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Operation Manual

Oil-Injected Screw Compressor Stages

22.7.2010
EU COMP GmbH, Reinhard Wundsam

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Introduction

Dear Customer,

EU COMP GmbH is a new company for engineering, development, supplying and servicing of screw compressor air ends, type oil-injected. The experience of our engineering capacities goes back to the very beginning of manufacturing this type of compressor worldwide in the late 50ths of the last century. EU COMP unifies this capacity power, and offers you the benefits of this.

EU COMP GmbH is located in Rheinfelden in Germany, close to Switzerland, Rheinfelden.

Which benefit you have from EU COMP?

What EU COMP offers to you as our OEM customer is a range of screw compressor air ends fom 7hp up to 200kW. Besides the german engineering, the manufacturing machines in Asia are mostly made in Germany, as much as we are using german bearing suppliers, and other european sources for standardized and high quality proven components. This serves to a highest degree of quality and reliability.

You have the benefits on your side, using EU COMP screw air ends:
- High quality of service, and product
- Short delivery time due to high manufacturing capacities
- Reasonable pricing because of using proven components
- Availability of air ends ready for sale in our worldwide warehouses
- Wide range of screw air ends, covering 7.5...200kW
- Encapsulated screw units are already in preparation
- Availability of air as much as natural gas compressors

Our manufacturing partners in Asia are certified by ISO 9001 Quality Standard System.

What is the next step?

If you are interested in expanding your business to include high efficiency, high performance EU COMP screw compressor air ends or or other components, please contact us by mail, phone. We look forward to hearing about your company and your other business activities.

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EU COMP´s oil-injected screw compressor stages

The main characteristics of EU COMP´s screw compressor stages are:

- State-of-the-art design
- High efficiency
- Vibration-optimized quiet running
- High volumetric efficiency
- Long service life
- High degree of operational reliability

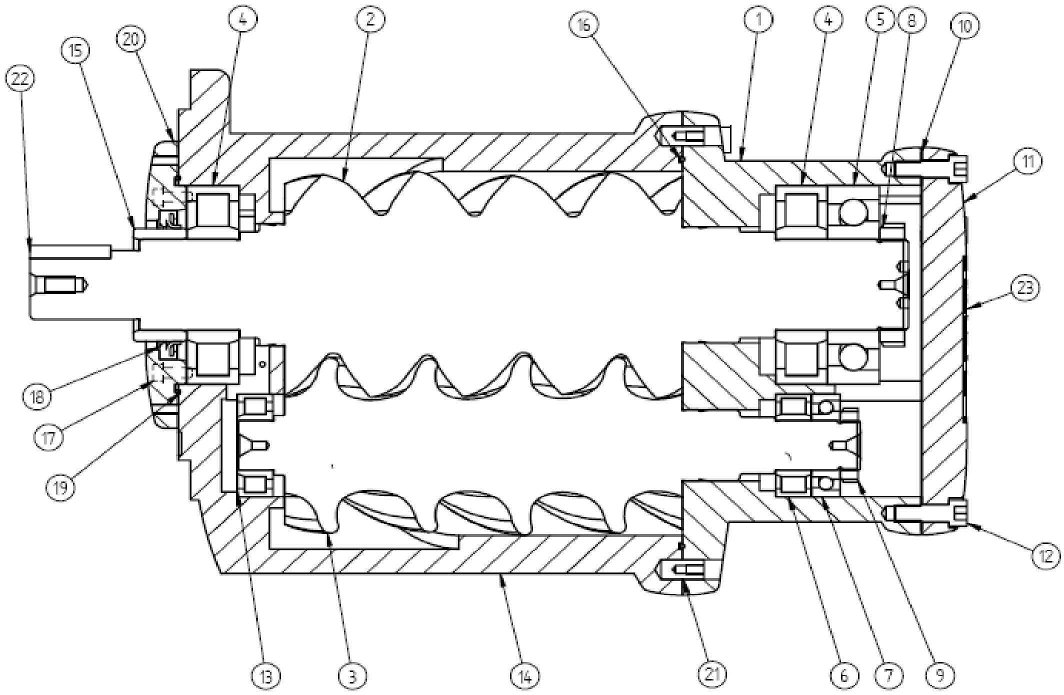

Fig: Inner design of EU COMP´s screw stages (series EU11… EU45)

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Description of items:

1	casing discharge bearing
2	male rotor
3	female rotor
4	cylinder roller bearing
5	angular roller bearing
6	cylinder roller bearing
7	angular ball bearing
8	welnut
9	welnut
10	gasket
11	end cover
12	bolt
13	cylinder roller bearing
14	rotor casing
15	lip seal sleeve
16	O-ring
17	bolt
18	double lip seal
19	O-ring
20	front cover
21	centering pin
22	fitting key
23	logo plate

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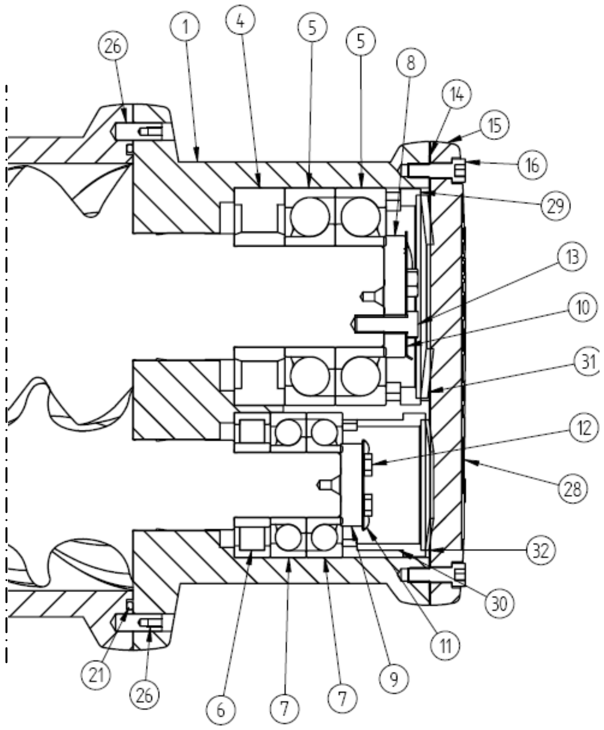

Fig: Discharge bearing system for EU75...EU160

Rotor shape:

The screw shape developed for EU COMP places high demands on energy efficiency and vibration-optimized quiet running. The male rotor has a convex rotor shape, the female rotor has a concave one. The rotors have tooth combinations selected to fit each other, which in partice is considered optimal in the work area under consideration. The male rotor has 5 teeth, the female rotor has 6. This tooth combination brings about the most effective energy increase in the compression medium, due to the similar circumference speed ratios of the two rotors, and thus reduces excessive fluid flowback. This ultimately results in optimized volumetric efficiency.

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Fig: EU COMP´s high precision rotors

The shaped parts, machined with high-precision grinding tools, correspond to the current world standard.

Fig: Grinding tools according to world standard

Efficiency:

The EU COMP screw compressors, compressor medium flowback through the gab between the rotors and the housing is minimized with the aim of optimizing the specific power consumption [kW/m^3/min]. In order to keep internal leakages losses low, the clearance between all components must be observed very precisely.

Extensive studies were conducted during the development of the rotors in order to become familiar with the influence of the machining processes on the dimensional stability of the rotor geometry. Analyses provide information on the

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precise distribution of temperature and force over the rotors under operating conditions.

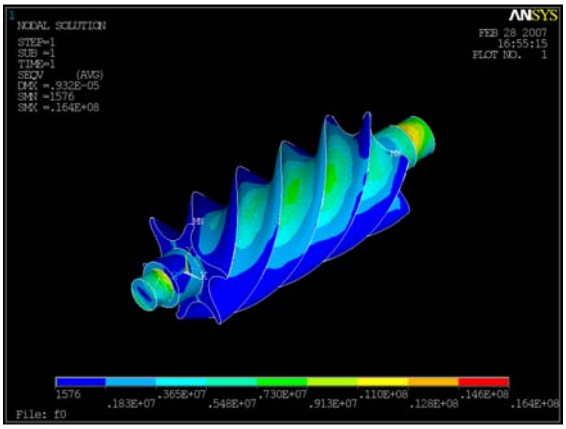

Fig: Analysis of rotors under operating conditions

In order to get closer to the aim of isothermal compression, the cooling of the compressor medium by the injected oil is calculated precisely. By optimizing the compressor heat, the workload of the compressor is reduced. The energy efficiency of your compressor system is thus also increased.

Maintenance:

EU COMP screw compressors have been designed with the aim of enabling maintenance work with minimum effort. The components affected here are easy for the user to access and maintain. The number of components has been reduced, on the condition however of maximum compressor reliability. The seals and bearing were thus generously dimensioned for a long service life and a high degree of operational reliability.

Maintenance instructions, maintenance kits and tolls are available in order to guarantee reliable operation of the screw compressor.

Reliability:

The highest aims during the design of the EU COMP screw compressors were energy efficiency, reliability and operational safety.

Precision roller bearings from globally recognised manufacturers and the combination of cylindrical roller bearings and angular contact ball bearings on the pressure side of both rotors ensure robust and long-lasting reliability, even under

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difficult operating conditions. Low process tolerances during the production of the major components of a screw compressor stage on predominantly European production machines ensure reliable operation.

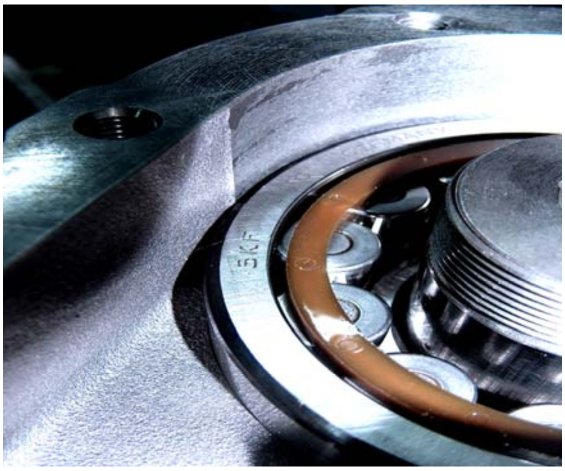

Fig: Analysis of rotors under operating conditions

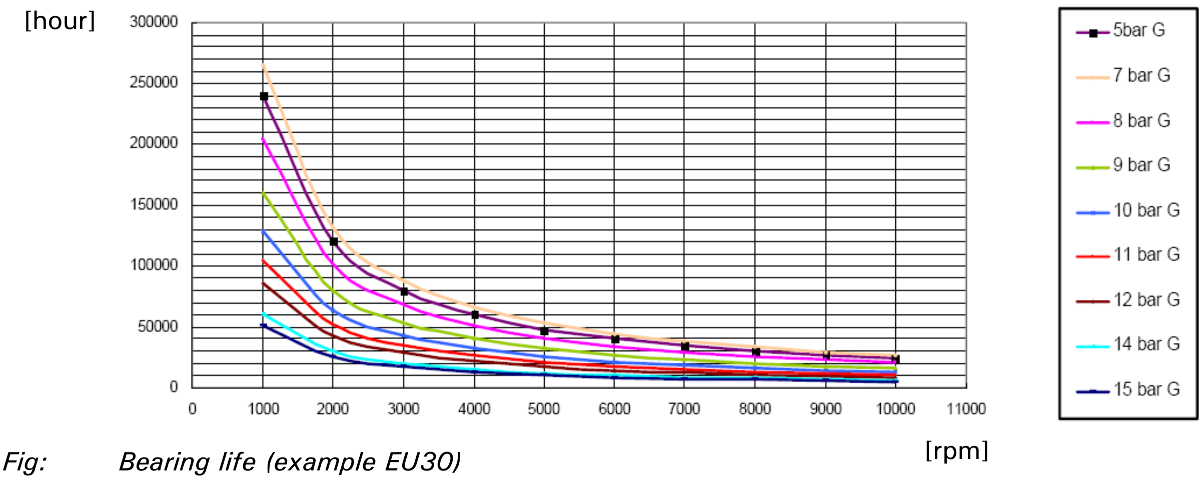

Fig: Bearing life (example EU30)

No leakage:

Leakage losses, whether external or internal, are never desirable. We take this requirement of our customers very seriously and have taken appropriate precautions in the development of the EU COMP screw compressor stages.

