaging condition for the impellers, port plates and casings. The cavitation causes erosion taking away metal particles and attacking the surface of the pump components. This is particularly damaging if the pump is handling corrosive gases, see chapter 14 for suggestions to correct the problem.

Pump series TRH, TRM and TRV are fitted with an anti-cavitation valve that should be left open (if required) see fig. 23 and 24 for the location. This valve should be connected toward the upper part of the discharge separator so that, depending upon the operating vacuum, the pump can either take air or discharge excessive liquid.

For OILSYS systems the anti-cavitation valve ITEM 13H is piped from pump ITEM 4 to the frame separator ITEM 1B.

During operation it must be avoided to have sudden and frequent variations from high to low vacuum. (e.g.: suddenly opening the suction valve when the pump is operating at pressures lower than 200 mbar).

This would flood the pump creating high power absorption that would put heavy stress on the motor and coupling.

Particular attention should be put on the quantity of the service liquid flow. The flow will depend upon the type of installation (see chapter 9), the pump size, and/or the desired temperature rise.

The flow of service water at 15 °C, for standard pumps and normal operating conditions at various vacuum levels, is listed on the specific pump curves and/or on tab. 3 of chapter 9.7.

Usually the temperature rise of service water, when handling dry air at 20 °C, is approximately 4 °C.

When condensable (e.g.: vapours) are present in the gas stream the heat load to be removed by the service water will be higher, therefore the service water temperature rise will be higher.

The service liquid flow and its temperature will affect the pump performance.

Generally the low service liquid flow will decrease the pump capacity, while a high service liquid flow will increase the absorbed power by flooding the pump (see chapter 17 for information and calculations).

Hard service water will generate lime build-up inside the pump. The severity of the deposit will vary with the water temperature. Lime or mineral deposits on the surface of the internal pump components will cause an increase of absorbed power, wear of the components and eventually will seize the pump.

It is recommended to monitor the water hardness and, if too high, treat the water. If there are no alternatives, there should be periodical flushing of the pump with a solution that will remove the specific deposits, or the pump must be periodically disassembled, cleaned of all incrustations and re-assembled.

Systems with total service liquid recovery require periodical change of the service liquid contained in the closed loop. The heat exchanger must be kept well cleaned of all mineral deposits for an effective thermodynamic heat exchange.

During operation, a closed loop system will lose some of the service liquid, due to evaporation and/or saturation of the discharged gases. It will be required to periodically make-up fresh liquid into the system.

This operation is not required for those systems that are fitted with a float type automatic make-up valve ITEM 8. This valve requires water at a pressure of approximately 2 bar.

Systems that handle condensable will experience a rise in the level of the service liquid in the separator. The excessive liquid will be overflowed through the overflow valve or connection.

If the specific gravity of the condensable is higher than that of the service liquid, the condensable must be discharged through the separator drain valve ITEM 11, preferably with system not running.

12.1 - "OILSYS" SYSTEMS

(For ITEM numbers refer to fig. 27 and legend of chapter 19).

It is very important to keep the service oil temperature under control; when the oil temperature exceeds 90 °C there is the danger of seizing the pump and the gasketing may start leaking.

Every 100-200 working hours it is suggested to check the oil level in the frame reservoir ITEM 1B, make-up oil if necessary and change the oil every 4000-6000 working hours (depending upon the use and the application).

Those installations where the handled gases are contaminated with dust or suspended solids that can alter the oil characteristics will require more frequent oil check and changes.

The frame is fitted with two inspection ports ITEM 43 which can be used for cleaning the frame reservoir after it has been drained of all the oil. Condensable, if present during evacuation, can be flushed right through the discharge of the separator (if they have low boiling point) or, when the system is idle, can be drained by opening valves ITEM 13F and/or 13L. During the service, the oil demister filter will be impregnated with oil particles; the pressure gauge ITEM 14 installed at the housing ITEM 1C will provide an indication of the filter being plugged; pressure reading over 0.3 bar is an indication that the filter needs replacement.

At higher discharge pressures the discharged air quality will decrease and the vacuum pump absorbed power will increase. The oil separated by the filter is accumulated at the bottom of the filter cartridge. To remove this oil there is a scavenger line with a regulating valve ITEM 13G that is connected to the vacuum pump suction flange. It is recommended to keep this valve ITEM 13G minimally opened.

To replace the oil demister filter, simply disconnect the oil scavenger line, remove the cover ITEM 1C, remove the used filter element, apply a liquid gasketing material over the 2 gasket faces of the new filter and place the latter in the housing, put in place the cover and the scavenger line.

For systems with separator cyclone ITEM 1D and recovery tank ITEM 1E it is required to periodically remove the accumulated materials. For this operation close the valve ITEM 13E between the cyclone and the reservoir, open the vent valve ITEM 12 situated at the upper part of the separator, open the reservoir drain valve ITEM 11A to discharge the collected materials. After the cleaning operation, return to the original position by reverting the above steps.

It is possible to by-pass the service liquid circulating pump by closing the suction and discharge valves and opening the valve ITEM 13C in the by-pass line. This will connect the frame reservoir directly with the heat exchanger.

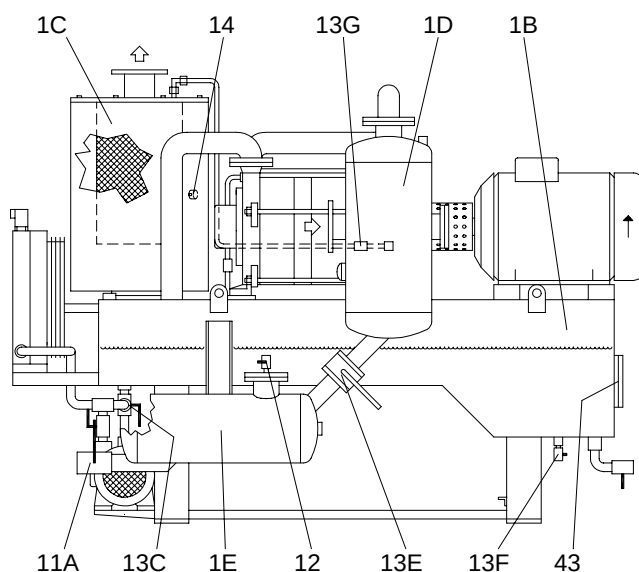


Fig. 27 (General schematic drawing)

13 - BEARINGS AND MECHANICAL SEALS MAINTENANCE

WARNING: The maintenance must be carried out with the pump turned off and the electrical power, or other driving mechanism, must be disconnected. The power should only be turned back on by the same person doing the maintenance. It is however recommended to have at least a team of two workers doing the maintenance and the supervisors should be fully aware of the work in progress.



