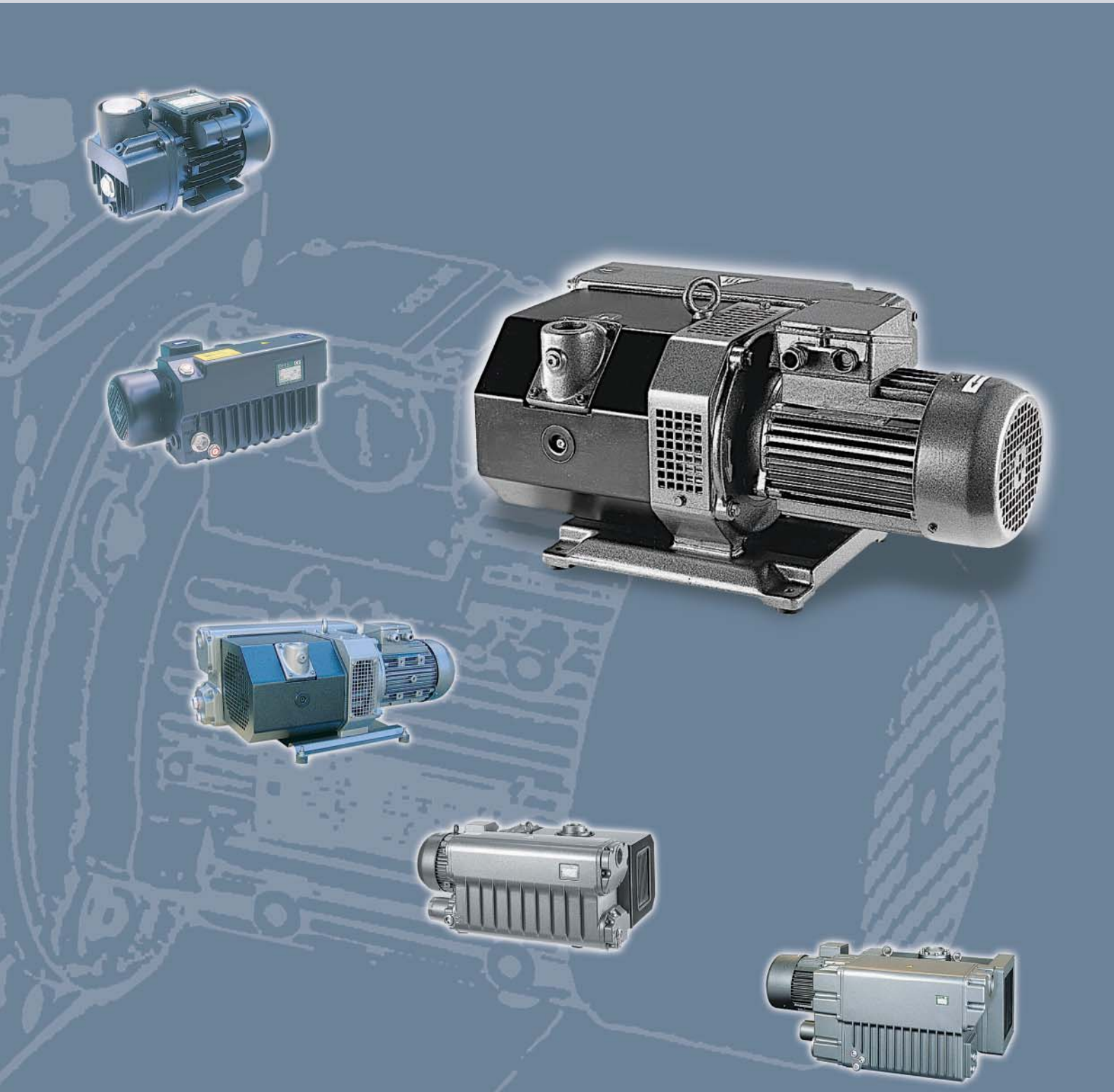
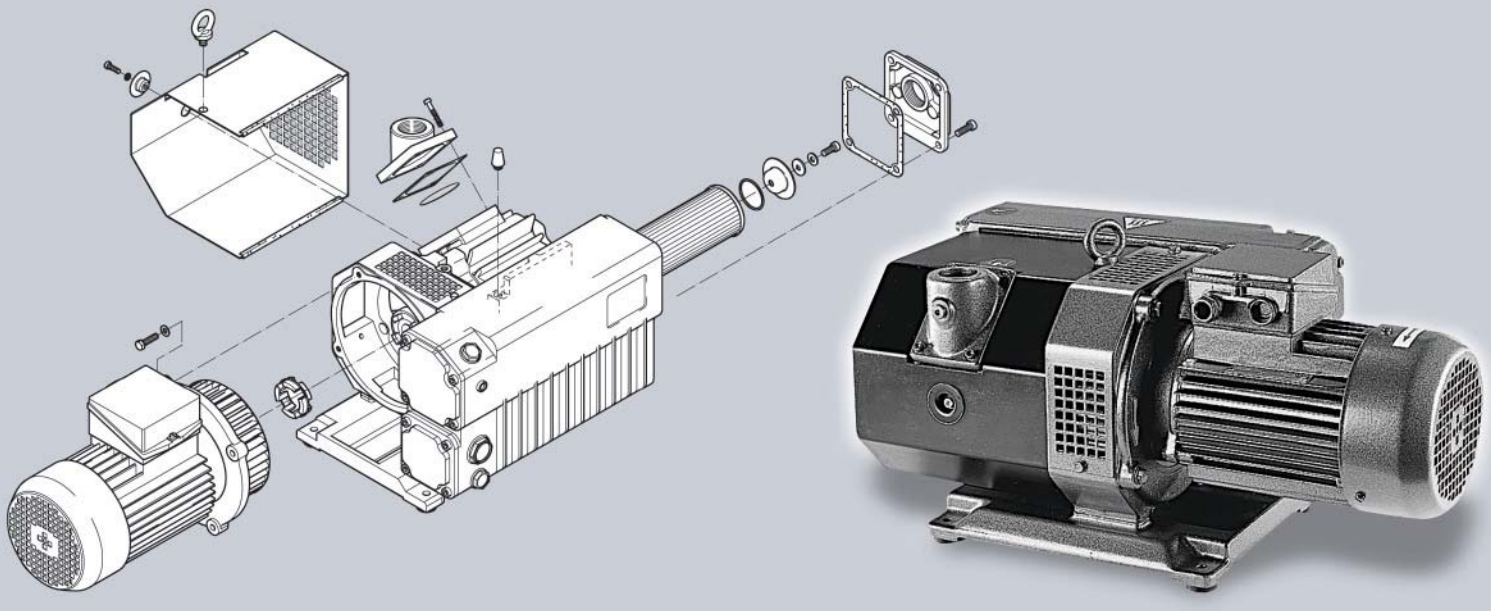
PVR oil lubricated rotary vane vacuum pump