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The housing components are secured against leakage with proven technology. Seals at critical points are obviously designed with O-rings.

Fig: Analysis of rotors under operating conditions

The use of shaft sealing systems with double lip seal ensures your customers the greatest possibile degree of security against leakage during the operation of the compressors.

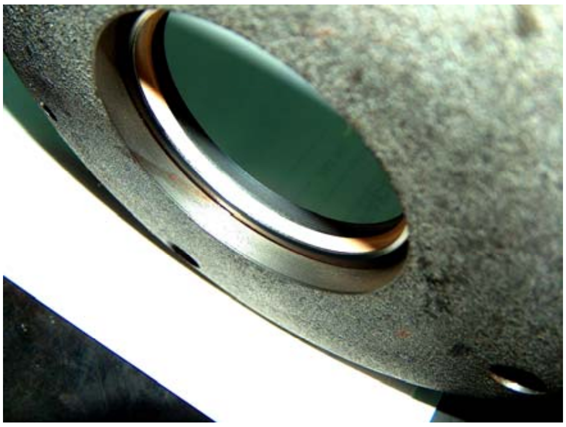

Fig: Double lip seal system for all of EU COMP´s air ends for compression of air.

Internal leakage losses from flowback of the compression medium through the gap between the rotors and between the rotors and the housing is kept as low as makes technical sense through the use of the latest manufacturing technology.

Low vibrations, long service life:

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Long bearing service life, quiet running of your EU COMP screw compressor stage and low vibrations are ensured by the use of high-precision-manufactured rotors. Male and female rotors are housed in precision roller bearings from globally recognized bearing manufacturers. High-precision design of the outlet contour ensures uniform output of the compressed medium from the compression chamber.

EU COMP solutions for belt/direct and gear driven air ends:

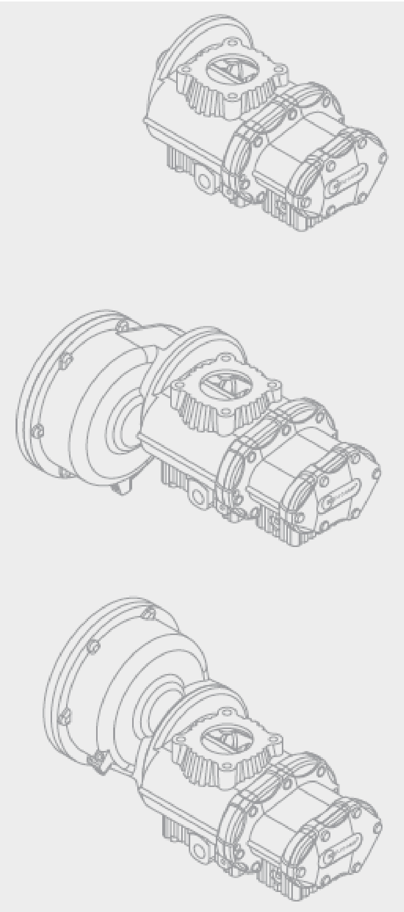

Fig: EU COMP offers both solutions: Direct/belt and gear driven air ends.

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Belt and gear driven air ends serve for screw block operation in conjunction with a drive unit. A widely used method of power transmission for stationary rotary screw compressors is the belt drive. This method offers the option of establishing the required transmission ratio by the selection of a suitable pulley diameter. Pulley production is also less expensive than that of gears for gear units. Belt drives are generally more efficient and flexible in terms of changed operating variables than gear solutions. In both cases (belt and gear unit), transmission losses of about 0.8% occur. A significant advantage of the direct drive is that such loss does not occur. Important information on correct belt tension and pulley alignment is provided in the annex.

In the case of gear driven air ends, any required block speed can be achieved at a given motor speed by the selection of a suitable transmission ratio. EU COMP offers a wide range of gear transmission ratios to meet specific customer requirements.

Fig: Gear driven air end

EU COMP offers its customers two gear driven air end versions: Gear case in a horizontal (”GH”) and vertical (”GV”) position with respect to the drive shaft of the male rotor.

Due to the horizontal and vertical design of the gear driven air end, it can be flexibly adapted to the varying mounting conditions within the machine.

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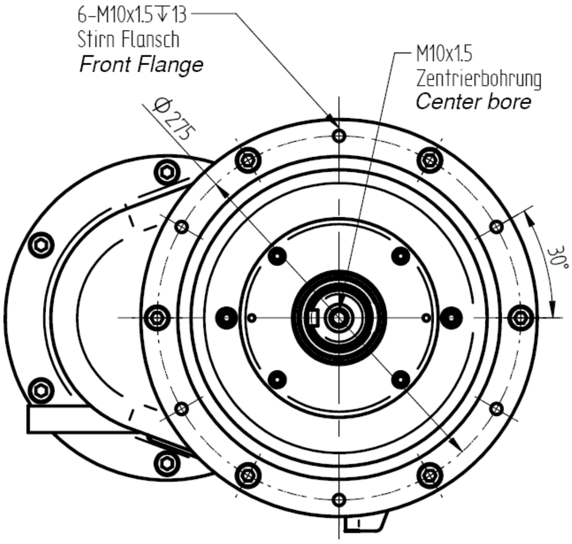

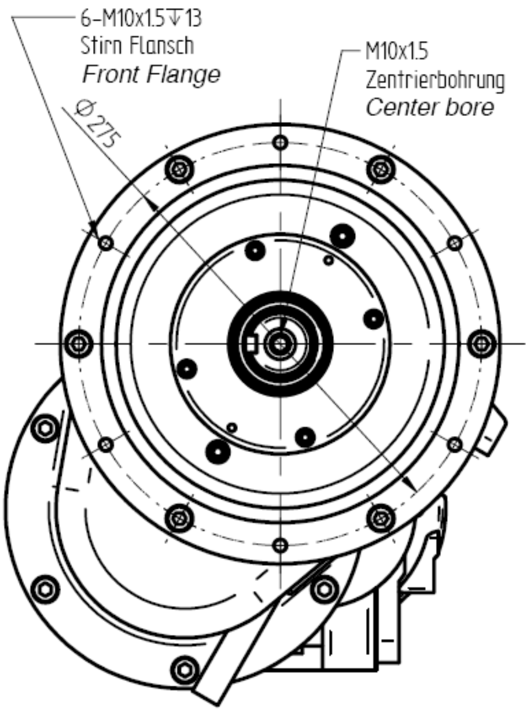

Fig: Horizontally and vertically mounted gear box for high flexibility in packaging (example EU37).

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Technical characteristics of air end sizes

	Unit	Screw Air end type							
		EU11	EU18	EU30	EU37	EU45	EU75	EU110	EU160
Center Distance	mm	55	70	80	90	97	130	154	180
Lobe Combination		5/6	5/6	5/6	5/6	5/6	5/6	5/6	5/6
Drive		male rotor	male rotor	male rotor	male rotor	male rotor	male rotor	male rotor	male rotor
Male Rotor Speed max	rpm	8.500	7.000	6.500	6.000	5.500	4.600	3.500	3.200
Tip Speed max	m/s	34	36	38	40	40	40	40	40
	f/s	10,4	11,0	11,6	12,2	12,2	12,2	12,2	12,2
Discharge pressure max	bar a	16	16	16	16	16	16	16	16
	psi a	232	232	232	232	232	232	232	232
Suction Volume flow max	m3/min	2,5	4,3	6	7,4	8,8	16	21	35
	cfm	88	152	212	261	311	565	742	1.236
weight	kg	23	50	59	79	93	206	336	662
	lbs	50	111	131	174	205	454	741	1.460
direction of rotation		ccw	ccw	ccw	ccw	ccw	ccw	ccw	ccw
belt site load	N	1.144	1.826	1.906	2.848	3.839	6.065	7.433	10.417

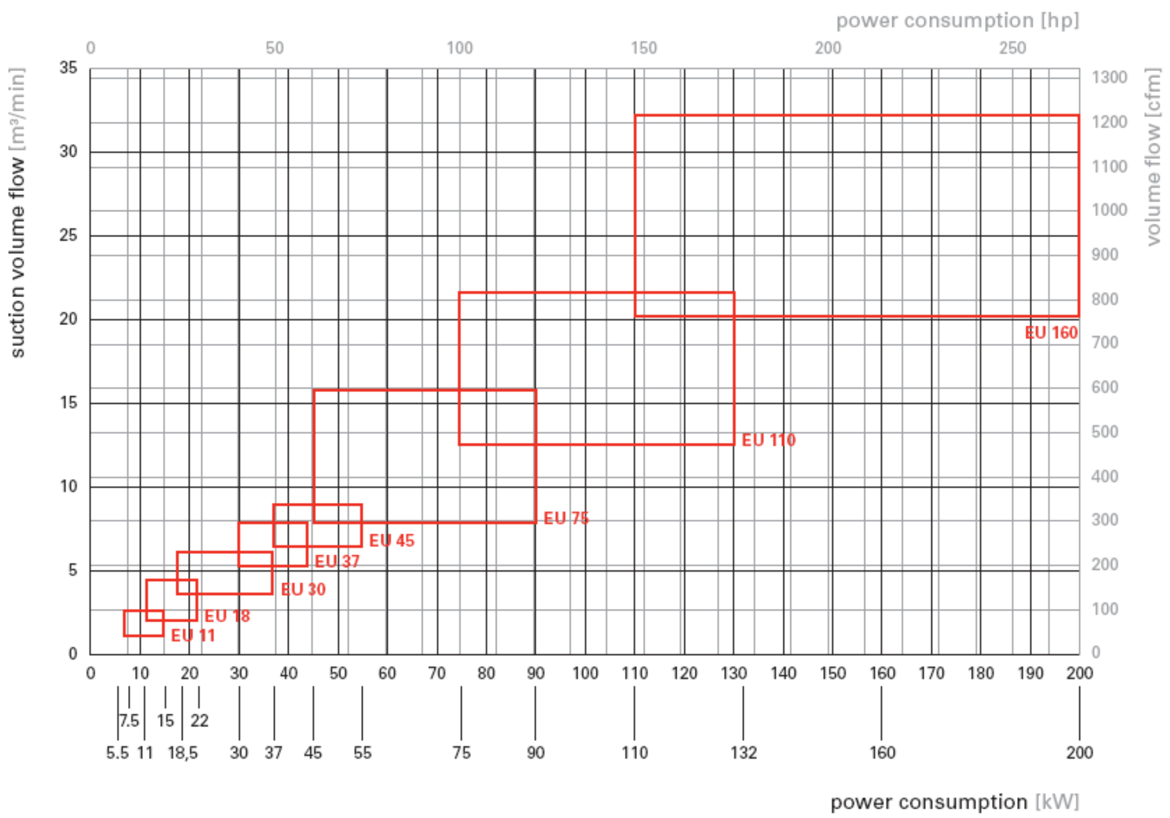

Fig: Technique on a glance

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EU SELECT sizing software

Manpower, their expertise, and their know-how is the basis of successful engineering. Yet, providing the most capable aids helps to focus on the essential, and not to loose any time. To fulfill customer´s requirements in regard to optimized selection of compressor air ends and related components, we offer the use of EU SELECT – a completely newly developped sizing program. It offers detailed data an all of our screw compressor air ends up to 200kW power consumption. It enables the user not only to size the compressor air ends itself, but to calculate complete screw compressor packages. The program is operated using the computer´s mouse to easily add and alter project details for an optimum screw compressor application. The process of sizing and selection is simplified and more efficient than ever before.