CAREFULLY FOLLOW THE SAFETY PROCEDURES LISTED IN CHAPTER 2.

13.1 - BEARINGS

At assembly time the pump bearings are lubricated with quality grease type "EP 3" (sealed bearings are greased for life). Bearings for pumps working in standard conditions should be lubricated every 2000/2500 working hours with a quality grease (see "Disassembly & Assembly" for the replacement of bearings).

Bearing temperature should not exceed the 85 °C during normal working conditions and normal environments.

Bearings can overheat for reasons such as too much grease, misalignment of flexible coupling, wrong bearings, excessive vibrations, bearing wear. See tab. 9 for bearing numbers and type used for each pump.

13.2 - MECHANICAL SEALS

Mechanical seals can be with many types of materials, design and installations (see fig. 28).

Their selection has been evaluated by POMPETRAVINI at the time of pump design, in function of the fluid and working conditions.

The seals are supplied with the proper flow of liquid for their lubrication, through internal pump passages. Upon request, the pump can be provided with seal lubrication coming from an outside source; the set-up must be such that the seals are guaranteed the liquid quantity and pressure as recommended by POMPETRAVINI or by the seal manufacturer.

For mechanical seal shaft size see tab. 9.

Mechanical seals normally fitted in the vacuum pumps are to DIN 24960 standards. See "Disassembly & Assembly Instructions" for major seal dimensions.

Normally mechanical seals do not require maintenance until there is a visible liquid loss (leakage). See "Disassembly & Assembly Instructions" for seal replacement.

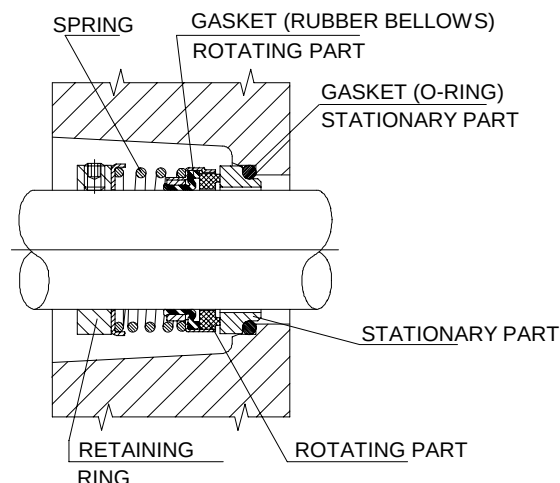


Fig. 28



Mechanical seals **MUST NOT** run dry! When seals are operated without lubricant and/or flushing liquid their faces and the elastomers may suffer damages beyond repair. It is suggested to check the conditions of the seal faces every approximately 4000 working hours.

Tab. 9

PUMP MODEL	BEARING			MECHANICAL SEAL	
	Quantity	Type	Grease Quantity each bearing - gr.	Quantity	Diameter mm
TRHE 32-4	1	6302.2RSR	---	1	16
TRHC and TRSC 32	2	6304.2RSR		2	22
TRHE 32-20/45/60 - TRSE 32		6305.2RSR			28
TRHE 40-110 - TRSE 40	1	6205.2RSR		1	22
TRMB 25-30	1	6204.2RSR			24
TRMB 32-50	1	6305.2RSR			28
TRMB 32-75	1	6306.2RSR			35
TRMB 40-110	1	6206.2RSR			45
TRMB 40-150	1	3208.2RSR			35
TRVB 40-110/150	1	6306.2RSR			45
TRMB 40-200 and 50-300	2	6208.2RSR			45
TRMB 40-200 and 50-300	1	3210.2RSR			45
TRMB 40-200 and 50-300	1	6308.2RSR			45
TRMB 40-200 and 50-300	1	6210.2RSR			45
TRMB 40-200 and 50-300	1	6208.2RSR			45
TRHC and TRSC 40	2	6306.2RSR		2	35
TRHE 40-140/190		6306.2RSR			35
TRSC and TRSE 50		6306.2RSR			35
TRHB 50 - TRVA 50 and 65		6308	20		43
TRHB/C 80 - TRSB/C 100		6310	35		55
TRHE 100 - TRSE 125	1	6314	50		75
TRHE 100 - TRSE 125	1	NU 314	50		75
TRHA 150 - TRSA 200	2	7320B.MB.UA	180	2	110
TRHA 150 - TRSA 200	1	22320ES.TVPB.C3	180		110

NOTE: The supplied data are for pumps in STANDARD construction. For special construction please contact POMPETRAVINI.

14 - TROUBLE SHOOTING: PROBLEMS, CAUSES AND SOLUTIONS

Consult the following table when problems are experienced, if solutions are not found in this chart or should there be any doubts, do not hesitate to contact POMPETRAVINI or your local representative.