P.V.R. s.r.l.
pompe per vuoto Rotant

P.V.R s.r.l.
pompe per vuoto Rotant

Oil lubricated rotary vane vacuum pump



Index

1 INTRODUCTION

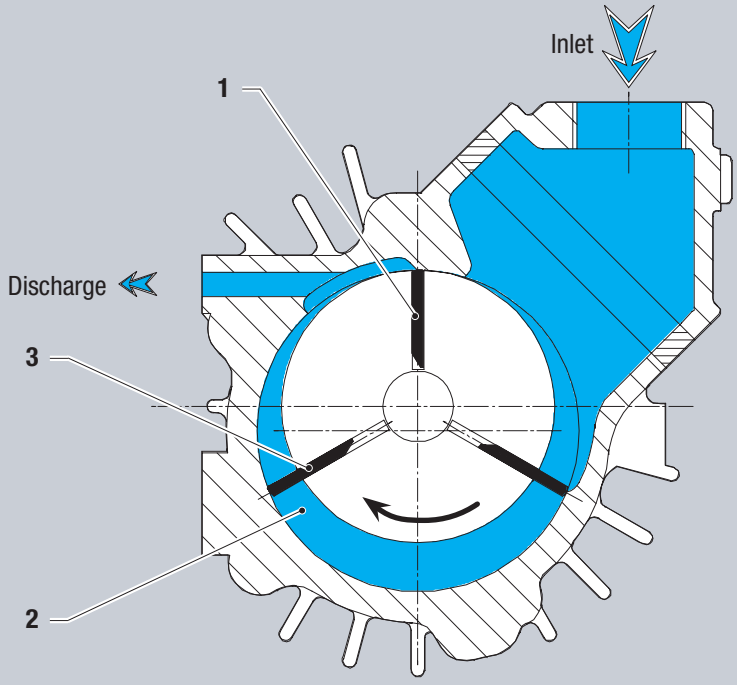
The purpose of this document is to introduce you in the world of oil lubricated rotary vane vacuum pumps.
Here you will find the description of the operating principle and of the pump components.
By means of this manual, you'll learn how to select the suitable pump type, according to the type of system the pump will have to be installed in.
The manual will be helpful to meet customer's requirements and to avoid that any unpleasant misunderstanding takes place once the sale has been completed.

The goal of this manual is to improve knowledge of **P.V.R.**'s products and thanks to your help we wish to optimize **P.V.R.**'s product image at the customer.
However, when our vacuum pumps have to be installed in new applications or any time there is a doubt on the good result of the installation, please ask the technical advice of our vacuum experts.
In this document, the pump type **EU 45/65/105** has been taken as a reference.

2 OPERATING PRINCIPLE

Vacuum pumps series **PVL** and **EU** are backing rotary vane, single-stage vacuum pumps with oil circulation system.
A rotor with three slots (**1**) is positioned eccentrically inside a body of pump (**2**) and it is supported by means of two end plates with their bearings.
Three vanes (**3**), free of sliding in the rotor slots, keep adhering to the body of pump surface when rotating, thanks to the centrifugal force.

Accordingly, three sections with variable volume are obtained and they generate an air flow from the suction area to the discharge one.
The capacity of the achieved flow is proportional to the volume included between the vanes and the rotor revolution numbers.



Oil lubricated rotary vane vacuum pump

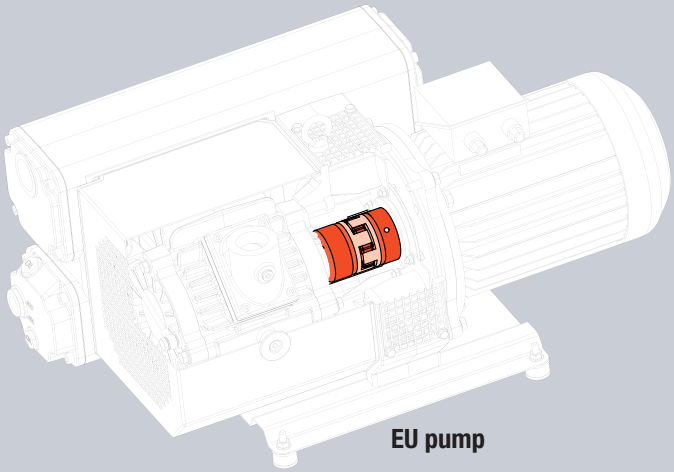
2.1 WHAT THE OIL IS NEEDED FOR?

Inside the body of pump, a specific oil amount is sucked, having a lubrication effect in the contact areas (vanes and bearing).
Besides, it acts as a sealing between the remaining clearances between the different organs in movement.

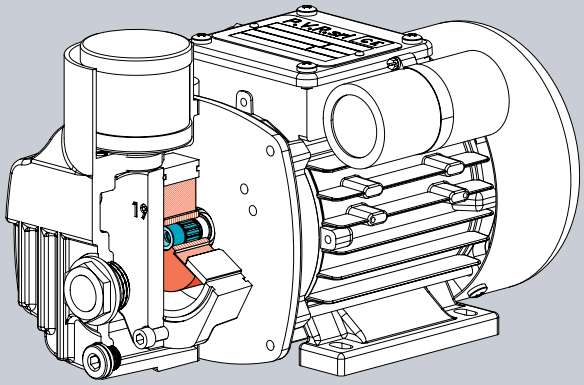
2.2 ELECTRIC MOTOR

(ref. picture 2)

The electric motor is the pump driving unit. It could be connected to the pump directly by means of a flange and elastic coupling (series **PVL** and **EU**) or, for the **EM** series, its shaft works as a coupling pin for allowing the rotor fitting. In this case, there isn't any elastic coupling for the motion drive.



EU pump

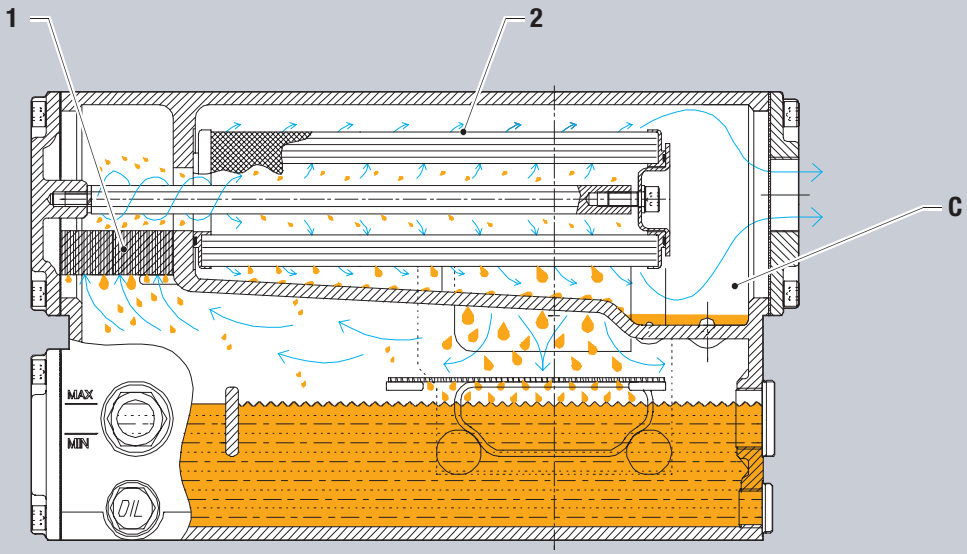


EM pump

2.3 SYSTEM FOR SEPARATING THE OIL FROM THE DISCHARGED AIR

The air containing oil goes through the first sector of the tank in the area which contains the lubricating oil charge. The heaviest parts fall directly to the bottom, while the light parts and the smokes are carried over by the flow and go through the demister (**1**). Here a first rough separation takes place, while the final separation is made through the exhaust filter (**2**).

The oil smokes gather in larger drops which fall to the second sector of the tank (**area C**).
The lubricant which cumulated is put again in circulation by means of the oil recovery line, while the air almost purified, is discharged from the tank through the discharge hole.

