OULUN AMMATTIKORKEAKOULU

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DESIGN OF HYDRAULIC CYLINDER FOR HAND-HELD TOOL

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Opinnäytetyössä kehitettiin uusi käsikäyttöinen työkalu FELCO Motion SA -yritykselle. Työkalun piti tuottaa 55 kN voima, työkierron aika oli korkeintaan 4 sekuntia ja paino korkeintaan 2 kg. Lisäksi työkalun suunnittelussa pitää käyttää mahdollisimman paljon osia työkaluista, joita yrityksellä on jo tuotannossa.

Työn suoritus aloitettiin määrittelemällä tavoitteet. Seuraavaksi kerättiin tietoa oletetusta työkierrosta, rasituksen jakautumisesta työkierron aikana ja työkalun eliniästä. Lisäksi eri ratkaisuvaihtoehtoja verrattiin toisiinsa morfologisella taulukolla ja MatLab-ohjelmalla tehdyillä laskuilla. Vertailun perusteella suunniteltiin elektromekaaninen ja elektrohydraulinen perusratkaisu, joista elektrohydraulinen ratkaisu valittiin jatkokehitykseen.

Elektrohydrauliselle konseptille kehitettiin uusi alumiininen kaksitoiminen hydraulisylinteri, sylinteriin liitettävä mekaniikka ja työkalun muovinen kuori. Tästä työkalun versiosta tehtiin kaksi perusmallia. Paremmaksi arvioitu ratkaisu valittiin ja siitä tehtiin lopullinen 3D-malli Solidworks-ohjelmistolla. 3D-mallin perusteella tehtiin rakenteelle staattisen kuormituksen simulaatiot, 2D-piirustukset ja vika-, virhe-, vaikutus- ja kriittisyysanalyysi.

Työkalun viimeisen version suorituskyky vastaa odotuksia mutta paino on 300 g yli 2 kg tavoitteen. Opinnäytetyöstä saatu tieto on hyödyllistä yritykselle, koska se voi tehdä prototyypin sen perusteella ja käyttää huolella tehtyä analyysia työkalun jatkokehityksessä.

Opinnäytetyöstä kirjoitettiin tätä yksityiskohtaisempi raportti FELCO Motion SA:lle. Julkisessa opinnäytetyössä on arkaluonteisia asioita jätetty pois ja keskitytty enemmän projektissa käytettyihin teorioihin ja analyysimenetelmiin. Opinnäytetyö on tehty englanninkielisenä, jotta yritys voi tarkistaa ja ymmärtää sen.

Asiasanat: hydrauliikka, hydraulijärjestelmät, tuotekehitys, analyysimenetelmät

ABSTRACT

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The goal of the thesis project was to design a concept prototype of a hand-held tool and to use components in the products the company has designed. The tool had to develop a 55kN force, maximum cycle time was four seconds and the hand part of the tool could weight no more than two kilograms.

In the first phase goals were defined and the information was gathered on the projected loading cycle, lifetime, different solutions, components and techniques used in them. The solution concepts were compared using a morphological table and calculations files done with MatLab program. Based on the rankings and performance calculations, two basic design choices were compared: an electro-mechanical and an electro-hydraulic solution.

The electro-hydraulic solution was chosen for further development. For it a new aluminium double acting hydraulic cylinder was designed along with a plastic tool body. Two different basic models of the tool were made for appraisal and one of them was chosen for development. The 3D-model, static loading simulations, 2D-drawings and initial failure mode, effects and criticality analysis (FMECA) were done for this solution

Performance goals for the tool were met but the tool was 300 g over the weight limit set of two kilograms. The conclusions of this project are useful for the company as they can make a prototype based on 2D drawings and use the information gathered on further development of the tool.

A thorough report of the work done is included in the report given to FELCO Motion SA. The public thesis focuses on the basic theory used in the project and on the design of the hydraulic cylinder.

Keywords: hydraulics, hydraulic cylinders, mechanical engineering, failure modes, effects and criticality analysis

PREFACE

I got the possibility to do an internship abroad in Switzerland. It lasted six months during which I developed a concept prototype of a hand tool for FELCO Motion. This internship gave me my first chance at working in an engineering firm and to really use all the knowledge I have acquired while studying. It was very challenging and a huge learning opportunity. I learned a lot about engineering, working as an engineer, working in a different culture and also about the Swiss culture itself.

I would like to thank Hannu Päätalo, a professor in OUAS for helping me acquire this internship and helping with the thesis writing process. I would also like to thank everybody working in FELCO Motion SA, both in the office and assembly, for welcoming me there and making my stay a great experience. I would like to especially thank Mr. Stephane Poggi for giving me the opportunity to work at FELCO Motion and Dr. Yves Rothenbühler for all the help and guidance he gave me during the project.

Oulu 30 May 2014

Tommi Mikkola

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1 INTRODUCTION

The goal of the thesis project was to design a concept prototype of a hand-held tool. An important goal of the project was to preferably use the same parts from the existing FELCO Motion SA products, mainly components from the F820 pruning shear (1, links Tools -> Power-assisted -> FELCOtronic electric tools -> Electroportable pruning shears -> FELCO 820).

The project consisted of different phases. In the first phase information was gathered on different solution possibilities, components and techniques used in them. A morphological table and calculations files done in MatLab program were used to compare the solution components. Based on the rankings and performance calculations an electro-hydraulic and an electro-mechanical solution were compared.

The electro-hydraulic solution was chosen for further development. For this solution the component choices were made from parts from supplier's inventory. The standard hydraulic cylinders were not light and compact enough and for this reason a completely new hydraulic cylinder was designed. Two different basic models were made for appraisal. One of these solutions was chosen the 3D-model and 2D-drawings were made of this solution. The failure mode, effects and criticality analysis (FMECA) was done only on this final solution.

As specified in appendix 1, the goals were met, with the exception of a complete cost analysis. Only a very rough analysis was made because time ran out and the offices were busy before Christmas, so there was not enough time to focus on making enquiries for the cost analysis.

A thorough report of the work done is included in the report given to FELCO Motion SA. This public thesis focuses on the basic theory used in the project and on the design of the hydraulic cylinder.

1.1 FELCO Motion SA

FELCO Motion SA is a world leading manufacturer of electronic pruning shears. It is a part of the FELCO group. FELCO group started in 1945 in the hands of Félix Flisch who started making high quality pruning shears. The modern FELCO group includes its main supplier of: PRETAT which manufactures all the forged aluminium parts, FELCO which manufactures manual pruning shears and steel components such as cutting heads, FELCO Motion which specializes in design development and assembly of electro-portable tools, and finally various companies which are responsible for the distribution of FELCO products globally (Figure 1).

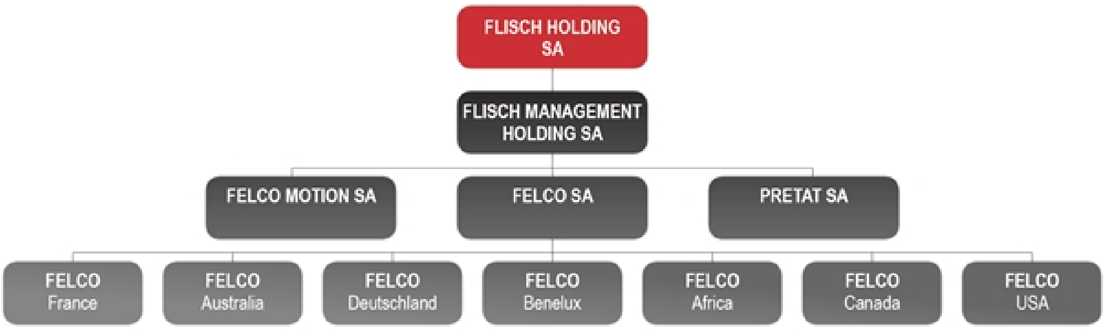

FIGURE 1. Structure of the FELCO Group (1, links About FELCO -> The people behind FELCO)

FELCO Motion is a separate company from FELCO and PRETAT. However they work together and so it was possible to use their experience and knowledge in the thesis project. This was very useful, for example when designing the forged aluminium parts.

1.2 FELCO 820

One of the main goals of the thesis project was to use components from existing FELCO Motion products such as F820 electronic pruning shear. The F820 is a multipurpose tool which can be used for: arboriculture, forestry work, parks and gardens, landscape gardening and viticulture. It can cut wood up 45mm diameter (1, links Tools -> Power-assisted -> FELCOtronic electric tools -> Electroportable pruning shears -> FELCO 820). Figure 2 shows the F820 pruning shear which is currently the most powerful electronic pruning shear developed by FELCO Motion and for this reason most of the components reused were chosen from it. The tool consists of the hand tool, control console and a backpack which contains the batteries and electronics. They are linked together with an electric cable.

FIGURE 2. F820 electronic pruning shear (1, links Tools -> Power-assisted -> FELCOtronic electric tools -> Electroportable pruning shears -> FELCO 820)

Because the hydraulic tool designed has much higher linear force requirement than F820, the main actuator from the pruning shear could not be used. However the basic idea of a tool split into hand tool and backpack, the Li-Po batteries and some electronics were reused.

2 HYDRAULICS

Hydraulic systems are a power transmission chains which convert mechanical energy into pressure and flow and back into mechanical movement again. Generally the initial mechanical energy is rotational movement which is created with an internal combustion engine or an electric motor. The transmission of pressure and flow is done with hydraulic oil and the final movement can be either rotational or linear movement. (2, p. 11.)

The benefits of hydraulic systems compared to other power transfer methods are:

- Good power to weight ratio of hydraulic systems
- small components
- easy and flexible transfer of energy with hydraulic hoses and piping
- possibility to remove the actuation from hydraulic power generation due to easy transfer of hydraulic energy
- hydraulic systems are self lubricating
- the possibility to control hydraulic systems manually or with modern electronics. (2, p. 12-13.)

There are few bad sides to hydraulic systems such as:

- the transmission fluid has to be clean
- the fluids have temperature dependant characteristics
- long distance power transmission causes power losses in the system
- in general hydraulic systems have bad total efficiency
- the components and hydraulic fluid require maintenance at regular intervals. (2, p. 12-13.)

There are two basic types of hydraulic systems, hydrodynamic and hydrostatic systems. The difference between the two is that in hydrostatic systems the energy transfer and actuation is done with hydraulic pressure and in hydrodynamic power transfer with the kinetic energy of the hydraulic liquid (2, p. 13). In modern machine design hydrostatic systems are used widely in mobile applications and so the thesis is more focused on them.

2.1 Hydrostatic systems

Hydrostatic systems are the most common type of systems in industry. They can be categorized in different ways: according to the components and construction, the control method, or by the application. According to construction they can be divided into open circuit, closed circuit or a half-open circuit. (2, pp. 14-16.)

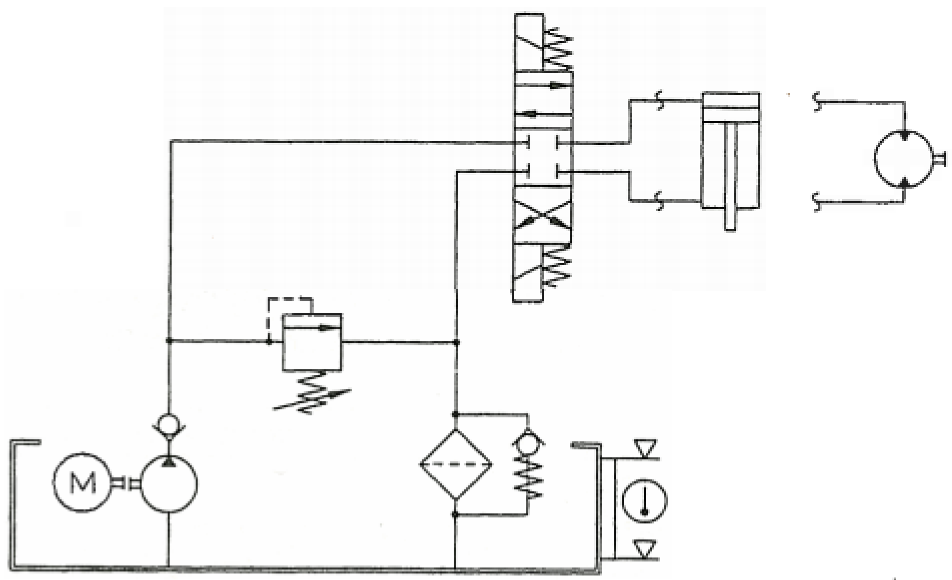

FIGURE 3. Open hydraulic circuit for a double acting piston (2, p. 14)

Open hydraulic circuits are very common in industrial hydraulics. They often have very large fluid reservoirs with single direction pump and valve control (Figure 3). They are mostly used for operating pistons but they can also be used for powering hydraulic motors. (2, p. 13.)

Figure 4 shows a closed hydraulic circuit which are often used to power hydraulic motors, and often in mobile applications. The main benefit of closed systems is that there is no need for a large oil reservoir and the system control can be done via changing the pump rotation direction and displacement. Small reservoir and fewer valves mean a lither, more compact system. (2, p. 14.)

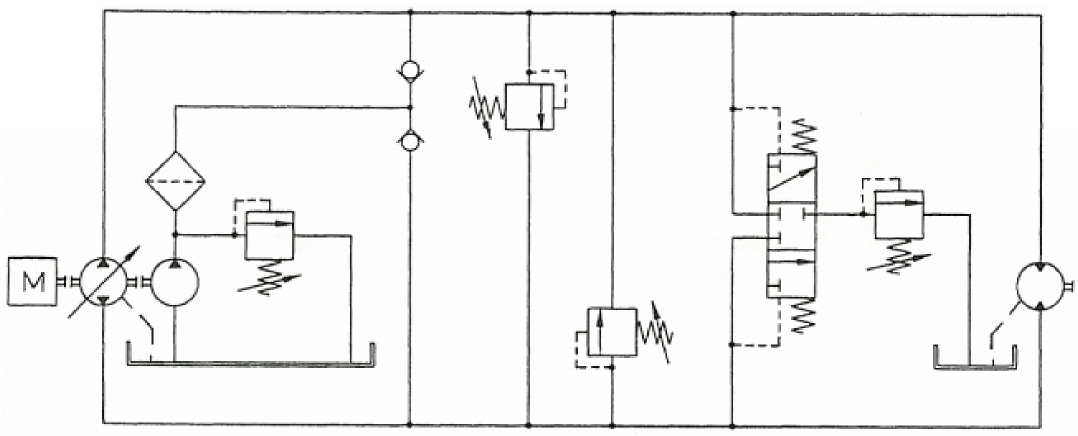

FIGURE 4. A closed hydraulic circuit for a hydraulic motor. Note the small secondary pump which compensates for any oil losses due to leaking, and improves system cooling (2, p. 14)

The half-open hydraulic circuit is a hydraulic system which has features of both closed and open circuits, and cannot be clearly defined as either. (2, p. 14.)

Furthermore hydraulic systems can be categorized into control systems and adjustment systems. Control systems are hydraulic circuits where the command value is set but the final output of the system is not verified. This means that final accuracy is dependent on external factors such as friction and temperature. Adjustment systems on the other hand have some kind of feedback loop in the system which compares the actual value to the command value and adjusts the system to make the actual value as close to command value as possible. This makes feedback systems much more resistant to external factors which might deteriorate system performance (2 p. 16).

Adjustment systems with feedback perform better but are more complicated and expensive. In the end it is application specific which kind of system is the best choice.

2.2 Hydraulic cylinder

In the thesis project a double acting hydraulic cylinder was used and not a hydraulic motor. For this reason the focus of the theory is on the formulae required for designing systems with hydraulic cylinders.

Hydraulic cylinders convert hydraulic power into linear mechanical movement. Depending on the cylinder construction, movement can be hydraulically powered in one direction and the return movement done with a spring or by the load. In this case the cylinder is called single acting cylinder. If the cylinder is hydraulically powered in both directions, it is a double acting cylinder (Figure 5). (2, p. 141.)

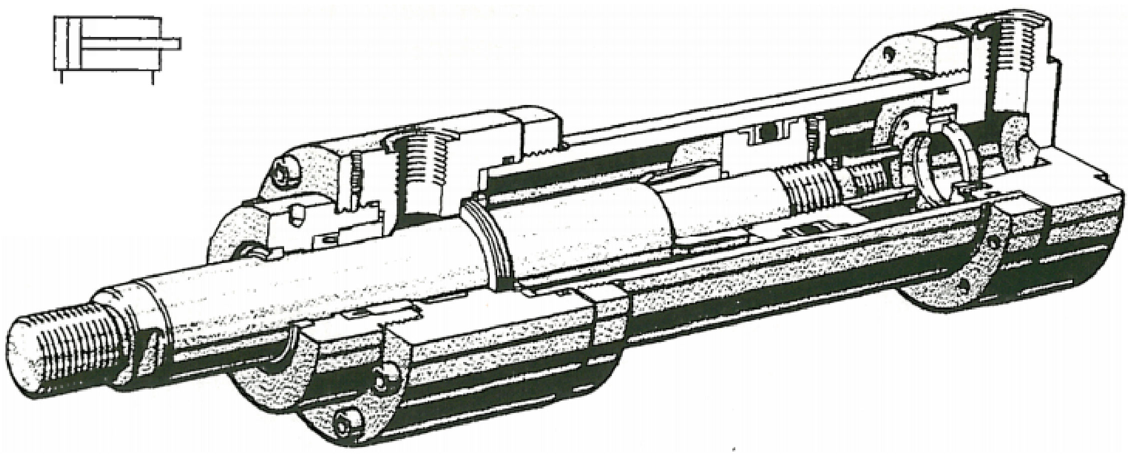

FIGURE 5. A double acting, single piston rod cylinder and the hydraulic symbol (2, p. 144.)

Cylinders which are built to be truly single acting are rare. Usually in their place is a cylinder with double acting construction but it is used as a single acting cylinder and the return movement is done with an external load. This allows the same cylinder to be used as a pulling or a pushing cylinder depending on how the hydraulic hoses are connected. (2, pp. 141-142.)

The movement speed of the cylinder depends on the volumetric flow and the effective piston area. Equation 1 shows the formula from calculating the movement speed of a hydraulic cylinder. The volumetric efficiency of the cylinder can lower the movement speed but in general the leaks are so small that calculations are done with $\eta_{vol} = 1$. (2, p. 145).

$$v = \frac{Q \cdot \eta_{vol}}{A} \qquad \textit{EQUATION 1}$$

v = movement speed (m/s)

Q = volumetric flow (m^3/s)

η_{vol} = volumetric efficiency

A = effective piston area (m^2)

The maximum force generated by hydraulic cylinders is the product of the system pressure, the effective piston area, and the hydro mechanical efficiency as shown in Equation 2 (2, p. 146).

$F = P \cdot A \cdot \eta_{hm}$ *EQUATION 2*

F = cylinder output force (N)

P = pressure inside the cylinder (Pa)

A = effective piston area (m^2)

η_{hm} = hydro mechanical efficiency

Double acting cylinders with a piston rod on one side have different movement speed and force in plus- and minus-directions due to the effective piston area being different. The piston rod creates an annular area which reduces effective piston area and results in less force but faster movement, in minus direction. When the piston area and annular area have a large ratio, the cylinders are called differential cylinders. In general the ratio is 2, so that a differential coupling can be used to have same movement speed in both directions. (2, p. 144.)

2.3 Hydraulic pumps

The most common way of producing hydrostatic power in industry is with a positive displacement pump. The basic working principle is the same in all the positive displacement pumps. They use a prime mover to power the pump which then moves the hydraulic fluid in the system. Movement of the hydraulic fluid is done by trapping the fluid in chambers which are open to intake and discharge lines alternately (2, p. 92).

The pumps move the hydraulic oil in the system but they do not create pressure. The pressure is created only when the movement of the hydraulic fluid is resisted, for example by the load on a cylinder (2, p. 93). The limit to the maximum pressure comes from the sealing of the system and from maximum torque driving the pump. One major component of the system sealing is the pump itself which acts as a seal between high pressure actuator side and the low pressure suction side (2, p. 93). When the maximum pressure goes over the limit of the sealing, oil leaks happen inside the system or out of the system, and cause degraded performance. When the maximum pressure goes over the limit set by maximum output torque of the main mover, the pump stalls.

The most common pumps can be divided by their design into following categories: gear pumps, screw pumps, vane pumps and piston pumps. They all have the same basic principle outlined earlier but they have different characteristics. Some of the features that change are: fixed displacement and variable displacement, single and double direction flow, maximum pressure and efficiency. (2, p. 92.)