Tab. 10 - LIST OF PROBLEMS

PROBLEM	LIST OF POSSIBLE CAUSES
Pump does not create or the vacuum is too low	1 - 2 - 3 - 4 - 9 - 11 - 18 - 19 - 22 - 23 - 24 - 25
Excessive noise	1 - 4 - 5 - 6 - 7 - 10 - 24
High power consumption	1 - 5 - 6 - 8 - 9 - 15 - 24 - 25
Vibration	5 - 6 - 7 - 8 - 10 - 12 - 13 - 24
Mechanical seal leaking	11 - 14
Pump loses liquid	11 - 19 - 23
Bearing failure	5 - 6 - 7
Pump does not start	1 - 6 - 20 - 21
Shaft partially or totally locked	6 - 10 - 15 - 16 - 21
Cavitation	3 - 4 - 8 - 9 - 17 - 24

	CAUSES	SOLUTIONS
1	Defective motor or wired wrong	Check the voltage, the frequency, motor type, power consumption, rotation, wiring connections, phase consistency
2	Leakage in suction piping	Repair piping; check valves for leakage
3	Service liquid high temperature	Lower the service liquid temperature; check the level of the service liquid; adjust the cooling liquid flow; adjust the radiator thermostat to lower temperature setting
4	Low service liquid flow	Increase the service liquid flow
5	Coupling misalignment	Re-align the coupling and the pump/motor assembly (see cap. 7)
6	Faulty bearing	Replace the bearing(see "Disassembly & Assembly Instructions")
7	Cavitation	Open the anti-cavitation valve or set the relief valve to a lower vacuum (see tab. 4 to 6)
8	High service liquid flow	Reduce the service liquid flow; adjust the by-pass valve
9	High back pressure	Check the discharge line for obstructions or high friction losses; reduce the back-pressure to maximum 0.1 bar
10	Wrong pump/motor assembly	Verify that the base surface is level and that all pump feet are resting on the surface, add spacers if required (see chapter 11)
11	Mechanical seal failure	Change the mechanical seal (see "Disassembly & Assembly Instructions")
12	Wrong pump mounting	Remount the pump (see chapter 7)
13	Piping weight resting on pump	Support the piping with hangers or other means (see chapter 11)
14	Inadequate seal lubrication	Check flushing liquid temperature, flow and pressure
15	Mineral deposits from hard water	Clean the pump
16	Foreign particles in pump	Disassemble the pump to remove the foreign objects (see "Disassembly & Assembly Instructions")
17	Low suction pressure	Open the vacuum regulating valve and/or the anti-cavitation valve (vacuum relief valve)
18	Wrong pump rotation	Reverse the rotation (see chapter 8)
19	Bad gaskets	Replace the defective gaskets (see the "Disassembly & Assembly Instructions")
20	Wrong motor connections	Check the electrical connections (connectors, fuses, breakers) and the power supply line (see chapter 8)
21	Pump seized	Disassemble and repair the pump (see "Disassembly & Assembly Instructions")
22	Pump undersized	Select a pump with higher capacity
23	Pump worn-out	Disassemble and repair the pump (see "Disassembly & Assembly Instructions")
24	Excessive liquid flow through suction line	Reduce the liquid flow through the pump suction; install a centrifugal separator (cyclone) before the pump
25	Instrumentation out of calibration	Check the working characteristics, replace if required

15 - REPAIRING AND REMOVING PUMP FROM THE INSTALLATION

Should there be the need for pump repair a knowledge of the specific "Disassembly and Assembly Instructions" is required.



FOLLOW THE SAFETY PRECAUTION MEASURES OUTLINED IN CHAPTER 2.

Before working on the pump it is important to:

- procure and wear the proper safety equipment (hard hat, safety glasses, gloves, safety shoes, etc.)
- disconnect the electrical power supply and, if required, disconnect the electrical cable from the motor
- close the isolating valves at pump inlet, outlet and service liquid
- let the pump cool down to ambient temperature if it has been handling hot fluids
- adopt safety measures if the pump has been handling hazardous liquids
- drain the pump internals of the pumped liquid through the draining connections, if necessary rinse with neutral liquid.

To remove the pump and the motor from the installation proceed as follows:

- remove bolts from pump suction and discharge flanges
- remove the coupling guard
- remove the spacer of the coupling, if there is one
- if required, remove the motor anchor bolts on the baseplate, for base mounted assembly, or the bolts on the adapter flange in the case of monoblock design
- remove the pump anchor bolts on the baseplate
- remove the pump from the installation. Avoid damaging other system components.

After pump repairs, re-install following the steps from "Assembly and Alignment" procedures and after (see the applicable chapters).

16 - SPARE PARTS

When ordering the pump it is good practice to also order the necessary spare parts, especially when there are no stand-by pumps in the installation. This will minimise unnecessary down times in the event of pump failure or routine maintenance.

It is therefore, recommended to stock the following spare parts for each pump size:

1	Impeller set
1	Complete shaft assembly
1	Bearing set
1	Mechanical seal set (or packing set)
1	Gasket sets
1	Radial seal ring set
1	Bearing spacer set
1	Coupling rubber insert set

For better parts management, the VDMA 24296 standards suggest to stock the number of parts as a function of the number of pumps being used in the plant.

On the pump nameplate are printed pump model, year of manufacture and pump serial number. When ordering spare parts always provide this information. Pump type, parts item number (VDMA) and description as per the pump sectional drawing and parts list is useful information that helps to supply correct spare parts for your pump.

We recommend the use of original spares: in case this is not respected, POMPETRAVAINI declines any responsibility for eventual damages and not correct running caused by not original spare parts.

17.1 - INFLUENCE OF SERVICE LIQUID TEMPERATURE, SPECIFIC GRAVITY AND VISCOSITY ON PUMP PERFORMANCE

The performance of liquid ring vacuum pumps is based on the use of water at 15 °C as service liquid. With water at different temperatures the pump capacity and the maximum attainable vacuum level will vary in function of the type of pump, as illustrated by the curve sets of fig. 29 and 30.

EXAMPLE: Pressure = 60 mbar - Water temperature = 24°C - Pump series TRH - Capacity (15°C water) = 120 m³/h
 From curves of fig. 30 we find the correcting factor of 0,80, therefore the actual capacity for the pump at the given conditions will be: 120 x 0,80 = 96 m³/h.
 The maximum suction pressure before incurring cavitation will be approximately 45 mbar.

Regarding the performance variation due to changes of specific gravity and viscosity, it can be assumed a proportional variation in power consumption however, the changes in capacity at different pressures must be analysed case by case. Please refer the conditions to POMPETRAVAINI when these corrections are needed.