Steps how to use:

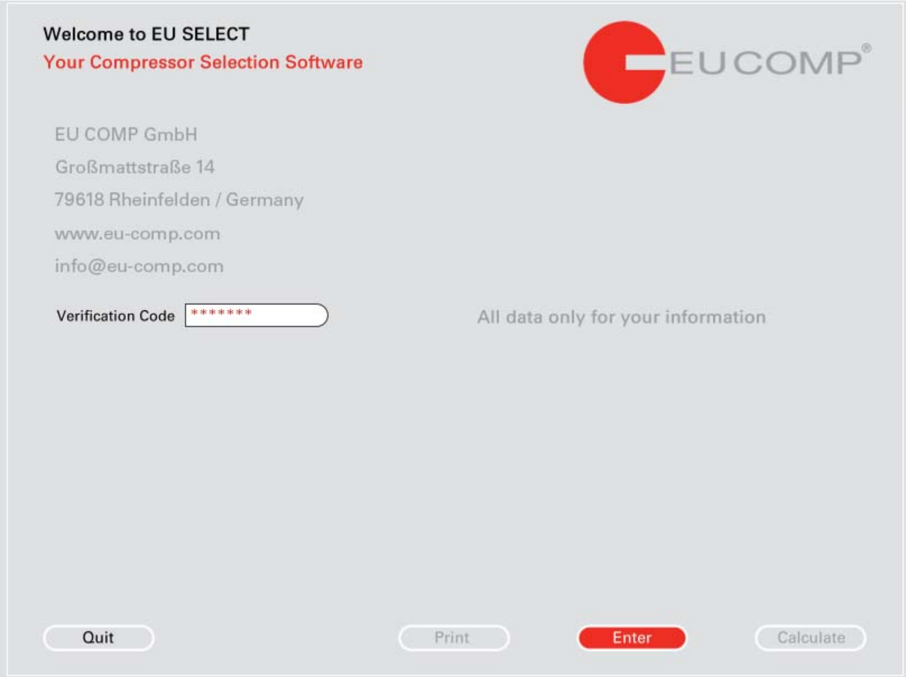

Fig: EU SELECT welcomes you (verification code you will receive from EU COMP directly)

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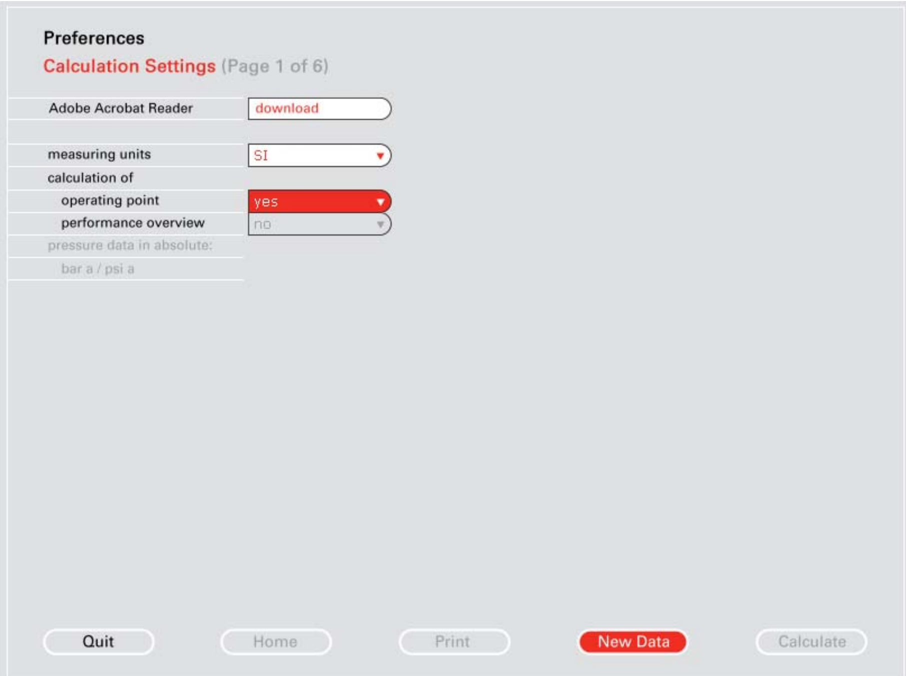

Fig: Decision, if an operating point or an performance overview is of interest.

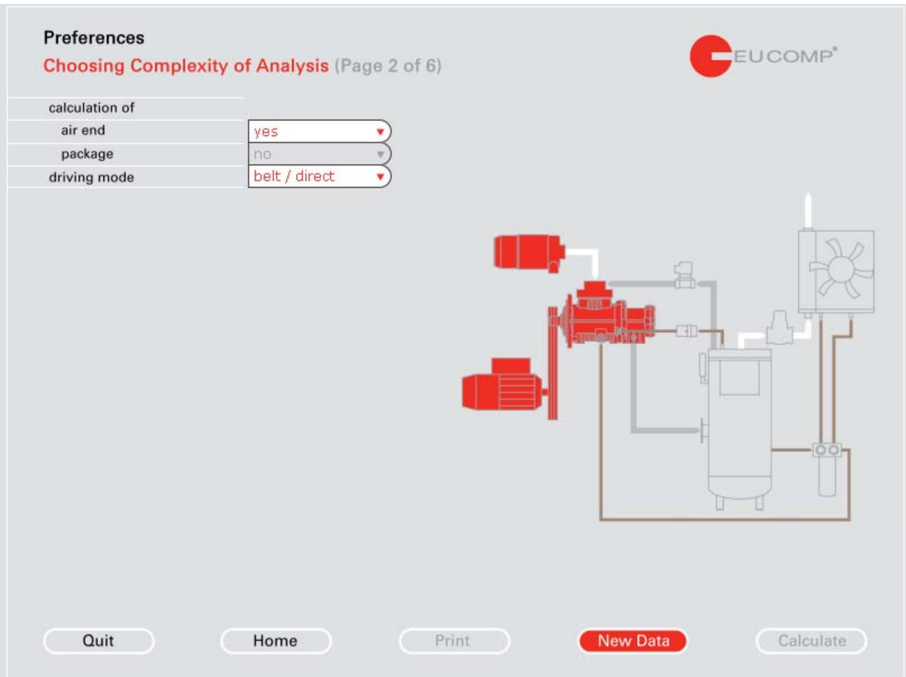

Fig: Calculation of a belt/direct or gear driven air end, or analysis of a package

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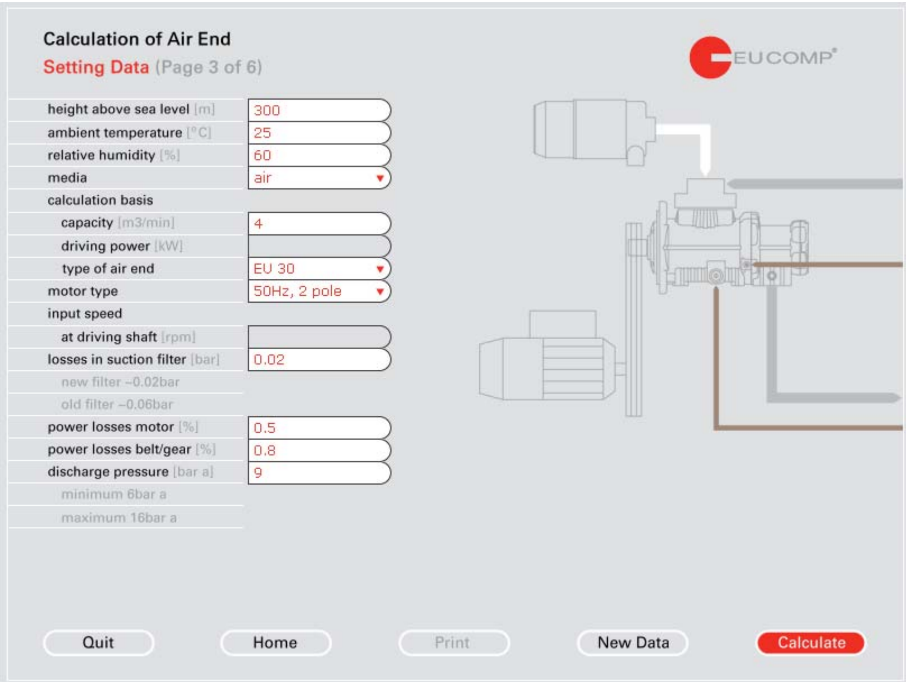

Fig: *Setting the operating data*

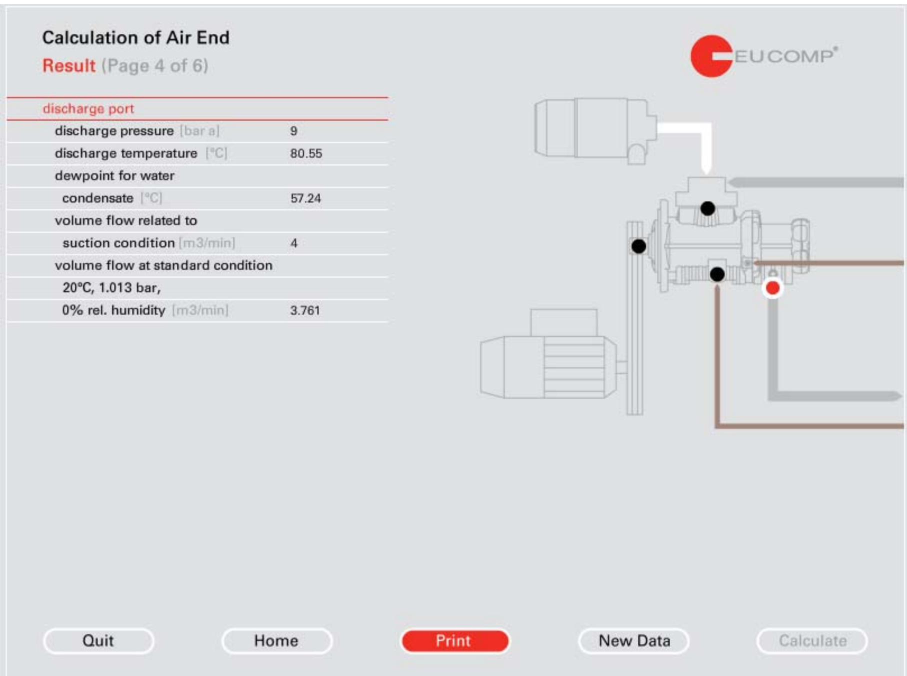

Fig: *Analysing the results*

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Fig: Calculation of the performance, visualized as curves