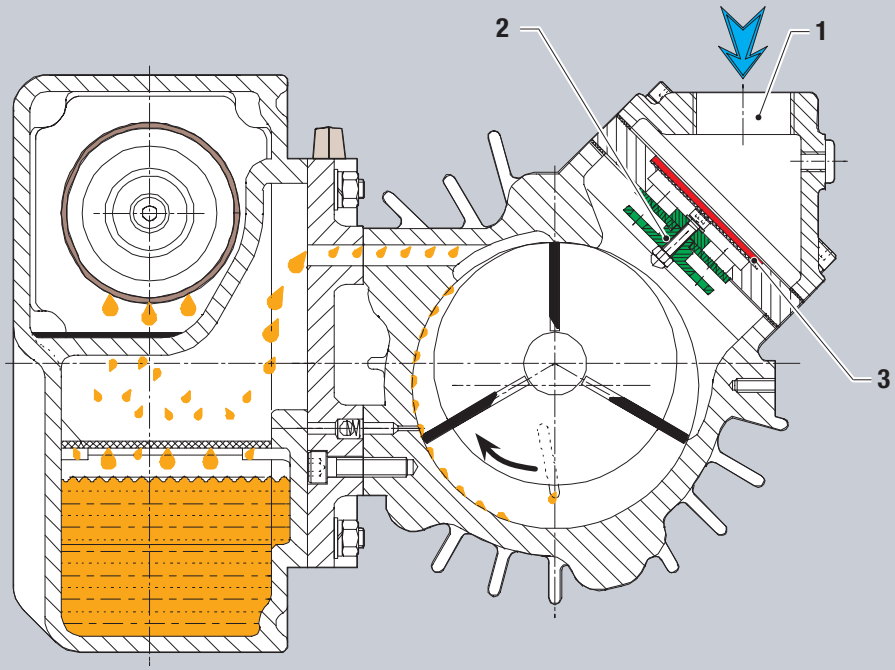


2.4 INLET PORT

Every pump is equipped with an inlet threaded port (**1**) to allow the pump connection to the application, by means of pipelines.
An inlet non-return valve (**2**) and a protection filter (**3**) are fitted on the pumps.
The valve prevents the air and the oil from coming back from the chamber to be pumped down, in case the pump is stopped with the system under vacuum.
The inlet protection filter is a s/s large mesh disk and it protects the pump from entering of parts of a certain size.
It is recommended to install an inlet external filter for protection from dust or other parts of small sizes.
On larger pumps (**PVL 400-540**) inlet paper elements are standard fitted.
Elements made of different materials and with different filtering power are available on demand.

2.5 PUMP COOLING

The pump cooling is made by heat removal by means of ventilation *(air cooling)*.
Smaller pumps, **EM** series, **PVL10** to **PVL35**, are cooled superficially by means of the electric motor fan.
On **EU 45/65/105** pumps, the pump is fitted with a centrifugal fan which generates the cooling flow.
Larger capacity pumps are cooled by an air/oil heat exchanger and a centrifugal fan.
In this way the lubricant is cooled before entering the body of pump.



2.6 PUMP LUBRICATION

The lubrication of the pump takes place by pressure difference through a circuit which connects the oil tank to the pump.
The pressure difference is given by the vacuum which is made in the pump, during its operation, and by the pressure in the tank *(atmospheric pressure + backpressure oil separators)*. This makes a flow in the tank which goes towards the pump body.
The higher the vacuum level is, the more oil goes in the pump body.
On the contrary, if the pump runs at the atmospheric pressure or outside the recommended vacuum levels, lubrication is poor or absent, as for **PVL** series.

Such a situation can damage the rotating parts of the pump body *(vanes and bearings)* seriously. Sometimes, the rotor inside the pump body may seize, too.
The lubricant is sucked inside the rotor in the body of pump so that the bearings and the vanes get lubricated.
Then, the oil goes out through the end plate slots to allow getting the contact areas between vanes and body of pump lubricated.
Then, the lubricant is expelled through the discharge holes in the body of pump and goes into the tank, where it is separated from the air.

2.7 OIL RECOVERY LINE CIRCUIT

The oil collected in the second sector of the tank (**area C**) is recovered through a line which connects this part to an internal area of the body of pump.

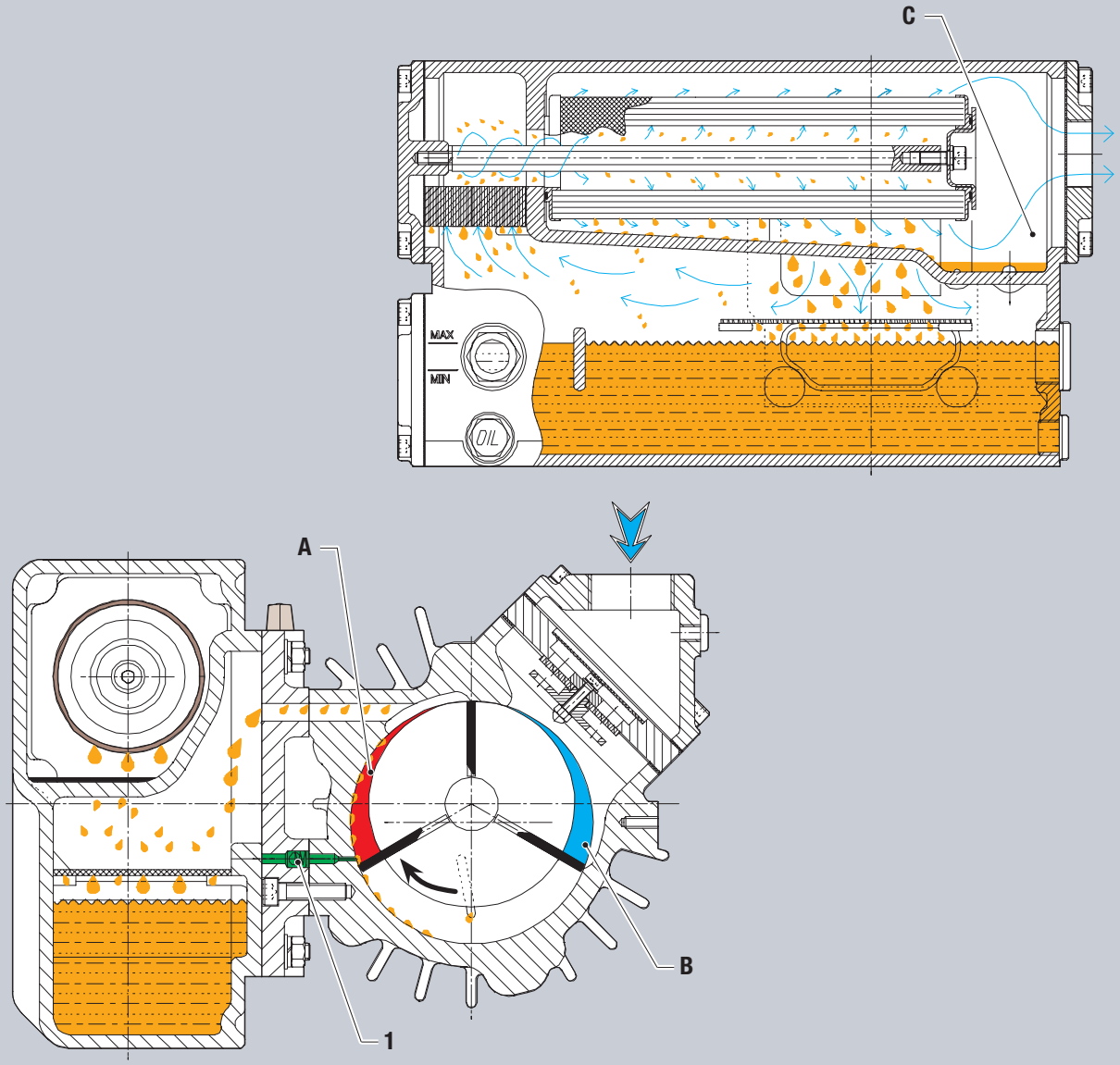
For **PVL** and **EU** pumps *(0.5 mbar)* the circuit ends near the discharge slots (**area A**) of the pump, while for the **PVL .../B** and **EU .../B** pumps *(10 or 20 mbar)* it goes to the inlet area (**area B**).