When choosing a pump, the required volumetric flow and pressure need to be known. Based on these values the torque, rotation speed and power required of the prime mover can be calculated. The volumetric flow produced by pump depends on the rotation speed, displacement per revolution and volumetric efficiency as shown in Equation 3 (2, p. 95).

$$Q = \eta_{vol} \cdot n \cdot V_k \qquad \textit{EQUATION 3}$$

Q = Volumetric flow (m^3/s)

V_k = displacement per revolution (m^3/r)

n = rotation speed (r/s)

η_{vol} = volumetric efficiency

The pressure difference between the suction- and pressure connections inside the pump causes leaking from the high pressure side to the low pressure side. This causes volumetric losses, which is represented by the volumetric efficiency coefficient. The coefficient is not a constant but it depends on the pressure and rotation speed of the pump (Figure 6). (2, p. 94.)

Hydromechanical losses in pumps are cause by the friction between moving parts inside the pump and by the losses caused by the viscosity of the hydraulic fluid (2, p. 95). The coefficient improves with increasing pressure because increasing pressure increases the gaps between moving parts and thus allows for a thicker lubricating film them as shown in Figure 6 (2, p. 96).

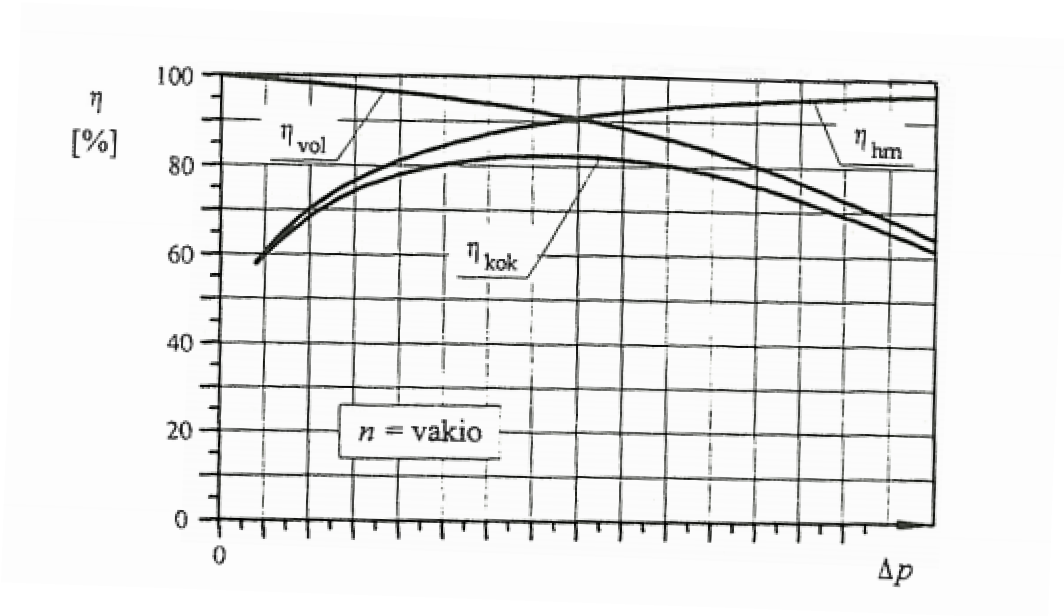

FIGURE 6. Volumetric efficiency, hydromechanical efficiency and the total efficiency as a function of pressure (2, p. 97)

Torque required to drive the pump depends on the displacement, pressure and the hydromechanical efficiency of the pump (Equation 4). For continuous use it is best to size the pump so that it can run at the pressure which gives the best total efficiency.

$$M = \frac{\Delta p \cdot V_k}{2 \cdot \pi \cdot \eta_{hm}}$$ *EQUATION 4*

M = torque required from motor (Nm)

Δp = pressure difference over the pump (Pa)

V_k = displacement per revolution (m^3/r)

η_{hm} = coefficient of hydromechanical efficiency

Finally the total power required from the motor has to be calculated (Equation 5). This is especially important when choosing an electric motor so that they do not overheat in continuous use. (2, p. 98)

$$P = \frac{Q \cdot \Delta p}{\eta_{kok}}$$ *EQUATION 5*

P = power required from the motor (W)

Q = volumetric flow (m^3/s)

Δp = pressure difference over the pump (Pa)

η_{kok} = total efficiency of the pump

3 FAILURE MODE, EFFECTS AND CRITICALITY ANALYSIS

Failure, effects and criticality analysis is an analysis method (FMECA) used to determine the reliability of a system and possible ways and effects of failure. Two types of analyses are used to determine the reliability: quantitative and qualitative. (3, p. 2.)

In the quantitative analysis different characteristics which describe the performance and reliability of the system are predicted and calculated. Typical characteristics used are values which give information on: average lifetime, failures during lifetime and safety. An example of this could be to use the average failure rate of parts to calculate the possibility of certain component or system failing. Quantitative analysis is done on component level failure criteria and is an important way of avoiding cascading failures. (3, p. 2.)

The qualitative analysis, on the other hand, is the way to find the different failure modes of systems. In a qualitative analysis humane errors or software errors are usually not taken into account. It is possible to limit FMECA to qualitative analysis but the best results are gained when both quantitative and qualitative analyses are done. (3, p. 2.)

The different failure modes are ranked according to how serious they are: by the impact on performance, the economical losses, and possible injuries caused by them. The criticality ranking is ranked according to how serious and the probability of occurrence. (3, p. 2.)

3.1 The purpose and application of FMECA

FMECA is an inductive method of determining reliability from bottom-up. It is mainly used in examination of material- and system failures. Generally only a limited analysis is done in the pre-planning stage to determine possible failure modes so that they can be easily removed or mitigated by changing the design in the early stage of project. In the final phase of the project a more complete analysis is done. When the analysis has been properly updated through the project, and it has sufficient accuracy and scope (system, subsystem, component or unit), it can be used in checking the final design. One purpose of such check could be to show that the system fulfills requirements for standards, regulations, and the user's requirements. (3, pp. 3-4.)

FMECA is an iterative method and is used as a part of the design process but the final results can also be used for example to determine maintenance schedule, frequency of calibration, or the performance and deployment tests required before acceptance of delivery. It is also a logical and well defined method of communicating information on reliability between different parties involved in the design, delivery, installation and usage of the system. (3, p. 4.)

3.2 Limitations of FMECA

FMECA is most effective when used on component level. However this makes it difficult to perform on complicated system which consists of multiple subsystems with multiple components. Especially, if the different modes of operation and effects of maintenance are taken into account, the amount of information and work required to perform the analysis is very large. Another shortcoming of FMECA is that it does not usually take into account humane errors. (3, pp. 4-5.)

3.3 Execution of FMECA

In order to perform basic FMECA the system is first divided into parts which can fail. These parts with their function are listed. For each part of the system the possible failure mode is listed with the reason for the failure. After this the local and system wide effects are listed. Local effects are the effects on the part itself and system wide effects are how they affect the whole system (3, p. 8). As an example if the pneumatic line on a train fails the local effect would be train brakes locking and the system wide effect would be the train stopping or, in extreme case, derailing.

Next the possible detection methods of failures are listed with suggestion on how to remove the failure method or mitigate the effects (3, p. 11.). The detection method is important as some failures can be hard to detect in the beginning but they are very dangerous in long run. An example could be fatigue loading causing a crack to grow until failure.

Finally the probability and criticality of the failures are listed. Continuing with the train example the probability of train stopping would be very high but the criticality low as it causes only delays in the train schedule. The train derailment failure mode would have a very low probability but very high criticality as it could cause loss of life and high economic losses. The final criticality level depends on the probability and criticality. (3, pp. 9-10.)

There are different ways of doing the final FMECA table. Table 1 shows the example used in SFS standard and usually the tables follow the same basic layout since they have to show the same elements.

TABLE 1. Example of an FMECA form. (3, p. 11)

ESIMERKKI VIKA-, VAIKUTUS- JA KRIITTISYYSANALYYSILOMAKKEESTA LIITE A

Tunnus nro ______ Analyysin tekijä ______ Suunnittelija ______ Päivämäärä ______

Laite	Tehtävä	Tunnus nro	Vioittu-mistapa	Vian aiheuttaja	Vian vaikutus		Vian havaitse-mistavat	Vaihto-ehtoisia varokeinoja tai parannus-ehdotuksia	Vian esiinty-mistoden-näköisyys	Kriitti-syystaso	Huo-mautus
					Paikal-liset vaiku-tukset	Vaiku-tukset koko järjes-telmän toimin-taan					

4 FUNCTIONAL ANALYSIS AND CONCEPT GENERATION

The design process starts by setting the goals and requirements for the final project (4, p. 100). Next step is to generate a solution concept. Often the problems are too complex to solve in one go and for this reason the problem is decomposed into subproblems. One way of doing this is with a functional analysis. (4, p. 101.)

The functional analysis splits the problem into subfunctions. Each subfunction is clearly defined in what it is and at what part of the working principle of the tool it is in (4, pp. 102-103). Usually this analysis is presented as a diagram with each subfunction as a block (Figure 7). The blocks are connected by lines with thin solid lines denoting transfer and conversion of energy, thick solid lines the movement of material, and dashed lines the movement of control and feedback signals. (4, p. 102.)

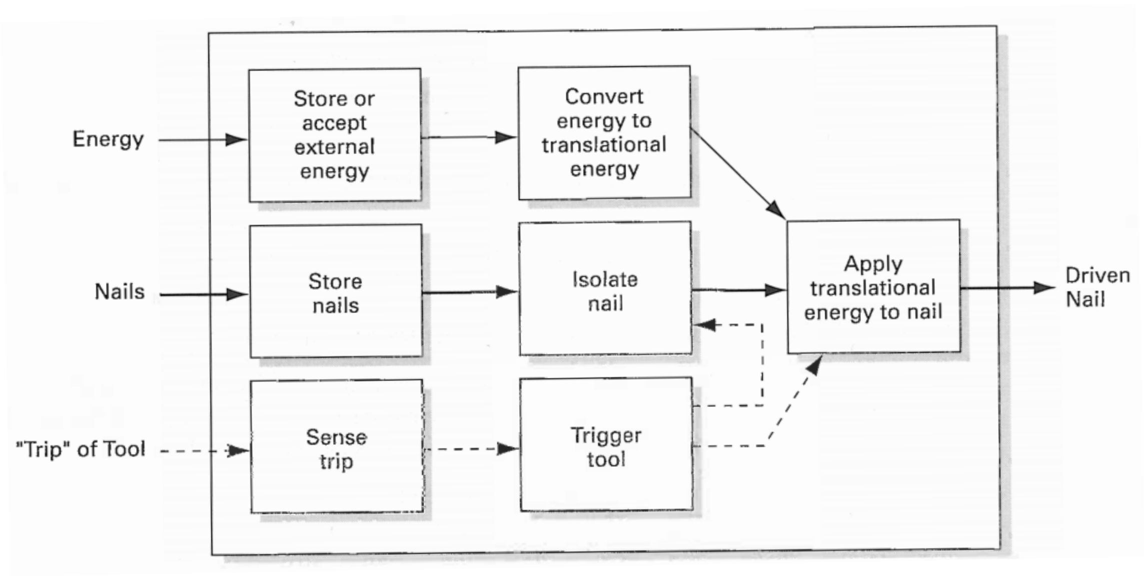

FIGURE 7. A function diagram of a hand-held nailer (4, p.102)

When the subfunctions have been defined, the next step is to research possible solutions for each subfunction. They are usually listed in concept combination table, also known as a morphological table (Figure 8). (4, p. 114.)

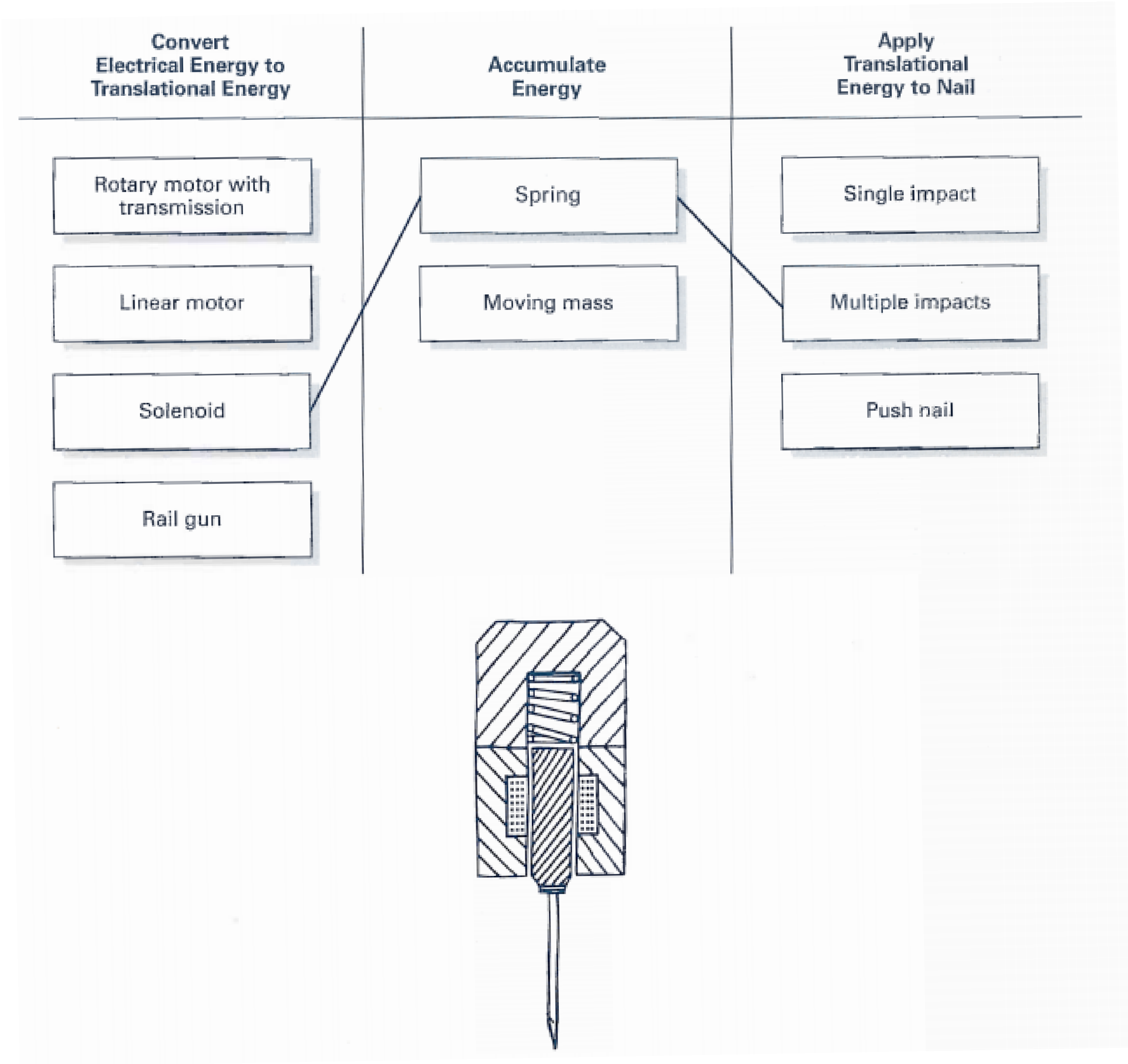

FIGURE 8. Example of a solution concept for the actuator on hand-held nailer. (4, p. 115)

Depending on the goals, different subfunction solutions can be combined to create a solution concept. Each combination usually has different results and different solution concepts with different characteristics can be made. One use for this could be in making products for different markets. In this case each solution could have a slightly different performance and price so that they match best with the targeted consumers. (4, pp. 114-118.)

The common way to choose the best solution is to rank them according to criteria (4, pp. 130-131). The criteria should be chosen so that they describe characteristics which are wanted from the final product. The grounds for rating of a criterion for a single solution should be such that it can be unambiguously set. For example prices and weights of different solutions are criteria which can be given clear numerical values for easy comparison. It is possible to use criterion such as ease of handling but their ranking is much more subjective.

After choosing the criteria they are compared against each other. They are given a rating of +, - or 0 depending on if they are rated as more important, less important or of equal value. Final net score gives each criterion their weighting (4, p. 130).

Finally the solutions are given ratings for the performance for each criterion. These ratings are multiplied by respective weighting and finally summed to give the total score for each solution (Table 2). This final score can be used to choose the best solution. (4, p. 134.)

TABLE 2. A comparison table of solutions listing the comparison criterion and their weighted ratings and scores. The total score gives a value which can be used to compare the solutions A, DF, E and G+ against each other. Higher score is the better solution. (4, p. 134.)

		Concept							
		A (Reference) Master Cylinder		DF Lever Stop		E Swash Ring		G+ Dial Screw+	
Selection Criteria	**Weight**	**Rating**	**Weighted Score**	**Rating**	**Weighted Score**	**Rating**	**Weighted Score**	**Rating**	**Weighted Score**
Ease of handling	5%	**3**	0.15	3	0.15	4	0.2	4	0.2
Ease of use	15%	**3**	0.45	4	0.6	4	0.6	3	0.45
Readability of settings	10%	2	0.2	**3**	0.3	5	0.5	5	0.5
Dose metering accuracy	25%	**3**	0.75	3	0.75	2	0.5	3	0.75
Durability	15%	2	0.3	5	0.75	4	0.6	**3**	0.45
Ease of manufacture	20%	**3**	0.6	3	0.6	2	0.4	2	0.4
Portability	10%	**3**	0.3	3	0.3	3	0.3	3	0.3
	Total Score Rank	2.75 4		3.45 1		3.10 2		3.05 3	
	Continue?	No		Develop		No		No	

5 OUTLINE OF THE THESIS PROJECT

The purpose of the project was to design a concept prototype of a hand-held tool for an application new to FELCO Motion. The tool should use same components from existing FELCO Motion products to take advantage of economies of scale. The project goal was to evaluate solutions and create a concept prototype of the tool in six months.

The development of the tool was started by making a project plan, timeline and defining the goals and requirements of the tool (Table 3). These gave an outline and limitations for the project.

TABLE 3. Goals and requirements for the tool

Date	F = Fixed req M = Minimum req. O = Optional req.	Requirement
		1. Performance
03.07.13	M	Piston actuation force 55kN
03.07.13	M	Cycle time must be maximum 4 seconds
03.07.13	M	Must work for 1 year without maintenance At 300 cycles per work day
03.07.13	M	Works in harsh conditions : rain
03.07.13	F	Uses existing forming dies
03.07.13	M	Design must have total efficiency of minimum 70 % for battery life
		2. Ergonomics
03.07.13	F	Usable by one hand
03.07.13	M	Maximum weight of tool is 2 kg
03.07.13	O	Must be well balanced
03.07.13	F	Rotating hydraulic piston
03.07.13	M	Maximum noise from tool is 85 db
		3. Finance
03.07.13	M	Stays within the specified cost limit
03.07.13	O	Uses same parts as other FELCO Motion products
03.07.13	O	Uses parts from same suppliers as other FELCO Motion products
		4. Regulations
03.07.13	F	The final product must fulfill requirements « Swiss made » marking
03.07.13	F	CE Marking
03.07.13	F	UL certification

The next step was to make an operating model analysis of the tool to decompose tool into functions. This functional analysis gave the template for further development.

The morphological table was done to evaluate the different solution concepts. In the table each different function has many different possible solutions. Criteria were defined for rating the solution and the rating was multiplied by weighting to give the final score. In order to give a weighting for the solution the pair comparison tables were distributed to four people in the office. Each person used a pair comparison table to give weighting to each criterion as they saw fit. These were then compared to the final table and the final combined weightings were used to compare different possibilities for solutions (Table 4).

TABLE 4. Pair comparison table with the combined results used to give weighting for different criterions

Pair comparison table combined									Instances	Weighting
Efficiency	A								3,75	0,104
Durability		B							5	0,139
Cost			C						4,5	0,125
Size				D					2	0,056
Weight					E				6,25	0,174
Force						F			7	0,194
Noise							G		1,75	0,049
Speed								H	5,75	0,160
									0	0,000
								Total	36	1,000

The criteria were chosen so that each solution concept could be given a numerical value when they were compared. For example the weights of different gearing choices, the estimated lifetime, or the cost of the components were used to compare solution concepts.

For further development purposes an analysis was done of the estimated lifetime and amount of cycles the tool would perform. For this purpose an analysis on how the load acts on the tool was done to find out the average load over time. The estimation was that the tool would go through 1 000 000 cycles in its lifetime.

Based on the ratings and final scores two solutions concepts were chosen for further development: an electro-mechanical and an electro-hydraulic solution. After further examination the focus was shifted to electro-hydraulic solution. This solution uses the motor and gearing from F820 pruning shear. Main actuator is a double acting hydraulic cylinder and the tool itself is divided into two parts. The hand-held part with the hydraulic cylinder and a back bag which contains the electronics, batteries, hydraulic unit and a small oil reservoir.