Fig. 29
Single stage pump
(series TRM, TRS, TRV)

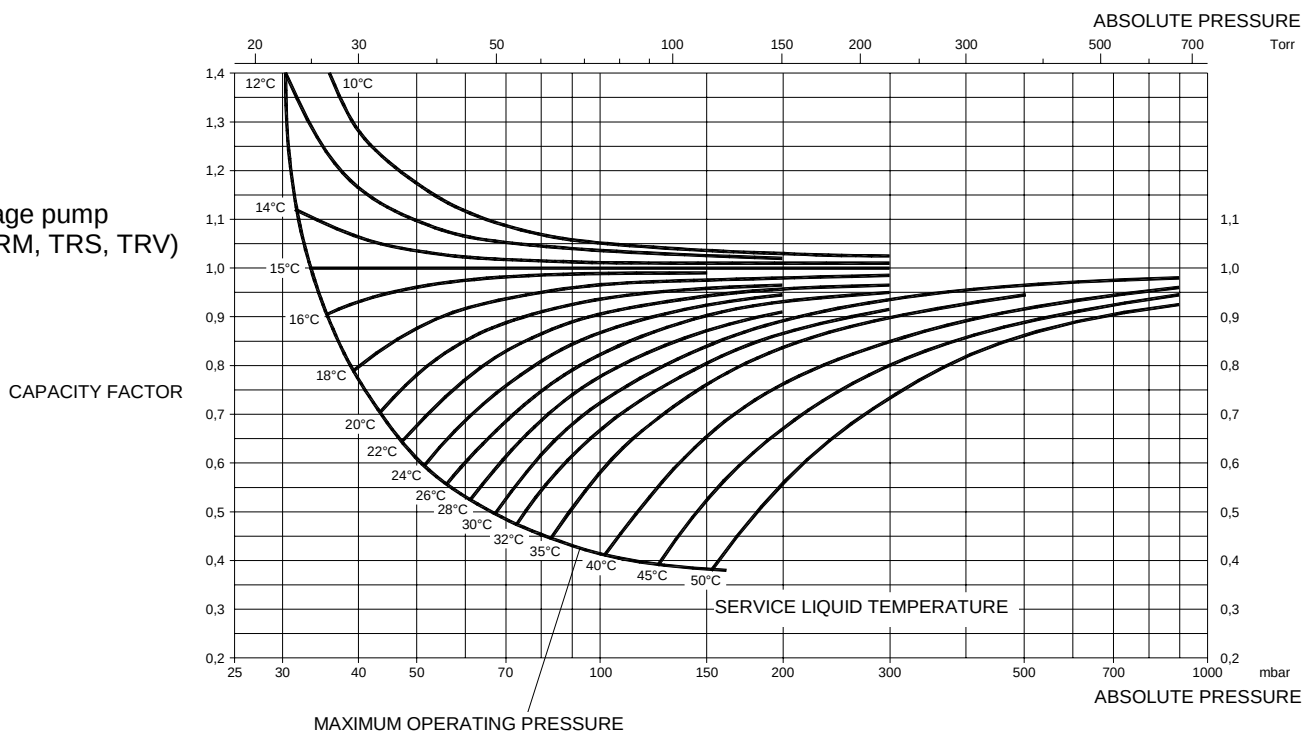
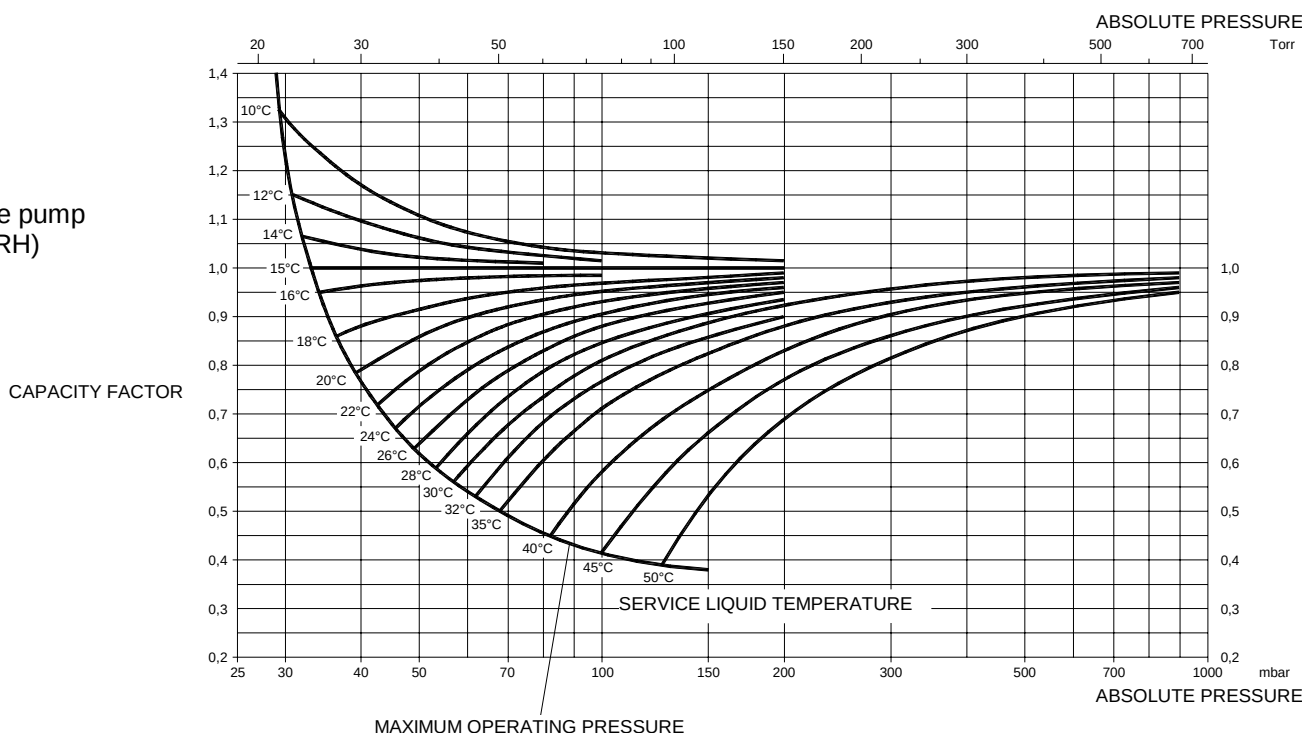