In the first case, the recovery takes place only when the pump is working at an inlet pressure lower than 400 mbar *(abs.)*. In the operating range from 1013 to 400 mbar *(abs.)* in this circuit there isn't any negative pressure but pressure.

To avoid air and oil coming back, a valve is fitted (**1**).
In **PVL .../B** and **EU .../B** the recovery takes place in the whole operating pump range to the detriment of the ultimate pressure. Practically speaking it is the same as if there would be a small hole in the inlet pipes.

WARNING

This circuit is the only constructive difference between the two pump versions.
The resulting different performances affect the right choice for the various applications.



2.8 DESCRIPTION OF THE GAS BALLAST VALVE CIRCUIT

This line connects the gas ballast valve to the inside of the body of pump in the same area where the oil recovery line finishes (**area A**).
For this reason, the air flow coming from outside takes place only when the pump is running at an inlet pressure lower than 300 mbar *(abs.)*.
In the pressure range from 1013 to 300 mbar *(abs.)*, the valve prevents the air and the oil from going back to outside.

Gas ballast valve operating principle
At a given temperature, the vapour may be compressed only up to the saturation pressure. If that point is overpassed, vapour condenses.
For example, at 100°C vapour may be compressed to only 1013,2 mbar. At higher pressure, the vapour will condense.
In a container of water *(at ambient temperature)*, the pump will start to lower the pressure to the water evaporation point *(if the water is at 25°C at sea level, the evaporation pressure will be 31.67 mbar absolute)*.

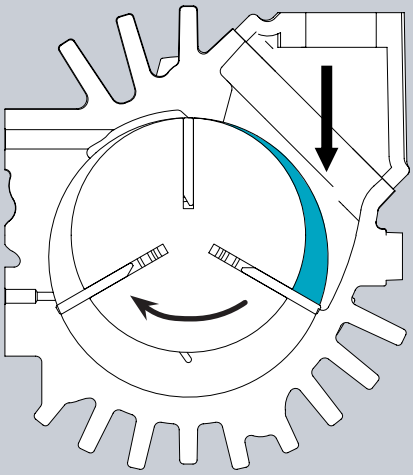
Looking at the picture, **phase 1**, the pump will start pumping a mixture of air and water vapour.

During **phase 2**, the intake volume is isolated from the original container and exhaust pipe. In this stage, the valve on the gas ballast valve opens and let air come in, to change the saturation pressure of the mixture.

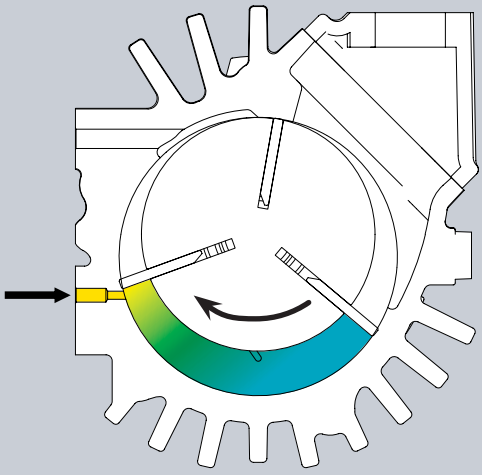
During the **final stage**, the mixture containing fresh air is exhausted. Having the saturation pressure changed, no condensation drops will form, and the intake vapour may be discharged from the pump without affecting its operation.

Therefore, the pump temperature is extremely important.
Please heat the pump before starting pumping any condensable gas.

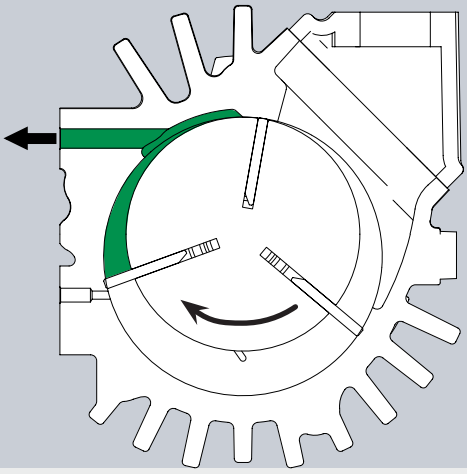
Phase 1



Phase 2

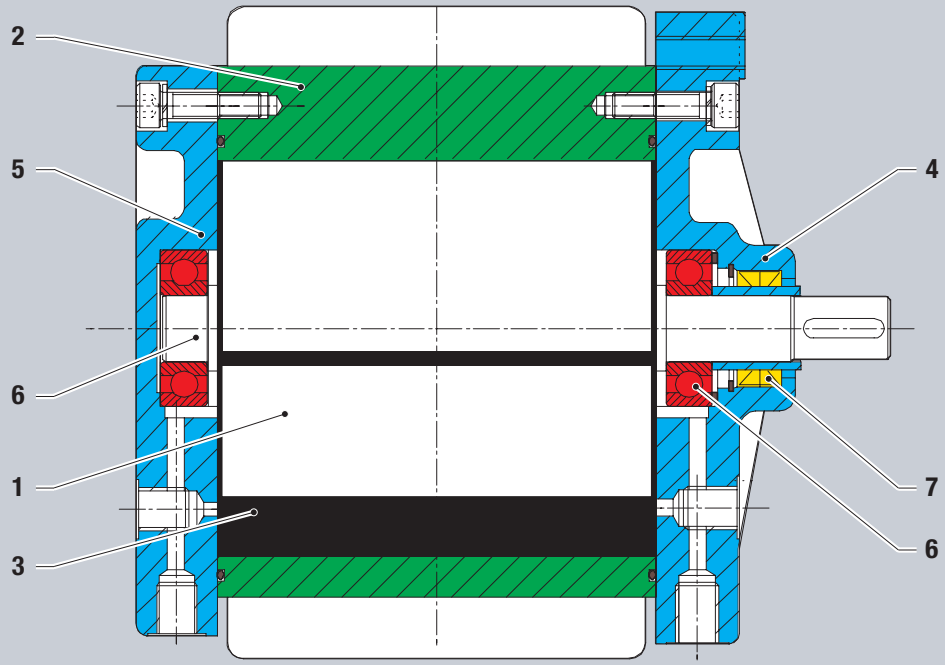


Final stage



2.9 MATERIALS USED FOR THE MAIN COMPONENTS

- **Rotor** (**1**) machined from a C45 steel bar.
- **Housing** (**2**) machined from a G20 or G25 grey cast iron casting.
- **Vane** (**3**) machined from composite materials on epoxy resins basis reinforced with carbon.
- **Motor end plate** (**4**) and **external end plate** (**5**) machined from G20 or G25 grey cast iron casting.
- **Bearing** (**6**) ball, roll or needle type *(depending on the pump size)*.
- **Oil seals shaft** (**7**) on the rotating shaft, made of Viton *(FKM)*.
- **Tank** made of hardened and tempered aluminium G Al Si 7 casting.