A double acting cylinder was chosen because it would not lose actuation force when compressing a spring, unlike a single acting cylinder. It also made possible to use hydraulic power for do the return movement at high speed. With double acting cylinder the movement is controlled with changing the electric motor movement direction, speed and the hydraulic pressure is limited by limiting the maximum allowed torque the motor can produce.

After the concept solution was chosen work, was started on the 3D model of the tool and initial FMECA. Two slightly different layout concepts were done with the same basic working principle and difference was that in them having different handling and weight characteristics. After a meeting one of these was chosen as final.

FMECA was updated as the work on the tool progressed and was used to determine what kind of maintenance the tool would require during its lifetime. For the hydraulic cylinder the most common failure modes were found from literature, articles, and from asking a person working hydraulics maintenance what were the most common failure modes in his experience.

Initial design calculations on the cylinder were done by hand but they were later verified with Solidworks simulations. For this reason a 3D model of the hand tool was made in Solidworks. It was used with Solidworks simulation to verify the design of the hydraulic cylinder, and to simulate the weight of the tool. Because the weight of the tool has such a high importance (Table 4) considerable time was used to optimize the form of the hydraulic cylinder, and other components, so that it would be as light as possible while being strong enough to withstand the pressure inside the system and not deform too much. The plastic body of the tool was designed to be suitable for injection molding manufacturing. Information on designing ABS-PC material for injection molding was found in Bossard plastic screw catalogue for screw bosses and Bayer plastics design guide for general wall thicknesses and minimum bend radii (6, pp. 19-43).

The final part of the work was to make 2D drawings of the tool parts. The drawings were done so that an accurate cost analysis for the tool could be done. They also show the many functional dimensions which are important for the working of the tool. An example of these would be the fit types, tolerances and surface qualities, of the hydraulic piston. Most of the required values were found from the supplier catalogues, such as the maximum allowed gap between parts and the required surface quality for a hydraulic seal. Other tolerances were chosen so that they were achievable with the manufacturing available and to be loose for economical reasons. Reason for this was to keep the costs low as in production costs rise quickly when tighter tolerances are used.

For the purposes of this public thesis only the design of the hydraulic cylinder is in detail.

6 HYDRAULIC SOLUTION

The basis of the hydraulic solution is a double acting hydraulic cylinder and a bidirectional pump. The system is controlled by changing the direction, speed and torque of the electric motor. These values correspond to the flow direction, volumetric flow and system pressure in the hydraulic system. Oil reservoir is needed because the volumetric flow out of the piston side is larger than the input on the piston rod side during return stroke. This is because the piston rod reduces the volume on the piston rod side. Draining of the excess flow is done via the pilot operated check valve (Figure 9).

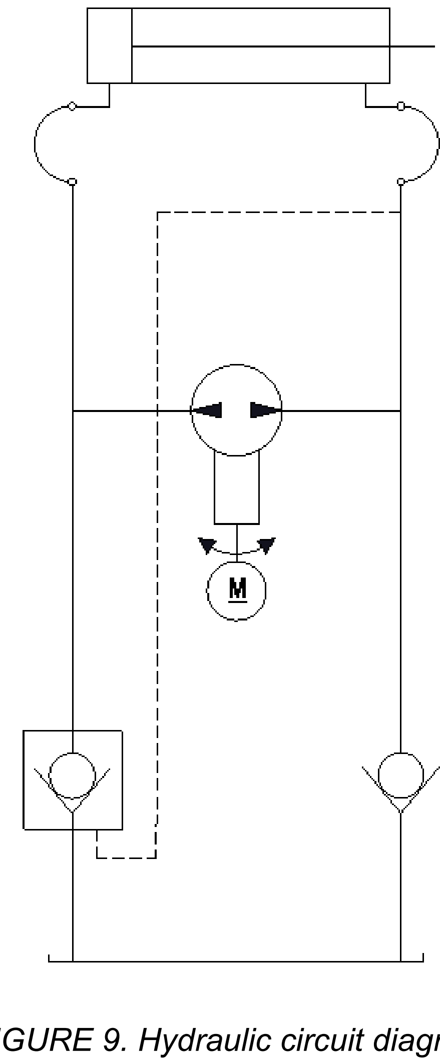

FIGURE 9. Hydraulic circuit diagram

7 DESIGN OF THE HYDRAULIC CYLINDER

High system pressure is good for a hand-held tool as it makes it possible to choose small components. Problem with high pressure is safety and price since with higher the system pressure the component cost goes up and possible leaks are more dangerous. For the tools hydraulic cylinder a system pressure of 25 MPa was chosen. First choice was to buy a standard hydraulic cylinder made from aluminium or a carbon fiber for low weight. Problem with standard aluminium cylinders was that the cylinders available didn't match our need for force and size in 25 MPa range. The carbon fiber composite cylinders were very interesting due to their lightness but they were expensive for prototype purposes and as a result it was decided to develop a new customized hydraulic cylinder.

7.1 Material for the cylinder

Forged aluminium EN-AW 7075-T6 (Appendix 2) was chosen as material for the cylinder because it combines the required lightness with very high yield strength, good corrosion resistance and good surface hardness for wear resistance. It has minimum yield strength of 460 MPa, minimum tensile strength 520 MPa and minimum surface hardness of 140 HB.

It has some weak areas: high modulus of elasticity makes it much easier to deform than steel, high friction when sliding against other aluminium surfaces, the possibility of friction welding together in situation with high surface pressure, possible galvanic corrosion. Most of these problems are avoidable with design choices. In this cylinder the aluminium piston does not come into sliding contact with other aluminium parts due to seals and wear rings. Possible galvanic corrosion spots are the steel inserts in the body but they are shielded from environments, they have a small surface area compared to aluminium and they are blue passivated screws.

7.2 Hydraulic system components

The system pressure, size of the hydraulic cylinder, and the volumetric flow required are needed to choose the hydraulic system components.

At 25 MPa the piston diameter required for creating the 55kN piston force is calculated with Equation 6, which is derived from Equation 2.

$$A = \frac{F}{P \cdot \eta_{hm}} \qquad \textit{EQUATION 6}$$

A = effective piston area (m^2)

F = cylinder output force (N), 55 000 N

P = pressure inside the cylinder (Pa), $25 \cdot 10^6$ Pa

η_{hm} = hydro mechanical efficiency, 0,9

Result for minimum area of $2{,}44 \cdot 10^{-3}$ m^2 which corresponds to piston diameter of 55.8 mm. This was rounded up to 56 mm and it was accepted since standard seals could be found in suppliers' catalogue for this size. Piston area corresponding to piston diameter of 56 is calculated in Equation 7. Equation 7 is derived from the basic equation for area of a circle (7, p. 24). The result is area for piston is 2,46 m^2.

$$A_{piston} = \left(\pi \cdot (\frac{dpiston}{2})^2\right) \qquad \textit{EQUATION 7}$$

A_{piston} = piston area (m^2)

d_{piston} = piston diameter (m), 0,056 m

Piston rod diameter of 45 mm was chosen because it is another standard size for sealing. Compared to the piston it is thick. This is to make the annulus area small and thus reduces the return movement force and increases the speed. In this application the return movement does not cause any loading on the cylinder and so a low force is not an issue. A fast return movement on the other hand is desired.

When the piston diameter is 56 mm and piston rod diameter is 45 mm, the piston annular area is calculated with Equation 8 which is derived from the equation for a circle ring (7, p. 24).

$$A_{annulus} = \left(\pi \cdot (\frac{dpiston}{2})^2\right) - \left(\pi \cdot (\frac{dpistonrod}{2})^2\right) \qquad \textit{EQUATION 8}$$

$A_{annulus}$ = piston annular area (m^2)

d_{piston} = piston diameter (m), 0,056 m

$d_{pistonrod}$ = piston rod diameter (m), 0,045 m

Result for annular area is $0{,}87 \cdot 10^{-4}$ m^2.

The pump chosen is PARKER H B S-519 miniature piston pump (Appendix 3). It has the maximum intermittent pressure of 27,6 MPa and displacement of 0.519 cm^3/r. The maximum rotation speed after gear is 4000 rpm and torque 2.6 Nm. Volumetric flow can be calculated with Equation 3.

$$Q = \eta_{vol} \cdot n \cdot V_k$$ *EQUATION 3*

Q = volumetric flow (m^3/s)

V_k = displacement per revolution (m^3/r), $5{,}19 \cdot 10^{-7}$ m^3/r

n = rotation speed (r/s), 66,67 r/s

η_{vol} = volumetric efficiency, 0,75

At 25 MPa pressure the pump gives volumetric flow of $2{,}6 \cdot 10^{-5}$ m^3/s. This value is used to calculate the plus movement. For minus movement there is no back pressure and so the volumetric efficiency goes up to 0.93. For minus movement the volumetric flow is $3{,}2 \cdot 10^{-5}$ m^3/s.

The torque required to run the pump at maximum pressure is calculated with Equation 4.

$$M = \frac{\Delta p \cdot V_k}{2 \cdot \pi \cdot \eta_{hm}}$$ *EQUATION 4*

M = torque required from motor (Nm)

Δp = pressure difference over the pump (Pa), $25 \cdot 10^6$ Pa

V_k = displacement per revolution (m^3/r), $5{,}19 \cdot 10^{-7}$ m^3/r

η_{hm} = coefficient of hydromechanical efficiency, 0,865

The torque required at maximum pressure is 2,4 Nm. This value is under the maximum allowed torque of 2.6Nm and so this pump can be used. The electric motor used can handle the power required as it is already used in F820 which used similar total power but at much higher work cycle.

The next step is to examine if this pump and cylinder combination fulfills the cycle speed requirement. The piston movement length used to calculate it is 28 mm. Equations 9 and 10 are used to calculate the theoretical movement speed of the piston. Equation 9 and 10 are derived from the equation for cylinder movement speed (Equation 1).

$$t_{plus} = \frac{s \cdot A_{piston}}{Q\eta_{volcyl}} \qquad \textit{EQUATION 9}$$

t_{plus} = time for plus movement (s)

s = movement length (m), $28 \cdot 10^{-3}$ m

A_{piston} = piston area (m^2), $2{,}46 \cdot 10^{-3}$ m^2

η_{volcyl} = cylinder volumetric efficiency, 0,95

Q_{25} = volumetric flow of the pump at 25 MPa, $2{,}6 \cdot 10^{-5}$ m^3/s

$$t_{minus} = \frac{s \cdot A_{annulus}}{Q\eta_{volcyl}} \qquad \textit{EQUATION 10}$$

t_{minus} = time for plus movement (s)

s = movement length (m), $28 \cdot 10^{-3}$ m

$A_{annulus}$ = piston annulus area (m^2), $0{,}87 \cdot 10^{-3}$ m^2

η_{volcyl} = cylinder volumetric efficiency, 0,95

Q_0 = volumetric flow of the pump with no back pressure, $3{,}2 \cdot 10^{-5}$ m^3/s

With these values the plus movement time is 2.8 seconds and a minus movement time 0.8 seconds. This makes the total cycle time approximately 3.6 seconds and is better than the required 4.0 seconds (Table 3).

After choosing the pump, the valves, hydraulic hose and hydraulic hose fittings are chosen. For the concept prototype normal hydraulic hoses with crimp fittings on the end and inline valves were chosen. This was done so that each component can be easily changed in the prototype assembly and different combinations can be tested. For the final product the valves would be cartridge type and set into a single hydraulic unit. A hose is used which is molded together with the electric wires to connect the hand tool to the power pack. This way they are molded into the same hose.

Hydraulic hose length is 1.6 m to enable easy handling. The length is same for the electric cable on F820 pruning shear. The double acting cylinder needs two hoses, one for each port on the cylinder. The chosen hose for the prototype is Aeroquip hose GH663-3 (Appendix 4). It is a DN5 size hose with outer diameter of 11.8 mm and minimum turn radius of 90 mm. It was mainly chosen because it was the smallest available size. The small diameter and turn radius ease handling.

To connect the hydraulic hose to the cylinder ports a crimp fitting is needed on the end of the hose. Ending chosen is a straight crimp fitting Aeroquip 1A5DL3 (Appendix 5). They are easy to install and cheap. It has M12x1.5 threading and a nut for connection.

Finally for the hydraulic port a Walterscheid GES 6 LR-WD stud (Appendix 6) was chosen. It is installed by threading it into the cylinder. The hydraulic port on the cylinder is size G1/8 and done according to standard DIN 3852-11 stud form E, BSP thread with captive seal (Appendix 7). Appendix 8 shows the nut and ring dimension for this type of fitting at size M6. It is the same M12x1.5 and so the nut from crimp fitting can be used on this stud.

Maximum volumetric flow is $3{,}2 \cdot 10^{-5}$ m^3/s which is equal to 1,92 l/min. For the check valve WALPRO P-RV 6 L was chosen (Appendix 9). It is a basic inline check valve and the size 6 L is suitable for low volumetric such as ours.

The chosen pilot operated check valve is Parker RH-1 (Appendix 10). It was the only inline valve currently in the suppliers catalogue and the only alternatives were cartridge valves. Problem with this valve is that too big for our needs. It has maximum pressure of 700 Bar and flow of 15 l/min. However since it was decided to choose inline valves, and since making a single manifold for a prototype is expensive, this is the initial choice.

7.3 Hydraulic cylinder

The initial design of the cylinder was made on paper with sketches and with Matlab calculations. After the initial design was done Solidworks was used to create 3D parts of the different components. These components were then fitted together in an assembly to make sure they fit together and that the required motion trajectories were possible without problems.

Static simulations were done on each part to make sure they would be able to handle the maximum stresses during operation and to help in optimizing weight. Finally the 2D drawings were made of all parts for verifying the design, for example to make sure that the tolerances are functional, and to give basis for making cost analysis.

A safety factor of minimum 1.5 was used for the design. This was done because the stresses are well defined and weight of the tool was very important. The requirement for low weight was the biggest reason for not using a larger safety factor.

The parts of the cylinder were designed to be manufactured by forging the aluminium for the basic shape and then machining the final shape and finish. The values used in calculations, such as surface hardness and yield strength also reflect this. In general forged aluminium has the best mechanical properties of the different manufacturing methods possible for aluminium. Certain parts, such as the piston, can also be machined from standard round hollow bar stock. This creates more material losses, but is probably cheaper than using a forging process.

7.3.1 Cylinder tube

The wall thickness required for the cylinder can be calculated from the formula for wall thickness of a thin walled cylindrical pressure vessel. Since the form of the vessel is cylindrical the hoop stresses are critical as they are twice as big as axial stresses. Minimum required wall thickness is calculated from Equation 11. (6.)

$$t = \frac{npr}{\sigma_h} \qquad \textit{EQUATION 11}$$

t = cylinder wall thickness (mm)

p = pressure inside the cylinder (MPa), 25 MPa

r = cylinder radius, 28 mm

σ_h = maximum allowable hoop stress, 460 Mpa

n = factor of safety, 1.5

The minimum required wall thickness of 2.8 mm.

For Equation 11 to be valid, the pressure vessel is has to be thin walled. A pressure vessel is considered thin walled if its radius is larger than 5 times its wall thickness (6). This is calculated in Equation 12.

$r > 5 * t$ *EQUATION 12*

The result for Equation 12 is r > 14. This means that Equation 11 can be used to calculate wall thickness.

When the simulations were run with 2.8 mm it was noticed that deformation was too large. For steel it would have been fine but with aluminium and its lower modulus of elasticity it deforms much more. When the cylinder tube balloons outwards too much then the piston seal will leak in the middle of movement. For these reasons the wall thickness chosen is 3.5 mm which limited the deformation (Figure 10).

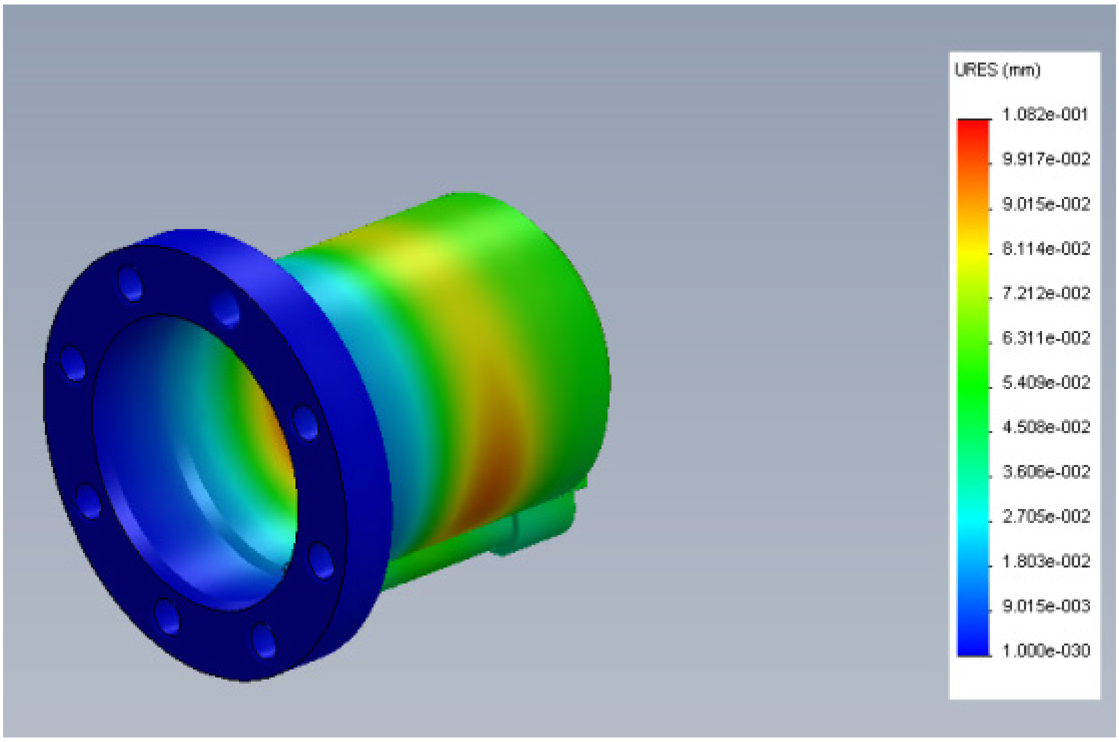

FIGURE 10. Deformation of the hydraulic cylinder under maximum pressure. The maximum 25 MPa pressure only affect the back end. On return movement the pressure is on the front end but it is minimal

The back end thickness is 10 mm and where the ports are the thickness is 13 mm. It is defined by deformation and the port thickness is the minimum value specified in the Walterscheid catalogue (Appendix 7). The strength of the ending was verified with Solidworks simulation (Figure 11). The highest stress concentration is in the end of the cylinder where cylinder wall transforms into the cylinder end. This because in that point the wall is affected by the hoop stresses in the cylinder wall and by the tension stress caused by the cylinder end trying to move axially. It still has the required factor of safety minimum 1,5.