Fig. 30
Two stage pump
(series TRH)



17.2 - SERVICE LIQUID TEMPERATURE CHANGE ACROSS THE PUMP

The service liquid of a liquid ring pump absorbs total heat Q_T as follows:

$$Q_T \text{ (kJ/h)} = Q_c + Q_K + Q_R$$

Where:

$Q_c = 0,9 \times P \times 3600 =$ Isothermal compression heat

$Q_K = m_v \times r =$ Condensation heat

$Q_R = m_g \times c_p \times \Delta T_a =$ Cooling heat (Generally negligible, ignored in calculation of Q_T)

$m_v =$ mass condensed incoming vapour in kg/h

$m_g =$ mass incoming gas in kg/h

$P =$ absorbed power at operating point in kW

$c_p =$ gas specific heat in kJ/Kg $\times$ K

$r =$ heat of vaporisation in kJ/Kg

$\Delta T_a =$ differential temperature in K, between incoming gas T_G and service liquid discharge temperature ($T_2 + \Delta T$)

K = Kelvin temperature

Once the Q_T is known it is possible to calculate the differential temperature ΔT of the pump service liquid:

$$\Delta T = \frac{Q_T}{Q_A \cdot \rho \cdot c_p}$$

Where:

$Q_T =$ total heat load before calculated in kJ/h

$Q_A =$ pump service liquid flow in m³/h

$\rho =$ service liquid density in kg/m³ (water = 1000)

$c_p =$ service liquid specific heat in kJ/kg $\times$ K

(Some values for c_p : Water = 4,2 - Air = 1,0 - Water Vapour = 1,84)

NOTE: It can be assumed that the discharge gas and service liquid have same temperature.

17.3 - OPERATION WITH PARTIAL RECOVERY OF SERVICE LIQUID

Where the working conditions will allow it, the service liquid temperature can be increased utilising a smaller quantity of fresh liquid from an outside source. A similar flow as the make-up is discharged to the drain while the balance of liquid required by the pump is recirculated. In these cases the service liquid working temperature rises and the pump capacity will require correction per curves of fig. 29 and 30. The system installation will be similar to the schematic of fig. 31.

Depending upon the affordable loss of capacity the service liquid temperature T_2 may be set and the make-up flow of fresh liquid Q_F can then be calculated:

$$Q_F \text{ (m}^3\text{/h)} = \frac{Q_A \cdot \Delta T}{T_2 - T_1 + \Delta T}$$

where:

$Q_F =$ Fresh make-up flow from outside source in m³/h

$Q_A =$ Total service liquid flow required for the operating conditions in m³/h

$\Delta T =$ Service liquid temperature rise (see chapter 17.2)

$T_2 =$ Service liquid temperature to pump

$T_1 =$ Temperature of make-up liquid

The fig. 31 indicates a generic schematic of a liquid ring vacuum pump in a partial recovery system.

By closing the recirculation line the system would become a "once through" installation where all the service liquid is drained, therefore:

$$Q_A = Q_F \quad \text{and} \quad T_2 = T_1$$

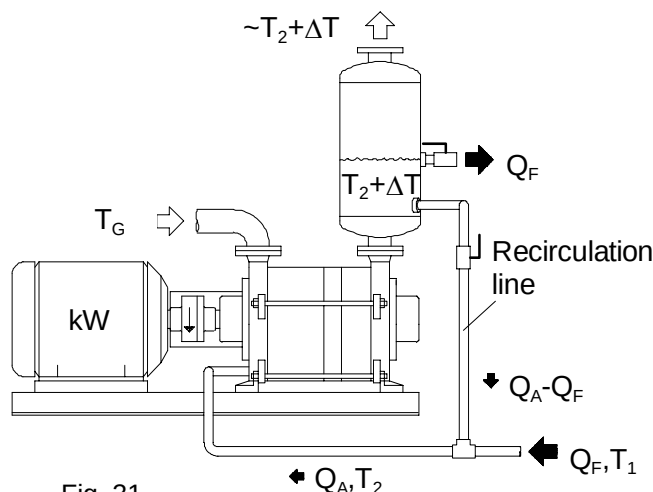


Fig. 31

17.4 - UNIT CONVERSION TABLE

Absolute pressure					Vacuum				Dry air flow at 15°C		Saturated vapour flow		Saturated water temperature		Vaporization heat
KPa	mbar	Torr	"Hg	Ata	%	mH2O	cmHg	"Hg	m3/kg	m3/kg	°C	°F	kJ/kg		
100	1013	760	30	1,033	0	0	0	0	0,816	1,673	100	212	2260		
90	900	700	25	0,9	10	1	10	5	0,9	2	95	210	2270		
80	800	600	20	0,8	20	2	20	10	1	2,5	90	200	2280		
70	700	500	15	0,7	30	3	30	15	1,5	3	85	190	2290		
60	600	400	10	0,6	40	4	40	20	2	4	80	180	2300		
50	500	300	7,5	0,5	50	5	50	25	2,5	5	75	170	2310		
40	400	250	6	0,4	60	6	60	30	3	6	70	160	2320		
30	300	200	5	0,3	70	7	70	35	3,5	7	65	150	2330		
25	250	150	4	0,25	75	7,5	75	40	4	8	60	140	2340		
20	200	100	3	0,2	80	8	80	45	5	9	55	130	2350		
15	150	75	2,5	0,15	85	8,5	85	50	6	10	50	120	2360		
10	100	50	2	0,1	90	9	90	55	7	11	45	110	2370		
9	90	45	1,8	0,09	91	9,1	91	60	8	12	40	100	2380		
8	80	40	1,5	0,08	92	9,2	92	65	9	13	35	90	2390		
7	70	35	1,3	0,07	93	9,3	93	70	10	14	30	80	2400		
6	60	30	1,1	0,06	94	9,4	94	75	11	15	25	70	2410		
5	50	25	0,9	0,05	95	9,5	95	80	12	16	20	60	2420		
4	40	20	0,7	0,04	96	9,6	96	85	13	17	15	50	2430		
3	30	15	0,6	0,03	97	9,7	97	90	14	18	10	40	2440		
2,5	25	12,5	0,5	0,025	97,5	9,75	97,5	95	15	19	5	32	2450		
2	20	10	0,4	0,02	98	9,8	98	100	16	20	0	32	2460		
1,5	15	7,5	0,3	0,015	98,5	9,85	98,5	105	17	21			2470		
1	10	5	0,2	0,01	99	9,9	99	110	18	22			2480		
0,9	9	4,5	0,15	0,009	99,1	9,91	99,1	115	19	23			2490		
0,8	8	4	0,12	0,008	99,2	9,92	99,2	120	20	24			2500		
0,7	7	3,5	0,1	0,007	99,3	9,93	99,3	125	21	25					
0,6	6	3	0,08	0,006	99,4	9,94	99,4	130	22	26					
0,5	5	2,5	0,06	0,005	99,5	9,95	99,5	135	23	27					