3 PUMP SIZING

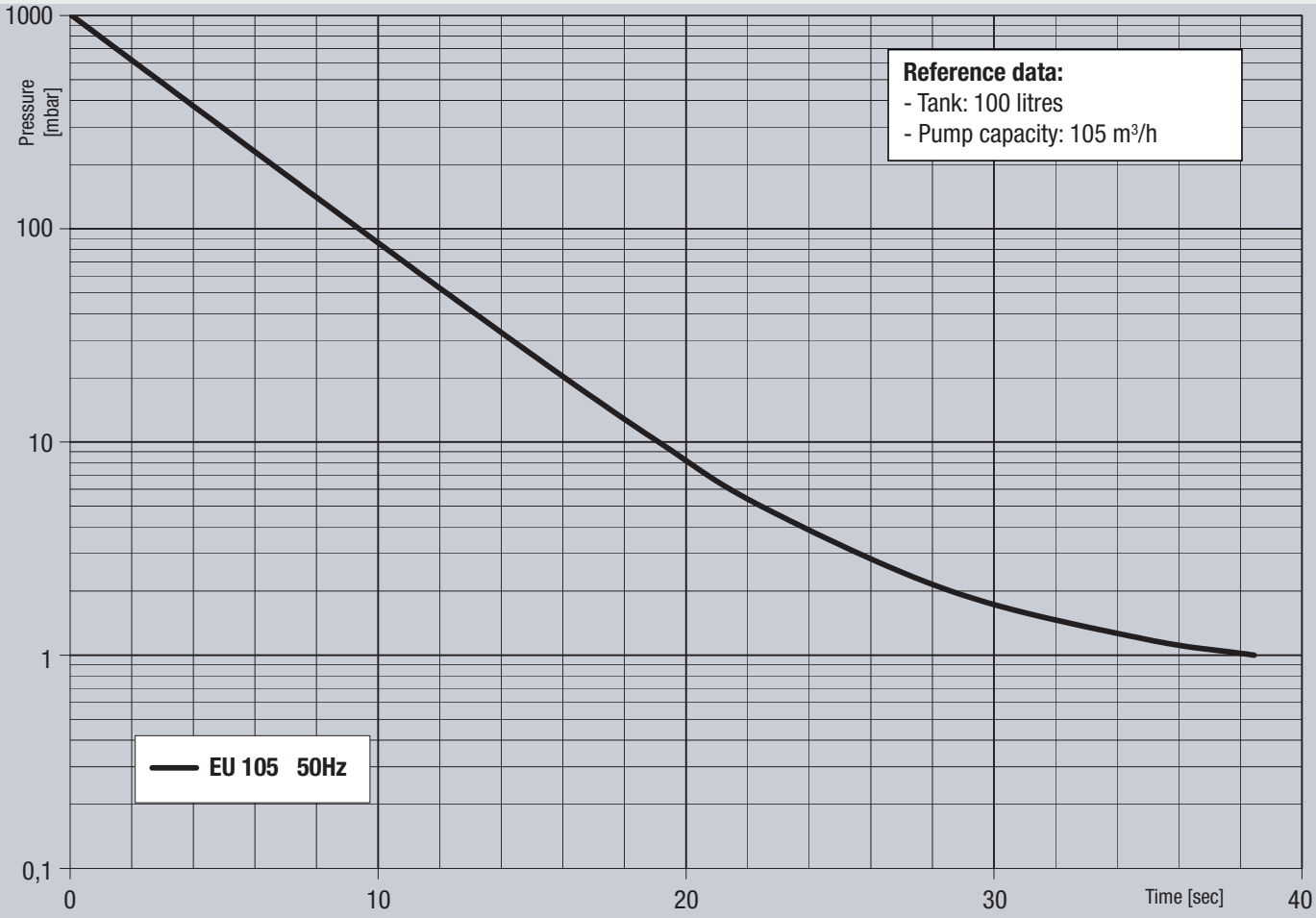
3.1 PUMPING DOWN TIME OF A TANK USING A VANE VACUUM PUMP

$$T = \frac{V}{S} \times \ln \frac{Pi}{Pf}$$

where:

T = Pumping down time *(h)*
V = Tank volume *(m^3)*
S = Effective capacity of the pump or pumping system *(m^3/h)*
Pi = Tank starting pressure *(mbar)*
Pf = Tank ultimate pressure *(mbar)*
Ln = Natural logarithm

This formula is not easy to be used as when the inlet pressure changes, the effective capacity of the pump decreases.
In order to get a more reliable result, it is better to use the pumping down time of a sample vessel with our vane vacuum pumps.



		PVL 10	PVL 15	PVL 25	PVL 35	EU 45	EU 65	EU 105	EU 160	EU 205	EU 300	PVL 400	PVL 540	EU 750	EU 1000
Nominal revoultions number on 50 Hz	*[rpm]*	1500												1000	
Nominal capacity 50 Hz	*[m³/h]*	13	18	25	36	48	69	105	152	207	290	417	553	780	1033
Nominal revoultions number on 60 Hz	*[rpm]*	1800												1200	
Nominal capacity 60 Hz	*[m³/h]*	16	22	30	43	58	83	126	182	248	348	500	664	936	1240

$$T_x = T_{105} \times \frac{S_{105}}{S_x} \times \frac{V_x}{V_{100}}$$

KEY TO SYMBOLS:

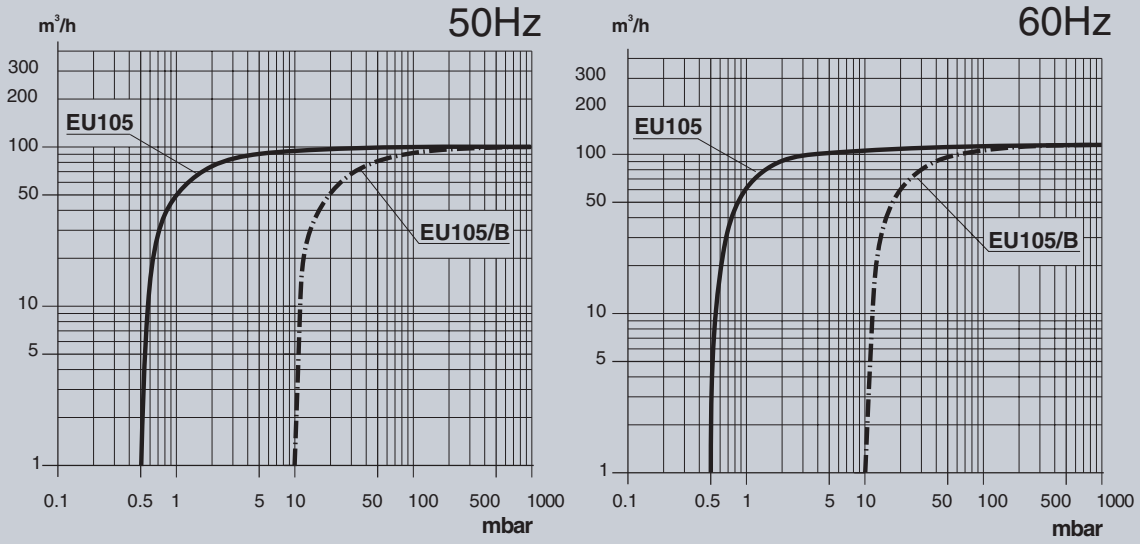
T_x = Pumping down time
T_{105} = Pumping down time got from the curve
S_{105} = Nominal capacity of the reference pump (105 m³/h)
S_x = Nominal capacity of the selected pump (see the table)
V_x = Tank volume to be pumped down
V_{100} = Reference tank volume (100 litres)

3.2 PERFORMANCE CURVES

The performance curve highlights the capacity flow when the inlet pressure changes.

At the pump ultimate pressure, its capacity is equal to zero.
The performance curve changes depending on the pump type *(EU or EU/B)*.