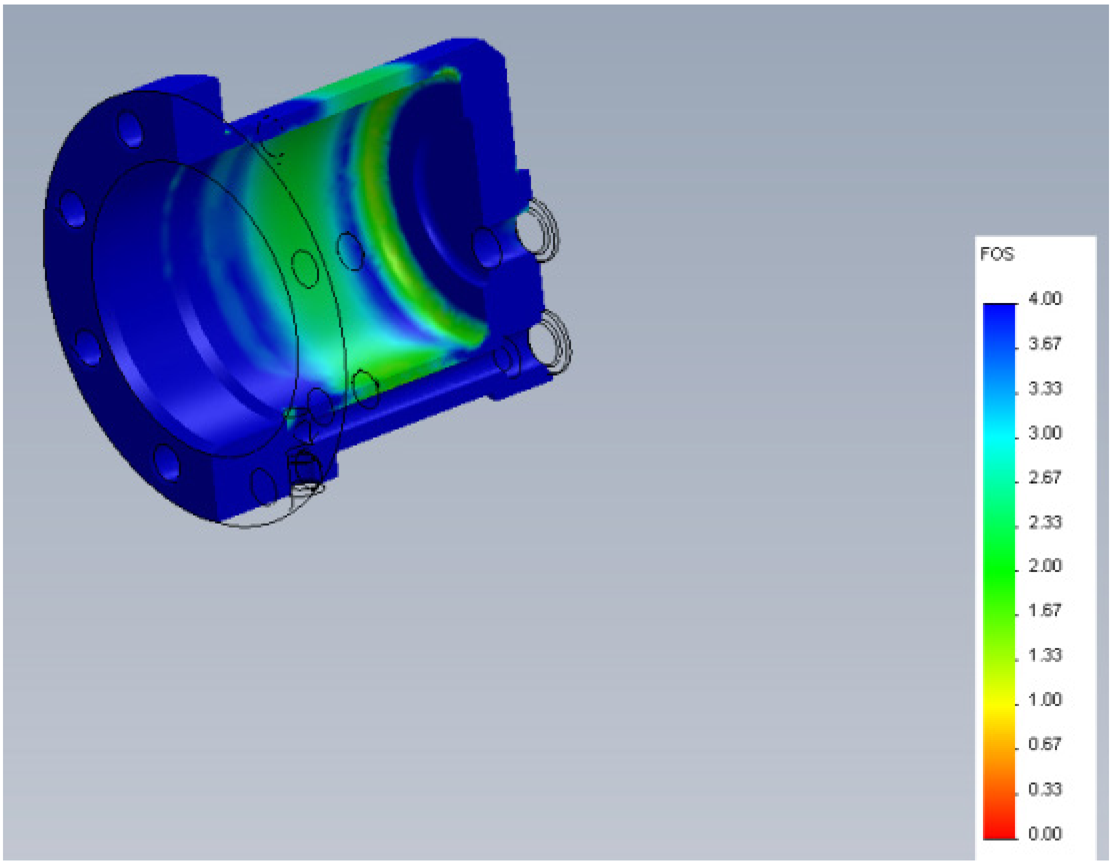

FIGURE 11. The factor of safety plot in the cylinder. Pressure used for the simulation is 25 MPa from the middle of the cylinder to the back end. The front end of the cylinder is not under direct stress as piston sealing stops the pressure

The second cylinder port is integrated into the cylinder body and it is placed in the end of the cylinder. One hole was drilled from the back end towards the front flange and another to connect it to the main cylinder tube. In order to plug this hole a Koenig MB 600-060 hydraulic plug was used (Appendix 11). Placement of the plug is shown more accurately in Figure 15, detail A. The dimensions of the plug port are defined the Appendix 11.

The front end of the cylinder is flared towards outside for a distance of 18 mm. With this the front end flange can be made slightly thicker to accommodate seal grooves.

Blue passivated steel inserts are set into the cylinder tube flange. Ensat M6 SBD 348 is a thin walled steel insert (Appendix 12/1-3). It was chosen because of its high pull out strength of over 20kN (Appendix 12/1) for M6 screws, it is a self tapping screw so installation is easy, and finally because the aluminium grade is very strong with high surface hardness which makes it well suited for using inserts.

The high pullout strength means that class 10.9 M6 screws can be used as their preload force is maximum 14.9 kN with friction coefficient of 0.08 (7, p. 778). In reality the friction coefficient will be higher due to steel-aluminium bolt head contact but this only makes it safer to use the insert. Advantages of using class 10.9 screws are that with fewer screws the assembly is faster and cheaper. Galvanic corrosion is a possible problem and for this reason the inserts are blue passivated and bolt zinced.

The type of insert used determines the dimensions of the flange (Appendix 12/2-3).

For calculation screw preload force of 12.6 kN was used (7, p. 778). With the maximum force developed by cylinder being 55 kN it gives a safety factor of 1,8.

7.3.2 Cylinder front end

The purpose of the front end is to seal the hydraulic cylinder and to hold tool in place a pin place through the holes in the end of the part. The end with pin holes has more wall thickness to withstand the force. The wall thicknesses were optimized with Solidworks simulations with minimum safety factor of 1,5 (Figure 12).

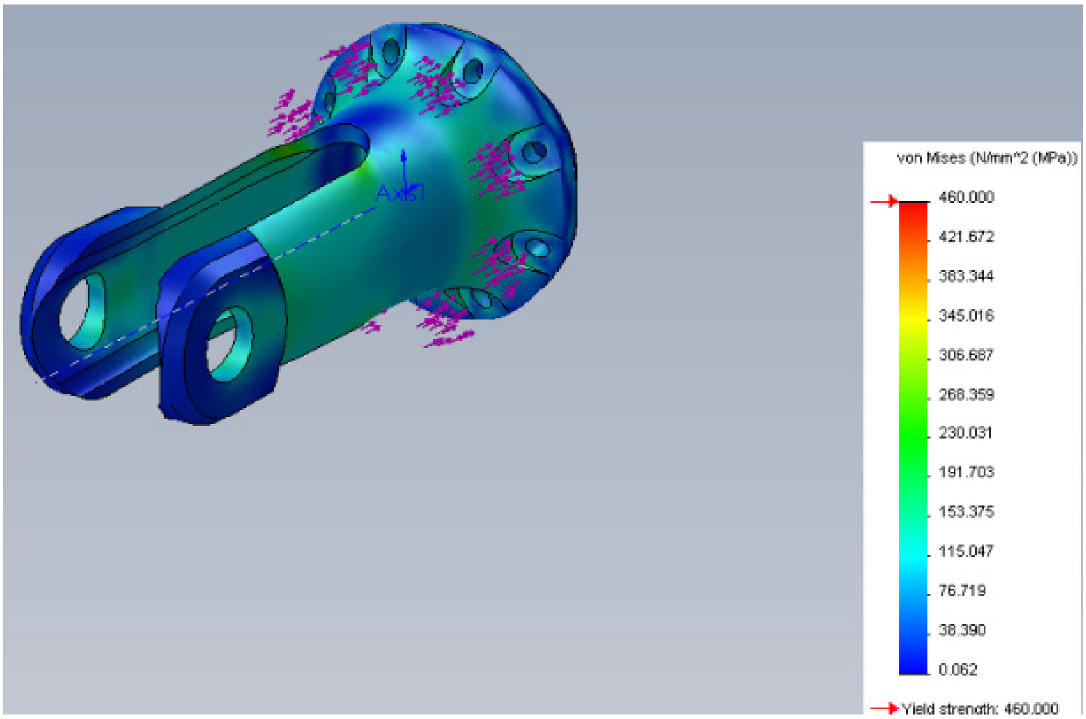

FIGURE 12. Tension stress test of the cylinder front end

In normal use the front end flange and piston should never come into contact. The cylinder tube and tool mechanism have been designed so that when the mechanism closes there is still a 3mm gap between the piston and the front end flange. This is done so that the maximum stress is moved outside the cylinder into the main mechanism which is stronger. Front end flange is strong enough to withstand the maximum 55kN force but it only has a safety factor 1.2. This way the front end can handle occasional contact between it and piston but not for each cycle during the life time

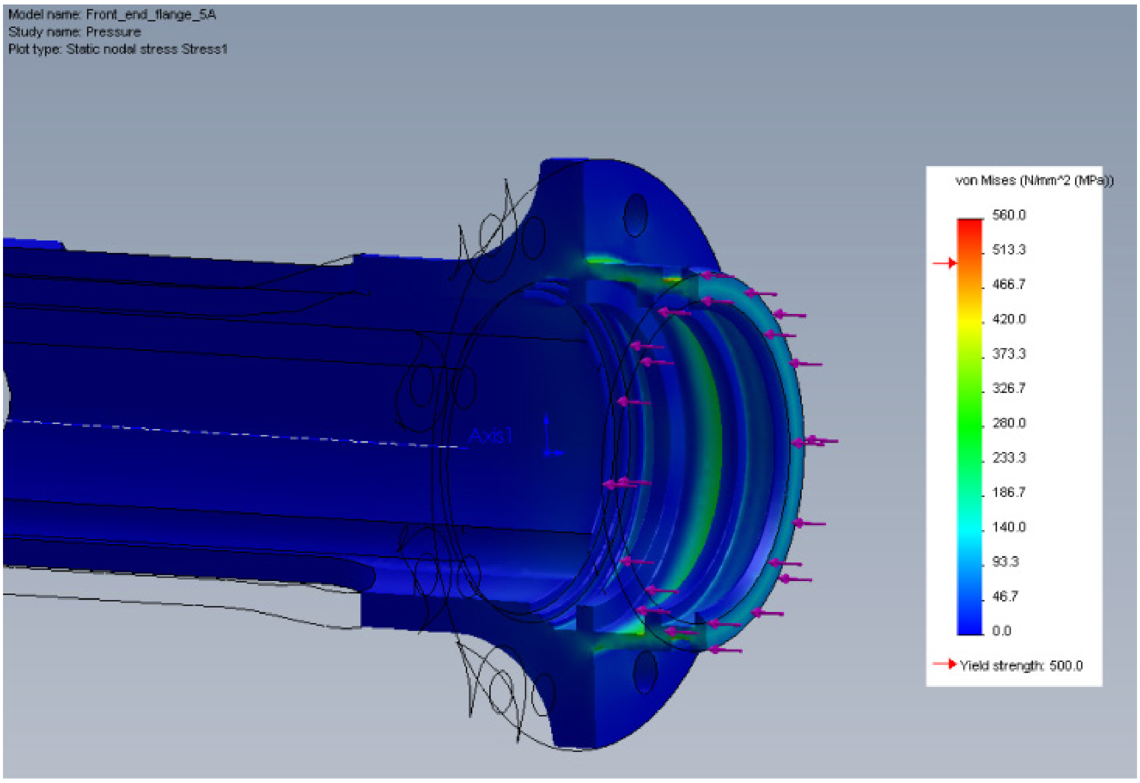

FIGURE 13. Study of the maximum piston force affecting the front end flange.

7.3.3 Piston

The hydraulic piston design is quite simple. It has a relatively thick piston rod which is machined partially hollow to reduce weight. There is a pin hole in the end for connecting it to the tool mechanism and the piston has grooves for seal and guide strip. The chamfers, tolerances and surface qualities were based on seal catalogues.

A study was done to find out if the hollowed out section can withstand the compressive force the piston rod is subjected to (Figure 14). Main failure points are the pin holes and the edges of the piston. They all have minimum 1.5 safety factor.

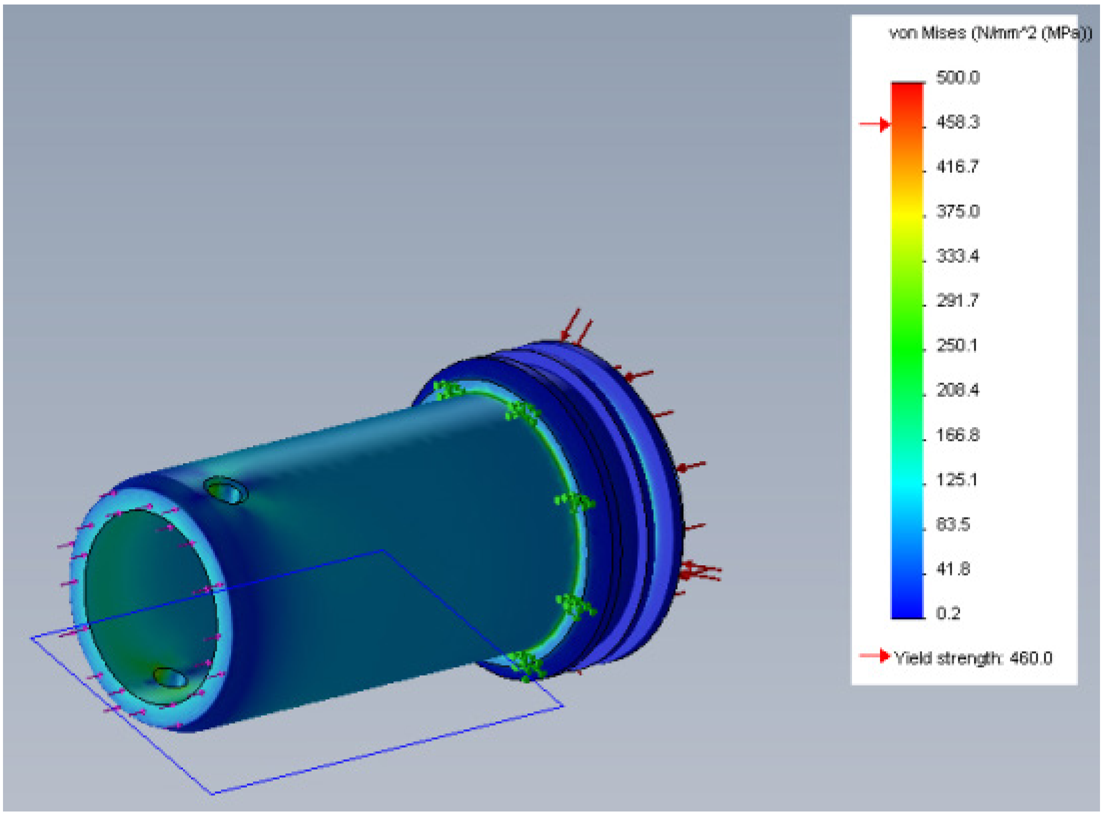

FIGURE 14. Study of compressive forces acting on the piston

Buckling analysis was not done as it was not available, and it was not required due to the piston rod always being supported by the front end flange and even at the maximum extension the buckling length is less than 50mm. This makes the diameter to length ratio very small.

7.3.4 Guide strips

The guide strips for the piston and piston rod were chosen because the different parts of the hydraulic cylinder are never completely concentric due to manufacturing tolerances and aluminium to aluminium contact in high pressure applications can result in seizing. With guide strips it is possible to replace them as they wear instead of replacing aluminium parts after wear. Guide strips also have better tribological behavior than aluminium so they reduce the stick-slip effect.

The rod and piston guide strips are Lubroseal LFSC rod guide strip and Lubroseal LKFP piston guide strip. Both are 2.5 mm thick and 6 mm wide and material is PTFE-bronze for good pressure and wear resistance (Appendix 13/1-4).

An alternative to guide strips would have been using hard anodized the aluminium. However hard anodizing also causes the maximum tensile strength of the material to lower in fatigue applications drastically. Because the tool is in the limits of low cycle fatigue during hard anodizing was not used.

7.3.5 Seals

The hydraulic cylinder is a double acting and it requires minimum of two seals: one seal for the piston and another for the piston rod. In addition to the piston and piston rod seals a wiper seal was chosen for the rod to keep contaminants from getting inside the cylinder and guide and O-ring seal for additional sealing between the front end flange and cylinder tube. The seals were chosen for mineral hydraulic fluids and all the dimensions for seal grooves are from the values given in the catalogue.

The maximum allowed gap between parts was an important consideration when choosing seals. The seal which allowed a larger gap and still held 25 MPa pressure was chosen to minimize part wear. This also allows for less accurate manufacturing tolerances.

The O-ring chosen was a basic O-ring with diameter of 2.5 mm. Model number ORM 0560-25 (Appendix 14/1-2). Dimensions for the groove were chosen according to the static application values Material is NBR for good chemical resistance for wide variety of different hydraulic fluids.

The wiper seal offers extra protection which is useful as the tool does not have filtering of the hydraulic oil and instead relies on yearly maintenance for oil changes. Wiper seal chosen is Lubroseal LWP8C (Appendix 15/7-8). The wiper was chosen because it is a double acting wiper and NBR seals have good chemical resistance. It offers good protection against any leakage of the main rod seal. The Maximum sliding speed is lower than other seals but that does not cause any problems.

The rod seal is LT20C 45/53x8.2mm (Appendix 15/1-3). The main reason for choosing this seal is the large interstice dimension it allows and with this size of the seal a hand assembly is possible. The gap between parts can be up to 0.4 mm while holding 26 MPa pressure. The seal material is Polyurethane, compared to NBR it is harder and has better wear resistance.

The piston seal is a two part composite seal LOMKP with PTFE-Bronze sealing element with prestressing Normatec O-ring NBR size 56x45x4mm (Appendix 15/4-6). The two part composite seal was chosen because it offered double acting sealing with the smallest groove size requirements, had very good performance characteristics and still allowed for a relatively large interstice dimension of 0.4mm maximum gap at 26 MPa. It is suitable for closed groove installation but because there are PTFE elements it has to be installed with care in order to not damage it.

Figure 15 shows the final hydraulic cylinder assembly. The piston here is at full extension allowed by the final actuator and shows the small gap left between piston and cylinder front end.

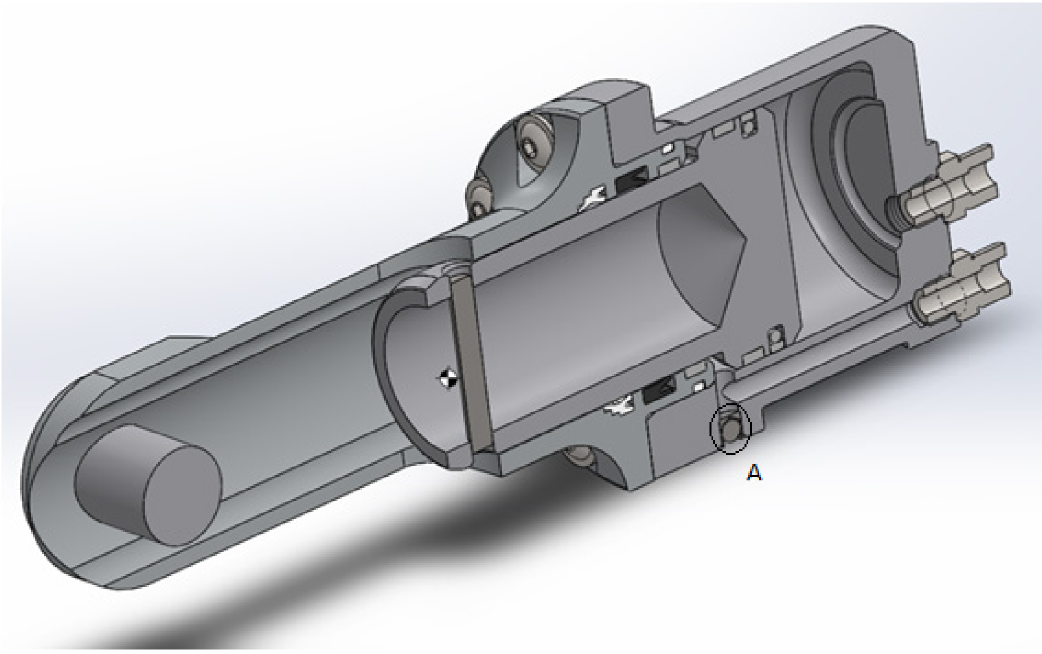

FIGURE 15. A cross-section view of the finished cylinder assembly. Detail A highlights the placement of the hydraulic plug. Placement of the hydraulic seals and guide strips is also shown.

8 CONCLUSIONS

The goal of the project was to develop a prototype concept, cost analysis and the prototype itself if there was time. A large part of the project was to reuse parts from existing FELCO Motion products.

Large amount of information was gathered for comparing solutions and choosing the best one. For this purpose a morphological table was done where different solution concepts were ranked with weighted ratings. Based on these rating an electro-mechanical and an electro-hydraulic solution were compared. The electro-hydraulic solution was chosen for further development.

For the electro-hydraulic solution the motor, electronics and batteries were reused from F820. The component choices were made for the hydraulic solutions and the hand tool was designed. The biggest parts of the hand tool development were to design a hydraulic cylinder to power it, the mechanism which the hydraulic cylinder powered and the plastic body of the tool.

Two basic layouts were made for the hand tool. Their main difference was different handling characteristics. One of them was chosen because it allowed using a lighter construction. For this final solution an initial failure mode, effects and criticality analysis, concept 3D model, static simulations and 2D drawings were done to verify and optimize the design. 2D drawings were done to show important functional values, such as hydraulic cylinder tolerances and the types of fit between different parts. The tolerances were chosen to be as loose as possible while still being functional. The reason for this was to keep the costs low as in production costs rise quickly when tighter tolerances are used. The 2D drawings make a more accurate cost analysis possible but it was not finished due to time limits. Because of the time limits the prototype was not built and neither was there enough time to get feedback on the forged aluminium part design from PRETAT SA.

The end result was mixed as it did not completely fill the goals of the project. In the final tool performance analysis the tool produced the required force but weight was 2.3 kg which goes 15% over the target. Cycle time of 3.6 s was under the speed requirement of 4 seconds. Rotation of the head is not in the prototype model and a proper cost analysis was not done. Other targets, such as noise limits, working in adverse weather and CE markings are achievable.

Despite the shortcomings, it gives a good base for further development as the initial design and concept evaluation was done thoroughly.

8.1 Considerations for further development

For the further development of the hydraulic cylinder there are things which deserve attention.

Sealing

The sealing system of the cylinder is possibly over engineered. By simplifying the sealing system costs could be driven down at the cost of performance. Also the seals chosen now are chosen for basic mineral hydraulic oil. If more ecological hydraulic oil is used, then the compatibility of the seals and hoses must be checked.

Screw connection of hydraulic cylinder

Currently eight M6, strength 10.9, screws are used to hold the front end to the cylinder tube flange. The pull out strength of steel inserts, and the number of screws must be verified.