WORKING PRINCIPLE

The HYDROSYS packages main components are: a liquid ring vacuum pump ITEM 4 from series **TRH, TRS, TRM, TRV**, an air/liquid separator reservoir ITEM 1, a heat exchanger ITEM 9, all mounted on a common and compact frame ITEM 30. When working, the vacuum pump discharges from the discharge port the gas handled with a portion of the liquid from the pump internal liquid ring. This liquid must be continuously returned to the pump.

The gas/liquid mixture is separated in a cylindrical tank (separator), the gas is vented through the top mounted discharge flange of the separator and the liquid is collected at the bottom of the separator ready to be returned to the pump.

During the suction and compression cycle of the vacuum pump, all the energy is transformed into heat energy and almost all of it is absorbed by the service liquid. Therefore the liquid must be cooled prior to be returned to the pump, either with a heat exchanger (total recovery system) or with the addition of cool make-up liquid (partial recovery system).

The **TOTAL RECOVERY** system (see fig. 32 and legend on following page) does not require an appreciable flow of make-up from an external source but only the necessary amount to compensate for the liquid lost due to evaporation, with the discharged gases.

The heat exchanger sizing should be based on using a minimum amount of cooling liquid (usually water) to keep the service liquid at the ideal temperature for the best efficiency of the vacuum pump. Remember, the higher the temperature of the service liquid the higher the losses in pump capacity and maximum vacuum, see chapter 17.

This system is particular suitable where the service liquid and the condensed gases cannot be discharged to the environment, either for pollution reasons or because the fluids are too valuable.

The **PARTIAL RECOVERY** system (see fig. 33 and legend on following page) requires a constant flow of cold make-up liquid from an external source. This liquid must be of the same nature as the service liquid being used by the pump. The mixture of the make-up and the service liquid being discharged by the pump, will have a constant temperature when enters the vacuum pump service liquid connection.

The same amount of service liquid taken from the outside source must be overflowed through the separator overflow connection situated at the pump shaft centreline.

This system is utilised in many applications for conditions where there is intermittent use, or low vacuum levels, or there is no danger of pollution and the liquid can easily be drained.

Furthermore this may prove to be the only alternative to the total recovery system for those installations where the cooling liquid is not available or it is too warm.

Numerous accessories are available to meet the customers' requests and suitable for the installation, process and maintenance.

For materials of construction and some engineering data see tab. 11 and 12.

(General schematic drawings)

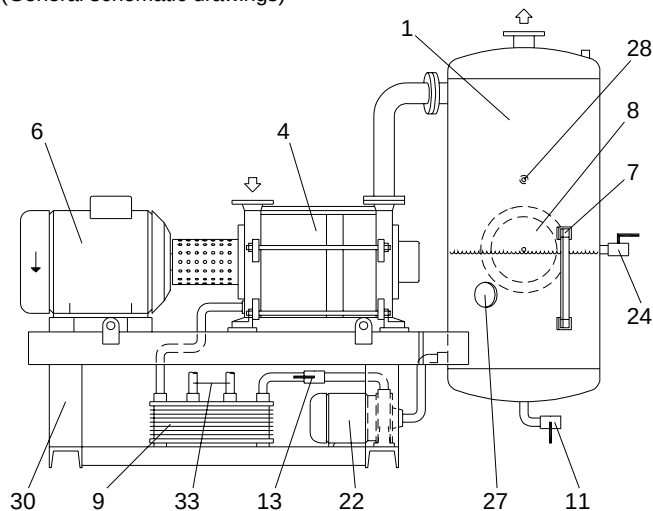


Fig. 32 - TOTAL RECOVERY system

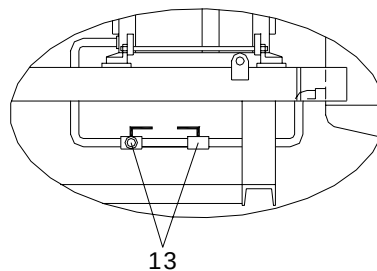


Fig. 33 - PARTIAL RECOVERY system

Tab. 11 - STANDARD MATERIALS FOR “HYDROSYS” SYSTEMS

COMPONENT		MATERIAL DESIGN	
Vacuum pump		GH - F - RA Carbon steel	A3
Separator reservoir			AISI 316 SS
Frame			
Heat Exchanger	Plates	AISI 316 SS	
	Gaskets	Nitrile rubber / Viton	
Circulating pump		Cast iron	AISI 316 SS
Piping		Carbon steel	
Valves – Thermometer		Brass	
Level gauge		Polycarbonate	“Pirex” Glass

For vacuum pump materials (GH - F - RA - A3) see chapter 4.