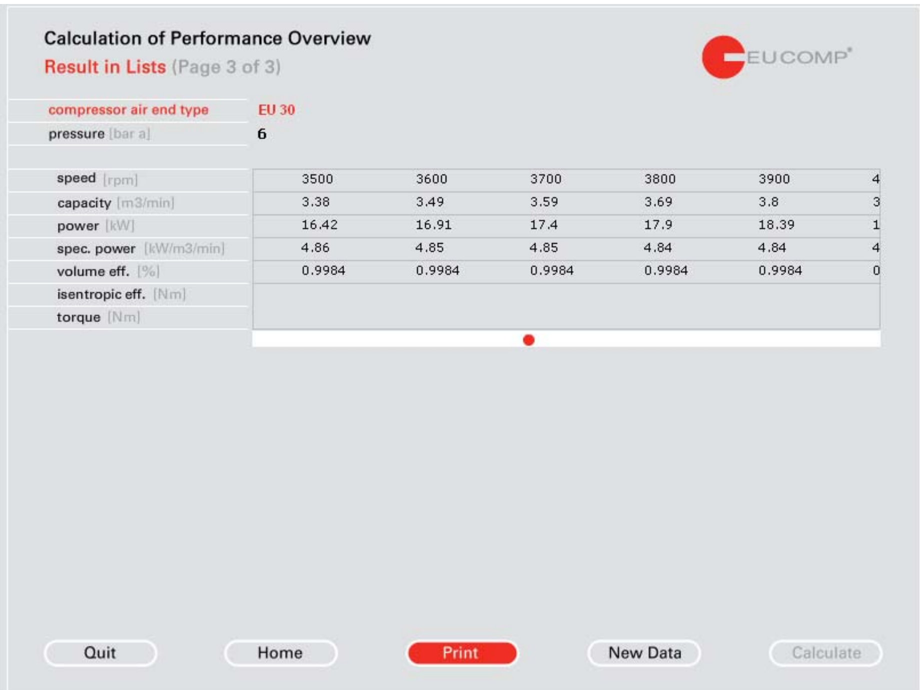

Fig: Calculation of the performance, visualized as a list of figures

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Recommendation for choosing the lubricant

Functionality of the lubricant:

Lubricants consist of the basic components basic oil and additives. Parameters such as viscosity, temperature behaviour, oxidation stability, emulsification tendency and further, specified below, are essentially influenced by the additives.

For securing of their function, screw compressors need an oil injection, which is to take over the substantial three functions:

1. Minimization of the friction and the wear in the compression chamber
2. Minimization of any leakages between the rotors and rotors/housing
3. Heat dissipation

Further functions are the avoidance of corrosion (for all rotating parts of the screw compressor), the stability against oxidation and perfect application in the deep and high temperature operation condition. It must have a high thermal stability and be resistant to the absorption of gases and to the dilution of gases. A long life span is preferred.

Type of lubricant:

EU COMP recommend the use of age-resisting and before corrosion protecting oil, which does not have a tendency for foaming. Mineral as well as synthetic oils can be used as lubricant. The recognition of synthetic oils is increasing. The lubricant should fulfil all requirements, which are described here and they never should be harmful to the compressor system and environment. Further more, wear-reducing additives have to be implemented for protection of bearings and gear system against friction, so that a load carrying capability of FZG- (fretting test) loadstage 9 is guaranteed at least.

Besides this, the used lubricant has to correspond to the general valid standards:

- Compressor oils DIN 51506 or
- Turbine oils DIN 51515 or
- Hydraulic oils DIN 51524

Detailed tests and relating recommendations for special lubricant brands are not possible for us due to the abundance of the oils present at the market and their quickly changing characteristics. Furthermore, the different characteristics of our customers´ screw compressor packages have a crucial impact on the lubricant´s life span.

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Selection of lubricants:

As a function of the oil injecting temperatures the viscosity of the lubricant is changing. Therefore we recommend as follows:

injection temperature of lubricant	up to 50°C	up to 60°C	up to 70°C
ISO-viscosity class	VG32	VG46	VG68

„ISO VG“ is the abbreviation for „ISO viscosity grade“ and indicates the classification of liquid industrial lubricants in viscosity classes. The testing is according to DIN 51519.

The viscosity describes the resistance, which a liquid opposes to the flowing. According to ISO VG, we differentiate between the dynamic and the kinematic viscosity. In the following, we are referring to the kinematic viscosity ([mm^2/s] = cSt formerly).

Relating to liquid industrial lubricants, the min and max of the kinematic viscosity (temperature of operation 40°C) are as follows:

- ISO VG 32 ...28,8 - 35,2 mm^2/s (=cSt)
- ISO VG 46 ...41,4 - 50,6 mm^2/s (=cSt)
- ISO VG 68 ...61,2 - 74,8 mm^2/s (=cSt)

In the case of a very low number of revolutions of the male rotor (< 15 m/s), we suggest to use the next higher viscosity class.

According to DIN ISO 3016, the pourpoint describes the temperature, whereby, when cooling down, the lubricant just remains fluid (under determined conditions). At least, it should be 5°C under the lowest ambient temperature. Self inflammations are to be avoided by a higher flash point. According to DIN ISO 2592, this is the lowest temperature, when a vapor-air-mixture inflames by external inflammation. In each case, the flash point should be higher than 200°C.

Impurity of the lubricant

- water:
  In order to avoid serious destruction of the lubricating film and relating damages of bearings and gears, in each case even small content of water in the oil circuit must be excluded. This is achieved by raising the discharge temperature to be higher than the dew point.

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- foreign particles:
  Heavy bearing damages can occur caused by foreign particles, for example grinding residues, salts or impact by gases in industrial plants or in the off-
  shore ambient. Therefore it is to be paid attention to an appropriate filtration of the lubricant. According to DIN ISO 4572 (multi pass test[1]), a grade of filtration of β_{25} (c) $\geq$ 75 is recommendable.

Please note that even new lubricants may contain foreign particles. A barrel of new oil can contain foreign particles similar in volume to that of a bar of chocolate. EU COMP strongly advise to filter all oil before filling in the oil circuit.

Oilfilter-bypasses could by virtue of their function allow the by-pass of foreign particles and thus finally cause damage of the screw compressor system.

In each case we advise to consult the respective lubricant supplier.

[1] Due to the changes in the way particles are measured and the fact that a new test dust (ISO MTD) is now utilized, a new standard for multi-pass testing was necessary. This new standard, ISO 16889, was replaced the old Multi-Pass Test Standard, ISO 4572.

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Screw compressor stage integrated in the compressor package

The functions of the screw compressor block are defined in the following main working steps:

- Filling the compression chamber by suction
- Transporting of medium drawn in by suction
- Compression of the medium with simultaneous oil injection
- Discharge of the hot pressurised medium mixed with lubricating oil

The compression chamber is formed by both rotors of the screw compressor block in a housing; the male and female rotor. It is formed by the profile gaps between the flanks of both rotors.

When both rotors turn, the profile gaps reduce thus producing the compression. Compression starts when the profile teeth close the suction duct.

The effective flow rate at the compressor block according to ISO1217 differs from that of the entire system and defines the delivery flow of the screw compressor stage....

... without air filter
... without belt
... without fan
... without system internal pressure losses (oil separator, oil cooler)

Prior to comparing effective flow rates, it must always be ensured that the values refer to the compressor block or to the entire system.

A non-return valve in the discharge nozzle of the air end and upstream of the oil separator prevents the compressed air from flowing back from the oil separator into the air end (e.g. when switching off the compressor). This prevents oil from entering the compression chamber or flowing out through the suction duct.

The mechanical separation of air and oil takes place in the oil separator by means of baffles or cycloids introduce the hot and compressed air/oil mixture. A separating effect of up to 99% can be achieved with a well designed oil separator.

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The compressed air is separated almost completely from the oil in the following fine separator (residual oil content 3...5 ppm).

Following the fine separator, the hot compressed air, before reaching the air aftercooler, flows to a minimum pressure valve which maintains a defined minimum pressure in the oil separator. This is important in case the compressor compresses against suction pressure and the oil supply is still maintained via the injection points.

A safety valve in way of the oil separator prevents the permissible maximum pressure being exceeded.

Oil circuit:

From the oil reservoir, the hot oil (under final compression pressure) discharged from the compressed air flows to the oil thermostat which either passes the oil through the oil cooler or directly to the injection point on the compressor casing via an oil restrictor. This thermostat controller cooler bypass ensures a constant oil injection temperature. In both cases, the oil flows through an oil filter in order to prevent the entry of foreign particles into the compression chamber.

In the oil cooler with combined radial flow fan, the excess heat is discharged to the cooling medium (usually air). The discharged heat energy corresponds to almost 100% of the input electrical energy!

The injected oil flow rate increases approximately linear with the final compression pressure. It can be calculated in addition to other essential technical data for screw compressor construction from EU COMP sizing software EU SELECT.

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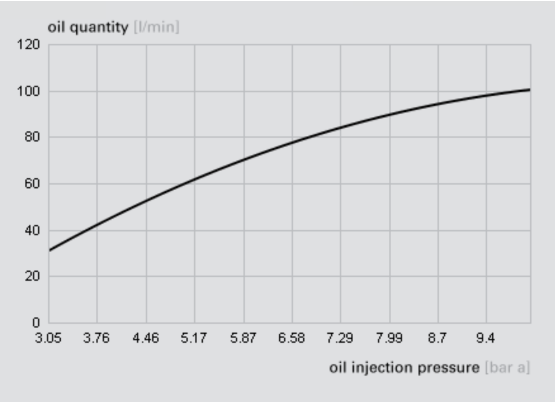

Fig: Correlation between the injected oil flow rate and final compression pressure based on the example of EU37.

The use of an oil pump in the oil circuit is unnecessary. The necessary pressure is built-up by the pressure difference between the final compression pressure in the oil tank and the pressure at the oil injection point of the compressor block.
The pressure at all oil injection points on the compressor is lower than the final compression pressure, but it is higher than the compressor suction pressure. A minimum pressure of 3 - 4 bar normally prevails at the oil injection point to ensure a sufficient supply of lubricating oil at the compressor injection points. If the final compression pressure should fall to ambient pressure (e.g. when switching off the system causing a fall in pressure in the oil separator), the previously mentioned non-return valve prevents the lubricating oil from flowing back into the compression chamber.

If the oil circuit should be exposed to ambient temperatures distinctly below freezing point, it is recommended to provide a device for heating the lubricating oil in the oil tank to enable the compressor to be started at any time.

Drive:

For stationary screw compressor systems used for industrial purposes, electric drive motors (three-phase asynchronous motors) are normally used.

Polzahl	2	4
50 Hz	3000	1500
60 Hz	3600	1800

Fig: Synchronous speeds in rpm at f=50 and 60 Hz for various pole numbers.

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Diesel engines are used for mobile systems. Motor speeds in North America are typically 1740 and 3450 rpm.