Oil lubricated rotary vane vacuum pump



3.3 UNITS CONVERSION

CONVERSION CHART

PUMPING SPEED

MULTIPLY NO. OF →

TO OBTAIN ↓

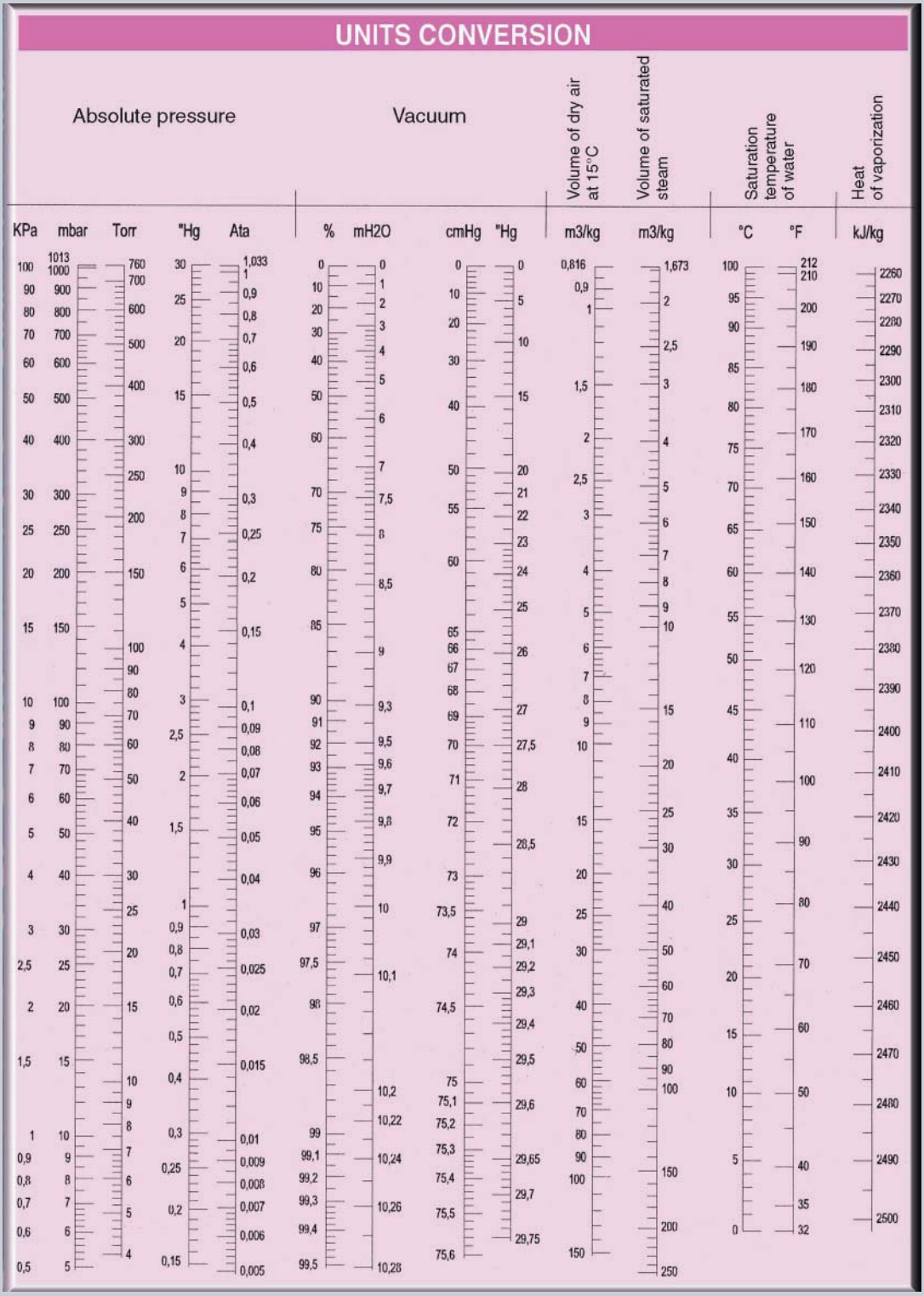
By	Litre/Sec.	Litro/Min	m³/h	C.F.M.
Litre/sec.	1	1.667×10^{-2}	0.2778	0.4719
Litre/min.	60	1	16.67	28.32
m³/h	3.6	6×10^{-2}	1	1.698
C.F.M.	2.12	3.53×10^{-2}	0.589	1

VOLUME AND CAPACITY

By	Litre	m³	ft³	U.S.Gal	Imp.Gal
Litre	1	10^{3}	28.32	3.785	4.545
m³	10^{-3}	1	2.83×10^{-2}	3.785×10^{-3}	4.545×10^{-3}
ft³	3.53×10^{-2}	35.3	1	1.33×10^{-2}	0.16
U.S.Gal	2.641×10^{-2}	264.17	7.48	1	1.2
Imp.Gal	0.219	219.96	6.228	8.32×10^{-2}	1

PRESSURE AND HEAD

By	Kilopascal kPa	Newton/m² Pascal	kg/cm²	P.S.I. ib/in²
Kilopascal kPa	1	10^{-3}	98	6895
Pascal Pa	1000	1	9.807×10^{4}	6895
Kg/cm²	0.0102	1.02×10^{-5}	1	0.0703
P.S.I. ib/in²	0.145	1.45×10^{-4}	14.23	1


UNITS CONVERSION
Absolute pressure
Vacuum
Volume of dry air at 15°C
Volume of saturated steam
Saturation temperature of water
Heat of vaporization
KPa
mbar
Torr
"Hg
Ata
%
mH2O
cmHg
"Hg
m3/kg
m3/kg
°C
°F
kJ/kg

3.4 TECHNICAL-COMMERCIAL QUESTIONNAIRE

The following questionnaire has been prepared to help gathering needed information to be able to size and choose the suitable pump or vacuum system.

P.V.R. s.r.l. pompe per vuoto Rotant	TECHNICAL-COMMERCIAL QUESTIONNAIRE Prepared by Sales Office Manager: *C. Scola* Approved by Management Representative: *A. Isella*	Mod. 4. 3. 1. 8 Rev. 2 Rif. P. 4.3.1 D.E.: 240204

COMPANY: ..... CONTACT PERSON: ..... SIGNATURE .....
Tel. No.: ..... **Fax:** ..... **E-mail:** ..... **Date:** .....
==========

ENQUIRY:

❑ Vacuum pump type..... ❑ Pumping group type .....
❑ Pump sizing ❑ System sizing
❑ Pump replacement ❑ Coupling to other pumps
❑ Central vacuum system ❑ Electric control panel
❑ Accessories.....
==========

APPLICATION DESCRIPTION: .....
Machine to be coupled to the pump:- type: ..... Manufacturer ..... Year: .....
Port size: ϕ_e..... mm Thread: ..... Electropneumatic valve ❑ No ❑ Yes
Standards or laws to be observed: .....

==========

INFORMATION ON THE OPERATING CYCLE: ❑ Pump down cycles ❑ Operation at a constant pressure*
Volume to be pumped down.....m^3 Ultimate pressure: ..... mbar $_{absolute}$ Time needed:.....
Time of operation at the ultimate pressure: ..... Time between two cycles:.....
Pump operation: ❑ Continuous ❑ Intermitting
Daily hours of operation: ..... Number of starting per hour: .....
*Needed effective capacity: ..... m3/h at a pressure of: ..... mbar min ..... max ..... mbar
==========

INFORMATION ON THE TREATED PRODUCT:
Description:.....Temperature:.....°C Gases or vapours: ..... Quantity: .....
Possibility of sucking dust or solid parts: ❑ No ❑ Yes Type: .....
Possibility of sucking liquid: ❑ No ❑ Yes Type: .....
==========

ENVIRONMENTAL CONDITIONS: ❑ Inside room ❑ External room
Ambient temperature: min .....°C max .....°C Height $_{asl}$: .....m

P.V.R. s.r.l. pompe per vuoto Rotant	**TECHNICAL-COMMERCIAL QUESTIONNAIRE** **Prepared by Sales Office Manager:** ***C. Scola*** **Approved by Management Representative:** ***A. Isella***	Mod. 4. 3. 1. 8 Rev. 2 Rif. P. 4.3.1 D.E.: 240204

==========

ELECTRIC VOLTAGE: .....V ± .....% Frequency: ❑ 50 Hz ❑ 60 Hz ❑ Variation through an inverter

==========

INFORMATION ON THE VACUUM SYSTEM:

Pipe inside diameter: (ϕ_i) .....mm Pipe total length ..... m

❑ Rigid ..... m ϕ_i..... mm ❑ Flexible ..... m ϕ_i..... mm

Tanks on line ❑ No ❑ Yes Volume m3

Please specify if filters or other protections are present on line ❑ No ❑ Yes

Description:.....