Fatigue behaviour

Loading of the cylinder is in the low cycle fatigue area. For this reason no special fatigue analysis was done and instead the design relies on the safety factor and the fact that the cylinder was designed with minimum yield limit of the material. For the tool to go into production a good lifetime testing is needed.

Material choices

Currently the material choice for the cylinder parts is aluminium EN-AW 7075-T6. Some weight could be saved by using magnesium for the piston. This would require thicker piston walls but could possibly save weight.

Prototype testing

A lot of issues and uncertainties in the project can be resolved by prototype testing. This is needed to prove that the concept works. It also helps in determining if the tool is within the performance limits.

9 DISCUSSION

This chapter contains my personal thoughts on the project.

For me personally, the most difficult parts of the project were: the huge amount of information to be gathered for the project, the limits of the project which were not completely clear to me from the beginning. It also highlighted some problems I had in the way I worked. I often got too caught up trying to perfect small details which took away time from designing the main parts and functions. This was bad since the goal was to do a concept prototype. In my opinion at this point of product development the focus should be more on the big picture instead of on the small details.

On other hand, these were the things which taught me most about engineering and moving to work life in general. I doubt that any other projects I will end up doing will be perfectly implemented according to the original plan, and now I know to avoid doing the same mistakes.

If I could go back in time and change some of the things I did, I would spend more time on the electronics and hydraulic unit. Especially the power pack design did not get enough attention. I would also do a model with much simpler sealing and compare the costs of a double acting cylinder to a single acting cylinder.

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APPENDICES

Appendix 1 Initial Data form.

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OULUN SEUDUN AMMATTIKORKEAKOULU

TEKNIIKAN YKSIKKÖ
KOTKANTIE 1, 90250 OULU
www.oamk.fi

LÄHTÖTIETOMUISTIO

Työn tiedot

Tekijä[1]	Tilaaja[2]
Tommi Mikkola	FELCO Motion SA

Tilaajan yhdyshenkilö ja yhteystiedot[3]

[redacted]

Työn nimi[4]

[redacted] **tool**

Työn kuvaus[5]

Aim of the project is to develop a [redacted] tool which has the [redacted] force of 6 tons. Project starts with analysis [redacted] tools and ends up in a concept prototype. The project will be done for FELCO Motion SA. Aim is to use same parts as in F820 pruning shear.

Työn tavoitteet[6]

To first analyze the [redacted] tool. Then use product development methods (for examplemorphological chart) to create different solutions. Then check the feasibility of solution by strenght and performance calculations on the critical parts, create an FMECA-analysis, a cost analysis, 3D model and 2D drawings of the prototype. The prototype itself will be built if there is enough time left in the end of the project.

Tavoiteaikataulut[7]

The project lasts 6 months from 17.6 - 17.12.2013.

Päiväys ja allekirjoitukset[8]

5/7/2013 Tekijän allekirjoitus	5/7/2013 Tilaajan allekirjoitus

1. Tekijän nimi, puhelinnumero ja sähköpostiosoite.
2. Työn teettävän yrityksen virallinen nimi.
3. Sen henkilön nimi ja yhteystiedot, joka yrityksessä valvoo työn suoritusta.
4. Työn nimi voi olla tässä vaiheessa työnimi, jota myöhemmin tarkennetaan.
5. Työ kuvataan lyhyesti. Siinä esitetään muun muassa työn tausta, lähtötilanne ja työssä ratkaistavat ongelmat.
6. Esitetään lyhyesti ja selvästi työn tavoitteet.
7. Esitetään projektin tavoiteaikataulu. Silloin, kun työllä on välitavoitteita, myös ne merkitään aikatauluun. Tavoiteaikataulun ja oppilaitoksen yleisaikataulun perusteella tekijä laatii oman aikataulunsa.
8. Lähtötietomuistio päivätään ja sen allekirjoittavat tekijä ja tilaajan yhdyshenkilö.

aractéristiques mécaniques: barres

s caractéristiques mécaniques réalisables situent entre le limites indiquées. Pour résistance à la traction, la limite d'élasticité 0,2% et l'allongement à la rupture, la limite férieure indiquée correspond à la valeur arantie (dans le sens du corroyage).

Si une malléabilité maximale est requise (pour des travaux de façonnage), la limite supérieure sera prescrite comme valeur maximale garantie pour la résistance à la traction et la limite d'élasticité à 0,2% des produits recuits.

larque déposée ymbole[2]	Etat[5] Alusuisse	DIN	Dimensions[18] Ronds∅ 4 et 6 pans ép. s. pans mm	Rectan-gulaire Epaisseur mm	Résistance à la traction R_m N/mm²	Limite d'élasticité à 0,2% R_p 0,2 N/mm²	Allongement de rupture min. A_5 %	Dureté Brinell approx. HB
lliages non trempants								
luminium pur 99,5 99,5	95	F 7	toutes	toutes	65–100	20– 60	25	20
	01	W 7	< 30	< 6	65– 90	20– 60	27	20
	14	F 10	< 18	< 5	100–140	70–130	7	30
eraluman-300 IMg3	95	F 18	toutes	toutes	180–230	80–150	14	45
eraluman-260[22] IMg2,7Mn	95	–	toutes	toutes	215–290	100–160	13	55
	01	–	toutes	toutes	215–285	85–160	16	50
eraluman-412[22] Mg4Mn	95	–	≥ 14	> 14	240–315	95–180	12	65
	01	–	toutes	toutes	240–315	95–160	17	60
eraluman-462 IMg4,5Mn	95	F 27	toutes	toutes	270–350	140–220	12	65
	01	W 27	toutes	toutes	270–350	110–200	12	60
lliages trempants								
xtrudal-043 IMgSi0,5	41	F 13	toutes	toutes	130–180	65–130	15	45
	61	F 22	< 50	< 50	215–260	160–230	12	70
nticorodal-053 IMgSi0,5	61	F 25	< 50	< 50	245–300	195–280	10	75
nticorodal-062[22] IMgSi0,7	61	–	≤ 100	≤ 100	270–330	225–300	8	90
nticorodal-100[3, 22] IMgSi1	07	–	toutes	toutes	90–140	40– 80	20	35
	41	–	≤ 30	≤ 30	205–280	110–200	14	70
	61	–	≤ 30	≤ 30	310–370	260–350	8	95
nticorodal-112 IMgSi1	07	–	toutes		90–150	40– 85	18	40
	41, 43	F 21	≤ 80	≤ 50	205–280	110–200	14	65
	61, 63	F 31	< 60	< 50	310–370	260–350	10	95
	61, 63	F 30	> 60–200	50–100	300–370	240–350	8	95
	61, 63	F 27	200–250	100–200	270–340	200–320	6	95

Marque déposée Symbole[2]	Etat[5] Alusuisse	DIN	Dimensions[18] Ronds∅ 4 et 6 pans ép. s. pans mm	Rectan-gulaire Epaisseur mm	Résistance à la traction R_m N/mm²	Limite d'élasticité à 0,2% R_p 0,2 N/mm²	Allongement de rupture min. A_5 %	Dureté Brinell approx. HB
Avional-102[20] AlCuMg1	41	F 38	< 50	< 20	380–510	260–450	10	110
	43	F 40	< 80	< 30	400–510	270–400	10	110
	43	F 36	80–200[29]	30– 70	360–470	220–370	7	110
	43	F 33	200–250[29]	70–200	330–450	200–330	6	110
Avional-152[20] AlCuMG2	41	F 44	< 50	< 30	440–560	310–450	10	115
	43	F 47	< 100	< 60	470–580	330–450	8	120
	43	F 40	100–200[29]	60–150	400–530	260–420	6	105
Avional-158 AlCu2MgNi	sur demande							
Avional-662[20] AlCuSiMn	61	F 44	< 50	< 50	440–580	360–520	8	120
	63	F 46	100	< 60	460–580	400–520	7	125
Unidur-102 AlZn4,5Mg1	63	F 35	≤ 100	≤ 60	350–420	290–370	10	105
	63	F 35	> 100–250[29]	60–150	350–410	270–360	7	105
Perunal-205[20] AlZnMgCu0,5	63	F 49	< 80	≤ 50	490–570	420–520	7	130
	63	F 47	80–200[29]	50–150	470–550	400–500	7	130
	64	F 46	50	≤ 30	460–570	380–520	7	125
Perunal-215[20] AlZnMgCu1,5	07	–	toutes		220–300	90–180	13	70
	63	F 52	80	< 50	520–650	460–630	7	140
	64	F 51	50	< 30	510–650	440–630	7	140
	63	F 51	80–120[29]	50– 80	510–650	450–620	7	140
	63	F 50	120–200[29]	80–150	500–650	440–600	5	140
Super-Perunal-249 AlZn8MgCu1,5	61	–	20–50		≥ 590	≥ 500	7	150
	63	–	≤ 50		≥ 610	≥ 530	5	150
Métal pour conducteurs électriques, non trempant								
Aluminium pur 99,5E[21] E-Al	95	–	≥ 12	–	65–100	25– 80	23	20
	14	F 10	≤ 18	–	100–140	70–120	7	28
Alliages pour conducteurs électriques, trempants								
Anticorodal-041[21] E-AlMgSi0,5	71	F 17	< 100	–	170–220	120–180	12	55
Anticorodal-051[21] E-AlMgSi0,5	61	F 22	< 100	–	215–280	160–240	12	75
Alliages de décolletage, trempants								
Anticorodal Pb-109[3, 23] AlMgSiPb	61	–	< 80	–	310–370	260–350	8	100
Avional Pb-118 AlCuMgPb	41	F 37	≤ 50	–	370–470	250–330	7	110
Decoltal-500 AlCuBiPb	64	F 37	< 50	–	370–440	270–320	8	120
	61	–	< 80	–	≥ 350	≥ 230	9	110

Caractéristiques technologiques

Valeurs indicative

Marque déposée Symbole[2]	Etat[5]	Résilience J/cm²	Limites d'endurance pour 10^7 alternances, N/mm² avec surface non-usinée Efforts alternés[15] R = –1	Flexions alternés[16] R = –1	Tractions répétées[17] R = ±0
Alliages non trempants					
Aluminium pur Al99,0–99,5	01, 02, 95 24 18	>100	– 30 40	– 40 50	– 60 80
Aluman-100 AlMn1	01, 02, 95 24 18	>100	– 40 50	– 50 60	– 70 90
Peraluman-100/101 AlMg1	01, 02, 95 24 18	>100	– 40 50	– 50 60	– 90 100
Peraluman-226 AlMg2Mn0,3	01, 02, 95 24 26	35	– 60 60	– 80 80	– 100 120
Peraluman-300/301 AlMg3	01, 02, 95 24 18	35	– 90 90	– 100 100	– 140 150
Peraluman-260 AlMg2,7Mn	01, 02, 95 22 24 26	35	– 100 100 100	– 110 110 110	– 130 140 140
Peraluman-410/412 AlMg4Mn	01, 02, 95 22	35	– 90	– 100	– 140
Peraluman-460/462 AlMg4,5Mn	01, 02, 95 22 24	35	– 100 110	– 110 120	– 140 150
Alliages trempants					
Extrudal-043[13] AlMgSi0,5	61	10	70	70	100
Anticorodal-053 AlMgSi0,5	41 61	– 10	– 70	– 70	– 100
Anticorodal-062[13] AlMgSi0,7	61	20	80	80	120
Anticorodal-080 AlMg1SiCu	07 41 61	– – 20	– – 80	– – 80	– – 100
Anticorodal-100[3] AlMgSi1	07 41 61	– – 20	– – 80	– – 80	– – 130

Marque déposée Symbole[2]	Etat[5]	Résilience J/cm²	Limites d'endurance pour 10^7 alternances, N/mm² avec surface non-usinée Efforts alternés[15] R = –1	Flexions alternés[16] R = –1	Tractions répétées[17] R = ±0
Anticorodal-110/112 AlMgSi1	07 41, 51 61, 63	– – 20	– – 80	– – 80	– – 130
Avional-100/102 AlCuMg1	07 43	– 30	– 100	– 100	– 160
Avional-150/152 AlCuMg2	07 43	– 20	– 100	– 100	– 160
Avional-158 AlCu2MgNi	sur demande				
Avional-662 AlCuSiMn	07 63	– 20	– 100	– 100	– 160
Unidur-102 AlZn4,5Mg1	63	30	90	90	160
Perunal-205/212 AlZnMgCu0,5	07 63	– 10	– 110	– 110	– 170
Perunal-215 AlZnMgCu1,5	07 63	– 10	– 110	– 110	– 180
Super-Perunal-215 AlZn8MgCu1,5	sur demande				
Métal pour conducteurs électriques, non trempant					
Aluminium pur 99,5E E-Al	01 24 18	>100	– 30 40	– 40 50	– 60 80
Alliages pour conducteurs électriques, trempants					
Anticorodal-041[13] E-AlMgSi0,5	71	10	70	70	100
Anticorodal-051 E-AlMgSi0,5	61 54	10 –	70 –	70 –	100 –
Alliages de décolletage, trempants					
Anticorodal Pb-109[3] AlMgSiPb	61	20	80	80	130
Avional Pb-118 AlCuMgPb	41	30	100	100	160
Decoltal-500 AlCuBiPb	64	30	100	100	160

Explication des chiffres voir page 29

Alliages de corroyage Alusuisse[1]

Les noms de nos alliages sont des marques déposées en Suisse et à l'étranger.

Marque déposée Symbole[2]	Désignation abrégée	Caractéristiques principales	Applications typiques
Alliages trempants			
Extrudal-043 AlMgSi0,5	Ed-043	Bonnes possibilités de façonnement et forme et épaisseur; résistance mécanique moyenne; haute résistance à la corrosion; très bonne aptitude à l'oxydation anodique décorative, bonne soudabilité avec métal d'apport.	Architecture, spécialement pour profilés délicats à hautes exigences de construction métallique.
Anticorodal-053 AlMgSi0,5 6063 A-GS ~	Ac-053	Résistance mécanique moyenne, haute résistance à la corrosion, formage facile, très bonne aptitude à l'anodisation décorative, bonne soudabilité avec métal d'apport.	Profilés pour construction, véhicules appareils, architecture; s'utilise partout où la haute résistance de l'Anticorodal-100/112 n'est pas requise.
Anticorodal-062 AlMgSi0,7 6063 A-GS	Ac-062	Haute résistance mécanique; bonne résistance à la corrosion, bonne soudabilité avec métal d'aport.	Eléments sollicités mécaniquement du bâtiment, constructions navales, de véhicules et d'appareils; électrotechnique et micro-mécanique de précision.
Anticorodal-080 AlMg1SiCu	Ac-080	Haute résistance mécanique, haute résistance à la corrosion, formage facile, très bonne aptitude au polissage. Apte à l'anodisation décorative, bonne soudabilité avec métal d'apport.	Eléments fortement sollicités dur bâtiment; construction navales, de véhicules et d'appareils; électrotechnique, micromécanique de précision. Anticorodal-100 exclusivement sous forme de profilés. Anticorodal-110 exclusivement sous forme de tôle. Anticorodal-112 exclusivement pour barres et profilés à parois épaisses et pièces forgées.
Anticorodal-100[3] AlMgSi1 6082 A-SGM07	Ac-100		
Anticorodal-110/112 AlMgSi1 ↓↓ Idem	Ac-110/112	Mêmes propriétés que Ac-80 et Ac-100. Ne se prêtent à l'anodisation décorative que sous certaines conditions.	
Avional-100/102 AlCuMg1 2017A A-U4G	Av-100/102	Haute résistance mécanique et haute ténacité, résistance moyenne à la corrosion, formage facile, forgeage très facile.	Pièces hautement sollicitées d'avions, de véhicules et de machines. Pièces forgées à haute résistance.
Avional-150/152 AlCuMg2 2024 A-U4G1	Av-150/152	Très haute résistance mécanique, résistance modérée à la corrosion, aptitude au formage moyenne.	Pièces fortement sollicitées d'avions, de véhicules et de machines; pièces forgées à haute résistance.
Avional-158 AlCu2MgNi AU2GN 2618.A	Av-158	Haute résistance statique et haute résistance au fluage à temperatures élévées, résistance moyenne à la corrosion.	Pièces d'avions et de machines fortement sollicitées.
Avional-662 AlCuSiMn A-U4SG 2014	Av-662	Très haute résistance mécanique résistance modérées à la corrosion.	Pièces d'avions et de machines fortement sollicitées, pièces forgées de haute résistance.
Unidur-102[4] AlZn4,5Mg1	Ur-102	Haute résistance mécanique à l'état trempé-revenu, bonne soudabilité. Sensible à la corrosion feuilletante et fussurante sous tension en cas de traitement thermique inapproprié.	Constructions soudées fortement sollicitées en ingénierie (ponts, grues, tours).
Perunal-205/212 AlZnMgCu0,5 7079 A-Z4GU	Pu-205/212	Très haute résistance mécanique, résistance moyenne à la corrosion, bonne aptitude au forgeage. Aptitude limitée au soudage (réparation).	Constructions fortement sollicitées d'avions, de véhicules et de machines, construction d'outils et de moules.
Perunal-215 AlZnMgCu1,5 7075 AZ5GU	Pu-215	Très haute résistance mécanique, résistance moyenne à la corrosion, bonne aptitude au forgeage.	Pièces d'avions et de machines les plus fortement sollicitées.
Super-Perunal-249 AlZn8MgCu1,5	Pu-249	Résistance mécanique la plus élevée, résistance moyenne à la corrosion.	Pour pièces les plus hautement sollicitées.

Marque déposée Symbole[2]	Désignation abrégée	Caractéristiques principales	Applications typiques
Métal pour conducteurs électriques[4], non trempant			
Aluminium pur 99,5E E-Al	99,5E	Très haute conductivité électrique; bon formage.	Matérial pour conducteurs électriques.
Alliages pour conducteurs électriques[4], trempants			
Anticorodal-041 E-AlMgSi0,5	Ac-041	Haute conductibilité électrique, résistance mécanique moyenne, formage facile.	Barres de connexion pour tous emplois; aussi en exécution étamée pour installations en locaux secs.
Anticorodal-051 E-AlMgSi0,5	Ac-051	Haute conductibilité électrique, résistance mécanique moyenne, bonne résistance à la corrosion.	Pour barres de connexion tubulaires.
Alliages de décolletage[4], trempants			
Anticorodal Pb-109[3] AlMgSiPb	AcPb-109	Bonne usinabilité, haute résistance mécanique, bonne résistance à la corrosion.	Pieces décolletées sur tours automatiques. Apte à l'anodisation décorative et dure.
Avional Pb-118 AlCuMgPb	AvPb-118	Très bonne usinabilité. Très haute résistance mécanique. Résistance modérée à la corrosion.	Pièces décolletées sur tours automatiques. Anodisation technique recommandée.
Decoltal-500 AlCuBiPb	Dc-500	Usinabilité optimale, haute résistance mécanique. Résistance modérée à la corrosion.	Pièces décolletées sur tours automatiques. Anodisation technique recommandée.
Tôles et bandes plaquées			
sur demande		Choix indépendant des propriétés de volume et de surface car sur un matériau de cœur on lamine à chaud puis evtl. à froid une couche d'épaisseur définie d'un autre alliage d'aluminium. On peut plaquer une face ou les deux.	Résistance à la fois mécanique et contre la corrosion; assemblages pour brasage; surface décoratives; réflecteurs; préparation pour placage ultérieur avec acier ou autres métaux par laminage.

Explication des chiffres voir page 29

Oildyne

Miniature Piston Pumps 5 Piston Design

Pressures to 276 bar (4000 psi)
Displacements from .156cc/rev to .865cc/rev (.01 to .05 in³/rev)

Pumping Efficiencies to 90% Allow You to Effectively Use .156 to .865 cc Flow Per Rev. at Pressures to 276 bar (4000 psi)

Once in a great while there's a breakthrough design whose versatility opens broad new opportunities. Oildyne's mini pumps are a prime example.

Mini pumps pump or meter hydraulic oil, brake fluid, and Mil 5606 with equal ease. Need greater versatility?

These fixed displacement axial piston pumps are efficient and powerful too. Tests run on 78 SUS viscosity fluid at 100°F @ 3000 psi showed 90 percent volumetric efficiency. Capable of 276 bar (4000 psi) operation, mini pumps are available in nine model sizes from .156 to .865 cc per revolution displacement.

Compact size, versatility, efficiency, power and speed are quietly combined in a very cost competitive package in Oildyne's mini pumps. They're suitable for most applications requiring compact power including automotive, marine, medical and military uses.

Mini Pump Features

- .156 to .865 cc displacement per revolution.
- Designed for open circuit systems
- Fixed displacement - Output is controlled by motor speed
- Operating temperature range -40°C to +149°C (-40°F to +300°F).
- Naturally aspirated to 5000 rpm and above depending upon viscosity
- Porting on sides or rear
- Will operate efficiently on extremely thin (1 cS) fluid
- Multiple pumps, special configurations and bi-directional pumps are available on special order.