The motor input power is that which the drive motor draws from the electrical system. It differs from the motor output power (mechanical power on the motor shaft) by the motor losses that are characterised by the motor efficiency. This includes separate fan motors or also fan impellers on the drive shaft that influence the motor loss. The rated motor power is the mechanical power transmitted to the motor shaft, which the motor is able to output at rated voltage and rated current under 100% load (data on motor rating plate).

The motor output power is divided into:

- Losses for driving the cooler fan
- Transmission losses through belt + gear unit

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- Compressor shaft power

Important information on the correct operation of three phase asynchronous motors is shown in the annex.

Control of screw compressor systems:

In order to adjust the flow rate of the compressor to the fluctuating requirement of the compressed air system, control of the compressor is necessary. The flow rate is regulated between the adjustable limiting values for maximum and minimum pressure. The following types of control are shown below:

- Start-stop control
- No-load control
- Speed control

Start-stop control:

The compressor assumes the operating states full load and rest. The drive motor starts on reaching a specific minimum pressure and initially switches off again when a set maximum pressure is reached. This type of control is determined by the permissible operating frequency of the driving electric motor. Exceeding this maximum value would activate the necessary overload protection of the motor in order to prevent excessive heating. The compressor itself is not subject to any operating frequency limitation.

Motorleistung [kW]	Schalthäufigkeit h
15–22	12
7,5–11	15

Fig: Operating frequency as a function of the motor size

It is generally recommended to attain an operating time of about 75% for a compressor. For this purpose, it is necessary to determine the maximum requirement of a compressed air system and co-ordinate selection of the compressor. If there is the intention to increase the air requirement due to expansion of the system, the compressed air supply section should be enlarged since subsequent expansion involves high costs.

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No-load control:

In contrast to start-stop control, the motor is not switched off on reaching the maximum pressure, but moves between no-load and full load. It becomes apparent that the advantage of the start-stop control (lower energy consumption) cannot be achieved due to the no-load costs of this type of control.

As a type of no-load control, the compressor operates in blow-off control (use in small systems) against a pressure limiting valve. When the set pressure is reached, the pressure limiting valve opens and the air is blown out to the atmosphere. A non-return valve prevents emptying of the pressure vessel.

Speed control:

The speed of the compressor drive motor is controlled as a function of the pressure reached. In the case of a three phase asynchronous motor, a frequency converter is used. The additionally necessary controllers however give rise to an efficiency loss of 3...5% in speed control. This includes a reduction of the motor efficiency at a reduced speed of up to 10% and the efficiency of the screw compressor is not in the optimal range at low drive speeds (about <1000rpm).

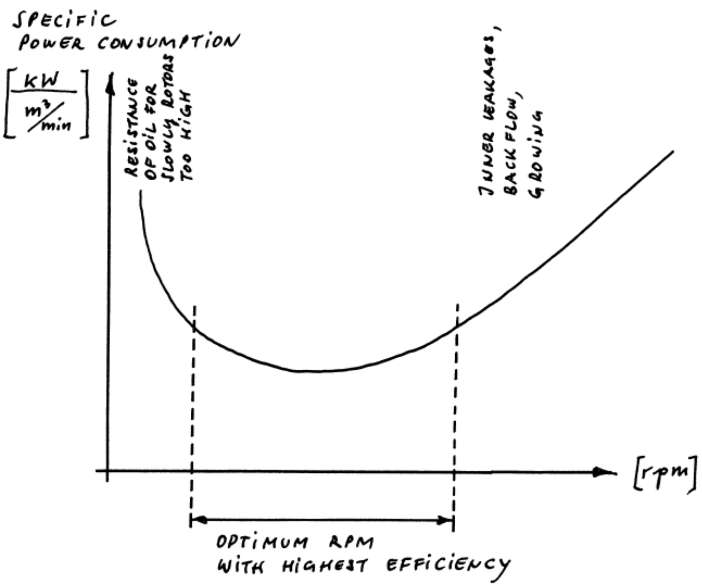

Fig: Schematic: Specific output as a function of the main rotor speed

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Dew point:

An important aspect for ensuring trouble-free operation of a screw compressor is the avoidance of condensate in the lubricating oil. Condensate must also be avoided in the compressed air system omponents.

Atmospheric air always contains water vapour. This is removed from the screw compressor by suction. The moisture produced depends mainly on the relative humidity. This depends on the air temperature and weather conditions. The absolute humidity is the amount of water vapour contained in a cubic centimetre of air. The saturation level is the maximum amount of water vapour a cubic centimetre of air is able to absorb at the respective temperature.

The following correlation applies to relative humidity:

$$\text{Relative humidity} = \frac{\text{Absolute humidity} * 100\%}{\text{Saturation level}}$$

The saturation level is temperature-dependent. The relative humidity changes with temperature. When the dew point is reached, the relative humidity rises to 100%. When the temperature is reduced, the contained water vapour begins to condensate. The lower the temperature reduced, the more water vapour condenses. When atmospheric air is compressed, the water vapour concentration increases. The concept of the pressure dew point is used in order to describe this water content in the compressed air. According to the above, it indicates the temperature at which water vapour from the compressed air begins to condense. The pressure dew point falls with a drop in pressure.

Failure to reach the pressure dew point will reduce the life expectancy of the screw compressor and downstream pneumatic system. For this reason, a sufficiently high temperature (above the pressure dew point!) in the compression chamber and downstream components is necessary in order to prevent bearing damage and mixed friction.

The use of dryers for the removal of condensate from the compressed air system is necessary.

Distinction is made between the following:

- Cooling dryers
- Adsorption dryers
- Absorption dryers

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Appendix

Belt tension and pulley alignment:

Important for installation and maintenance of the belt-driven screw compressor block in addition to the correct belt tension is also pulley alignment. One of the common reasons for unplanned downtime of belt-driven machinery is pulley misalignment. Pulley misalignment can increase wear on pulleys and belt as well as vibration and noise levels, which can result in unplanned machinery downtime. Another side effect of increased vibration is premature bearing failure. That too can cause unplanned machinery downtime. Traditional methods, such as using the naked eye or a straight edge, are the most common alignment methods. However, these methods are inaccurate and require trial and error, which is time consuming.

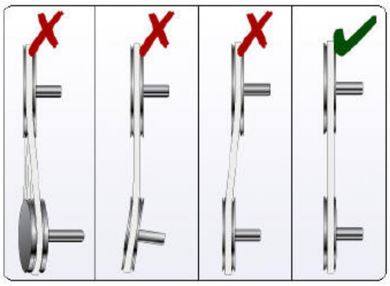

Fig: Pulley alignment

Accurate pulley and belt alignment helps you:

- Reduce wear on pulleys and belts
- Reduce friction and thereby energy consumption
- Reduce vibration and noise
- Increase bearing life
- Increase safety
- Increase machinery uptime
- Reduce costs of replacing components and machinery down time

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Three-phase asynchronous motor:

In order to reduce nominal current requirement peaks when starting the compressor, star-delta starting is recommended when using a three-phase asynchronous motor. For this purpose, star-delta switches or appropriate contactor combinations are used and all six winding ends connected. Starting takes place star-connected, whereby the phase voltage is only one third of the line voltage compared to the delta connection (= operating connection), where the full line voltage is applied to the phase. As the torque is roughly proportional to the square of the voltage, it reduces in the star connection to about one third of the value in the operating connection. The nominal current also reduces accordingly. After starting, the motor is switched to delta.

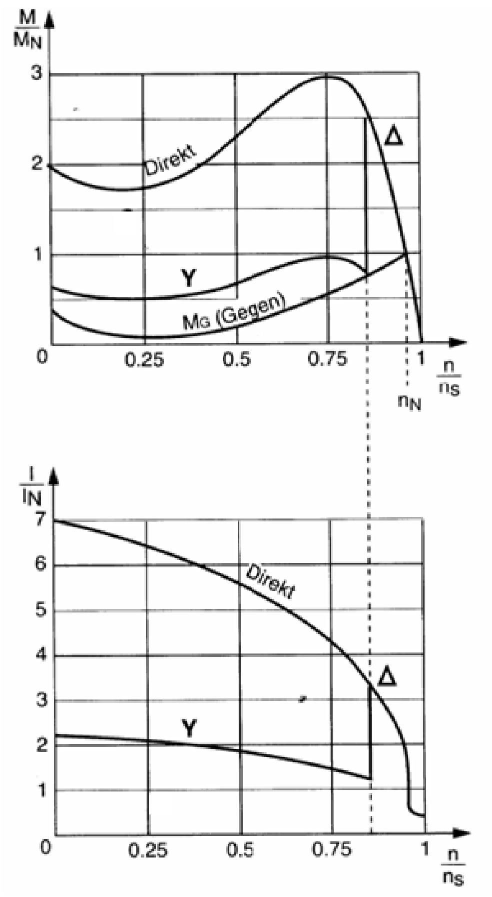

Fig: Star-delta starting characteristics

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Determination of the pressure dew point:

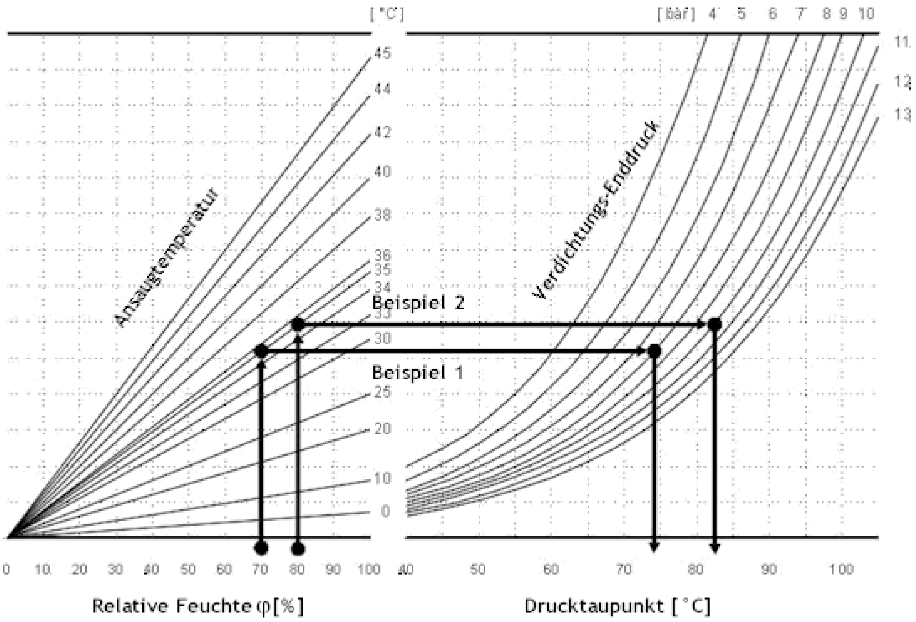

Fig: Determination of the pressure dew point

Determination of the pressure dew point is to be explained based on an example: The suction conditions are characterised by a suction temperature of 35°C and a humidity of 70%. At a final pressure of 8 bar, this results in a pressure dew point of about 73°C. It is important to ensure that the temperature level in the compression chamber up to the aftercooler is always above this pressure dew point in order to prevent condensation.

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Determination of the sound power level:

The human ear perceives sound to a greater or lesser extent at different frequencies. In addition, background noise disturbs the audibility.