SOME EXAMPLES OF “HYDROSYS” SYSTEMS (General schematic drawings)

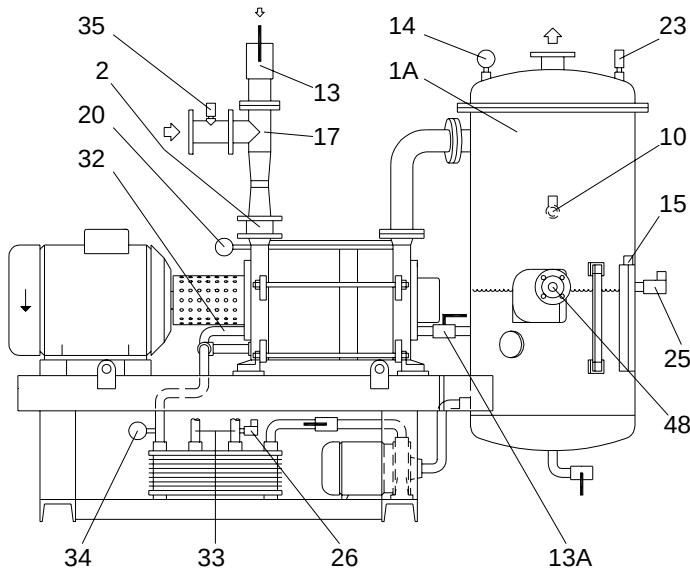


Fig. 34 - Accessories upon request

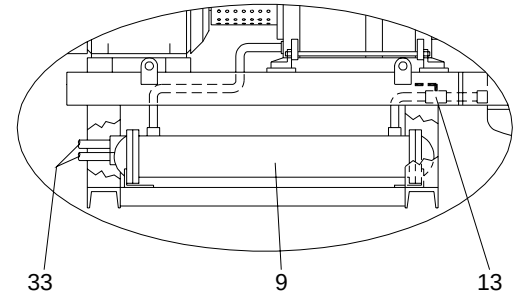


Fig. 35 - Option with Shell & Tubes heat exchanger

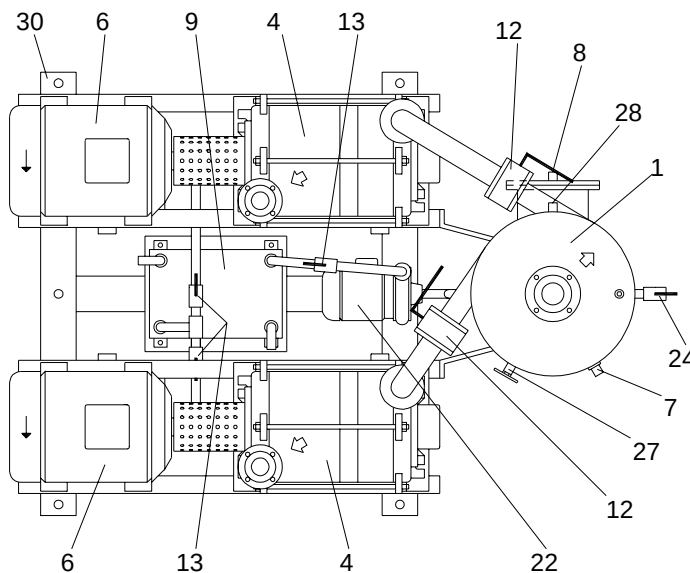


Fig. 36 - Duplex system, total recovery (Top view)

LEGEND

- 1 Separator reservoir
- 1A Separator reservoir with removable lid
- 2 Check valve
- 4 Vacuum pump
- 6 Electric motor
- 7 Level gauge
- 8 Float valve
- 9 Heat exchanger
- 10 Solenoid valve liquid make-up
- 11 Drain valve
- 12 Isolating valve
- 13 Service liquid flow regulating valve
- 13A By-pass valve
- 14 Pressure gauge
- 15 Level switch
- 17 Air ejector
- 20 Vacuum gauge
- 22 Circulating pump
- 23 Pressure relief valve
- 24 Overflow valve
- 25 Solenoid valve for overflow
- 26 Solenoid valve for cooling liquid
- 27 Thermometer
- 28 Fill connection
- 30 Frame
- 32 By-pass piping
- 33 Connection cooling lines
- 34 Temperature switch
- 35 Vacuum relief valve
- 48 Automatic drain valve (for systems used as Compressor only)

Tab. 12 - GENERAL AND NOT BINDING ENGINEERING DETAILS FOR “HYDROSYS” & “OILSYS” SYSTEMS

PACKAGE SERIES	Motor size	Dry weight without Pump and Motor kg		Service Liquid Quantity litres	Service Oil Quantity litres
		HYDROSYS	OILSYS		
HYDROSYS 2	3 kW 2 poles / 50 Hz	80	180	12	40
HYDROSYS 3	4 kW 4 poles / 50 Hz	90	220	35	98
HYDROSYS 4	7,5 kW 4 poles / 50 Hz	120	280	50	110
HYDROSYS 5	15 kW 4 poles / 50 Hz	150	350	80	145
HYDROSYS 6	30 kW 4 poles / 50 Hz	230	500	135	186
HYDROSYS 7	45 kW 6 poles / 50 Hz	500	750	320	360

WORKING PRINCIPLE

OILSYS packages main components are: a liquid ring vacuum pump ITEM 4 from series **TRH, TRS, TRM, TRV**, an air/liquid separator reservoir ITEM 1B which is also a self-contained frame, a heat exchanger ITEM 9 and an oil demister filter ITEM 1C.