General Specifications

Model	156	206	259	311	346	417	519	692	865
Displacement									
In^3 per rev.	.0095	.0126	.0158	.0190	.0211	.0255	.0317	.0422	.0527
cc /rev	.156	.206	.259	.311	.346	.417	.519	.692	.865
GPM @ 3000 RPM	.123	.163	.205	.247	.274	.330	.411	.548	.685
cc/min @ 3000 RPM	467	618	778	934	1038	1252	1557	2076	2590
Max RPM @ rated pressure									
W/O supercharge	4400	4200	4000	3800	3800	3700	3700	3600	3500
Operating Pressure (psi)									
Continuous	3500	3500	3500	3500	3500	3500	3500	3250	3000
Intermittent	3750	3750	3750	3750	3750	3750	3750	3500	3500
Maximum	4000	4000	4000	4000	4000	4000	4000	3750	3500

Parker Hannifin Corporation
Oildyne Division
Minneapolis, MN 55428 USA

Standard Product Ordering Code

H [ ] [ ] – [ ] – [ ] – [ ] [ ] – S

COMPONENT
H High Pressure Pump

ROTATION
R CW
L CCW
B Bi-rotational

CONFIGURATION
S Single pump
T Tandem pump

SINGLE or 1st PUMP SIZE

CODE	DISP.
156	.156 cc/rev
206	.206 cc/rev
259	.259 cc/rev
311	.311 cc/rev
346	.346 cc/rev
417	.417 cc/rev
519	.519 cc/rev
692	.692 cc/rev
865	.865 cc/rev

2nd PUMP SIZE

CODE	DISP.
000	Single pump
156	.156 cc/rev
206	.206 cc/rev
259	.259 cc/rev
311	.311 cc/rev
346	.346 cc/rev
417	.417 cc/rev
519	.519 cc/rev
692	.692 cc/rev
865	.865 cc/rev

SEALS
B Buna N
V Fluorocarbon Rubber
E EPR

SHAFT & MOTOR
OO Std. .81" shaft, no motor
OR 12 VDC, 1/3 hp, Perm. Mag., close coupled
OM 24 VDC, 1/3 hp, Perm. Mag., close coupled
AA 115 VAC, 3450 rpm, 1/3 hp, cap. start
AD 230 VAC, 3450 rpm, 1/3 hp, cap. start
CC 56C Kit, includes long shaft
CO Long shaft, no motor (for use with 56C kit)
RO No shaft, replacement pump for use only with close coupled DC motor
AO Pump and shaft ***only*** for use with standard 115 and 230 VAC motors above
ZZ Contact Factory for specials

PUMP BODY
S Standard

NOTES:
1. Tandem pumps must have larger displacement called out first
2. Tandem pumps are not available with the standard AC or DC motors - only plain shaft or 56C Kit
3. Drive shaft input torque must be under 3.5 n-m (525 in-oz) [equivalent to HRS865 operating at 207 bar (3000 psi); refer to catalog performance curves for torque data]
4. Bi-rotational pumps require the side port as case drain
5. For configurations not shown above please contact Oildyne

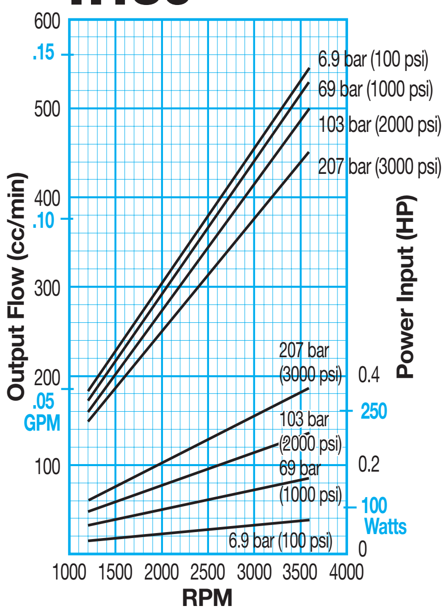
Parker Hannifin Corporation
Oildyne Division
Minneapolis, MN 55428 USA

Performance Data

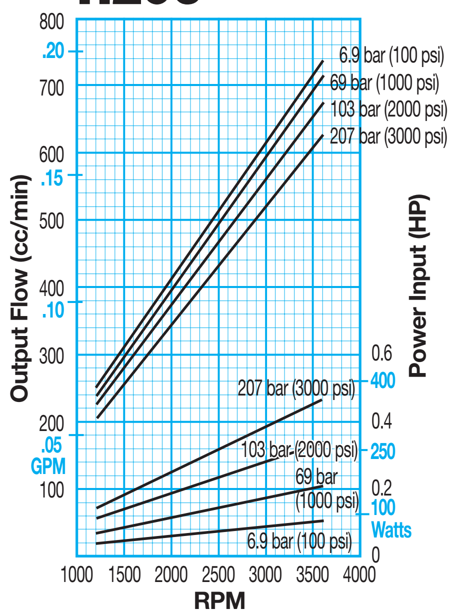
Performance data shown are the average results based upon a series of laboratory tests of production units and are not necessarily representative of any one unit. Tests were run with oil at 78 SUS at 38°C (100°F).

In accordance with our policy of continuing product development, we reserve the right to change specifications shown without notice.

H156



H206



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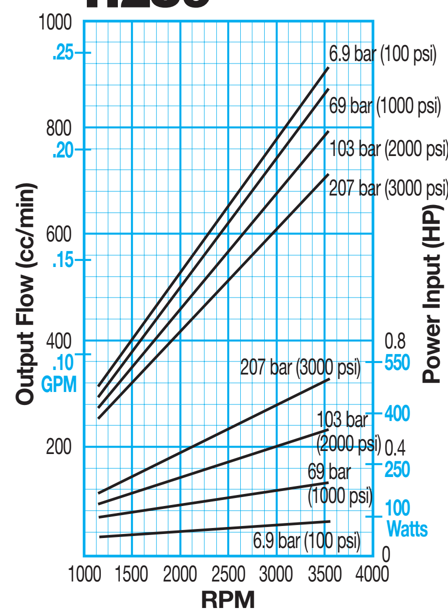
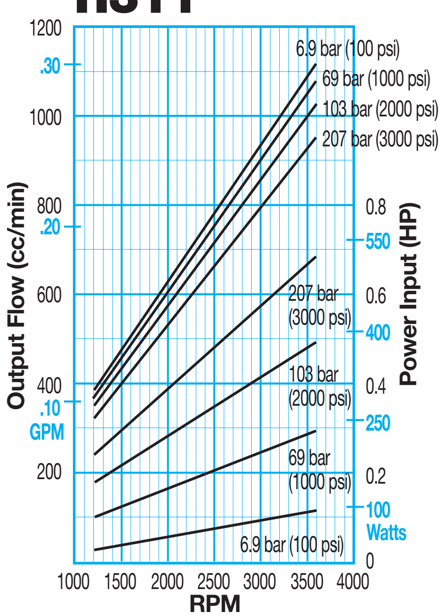


H311



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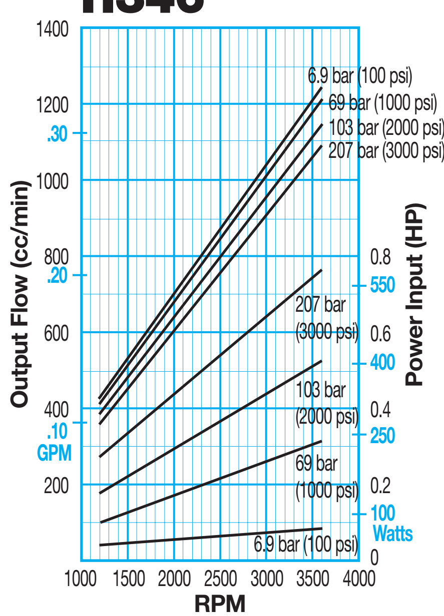

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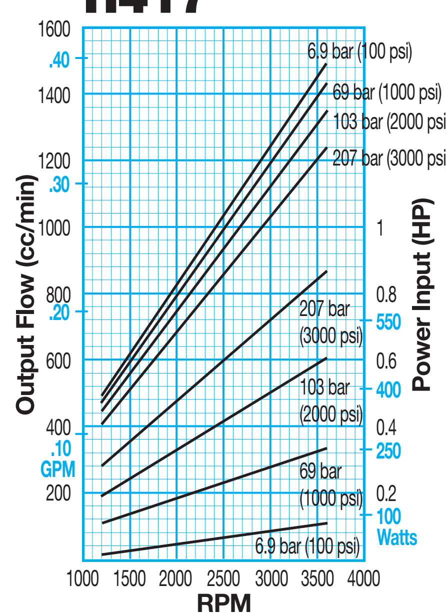

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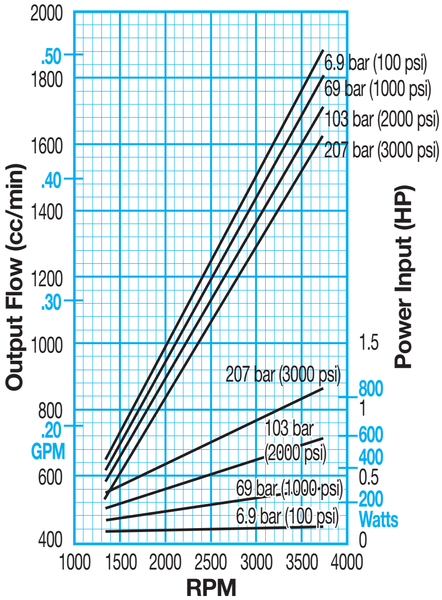
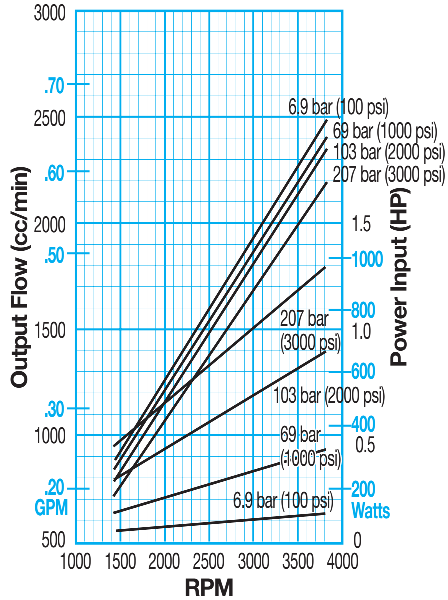
Oildyne Division
Minneapolis, MN 55428 USA

Performance Data **Miniature Piston Pumps**

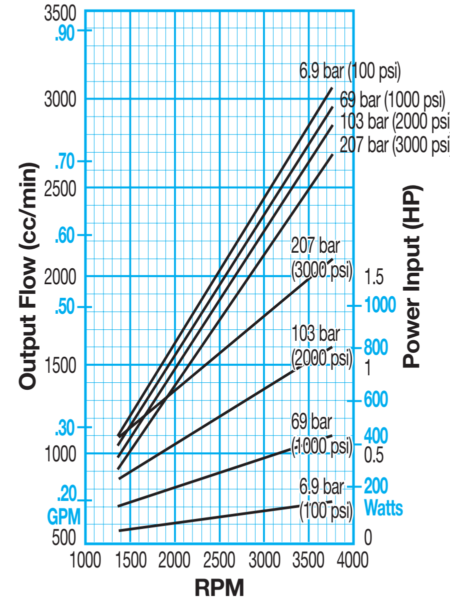
H519



H692



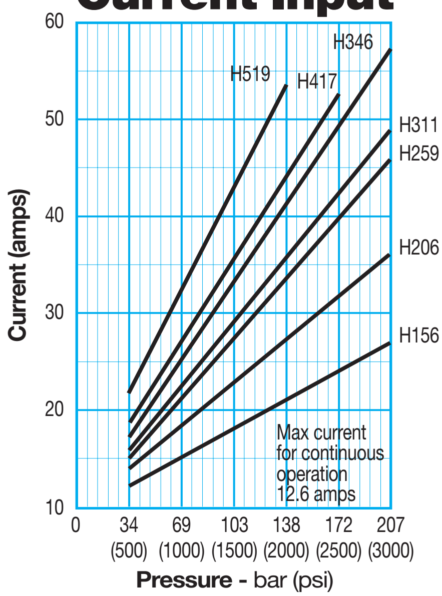
H865



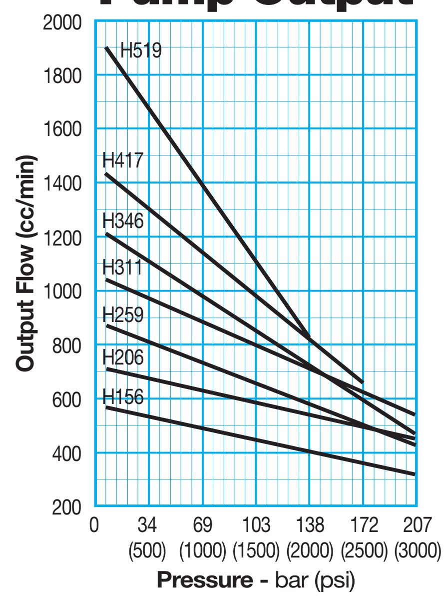
Typical Performance Data

at 12 VDC as assembled with a standard DC motor

Current Input

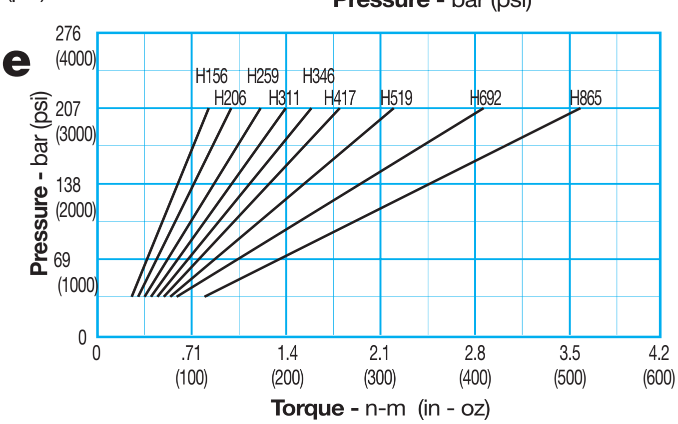


Pump Output



Average Input Torque

Speed: 3000 RPM



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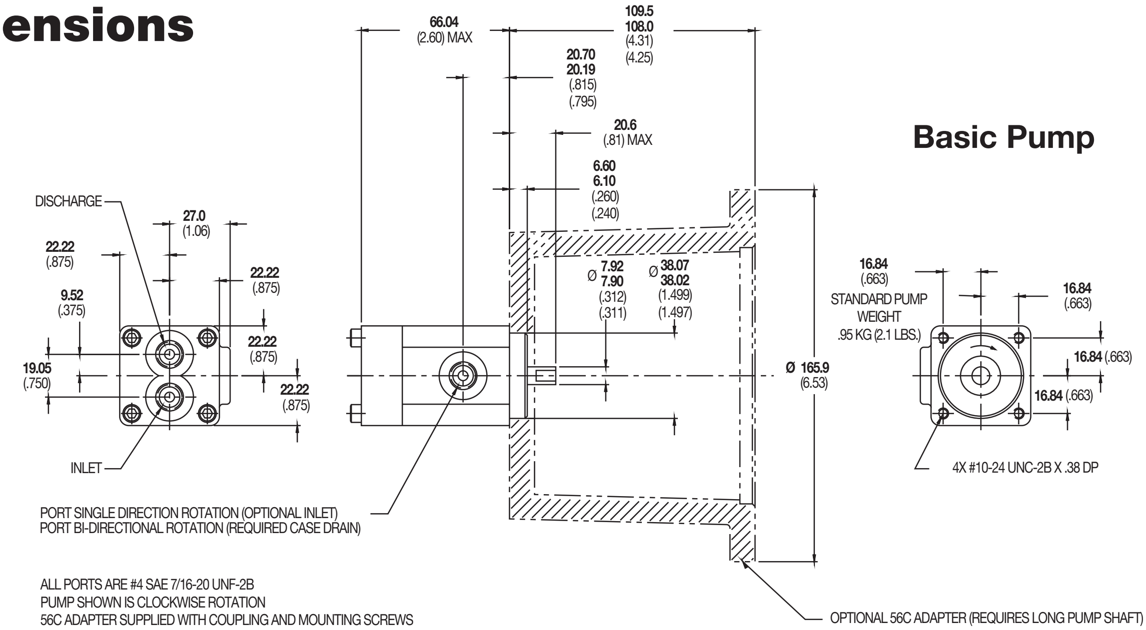
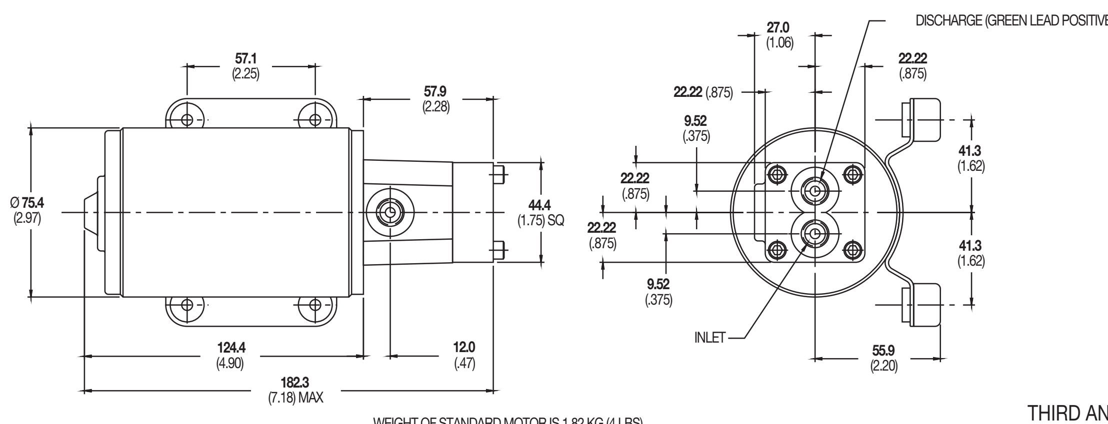
Minneapolis, MN 55428 USA

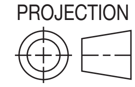
Dimensions

Basic Pump

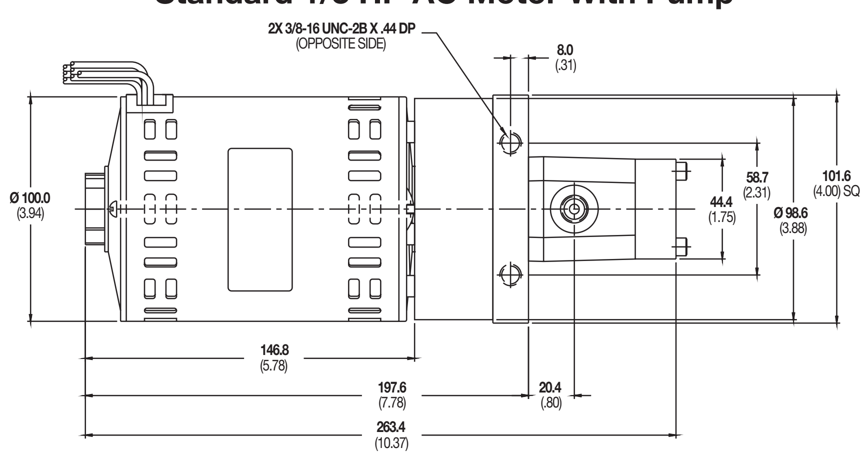


Standard 1/3 HP DC Permanent Magnet Motor With Pump





Standard 1/3 HP AC Motor With Pump



Note: All dimensions in **mm** (inches).

GH663 Hydraulikschlauch 1SN

Technische Daten:

Temperaturbereich:
-40°C bis +100°C
max. +125°C
Luft* max. +70°C

Anwendung:
Für Hydrauliksysteme auf Mineralölbasis und Wasser-Glykol Emulsionen, leichtes Heizöl, Schmieröl, Luft* und Wasser.

Aufbau:
Seele synth. Gummi NBR
Druckträger 1 Drahtgefl.
Decke synth. Gummi CR

Caractéristiques techniques

Plage de température:
-40°C à +100°C
jusqu`a +125°C
Air* jusqu`a +70°C

Applications:
Pour circuits hydrauliques à base d'huiles minérales et à èmulsions eau/glycols, fuel, huiles de lubrification, air* et eau.