For the assessment of "how loud" a compressor runs, ISO 3744 recommends determining the sound power level of noise sources using sound pressure level measurements. In order to find reliable comparative values, it does not suffice to rely on subjective hearing only.

To relate the contents of the directive ISO 3744 is the not the intended aim of this operation manual, so that only reference is made to the same.

There are different measuring surfaces with specific measuring paths which generally determine whether the noise source is located between two reflecting planes or, e.g. on one reflecting plane:

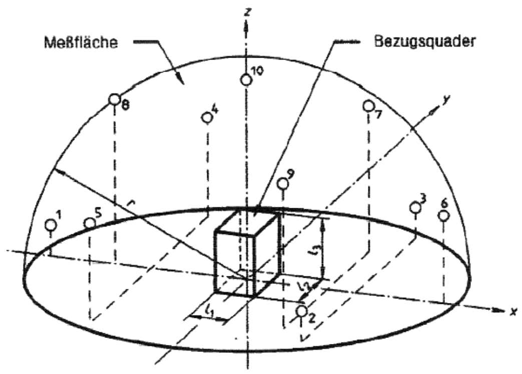

Fig: Microphone arrangement on a half sphere measuring surface

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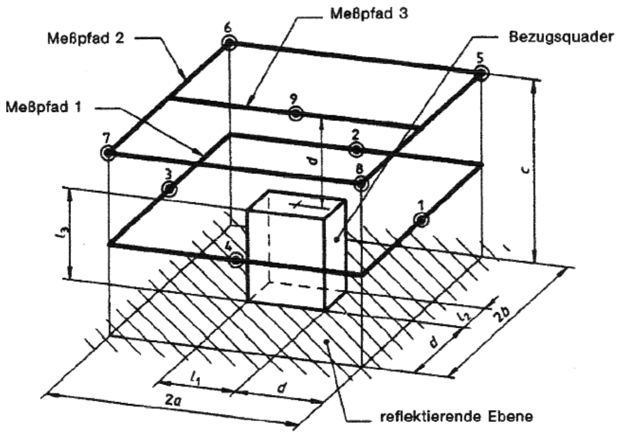

Fig: Microphone arrangement got a small machine (measuring distance 1m)

The sound pressure level concept derived from the sound power level refers always to a specific distance to the noise source. In the case of stationary machines, this is normally 1m, for mobile machines, this is 7m (CAGI Pneurop). The sound pressure level should also be specified together with ambient data. If this data is not provided, these are free field measurements, where sound waves are unable to be reflected through any objects.

Distinction is made between five types of sound reduction:

- Sound insulation
- Sound absorption
- Vibration insulation
- Vibration damping
- Noise source damping

The following sound pressure level measuring results are shown as an example for EU COMP air ends EU11 and EU37:

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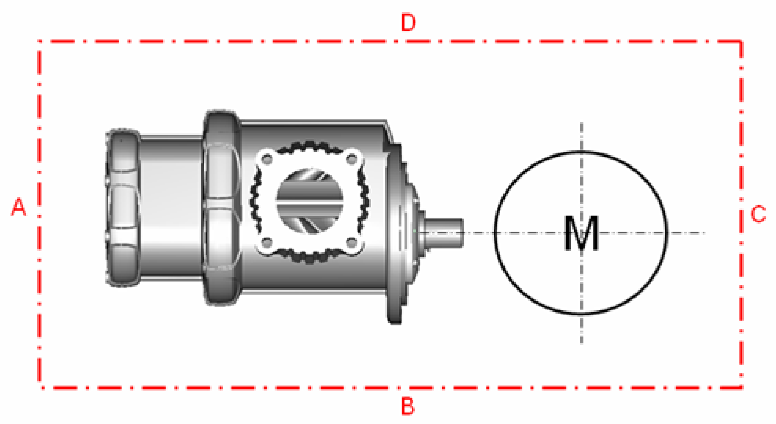

Distance microphone - measured object 1m
Background noise 61,0 db(A)

Door of package	A	B	C	D	Top	Average
...open	77,4	78,2	78,1	80,4	80,4	79,08
...closed	69,8	72,8	77,0	73,0	78,1	75,14

all data in db(A)

Fig: Sound measurement data EU11

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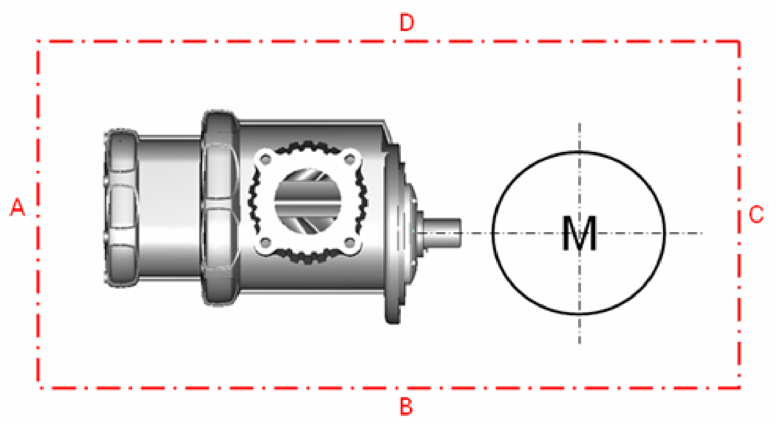

Distance microphone - measured object 1m
Background noise 59,1 db(A)

Door of package	A	B	C	D	Top	Average
...open	84,1	85,4	76,4	86,2	81,4	83,81
...closed	72,4	76,3	75,2	74,4	80,5	76,68

all data in db(A)

Fig: Sound measurement data EU37

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Protection of anti-friction bearings

Bearing damage is usually noticeable by a gradual reduction in operational performance. A reduction of the bearing efficiency is already considered as bearing damage, not only total failure.

A typical cause is material flaking on the running faces in the case of fatigue damage. Significant damage can often be prevented by looking out for irregular running or listening for unusual noise. Sudden bearing damage can be best identified by monitoring the bearing temperature. This kind of damage occurs, e.g. on lubrication failure.

The cause of bearing damage can be very different:

Unusual loading in operation:

- Overload, underload
- Vibrations
- Excessive speed

Unfavourable ambient influences:

- External heat
- Dust, dirt
- Conductive continuity
- Moisture
- Aggressive media

Incorrect lubrication:

- Unsuitable lubricant
- Lubricant deficiency
- Excessive lubrication

Incorrect fitting during inspection measures:

- Incorrect fitting method
- Uncleanliness
- Fit too tight
- Fit too loose
- Tilt

Please make sure, that you avoid all given possibilities for failure of bearings.

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Fundamentals for failure free operation:

The following is a general overview of steps you will proceed with to make sure, that no failure will happen with your air end, and compressor.

Assembling:

- Be sure, that the driving motor turns around in the correct direction:

  1. Belt/Direct driven: Anti clockwise, watching on the facial side with driving shaft.

  2. Gear driven: Clockwise, watching on the facial side with driving shaft.

- Do not transmit mechanical tension on the air end´s casing in order to avoid touching of rotors inside the compression chamber.

Advisable is mounting the air end only by three bolts:

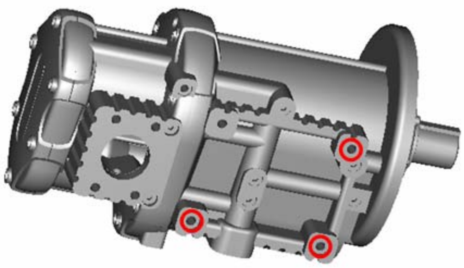

Fig: Mounting of air end

- Do not mount the compression chamber and the discharge port on one plate, which is not necessarily 100% flat. This can cause not only air leakages, but also deflection of the housing.

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Bild: *Wrong mounting of the air end*

Better is to use two separate fixing plates or flexible tubes as discharge line:

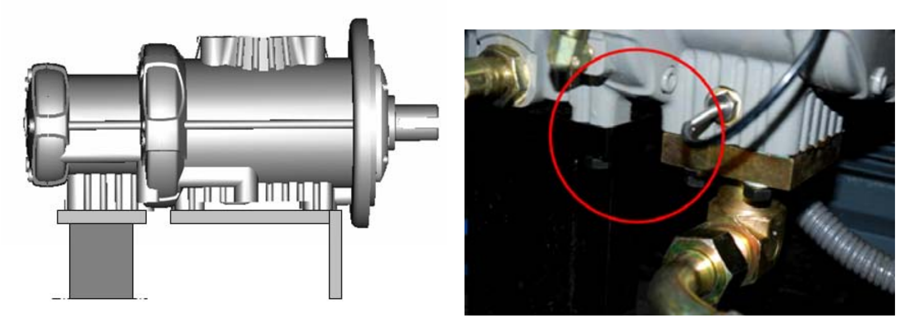

Bild: *Mounting of the air end*

- Using a pulley-belt arrangement, you are free to choose the angle α for your assembling:

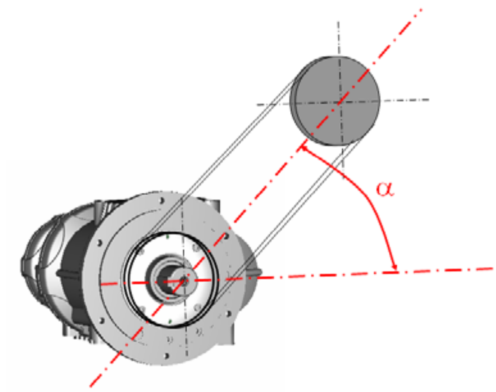

Bild: *You are free to choose* α

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- Please use a distance sleeve to fix the inner ring of the lip seal system.

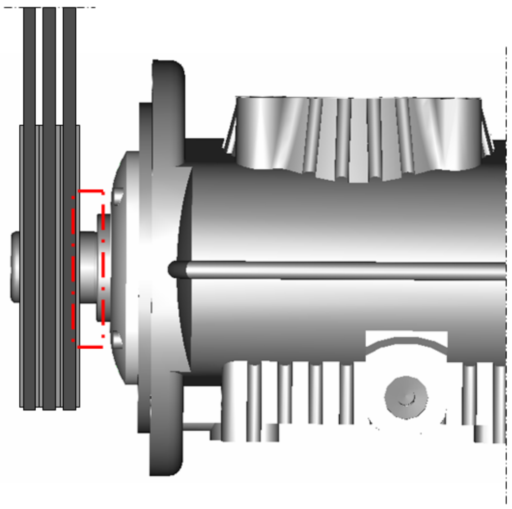

Bild: Distance sleeve requested.

- To prevent bearing damage under operating conditions, exact alignment of the drive motor shaft and screw compressor block is necessary.

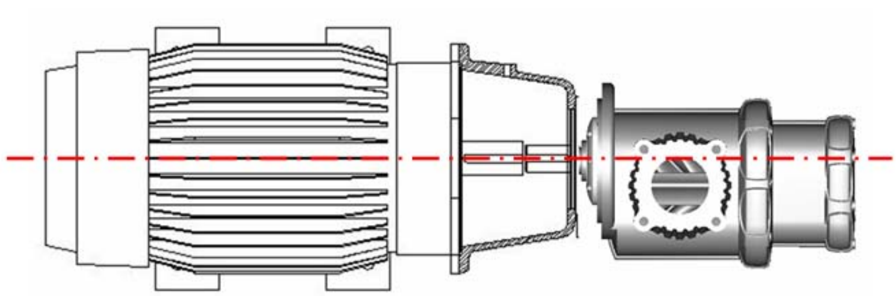

Fig: Motor adapter housing for alignment of motor and air end

- In this connection, reference is made once again to necessary pulley alignment in the case of a belt drive.