==========

INFORMATION ON PUMPS ALREADY EXISTING ON THE SYSTEM OR PUMPS TO BE REPLACED:

Vane pump: Type .....Manufacturer: ..... ❑ to be replaced ❑ to be coupled

Oil used: ❑ Mineral ❑ Synthetic (type.....)

Roots pumps Model: .....Manufacturer: .....❑ to be replaced ❑ to be coupled

Other pump models: Model: .....Manufacturer: .....❑ to be replaced ❑ to be coupled

Date .....P.V.R. Sales Dept. (signature)_____/ QUOTATION Nr. .....

⚠ WARNING ⚠

In order to get a reply, it is essential that all the fields are filled in.

3.5 LUBRICANTS

Use the mineral oil for compressor according to **DIN 51506** group **VC-VCL** or **VDL** classification **ISO L-DAG**.
It is also possible to use synthetic oil polyalphaolefins *(PAO)* oils classification **ISO L-DAH** and **ISO L-DAJ** that may lengthen the oil change until 2000 hours of operation.
Alternatively, use motor oil **SAE 10W-30** *(PVL10-35 and EU45-65)* and **SAE 15W-40** *(EU105 to EU 1000)*.

The ambient temperature where the pump has to be installed in is very important for the lubricant choice.
The lubricant normally used for a pump, considering a standard ambient temperature of **20°C**, can be used within **5** and **40°C**.
If temperature is **<5°C**, please use a more fluid oil.

4 ACCESSORIES

4.1 AIR FILTER

When a vacuum pump has been selected for a specific application, please always consider that the pump could only handle air or small quantities of water vapour. Therefore, it is essential to check that any dust or other substance are present in the process, to prevent any pump damage.
The pump could be equipped with external filters, which stop the sucked dirty. The filter housings could contain three different type of elements, i.e. paper, polyester, stainless steel.
Paper elements are usually used in the systems where the handled products are dry *(paper industry, packaging, handling, etc.)*.

Polyester elements are used in systems where dust is very thin *(processing of coffee, flour, etc.)*. Their advantage is that they can be washed.
Filters with stainless steel element are recommended for those systems where remarkable quantities of water vapour are pumped *(meat tumblers, vacuum washing machines, etc.)*. These filters are available with filtering power of 60 and 15 micron and they can be cleaned with aggressive products, too.

Paper element

Polyester element

Stainless steel element

4.2 SAFETY

On demand it is possible to get the pump equipped with following safety devices, which protect the pump from any anomaly that might compromise its good operation.

The sensors are as follows:

- Low oil level gauge;
- Pressure switch/ pressure gauge to check exhaust filters blockage;
- Bimetallic temperature switch.

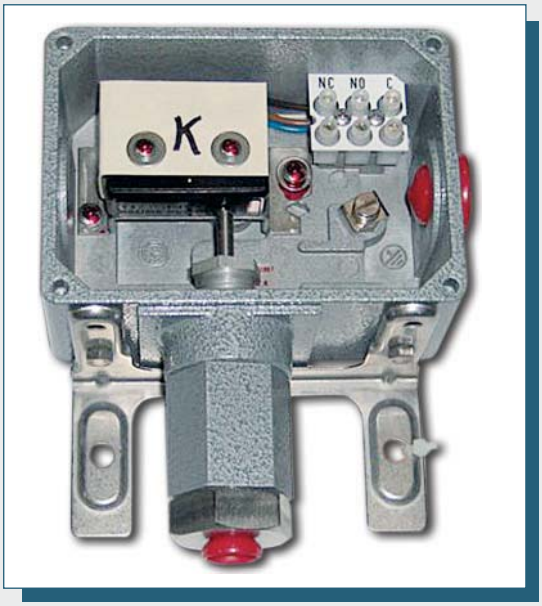
Low oil level switch
It checks that inside the tank there is always a sufficient amount of oil. It is formed by a small float which runs on a probe and it opens or closes a contact positioned inside the probe itself.
The sensor is installed having the contact **NC** *(normally closed)* in presence of oil.
When the contact is installed in the electric system, please allow 10-15 sec. delay. During that time, the signal will be continuous.
This action is taken to prevent any false signals, which might come from the sensor oscillating because of air flow present in the tank.

Bimetallic temperature switch

Low oil level switch

Pressure switch
It gives a signal that the pressure inside pump tank is higher than the allowed threshold.
Such a value is equal to the maximum pressure allowed by the exhaust filter. The contact is usually installed as **NC**. The signal shouldn't get delayed and therefore the pump must be stopped immediately.

Bimetallic temperature switch
It gives the signal that the pump temperature has overpassed the safety threshold.
This accessory is available for **EU 105-1000** and **PVL 400-540**.



Pressure switch

5 APPLICATIONS

Please find the list of the main applications where our pumps are used.

- Vacuum packaging machine
- Vacuum tumbler
- Continuous de-areation tunnel
- Vacuum packing machines
- Thermoforming machine