Construction:
Tube int. en NBR;
Renforcement: 1 tresse acier; Tube ext. en gomme synth. En CR

Dati tecnici:

Range di temperatura:
-40°C / +100°C
fino a +125°C
Aria* fino a +70°C

Applicationi:
Per circuiti idraulici con olii a base minerale ed emulsioni di acqua e glicole, olio cumbustibile leggero, olii lubrificanti, aria*ed acqua.

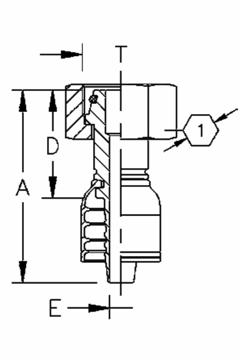
Costruzione:
Condotta interna in NBR
Rinforzo con una treccia d`acciaio, Rivestimento in gomma sint. CR

GIRMATIC Art. Nr.	Bestell-Nr.	DN	Size 1/16"	I.D.	A.D	Min. Biegeradius MM	Max. Betriebsdruck Bar	Min. Berstdruck Bar	Gewicht Kg/m
503275	GH663-3*	5	3	4,8	11,8	90	250	1000	0,19
504878	GH663-20*	31	20	31,8	43,5	420	65	260	0,95
504879	GH663-24*	38	24	38,1	50,6	500	50	200	1,35
504880	GH663-32*	51	32	50,8	64,0	630	40	160	2,2

*EN583/1SN

GIRMATIC

DL SH681 / SH663 / GH781 / FC619



Dichtkopf DKOL, leichte Baureihe

* 1-wire
** 2-wire

GIRMATIC Art. Nr.	Part Number	Thread T	Flange	Tube O.D mm	ND	Hose Size	A mm	D mm	H mm	E Ø mm	HEX 1	HEX 2	K Ø mm
503050	1A5DL3	M12x1,5		6	5	3	39,7	22,2		2,5	14		
502070	1A5DL4	M12x1,5		6	6	4	44,8	21,4		4,2	14		
503056	1A6DL4	M14x1,5		8	6	4	46,0	22,6		4,2	17		
503064	1A6DL5	M14x1,5		8	6	5	46,2	22,3		5,3	17		
503078	1A6DL6	M14x1.5		8	6	6	48,5	23,2		6,7	17		
503059	1A8DL4	M16x1,5		10	6	4	48,2	24,8		4,2	19		
503067	1A8DL5	M16x1,5		10	8	5	50,7	26,8		5,3	19		
503079	1A8DL6	M16x1,5		10	10	6	50,5	25,2		6.7	19		
502062	1A10DL4	M18x1.5		12		4	50,0	26,6		4,2	22		
502673	1A10DL6	M18x1,5		12	10	6	51,2	25,9		6,7	22		
502660	1A12DL8	M22x1,5		15	12	8	58,3	28,6		9,6	27		
502652	1A16DL8	M26x1.5		18		8	59,6	29,9		9,6	32		
502376	1A16DL10	M26x1,5		18	16	10	59,2	29,8		12,8	32		
502343	1A20DL8	M30x2.0		22		8	62,0	32,3		9,6	36		
502381	1A20DL10	M30x2.0		22		10	62,0	32,6		12,8	36		
502389	1A20DL12	M30x2,0		22	19	12	62,5	32,3		15,5	36		
502403	1A20DL16	M30x2.0		22		16	64,7	30,3		20,7	36		
502408	1A25DL16	M36x2,0		28	25	16	68,2	33,8		20,7	41		
502416	1AP32DL20*	M45x2,0		35	31	20	83,7	39,7		26,6	50		
502418	1AT32DL20**	M45x2,0		35	31	20	83,7	39,7		26,6	50		
502427	1A32DL24	M45x2,0		35		24	81,1	34,8		32	50		
502441	1A40DL24	M52x2,0		42	38	24	87,2	40,9		32	60		

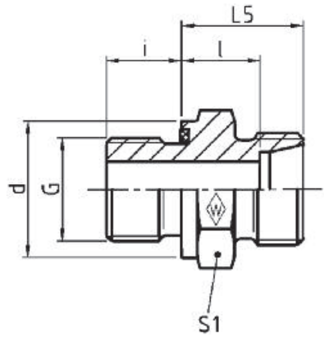
Male stud coupling (body only)
Gerade-Einschraubstutzen
Union simple mâle (corps)

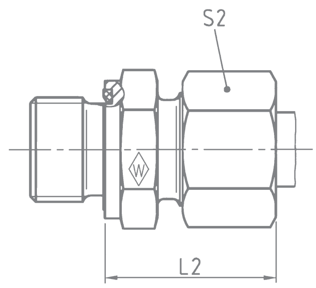
GES …… R-WD

with captive seal: NBR* (e. g. Perbunan)
Stud thread: BSP thread (parallel)

mit Weichdichtung NBR* (z. B. Perbunan)
Einschraubgewinde: Whitworth-Rohrgewinde (zylindrisch)

avec joint mou: NBR* (p. ex. Perbunan)
Filetage mâle: Whitworth (cylindrique)





E

DIN-ISO 228 (R …, DIN 259)

Series / Reihe / Série	bar / PN / (psi)	Tube OD / Rohr-AD / Tube Ø ext.	G	Type / Typ / Désignation	Reference / Best.-Nr. / Réf.	kg per 100 pcs. / kg per 100 St. / kg par 100 p.	L_5	L_2	l	i	d	S_1	S_2
	500 (7252)	6	G 1/8 A	**GES 6 LR-WD**	**WAL037615**	1,5	15,5	23	8,5	8	13,9	14	14
		6	G 1/4 A	**GES 6 L/R 1/4-WD**	**WAL606456**	3,0	17	24,5	10	12	18,9	19	14
		8	G 1/4 A	**GES 8 LR-WD**	**WAL037616**	2,5	17	25	10	12	18,9	19	17
		8	G 1/8 A	**GES 8 L/R 1/8-WD**	**WAL606457**	1,7	16,5	24	9,5	8	13,9	14	17
	400 (5801)	8	G 3/8 A	**GES 8 L/R 3/8-WD**	**WAL606458**	4,8	18,5	26	11,5	12	21,9	22	17
	500 (7252)	10	G 1/4 A	**GES 10 LR-WD**	**WAL037617**	3,0	18	26	11	12	18,9	19	19
		10	G 3/8 A	**GES 10 L/R 3/8-WD**	**WAL027596**	4,0	19,5	27	12,5	12	21,9	22	19
		10	G 1/2 A	**GES 10 L/R 1/2-WD**	**WAL606414**	5,2	21	27,5	13	14	26,9	27	19
	400 (5801)	12	G 1/4 A	**GES 12 L/R 1/4-WD**	**WAL037618**	3,5	19	27	12	12	18,9	19	22
		12	G 3/8 A	**GES 12 LR-WD**	**WAL037619**	4,0	19,5	27	12,5	12	21,9	22	22
		12	G 1/2 A	**GES 12 L/R 1/2-WD**	**WAL024957**	6,5	20	28	13	14	26,9	27	22
		15	G 1/2 A	**GES 15 LR-WD**	**WAL037620**	6,5	21	28,5	13,5	14	26,9	24	27
		15	G 3/8 A	**GES 15 L/R 3/8-WD**	**WAL604985**	4,9	20,5	29	14	12	21,9	27	27
		18	G 1/2 A	**GES 18 LR-WD**	**WAL037621**	7,0	22	31	14,5	14	26,9	27	32
		18	G 3/4 A	**GES 18 L/R 3/4-WD**	**WAL605124**	13,5	22	31	14,5	16	31,9	32	32
	250 (3626)	22	G 3/4 A	**GES 22 LR-WD**	**WAL037622**	10,5	24	33	16,5	16	31,9	32	36
		28	G 1 A	**GES 28 LR-WD**	**WAL037623**	16,5	25	34	17,5	18	39,9	41	41
		35	G 1 1/4 A	**GES 35 LR-WD**	**WAL037624**	27,0	28	39	17,5	20	49,9	50	50
		42	G 1 1/2 A	**GES 42 LR-WD**	**WAL037625**	34,5	30	42	19	22	54,9	55	60
S	800 (11603)	6	G 1/4 A	**GES 6 SR-WD**	**WAL037626**	3,5	20	28	13	12	18,9	19	17
		8	G 1/4 A	**GES 8 SR-WD**	**WAL037627**	4,0	22	30	15	12	18,9	19	19
		8	G 3/8 A	**GES 8 S/R 3/8-WD**	**WAL371292**	6,2	22,5	30,5	15,5	12	21,9	22	19
		10	G 3/8 A	**GES 10 SR-WD**	**WAL037628**	5,5	22,5	31	15	12	21,9	22	22
		10	G 1/4 A	**GES 10 S/R 1/4-WD**	**WAL602927**	4,7	22	30,5	14,5	12	18,9	19	22
		10	G 1/2 A	**GES 10 S/R 1/2-WD**	**WAL606460**	13,9	25	33,5	17,5	14	26,9	27	22
	630 (9137)	12	G 3/8 A	**GES 12 SR-WD**	**WAL037629**	9,5	24,5	33	17	12	21,9	22	24
		12	G 1/4 A	**GES 12 S/R 1/4-WD**	**WAL606425**	5,8	24	32,5	16,5	12	18,9	22	24
		12	G 1/2 A	**GES 12 S/R 1/2-WD**	**WAL027858**	9,5	25	34	17,5	14	26,9	27	24
		14	G 1/2 A	**GES 14 SR-WD**	**WAL037630**	9,5	27	37	19	14	26,9	27	27
		16	G 1/2 A	**GES 16 SR-WD**	**WAL037631**	9,0	27	37	18,5	14	26,9	27	30
		16	G 3/8 A	**GES 16 S/R 3/8-WD**	**WAL371285**	8,5	26	36,5	18	12	21,9	27	30
		16	G 3/4 A	**GES 16 S/R 3/4-WD**	**WAL066454**	15,5	29	39	20,5	16	31,9	32	30
	420 (6091)	20	G 3/4 A	**GES 20 SR-WD**	**WAL037632**	15,0	31	42	20,5	16	31,9	32	36
		25	G 1 A	**GES 25 SR-WD**	**WAL037633**	26,5	35	47	23	18	39,9	41	46
		25	G 3/4 A	**GES 25 S/R 3/4-WD**	**WAL066516**	24,5	35	47	23	16	31,9	41	46
		30	G 1 1/4 A	**GES 30 SR-WD**	**WAL037634**	42,0	37	50	23,5	20	49,9	50	50
		38	G 1 1/2 A	**GES 38 SR-WD**	**WAL037635**	56,5	42	57	26	22	54,9	55	60

L_2 = approximate length with nut tightened
L_2 = Ungefährmaß bei angezogener Überwurfmutter
L_2 = longueur approximative, l'écrou étant bloqué

* FPM (e. g. Viton) on request
* FPM (z. B. Viton) auf Anfrage
* FPM (p. ex. Viton) sur demande

Studs and port forms | Einschraubzapfen und Einschraublöcher | Implantations, embases et taraudages

B

Metric ISO thread (parallel) DIN 13
BSP thread (parallel) DIN-ISO 228 (up to now DIN 259)

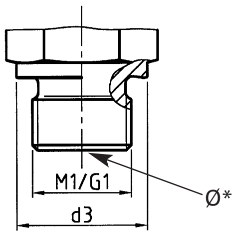
Metrisches ISO-Gewinde (zylindrisch) DIN 13
Whitworth-Rohrgewinde (zylindrisch) DIN-ISO 228 (bisher DIN 259)

Filetage métrique ISO (cylindrique) DIN 13
Filetage Whitworth (cylindrique) DIN-ISO 228 (jusqu'ici DIN 259)

Stud form B
DIN 3852-1 / ISO 9974-3 (metric)
DIN 3852-2 / ISO/DIS 1179-4 (BSP thread)
metal-to-metal seal

Einschraubzapfen Form B
DIN 3852-1 / ISO 9974-3 (metrisch)
DIN 3852-2 / ISO/DIS 1179-4 (Rohrgewinde)
Abdichtung durch Dichtkante

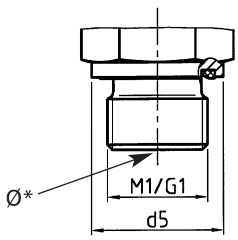
Implantation forme B
DIN 3852-1 / ISO 9974-3 (métrique)
DIN 3852-2 / ISO/DIS 1179-4 (filetage Whitworth)
étanchéité par arête métal



Stud form E
DIN 3852-11 / ISO 9974-2 (metric)
DIN 3852-11 / ISO/DIS 1179-2 (BSP thread)
with captive seal (WD)

Einschraubzapfen Form E
DIN 3852-11 / ISO 9974-2 (metrisch)
DIN 3852-11 / ISO/DIS 1179-2 (Rohrgewinde)
Abdichtung durch Weichdichtung (WD)

Implantation forme E
DIN 3852-11 / ISO 9974-2 (métrique)
DIN 3852-11 / ISO/DIS 1179-2 (filetage Whitworth)
étanchéité par joint mou (WD)

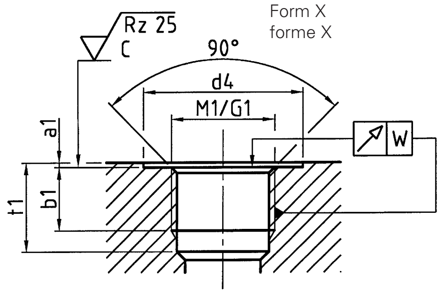


Port form X,Y
DIN 3852-1 / ISO 9974-1 (metric)
DIN 3852-2 / ISO/DIS 1179-1 (BSP thread)
(for parallel stud threads)

Einschraubloch Form X,Y
DIN 3852-1 / ISO 9974-1 (metrisch)
DIN 3852-2 / ISO/DIS 1179-1 (Rohrgewinde)
(für zylindrische Einschraubgewinde)

Trou taraudé, forme X,Y
DIN 3852-1 / ISO 9974-1 (métrique)
DIN 3852-2 / ISO/DIS 1179-1 (filetage Whitworth)
(pour filetages mâles cylindrique)

form X
Form X
forme X



M_1	d_3	$d_4^{+0,4}$	d_5	$a_{1\ max}$	$b_{1\ min}$	$t_{1\ min}$	Ø* LL	Ø* L	Ø* S	W
M 8 x 1	12	13	12	1	8	13,5	3,5	-	-	0,1
M 10 x 1	14	15	13,9	1	8	13,5	5	4	-	0,1
M 12 x 1,5	17	18	16,9	1,5	12	18,5	-	6	4	0,1
M 14 x 1,5	19	20	18,9	1,5	12	18,5	-	7	5	0,1
M 16 x 1,5	21	22	21,9	1,5	12	18,5	-	9	7	0,1
M 18 x 1,5	23	24	23,9	2	12	18,5	-	11	8	0,1
M 20 x 1,5	25	26	25,9	2	14	20,5	-	-	10	0,1
M 22 x 1,5	27	28	26,9	2,5	14	20,5	-	14	12	0,1
M 26 x 1,5	31	32	31,9	2,5	16	22,5	-	18	-	0,2
M 27 x 2	32	33	31,9	2,5	16	24	-	-	16	0,2
M 33 x 2	39	40	39,9	2,5	18	26	-	23	20	0,2
M 42 x 2	49	50	49,9	2,5	20	28	-	30	25	0,2
M 48 x 2	55	56	54,9	2,5	22	30	-	36	32	0,2

G_1	d_3	$d_4^{+0,4}$	d_5	$a_{1\ max}$	$b_{1\ min}$	$t_{1\ min}$	Ø* LL	Ø* L	Ø* S	W
G 1/8A**	14	15	13,9	1	8	13	5	4	-	0,1
G 1/4A**	18	19	18,9	1,5	12	18,5	-	7	5	0,1
G 3/8A**	22	23	21,9	2	12	18,5	-	9	8	0,1
G 1/2A**	26	27	26,9	2,5	14	22	-	14	12	0,1
G 3/4A**	32	33	31,9	2,5	16	24	-	18	16	0,2
G 1 A**	39	40	39,9	2,5	18	27	-	23	20	0,2
G 1 1/4A**	49	50	49,9	2,5	20	29	-	30	25	0,2
G 1 1/2A**	55	56	54,9	2,5	22	31	-	36	32	0,2

Metric taper thread to DIN 158
BSP thread (taper) DIN 3858

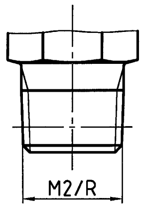
Metrisches kegeliges Außengewinde DIN 158
Whitworth-Rohrgewinde (kegelig) DIN 3858

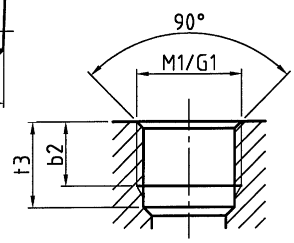
Filetage métrique (conique) DIN 158
Filetage Whitworth (conique) DIN 3858

Stud form C
DIN 3852-1 (metric)
DIN 3852-2 (BSP thread)
taper thread

Einschraubzapfen Form C
DIN 3852-1 (metrisch)
DIN 3852-2 (Rohrgewinde)
Abdichtung durch Kegelgewinde

Implantation forme C
DIN 3852-1 (métrique)
DIN 3852-2 (filetage Whitworth)
étanchéité par filetage conique





Port form Z
DIN 3852-1 (metric)
DIN 3852-2 (BSP thread)
(for taper stud threads only)***

Einschraubloch Form Z
DIN 3852-1 (metrisch)
DIN 3852-2 (Rohrgewinde)
(nur für kegelige Einschraubgewinde)***

Trou taraudé, forme Z
DIN 3852-1 (métrique)
DIN 3852-2 (filetage Whitworth)
(exclusivement pour filetages mâles coniques)***

M_2	$b_{2\ min}$	$t_{3\ min}$
M 8 x 1 keg	5,5	10
M 10 x 1 keg	5,5	10
M 12 x 1,5 keg	8,5	13,5
M 14 x 1,5 keg	8,5	13,5
M 16 x 1,5 keg	8,5	13,5
M 18 x 1,5 keg	8,5	13,5
M 20 x 1,5 keg	10,5	15,5
M 22 x 1,5 keg	10,5	15,5

R	$b_{2\ min}$	$t_{3\ min}$
R 1/8 keg	5,5	9,5
R 1/4 keg	8,5	13,5
R 3/8 keg	8,5	13,5
R 1/2 keg	10,5	16,5

* Stud hole. For special types, deviating holes may be required
* Bohrung des Einschraubzapfens. Sonderbauformen können abweichende Bohrungen haben.
* Trou d'implantation. Pour quelques types spéciaux, des trous différents peuvent être nécessaires.

** For female threads, A does not apply.
** Bei Innengewinde entfällt A.
** Pour les taraudages, A n'est pas applicable.

***Attention: Additional sealing material required!
***Achtung: Zusätzliches Dichtmittel erforderlich!
***Attention: Il faut prévoir un produit étanchéité supplémentaire!

Nuts and rings for WALFORM tube fittings
Rohr-Anschlußteile für WALFORM-Rohrverschraubungen
Eléments de raccord pour raccords à WALFORM

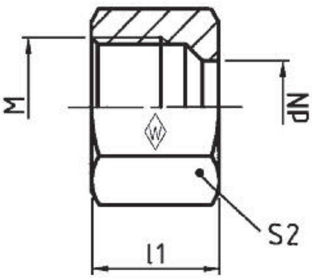
D

M ......

Nut

Überwurfmutter

Ecrou

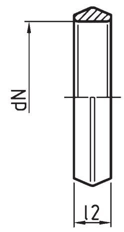


WF-WD ......