- To be noted when adjusting the belt tension are the following maximum radial forces that can be transmitted to the male rotor:

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EU11	
Direct/Belt	
1.717	

EU18	
Direct/Belt	Gear
5.562	35.927

EU30	
Direct/Belt	Gear
772	82.963

EU37	
Direct/Belt	Gear
6.231	73.973

EU45	
Direct/Belt	Gear
8.200	70.065

EU75	
Direct/Belt	Gear
13.307	

EU110	
Direct/Belt	Gear
27.096	

EU160	
Direct/Belt	Gear
21.616	

Fig: Maximum radial forces for male rotor shaft (all numbers in [N])

- Recommended is a user-friendly (assembly, maintenance) and space-saving design. It should be taken into account that the space within the acoustic enclosures, arrangement of the components within the compressor as well as the materials used have a significant influence on sound emission.

- Components to be accessed for maintenance measures should be easily accessible from the side of the machine.

- Hot air rises: Based on this principle, it is recommended to attach the cooler and fan to the roof of the screw compressor casing.

- Separate sections with additional casing and sound insulation increase the sound emission reduction effect. Such sections are conceivable for the cooling air to be sucked in or a dryer to be possibly be integrated.

- Ensure that the fan operates with low noise.

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- Make sure, that you choose a driving motor with bearing system against axial movement on B-side. Also use a flexible coupling, so that any axial movement is not damaging the gear box´bearing system.

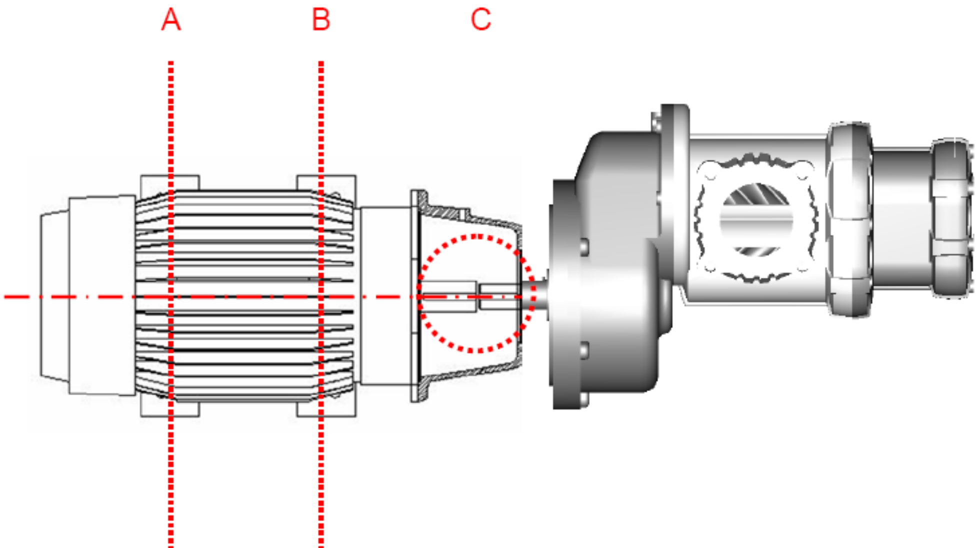

Fig: Protection against axial load on gear box´ bearing system

- Pipes inside and outside the compressor should not be too long and not have too many bends as this will result in considerable flow losses. Pipes should also not have too many connecting points in order to prevent leaks.

- Vibrating elements within the machine should not come into contact with other components in order to avoid sound and vibration transmission.

- Use the bottom of the machine as an oil tray in order to avoid oil spillage in the event of an oil leak.

- Arrange the machine using the five types of sound reduction:

  - Sound insulation
  - Sound absorption
  - Vibration insulation
  - Vibration damping
  - Sound source damping

- Use sound insulation mats, e.g. of foam. A sound emission of only 72 db (A) under full load is possible! High density porous materials are recommended for this purpose (foam: 30 kg/m3)

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- As previously mentioned, the use of acoustic barriers between the noise source and outside of the machine (e.g. additional sections) are useful sound insulation options.

- Vibration dampers prevent the transmission of structure-borne sound and vibrations. Selection of the correct material (steel springs, plastic, rubber...) depends on the vibration frequency, weight of the frame including air end and components as well as the position of the centre of gravity.

- The piping between vibrating elements of the machine should be installed with flexible bridges in order to prevent the transmission of forces. The piping to the aluminium cooler in particular (brittle material) should be flexible.

- Provide the oil tank with baffles and cycloid introduction of the hot, pressurised air/oil mixture in order to achieve a high separating effect as possible.

- Counteract foam formation in the oil tank with a larger oil tank volume so that the oil has sufficient time to reform from the foam to liquid.

- Provide a sight-glass on the oil tank in order to monitor the oil level.

- If the compressor is used in an environment with temperatures below freezing, install an oil tank heater.

- The air sucked in for entry into the suction filter should be as cold as possible. To be taken into account are the flow characteristics of the cooling air and alignment of the suction of the suction filter.

- Avoid any heat transfer between the various heat sources on the air end, drive motor, oil tank and cooler. Note that hot air rises and take radiated heat into account.

- The introduced cooling air should cool the drive motor as well as the air end.

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- To be noted is that the efficiency of the fine separator filter in the standard version depends largely on the temperature:

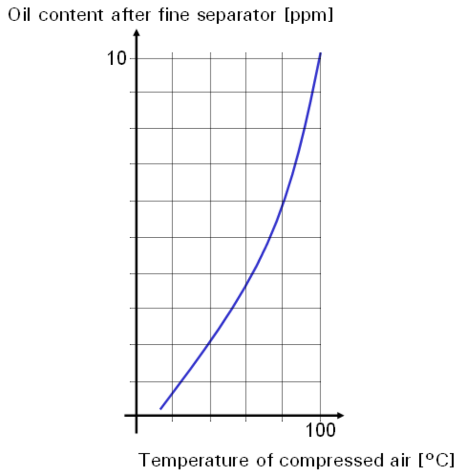

Fig: Residual oil content after the fine separator as a function of the temperature of the circulating compressed air.

- Avoid any foreign particles (for example dirt, or painting color) to enter the lip seal system (for example by dirty ambient, or coloring the lip seal sleeve. These would increase the possibility of lip seal leaking immediately.

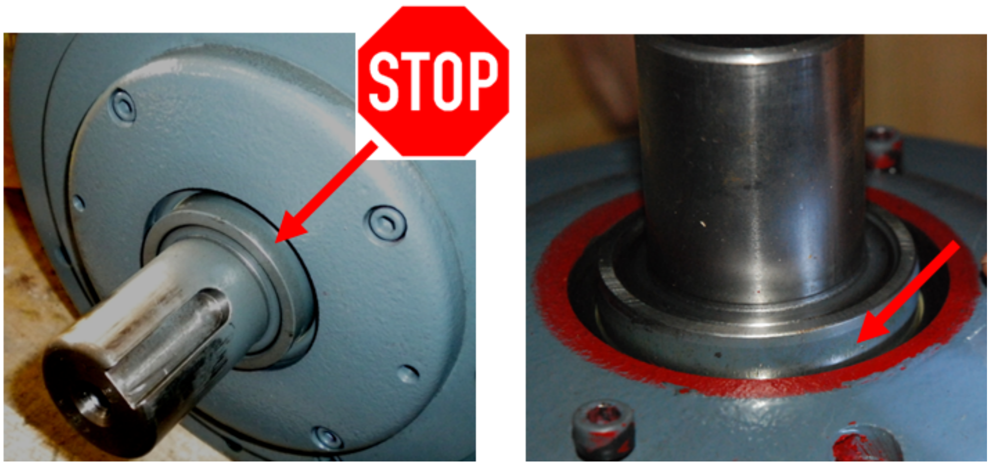

Fig: Protect the lip seal system by avoiding any foreign particles.

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Fig: Protect the lip seal system by avoiding any foreign particles.

- Try to mount the air end on a stable, and exactly mounted frame. Any incorrectness will cause failure of the whole system.

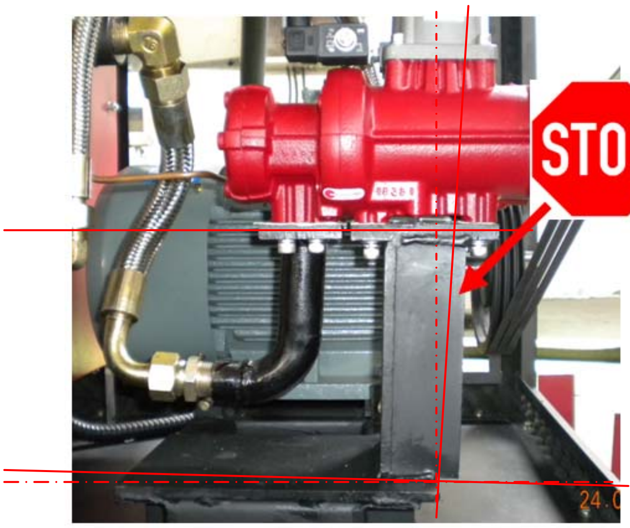

Fig: Protect the lip seal system by avoiding any foreign particles.

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- Avoid any forces on the casing, or connected parts except the turning on the driving shaft of airend. This could cause casing leakage or even touching of rotors in the airend.

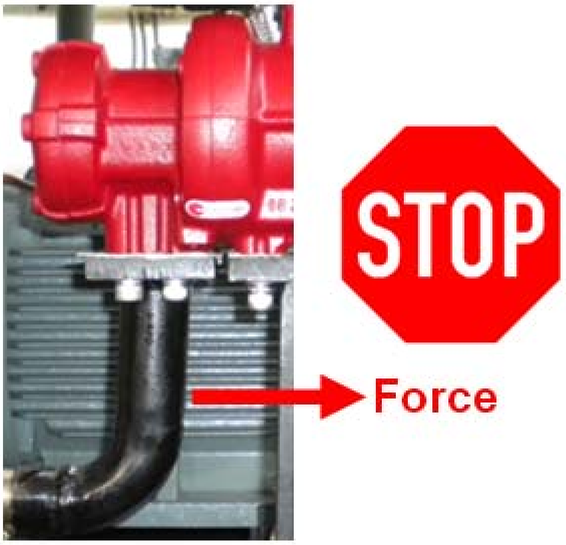

Fig: Protect the lip seal system by avoiding any foreign particles.

- The air, which is sucked into the suction valve, and the airend must be as cool as possible. Please make sure, that suction pipe of suction filter is far away from hot temperature, and also sources of dirt.

Fig: Suction pipe far away from hot temperature, and sources of dirt.

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- Avoid any unnecessary vibration of airend. Vibration always means sound emission, and instability of the system.

Fig: No mounting of additional parts to the airend, which can cause vibration.

- Avoid overfilling of the oiltank, which could cause backflow of oil through the airend, and outside the suction filter. Also this would effect heavily on efficiency of airend, and bearing life because of heavy load for the bearings.