Turbine type mineral oil, or equal (see tab. 13), is used for service liquid. The characteristics of the chosen oil are such that at pressures below 100 mbar, the pump capacity is greater than what would be when using water, and higher vacuum levels are attainable. When working, the vacuum pump discharges the gas handled with a portion of the liquid in the special frame ITEM 1B that acts as separator of gas from the oil and let settle any condensable or particles coming through the pump suction flange. The circulator pump ITEM 22 pumps the oil back to the vacuum pump after it has been through the heat exchanger ITEM 9 and cooled at about 60/80 °C. The gas is vented after being cleaned of all oil with the special oil demister element; a pressure gauge ITEM 14 on the filter housing ITEM 1C gives indication of the degree of dirt contained by the filter element. Special inspection openings ITEMS 43 are easily accessible for maintenance and cleaning of the frame separator. Contrary to rotary vane vacuum pumps, there are no moving parts that come in contact with each other, therefore there is no need for lubrication of the pump internals; these are very robust and reliable pump packages which offer extended operating life even when handling condensable gases. See tab. 14 for materials of construction and tab. 12 in chapter 18 for some engineering data.

Tab. 13 - SUGGESTED OILS

MANUFACTURER	TYPE
AGIP	OTE 32
ESSO	TERESSO 32
LUBRA	OLNEO 32
MOBIL	DTE LIGHT 32
SHELL	TURBO OIL 32
TOTAL	PRESLIA 32

COMPONENT	MATERIAL DESIGN
Vacuum pump	GH - F - RA
Frame separator reservoir	Carbon steel
Heat exchanger air-oil	Cooler core
	Shroud
	Fan – Guard
Circulating pump	Cast iron
Piping	Carbon steel - Carburite rubber
Valves – Thermometer	Brass
Level gauge	Polycarbonate

Tab. 14 - STANDARD MATERIALS FOR "OILSYS" SYSTEMS

See chapter 4 for vacuum pump materials of construction (GH - F - RA).

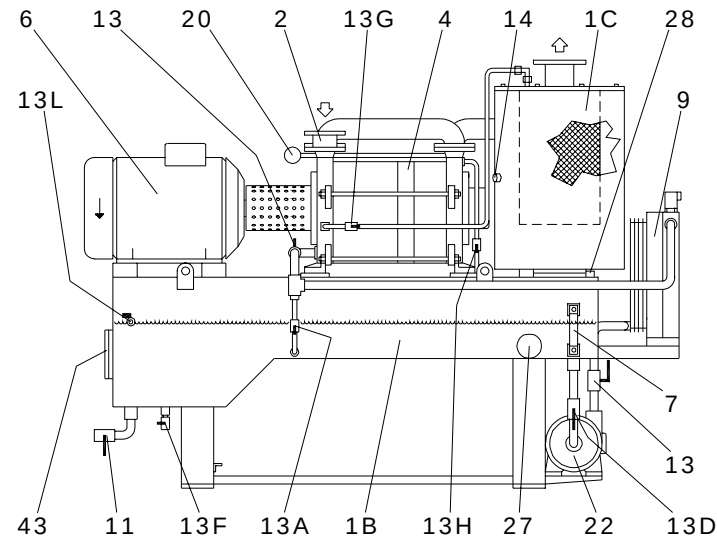


Fig. 37 - STANDARD design

LEGEND

1B - Frame separator	11 - Drain valve
1C - Filter housing	11A - Drain valve
1D - Cyclone separator	12 - Overflow valve
1E - Collecting tank	13 - Flow regulating valve
2 - Check valve	13A - By-pass valve
4 - Vacuum pump	13C - By-pass valve
6 - Electric motor	13D - Isolating valve
7 - Level gauge	13E - Isolating valve
9 - Heat exchanger	13F - Condensate drain valve

13G - Oil drain valve
13H - Anti-cavitation valve
13L - Condensate drain valve
14 - Pressure gauge
20 - Vacuum gauge
22 - Circulating pump
27 - Thermometer
28 - Fill connection
43 - Inspection openings

(General schematic drawings)

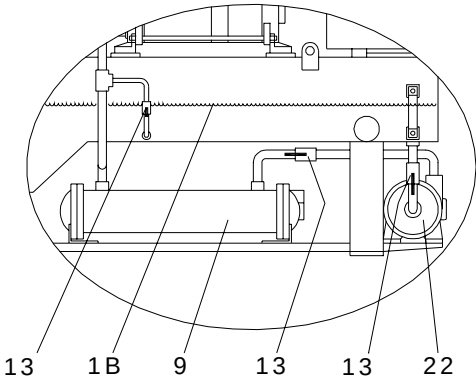


Fig. 38 - Option with Shell & Tube heat exchanger

NOTES

PUMP model	Serial Number	Computer Number	Year of manuf.
.....			

GAS handled	Capacitym ³ /h	Suction Pressurembar	Discharge Press.mbar	Temperature°C
☐ Lethal ☐ Toxic ☐ Noxious ☐ Corrosive ☐ Malodorous ☐				

Service LIQUID	Capacity	Temperature
.....	 m ³ /h	 °C

TOTAL WEIGHT
.....KGS.

MAXIMUM DIMENSIONS	
	X =cm Y =cm Z =cm

NOISE (measured at 1 m)	
Pressure	=.....dB(A)
Power	=.....dB(A)

INSTALLATION	
☐ Inside	☐ Outside
☐ Explosive area	☐

SERVICE	
☐	Continuous
☐	Intermittent
☐	

MOTOR type / Frame	No Poles	No Revolutions	Absorbed power	Installed power
.....		RPM	Amp	kW /HP
Frequency	Supply	Enclosure	Insulation class	Absorbed power
.....Hz	Volt	IP.....		kW /HP

COMMENTS

[illegible]

MONOSTAGE CENTRIFUGAL PUMPS

**MAGNETIC DRIVE
MONOSTAGE CENTRIFUGAL PUMPS**

SELF-PRIMING CENTRIFUGAL PUMPS

**MAGNETIC DRIVE
SELF-PRIMING CENTRIFUGAL PUMPS**

MULTISTAGE CENTRIFUGAL PUMPS

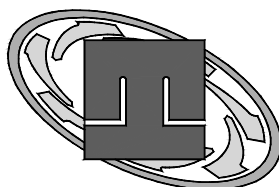
LIQUID RING VACUUM PUMPS

LIQUID RING COMPRESSORS

**PACKAGE VACUUM UNITS WITH PARTIAL OR TOTAL
SERVICE LIQUID RECIRCULATION**

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