Oil lubricated rotary vane vacuum pump

Vacuum packaging machines

Vacuum tumbler

Vacuum tumbler

Vacuum tumbler

Thermoforming machine

Oil lubricated rotary vane vacuum pump

Thermoforming machine

Thermoforming machine

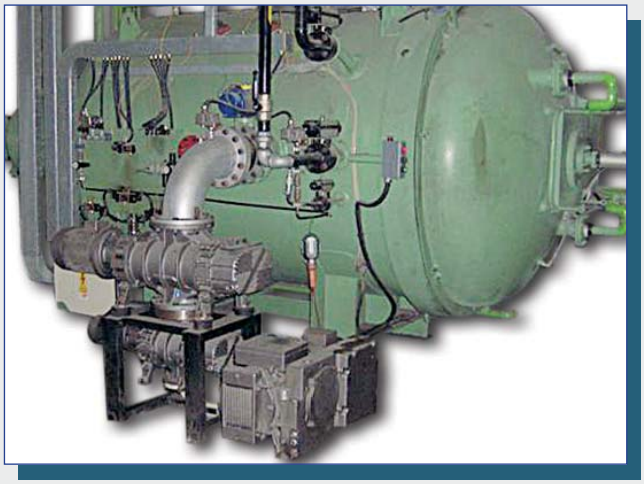
Vacuum packaging machine

Vacuum packaging machine

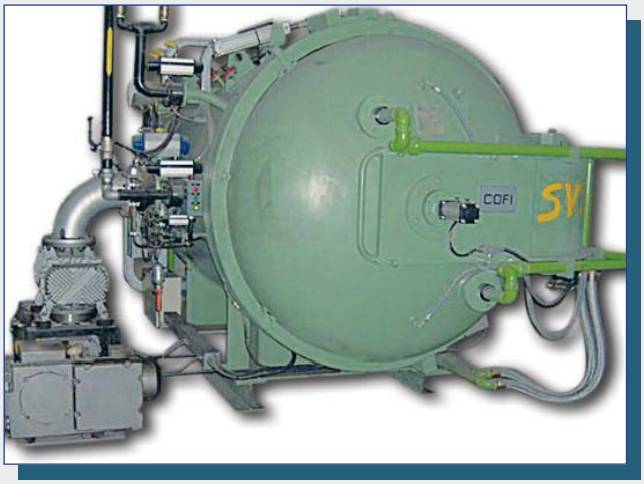
Continuous de-areation tunnel

Continuous de-areation tunnel

Oil lubricated rotary vane vacuum pump



Heat treatment



Heat treatment

Lifting and handling

Lifting and handling

Central vacuum system

FOOD INDUSTRY	
Vacuum packaging machines	*(belt type or static type)* for ham or fresh meat (*).
Automatic vertical packaging machines	for coffee and rice (*).
Thermoforming machines	for vacuum and/or modified atmosphere packaging, using trays (*).
Automatic vacuum and /or modified atmosphere thermosealing machines	used to tightly seal plastic containers.
Equipment for continuous packing of Sausages & Salami	
Vacuum mixing and blending machines	for sausages.
Vacuum tumbler	for cooked ham.
Continuous de-aeration tunnel	for cooked ham.
Mixing and blending machines	for pasta and bread processing - Presses.
Poultry slaughtering plants	
Vacuum refrigeration plants	for (*)vegetables.
Vacuum presses	for extraction of wine juices.
Bottling filling machines	for beverages
Vacuum double sealers	for metal containers.
Vacuum chambers	for treatment of agricultural product.

(*) Possible application of pump with vacuum booster

MARBLE INDUSTRY	
CNC milling machines, boring machines, routing machines, vertical profiling machines	having vacuum tables for slab or plate hold-down (#).
Machinery to lift, transport and handling of slabs and machined parts	Loading and unloading of block cutting machines (#).
Systems for production of agglomerates	
Sintering machines for diamond tools	

WOOD INDUSTRY	
CNC routing machines, vertical boring machines	fitted with vacuum tables for panel hold-down (#).
Suction cup mechanical handler	for panel-boards (#). Loading and unloading of conveying production lines.
Presses	for plywood.

GLASS INDUSTRY	
Autoclaves	for laminated glass.
Presses and blow machines	for hollow glass.
Cutting machines, edging machines, engraving of flat glass	fitted with vacuum operated system for hold-down with suction cups.
Handling machines, loading and tilting machines with suction cups	to lift and to move glass sheets and machined products (#).

(#) Possible application for central vacuum systems

Oil lubricated rotary vane vacuum pump

MECHANICAL, METALLURGICAL AND ELECTROMECHANICAL INDUSTRY IN GENERAL	
Modular equipment	for CNC machines fitted with vacuum holding system.
Pressing and/or folding machines	for metal sheets fitted with vacuum loading and unloading machine (#).
Industrial robots and installations	fitted with vacuum systems for sheet metal handling in processing lines.
Sheet metal buffing machines	fitted with vacuum table.
Vacuum casters	for metal fusion.
Ovens	for brazing, quenching, nitriding and recovery treatments (*).
Treatment and degassing of insulating oil	in electric transformers (*).
Vacuum impregnation systems	for electric motors and electrolytic capacitors.
Decontamination and purification systems	for hydraulic and other oils used for the lubrication and/or in oil-pressure equipment.
Vacuum drying chambers	for castings.
Laser chambers	for cutting machines (*).
Autoclaves	for composite material treatment.
Resins degassing installations	

(#) Possible application for central vacuum systems
(*) Possible application of pump with vacuum booster

PAPER CONVERTING INDUSTRY
Corrugated board press and converting machines.

VARNISH INDUSTRY
Mixers and/or dispenser of hydraulic oils with degassing system.

CERAMIC INDUSTRY	
Mixer and degassing machines	for ceramics, clay and terracotta, extruders.
Mixer and degassing machines of plaster	for the production of dies.
Automatic handling and/or warehousing devices	fitted with carts having vacuum systems (#).

(#) Possible application for central vacuum systems

PHARMACEUTICAL, CHEMICAL, COSMETIC INDUSTRY	
Thermoforming machines	for packaging pharmaceutical products *(syringes, gauze, etc.)*.
Vertical mixers	with degassing system for creams, ointments and toothpaste.
Vacuum granulating machines and dryers	for pharmaceutical products (*).
Central vacuum systems	for chemical, pharmaceutical and university laboratories (#).
Vacuum solvents recovery and treatment plants	
Central vacuum systems	for operating rooms and hospital beds (#).
Automatic mixers with degassing systems	for plaster coating.
Vacuum filling systems	for packaging pharmaceutical products.
Filling and sealing machines	for aerosol cans or small bottles for pharmaceutical and chemical products.

(#) Possible application for central vacuum systems
(*) Possible application of pump with vacuum booster

RUBBER AND PLASTIC INDUSTRY	
Thermoforming machines	for plastic objects *(plates, trays, cups, containers)*.
CNC machining centres	for cutting plastic and/or composites components.
Vacuum assisted machines or presses	for injection of rubber or plastic (**#**).
Extruders	for blown film.
Extruders	for master-batch.
Laboratory micro-extruders	
Systems for sublimation and condensation	coating on plastic products (*****).
Autoclaves	for tyre top capping using vacuum devices.

(**#**) Possible application for central vacuum systems
(*****) Possible application of pump with vacuum booster

GOLDSMITH INDUSTRY
Vacuum degassing for casting and micro-casting

SHPIBUILDING INDUSTRY	
Central vacuum plants and systems for dejection, evacuation and conveying	from toilettes to storage containers.

GENERAL INDUSTRY	
Motor pump priming industry	for turbid, muddy, slimy waters.
Blister packaging machines, thermosealing machines.	
Plants and machines	for the movement of abrasive grinding wheel.

APPLICATIONS FOR ROOTS PUMPS

FOOD INDUSTRY	
Vacuum packaging machines *(belt type or static type)* for ham or fresh meat	Air is removed from the package *(tray or bag)* so that the product is better preserved.

MECHANICAL, METALLURGICAL AND ELECTROMECHANICAL INDUSTRY IN GENERAL	
Ovens for nitriding	Pressure inside the ovens must reach values near to **1x10^{-2} mbar** so that the process can start.
Treatment and degassing of insulating oil in electric transformers	Water/humidity must be removed from the oil. Roots pumps are needed to speed up the process.

MECHANICAL, METALLURGICAL AND ELECTROMECHANICAL INDUSTRY IN GENERAL	
Vacuum drying chambers for castings	The vacuum pumping unit formed by rotary vane pumps and Roots pumps is used to let evaporate the residual of water remained after having washed the aluminium engine housings. The achieved residual pressure is 10 mbar. The Roots pump is used to speed up the cycle.

PHARMACEUTICAL, CHEMICAL, COSMETIC INDUSTRY	
Vacuum granulating machines and dryers for pharmaceutical products	The vacuum pumping system must dry the product *(powders, etc.)* in tray dryer before it is used.

RUBBER AND PLASTIC INDUSTRY	
Systems for sublimation and condensation coating on plastic products	Pressures equal to **1x10^{-5} mbar** must be achieved to start the coating and/or the surface coating by physical vapour deposition *(PVD)*. The pumping system is needed to prime a diffusion pump to achieve the stated pressures.

OTHERS	
Desalination plant	The technology being employed is called low temperature thermal desalination *(LTTD)*. Warm water is injected into a flash chamber, which is maintained in vacuum. The vapour generated is condensed, using cold deep seawater. Thus fresh water is produced.

6 OPERATING AND SERVICING INSTRUCTIONS MANUAL

(ref. to EU45/65 instructions manual)