Fig: No overfilling of oiltank

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See the arrangement of filling port together with oil level indicator:

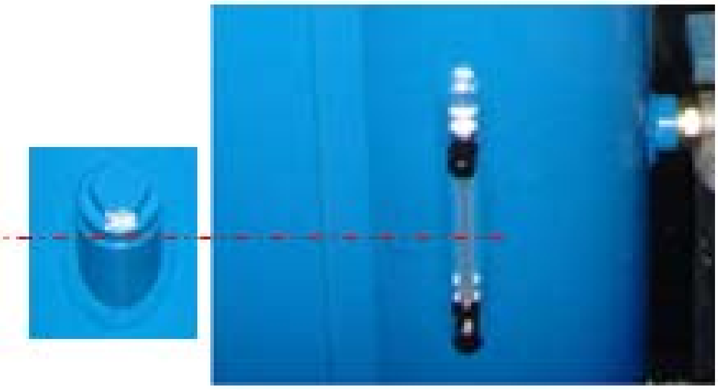

Fig: *Arrangement of filling port*

- Suction valve may not be 100% closed in off-load mode, as the upcoming vacuum will create non-stability of the male rotor, and cause it´s axial movement back, and forwards. This finally will create high sound-emission, and vibration.

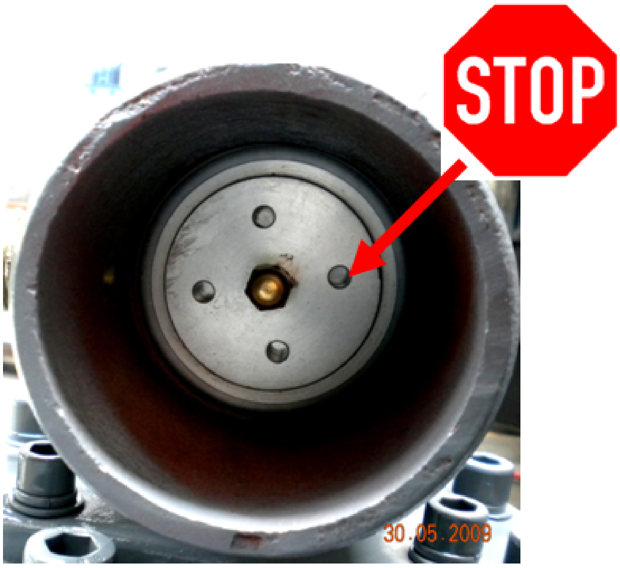

Fig: *Avoid suction valve, which is closed 100% in off-load – apply bypass*

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Fig: Suction valve with bypass

- Additionally to the bypass, mount a piping from the oil-tank to the suction valve (downstream of valve butterfly) to build up a counter pressure in off-load to stabilize the pair of rotor against axial movement. No reason to supply this counter-pressure upstream the suction valve. This will only vent the air filter.

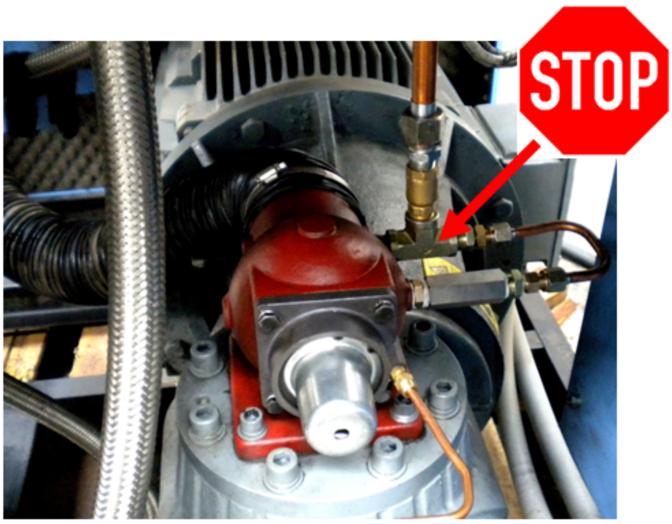

Fig: Wrong: Counter pressure from oil-tank in off-load upstream of suction valve.

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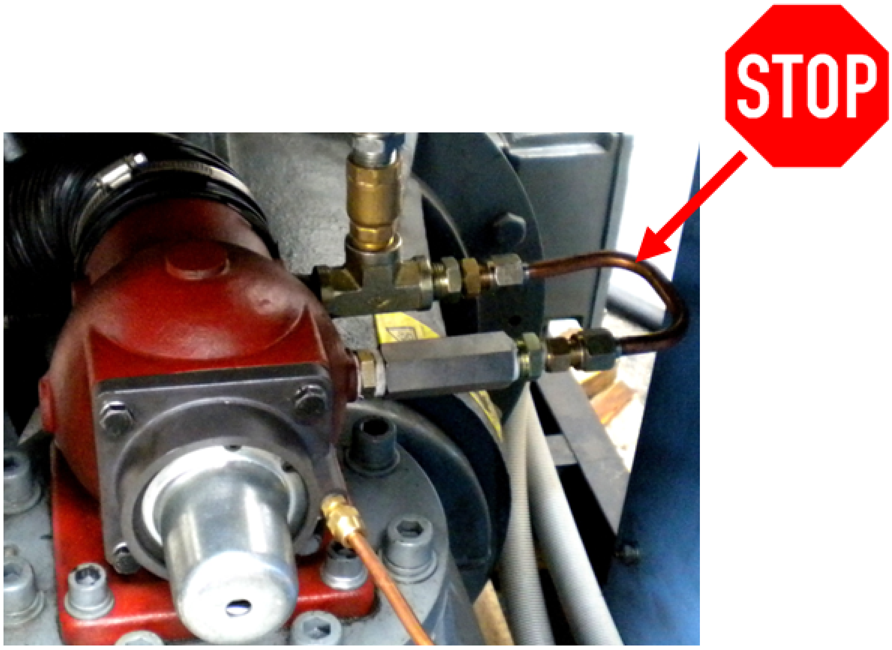

Fig: Wrong: Too small dimensioned piping for building up counter pressure for the rotors in oll-load.

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Trouble Shooting

Situation	Possible Reason
Compressor unable to start	No electrical power Lubricant very viscous due to low ambient temperature Loose wiring connection Driving motor defective Pressure switch incorrectly adjusted or faulty
Driving motor starts but stops immediately	Voltage dropped Loose wiring connection
Driving motor stalls when the suction valve is closed	Driving diesel motor too cold Driving motor overloaded idle speed too low
Driving motor overload	Voltage dropped Electrical phase out Too high discharge air pressure Compressor malfunction
Air end is not turning around	check bypass solenoid Dismount belt, and check, if rotors are blocked check belt
Air end´s discharge pressure too low	engine speed to low air filter clogged male rotor speed too low restricted inlet

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	defective valves leaking in the air piping pressure swith defective drive belt slipping compressor incorrectly sized for the altitude at operation location
Discharge pressure decreases	Minimum pressure valve sticking
Air end is overheating	wrong oil ambient temperture too high compressor oil level too low fan not working cooler fins plugged cooling surfaces excessively dirty restricted air flow through cooler clogged cooler
Fan motor overload	Voltage dropped Electrical phase out
Safety valve blows	Operating pressure has been misadjusted Defective safety valve
The backflow of the compressed air to the suction filter	Check valve malfunction Auto water supply system malfunction Suction valve is leaking
Abnormal bearings noise and fierce vibrations	Compressor bearings malfunction Main motor bearings malfunction

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Oil in discharge air	Fine separator filter saturated Drain line is blocked oil level too high condensate in lubricant
pressure relief valve activates	regulator set too high safety valve defective pressure control plugged Fine separator clogged
Intake control does not close	valve clogged valve frozen
Excessive vibration	incorrect speed loose pulley driving motor out of balance foundation or frame inadequate piping inadequately supported bearing

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Warranty

EU COMP GmbH, called "EU COMP" declares the following warranty regulation:

EU COMP warrants that its Rotary Screw Compressor Stages conforms to applicable drawings and specifications proved in writing by EU COMP. The screw compressor stages assembly will be free from defects in material and workmanship for a period of two years from the date of invoice (lip seal system restricted on one year under condition of professional operation, and assembling of the rotary screw compressor stage into the buyer´s package). If within such period EU COMP receives from the Buyer in written notice of an alleged defect or nonconformance of the unit, and if in the judgment of EU COMP these items do not conform or are found to be defective in material of workmanship, EU COMP will at its option either, (a) furnish a Service Representative to correct defective workmanship or (b) upon return of the item FOB, EU COMP´s original shipping point, repair or replace the item or issue credit for the replacement item ordered by Buyer. Defective material must be returned within thirty (30) days of return shipping instructions from EU COMP. Failure to do so within specified time will result in forfeiture of claim or (c) refund the full purchase price for the item without interest. This warranty does not cover damages caused by accident, misused, negligence or improper lubrication. Buyer must use a compressor lubricant according to EU COMP´s written recommendation for proper lubrication, or warranty shall be void. If the screw compressor stages is disassembled the warranty is void. EU COMP sole responsibility and Buyer's exclusive remedy hereunder is limited to such repair, replacement, or repayment of the purchase price. The engine and other parts not of EU COMP manufactures are not covered by EU COMP´s warranty. EU COMP shall have no responsibility for any cost or expense incurred by Buyer from inability of EU COMP to repair under said warranty when such inability is beyond the control of EU COMP or caused solely by Buyer.
There are no other warranties, express, statutory or implied, including those of merchantability and of fitness of purpose; nor any affirmation of fact or representation that extends beyond the description of the face hereof.
The total responsibility of EU COMP for claims losses liabilities or damages whether in contract or tort arising out of or related to its products shall not exceed the purchase price. In no event shall EU COMP be liable for any special, indirect, incidental or consequential damages of any character including, but not limited to, loss of use of productive facilities or equipment, loss of profits, property damage, expenses incurred in reliance on the performance of EU COMP, or lost production, whether suffered by Buyer or any third party.

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Used abbreviations

description	unit	explanation
Length	mm	millimeter
Rotation speed	rpm	revolutions per minute
Tip speed	m/s	meters per second
Shaft Power	kW	kilo Watt
	HP	Horse Power
Pressure	bar a	bar absolut
	psig	pounds per square inch
Volume flow	m3/min	cubic meter per minute
	cfm	cubic feet per minute
Direction of rotation	C.W.	Clock Wise
	C.C.W.	Counter Clock Wise
Weight	kg	kilo grams
	lbs	pounds

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SI unit converter

Linear:

1 Centimeter (cm)	= 0.394 Inch
1 Inch	= 2.54cm
1 Meter (m)	= 3.281 Feet
1 Feet	= 30.48cm

Volume:

1 Liter	= 0.220 Imperial
1 Imp. Gal	= 4.546 l
1 US Gal.	= 3.785 l
1 Cubic In.	= 0.016 l
1 Cubic meter (m^3)	= 35.315 Cubic Feet
1 Cubit Feet	= 0.028 m^3

Weight:

1 Kilogram (kg)	= 2.205 Pounds
1 Pound	= 0.454 kg

Power:

1 Kilowatt (kW)	= 1.36 HP
1 HP	= 0.736kW

Pressure:

1 bar	= 14.5 Pounds per square inch (psi)
1 psi	= 0.0689 bar
1 bar a (absolut)	= 0 bar g (gauge)

Capacity:

1 Cubic Meter m^3	= 35.31 Cubic feet
1 cfm	= 0.0283 m^3/min