WALFORM capitve seal FPM* (e. g. Viton)

WALFORM-Weichdichtung FPM* (z. B. Viton)

Joint mou WALFORM FPM* (p. ex. Viton)

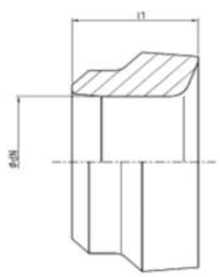


Series Reihe Série	bar PN (psi)	Tube OD Rohr-AD Tube Ø ext. d_N	**Type** **Typ** **Désignation**	**Reference** **Best.-Nr.** **Réf.**	kg per kg per kg par 100 p.	M	l_1	l_2	S_2	**Type** **Typ** **Désignation**	**Reference** **Best.-Nr.** **Réf.**
L	500 (7252)	6	**M 6 L**	**WAL039842**	0,9	M 12 x 1,5	14,5	2,7	14	**WF-WD 6 L/S VI**	**WAL610871**
		8	**M 8 L**	**WAL039843**	1,4	M 14 x 1,5	14,5	2,7	17	**WF-WD 8 L/S VI**	**WAL610872**
		10	**M 10 L**	**WAL039844**	2,0	M 16 x 1,5	15,5	2,95	19	**WF-WD 10 L/S VI**	**WAL610873**
	400 (5801)	12	**M 12 L**	**WAL039845**	2,5	M 18 x 1,5	15,5	2,95	22	**WF-WD 12 L/S VI**	**WAL610874**
		15	**M 15 L**	**WAL039846**	4,0	M 22 x 1,5	17	2,95	27	**WF-WD 15 L VI**	**WAL610875**
		18	**M 18 L**	**WAL039847**	6,0	M 26 x 1,5	18	2,95	32	**WF-WD 18 L VI**	**WAL610877**
	250 (3626)	22	**M 22 L**	**WAL039848**	8,0	M 30 x 2	20	2,95	36	**WF-WD 22 L VI**	**WAL610879**
		28	**M 28 L**	**WAL039849**	8,5	M 36 x 2	21	2,95	41	**WF-WD 28 L VI**	**WAL610881**
		35	**M 35 L**	**WAL039850**	13,0	M 45 x 2	24	3,5	50	**WF-WD 35 L VI**	**WAL610883**
		42	**M 42 L**	**WAL039851**	21,0	M 52 x 2	24	3,5	60	**WF-WD 42 L VI**	**WAL610885**
S	800 (11603)	6	**M 6 S**	**WAL039852**	1,5	M 14 x 1,5	16,5	2,7	17	**WF-WD 6 L/S VI**	**WAL610871**
		8	**M 8 S**	**WAL039853**	1,7	M 16 x 1,5	16,5	2,7	19	**WF-WD 8 L/S VI**	**WAL610872**
		10	**M 10 S**	**WAL039854**	3,0	M 18 x 1,5	17,5	2,95	22	**WF-WD 10 L/S VI**	**WAL610873**
	630 (9137)	12	**M 12 S**	**WAL039855**	3,5	M 20 x 1,5	17,5	2,95	24	**WF-WD 12 L/S VI**	**WAL610874**
		16	**M 16 S**	**WAL039857**	6,0	M 24 x 1,5	20,5	2,95	30	**WF-WD 16 S VI**	**WAL610876**
	420 (6091)	20	**M 20 S**	**WAL039858**	9,5	M 30 x 2	24	3,7	36	**WF-WD 20 S VI**	**WAL610878**
		25	**M 25 S**	**WAL039859**	19,5	M 36 x 2	27	3,7	46	**WF-WD 25 S VI**	**WAL610880**
		30	**M 30 S**	**WAL039860**	21,5	M 42 x 2	29	3,85	50	**WF-WD 30 S VI**	**WAL610882**
		38	**M 38 S**	**WAL039861**	31,0	M 52 x 2	32,5	3,5	60	**WF-WD 38 S VI**	**WAL610884**

* NBR (e. g. Perbunan) and EPDM on request
* NBR (z. B. Perbunan) und EPDM auf Anfrage
* NBR (p. ex. Perbunan) et EPDM sur demande

Sustain rings for WALFORMplus SR
Stützringe für WALFORMplus SR
Bagues d'appui pour WALFORMplus SR

Dimensions Abmessungen Dimensions	Tube OD Rohr-AD Tube Ø ext. dN	**Type** **Typ** **Désignation**	**Reference** **Best.-Nr.** **Réf.**	l_3
6 x 1,0	6	**WF-Plus-SR 6 L/S**	**WAL625132**	5,3
8 x 1,0	8	**WF-Plus-SR 8 L/S**	**WAL625133**	5,6
10 x 1,0	10	**WF-Plus-SR 10 L/S**	**WAL625134**	5,8
12 x 1,0	12	**WF-Plus-SR 12 L/S**	**WAL625135**	5,8
15 x 1,0	15	**WF-Plus-SR 15 L**	**WAL625136**	5,7
16 x 1,5	16	**WF-Plus-SR 16 S**	**WAL625137**	5,7
18 x 1,5	18	**WF-Plus-SR 18 L**	**WAL625138**	6,0
22 x 1,5	22	**WF-Plus-SR 22 L**	**WAL625139**	6,6
30 x 2,0	30	**WF-Plus-SR 30 S**	**WAL625140**	7,6
35 x 2,0	35	**WF-Plus-SR 35 L**	**WAL625141**	7,6
42 x 2,0	42	**WF-Plus-SR 42 L**	**WAL625142**	7,6

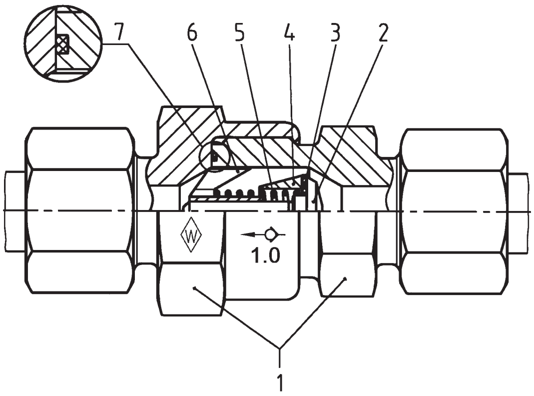


Non-return valve
Rückschlagventil
Clapet anti-retour

Technical details

Technische Hinweise

Dètaile technique



1 Body	1 Stutzen	1 Corps
2 Cone	2 Bolzen	2 Clapet
3 Sealing washer	3 Dichtungsscheibe	3 Rondelle d'étanchéité
4 Sleeve	4 Hülse	4 Cuvette
5 Pressure spring	5 Druckfeder	5 Ressort de compression
6 Valve guide	6 Bolzenführung	6 Guide du clapet
7 O-ring	7 O-Ring	7 Joint torique

Application

for hydraulic fluids and compressed air. In order to guarantee the suitability of the valves for your particular application, we request a description of the medium, possibly also the concentration, maximum working pressure including peak pressure, temperature and frequency of the valve operation.

Design

Walterscheid non-return valves are fitted with a 90° taper and a sealing washer made of FPM (e. g. Viton).
The design of the internal components provides favourable flow conditions for the fluids.

Working temperature

Temperature range from
– 20 °C to + 100 °C (– 4 °F to + 212 °F)

Materials

1. Body: Steel, cold-galvanized
2. Cone: Steel, cold-galvanized
3. Sealing washer: FPM
4. Sleeve: Steel, cold-galvanized
5. Pressure spring: Steel
6. Valve guide:
   Tube OD 6-28 mm: Brass
   Tube OD 30-42 mm: Steel, cold-galvanized
7. O-ring: FPM

Opening pressures

The non-return valves are adjusted at the factory to an opening pressure of 1.0 bar. Additional pressure ratings from 0.5 to 3.0 bar available on request.

Design

Sealing at the stud thread of the non-return valve is achieved by a captive seal.
Symbols indicating opening pressure and direction of flow are marked on the valve.

Assembly

The valve bodies are supplied ready-assembled and pre-set to the desired opening pressure. When connecting or dismantling tubes, the hexagon nearest to the nut must be held firmly to avoid the risk that the sealing edge at the inside of the valve body will work loose.

Verwendung

für Hydraulikflüssigkeiten und Druckluft.
Um die Eignung der Ventile für Ihre Einsatzfälle gewährleisten zu können, bitten wir um Angabe des Mediums, evtl. auch Konzentration, max. Betriebsdruck einschl. Druckspitzen, Temperatur und Häufigkeit der Ventilbetätigung.

Konstruktion

Walterscheid-Rückschlagventile sind ausgestattet mit 90°-Kegel und einer Dichtscheibe aus FPM (z. B. Viton).
Die Formgebung der Innenteile ermöglicht einen strömungsgünstigen Durchfluß der Medien.

Betriebstemperatur

Temperaturbereich von – 20 °C bis + 100 °C.

Werkstoffe

1. Stutzen: Stahl verzinkt
2. Bolzen: Stahl verzinkt
3. Dichtungsscheibe: FPM
4. Hülse: Stahl verzinkt
5. Druckfeder: Stahl
6. Bolzenführung:
   6-28 mm Rohr-AD: Messing
   30-42 mm Rohr-AD: Stahl verzinkt
7. O-Ring: FPM

Öffnungsdrücke

Serienmäßig sind die Rückschlagventile auf einen Öffnungsdruck von 1,0 bar eingestellt.
Abweichende Öffnungsdrücke von 0,5 bis 3,0 bar auf Anfrage.

Ausführung

Die Abdichtung am Einschraubgewinde der Rückschlagventile erfolgt mit Weichdichtung.
Die Ventile sind mit Öffnungsdruck und Strömungsrichtung gekennzeichnet.

Montage

Ventilgehäuse werden fertig montiert mit dem gewünschten Öffnungsdruck geliefert. Bei der Rohrmontage bzw. -demontage ist darauf zu achten, daß der, der Überwurfmutter nächstliegende Stutzensechskant gegengehalten wird, um ein Lösen der Dichtkante am Ventilstutzen (innen) zu vermeiden.

Utilisation

pour les fluides hydrauliques et l'air comprimé. Pour assurer l'aptitude des soupapes à leur domaine d'utilisation, nous vous prions de bien vouloir nous indiquer le fluide utilisé et, si possible, la concentration, la pression maximale de service, y compris les pressions de pointe, la température et la fréquence d'actionnement des soupapes.

Construction

Les clapets anti-retour sont munis d'un cône de 90° et d'une rondelle d'étanchéité en FPM (p. ex. Viton).
La forme des pièces intérieures permet un bon écoulement des fluides.

Température de service

Plage de températures de – 20 °C à + 100 °C.

Matériaux

1. Corps: Acier galvanisé
2. Clapet: Acier galvanisé
3. Rondelle d'étanchéité: FPM
4. Cuvette: Acier galvanisé
5. Ressort de compression: Acier
6. Guide du clapet:
   Ø ext. du tube 6-28 mm: Laiton
   Ø ext. du tube 30-42 mm: Acier galvanisé
7. Joint torique: FPM

Pressions d'ouverture

Les clapets anti-retour sont tarés en série, avec pression d'ouverture de 1,0 bar. Sur demande, ils sont livrables avec des tarages différents soit de 0,5 à 3,0 bar.

Exécution

L'étanchéité sur le filetage mâle du clapet anti-retour se fait par un joint mou. La pression de tarage et le sens de passage sont marqués sur les clapets.

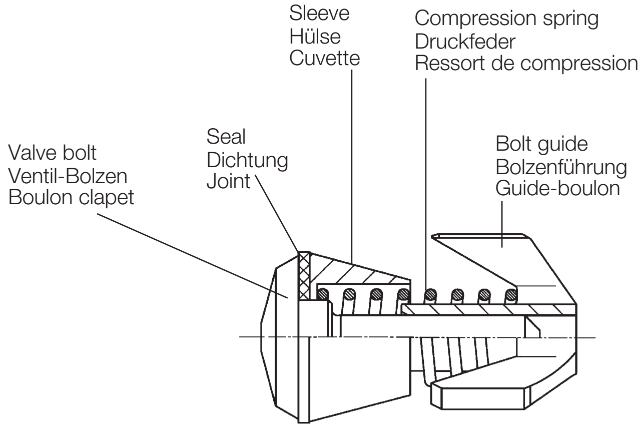
Montage

Les corps de clapets sont livrés complètement assemblés, avec tarage pour la pression d'ouverture voulue. Lors du montage ou du démontage du tube, maintenir le six-pans du corps qui se trouve le plus proche de l'écrou, afin que l'arête d'étanchéité à l'intérieur du corps ne se détache pas.

Non-return valve (Valve insert)
Rückschlagventil (Ventileinsatz)
Clapet anti-retour (Insert clapet)

for 1 bar opening pressure
für Öffnungsdruck 1 bar
pour une pression d'ouverture de 1 bar

Fitting dimensions on request
Einbaumaße auf Anfrage
Cotes de montage sur demande



Nominal width Nennweite Largeur nomin.	Tube OD Rohr-AD Tube Ø ext.	**Reference Best.-Nr. Réf.**
6	6–12	**WAL032431**
10	14–18	**WAL032438**
16	20–28	**WAL032445**
25	30	**WAL032451**
32	35–42	**WAL032457**

The valve insert for nominal width 16 can be fitted in this position only.

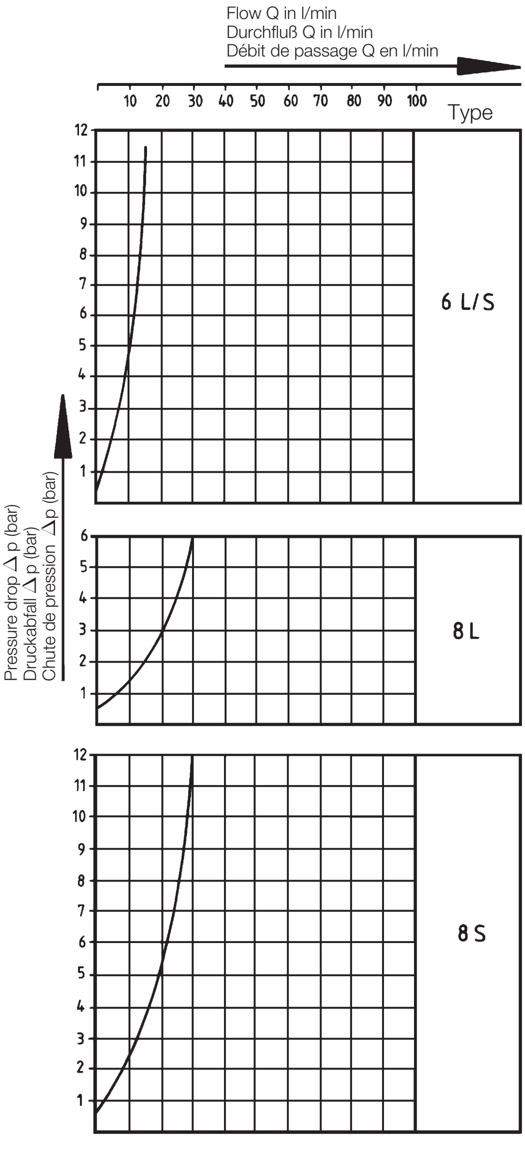
Der Ventileinsatz der Nennweite 16 kann beim Einbau nicht umgekehrt eingesetzt werden.

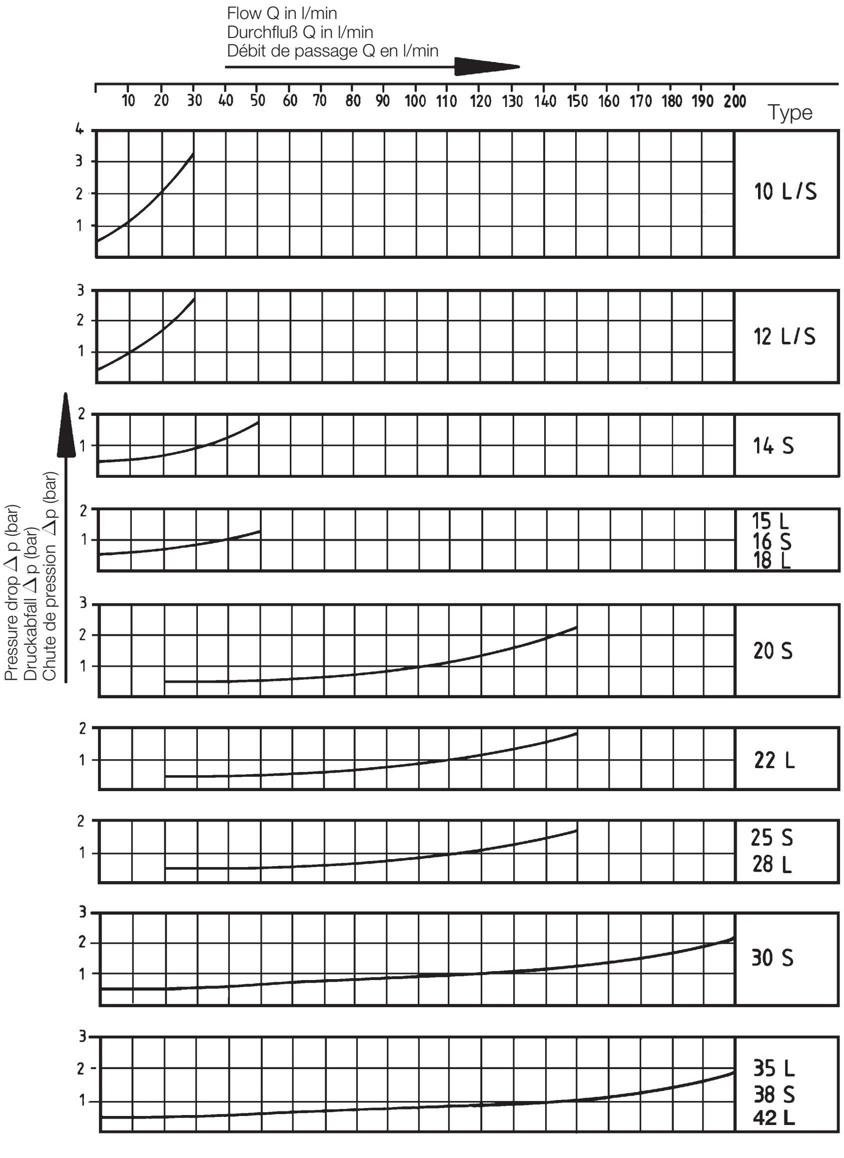
L'insert clapet de largeur 16 ne peut être installé que dans cette position.

Pressure loss – Non-return valve –
measured with hydraulic oil 35 mm²/s
Opening pressure 0.5 bar

Druckverlust bei Rückschlagventilen
gemessen mit Hydrauliköl 35 mm²/s
Öffnungsdruck 0,5 bar

Perte de pression – Clapet anti-retour –
mesurée avec de l'huile hydraulique 35 mm²/s
Pression d'ouverture 0,5 bar





L

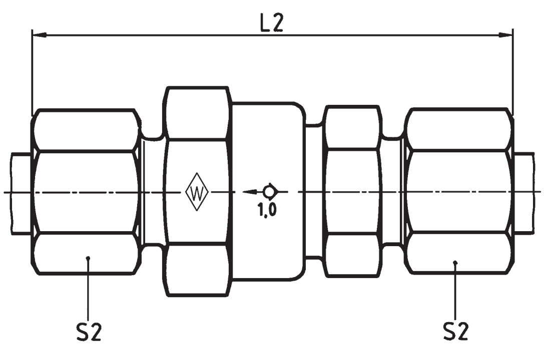
Non-return valve
Rückschlagventil
Clapet anti-retour

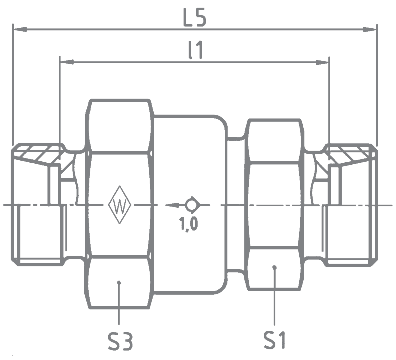
P-RV ......

Tube connection both ends

Beidseitiger Rohranschluß

Raccord sur tube des deux côtés





Series / Reihe / Série	bar / PN / (psi)	Tube OD / Rohr-AD / Tube Ø ext.	**Type / Typ / Désignation**	**Reference / Best.-Nr. / Réf.**	kg per 100 pcs. / kg per 100 St. / kg par 100 p.	L_2	L_5	l_1	S_1	S_2	S_3	Ø outlet / Ø entspr. Durchlaß / Ø de passage correspondant
L	400 (5801)	6	**P-RV 6 L**	**WAL374062**	12,7	67	52	38	22	14	27	4,0
		8	**P-RV 8 L**	**WAL374063**	14,7	67	52	38	22	17	27	6,0
		10	**P-RV 10 L**	**WAL374064**	14,8	67	52	38	22	19	27	7,5
		12	**P-RV 12 L**	**WAL374065**	19,1	68	53	39	22	22	27	7,5
		15	**P-RV 15 L**	**WAL374066**	27,3	74	58	44	27	27	32	11,0
		18	**P-RV 18 L**	**WAL374067**	35,5	80	63	48	27	32	32	11,0
	250 (3626)	22	**P-RV 22 L**	**WAL374068**	61,8	92	75	60	41	36	46	18,5
		28	**P-RV 28 L**	**WAL374069**	76,5	99	81	66	41	41	46	18,5
		35	**P-RV 35 L**	**WAL374070**	168,0	114	92	71	60	50	70	29,0
		42	**P-RV 42 L**	**WAL374483**	223,5	101	87	65	60	60	70	29,0
S	400 (5801)	6	**P-RV 6 S**	**WAL374071**	14,1	71	56	42	22	17	27	4,0
		8	**P-RV 8 S**	**WAL374072**	15,3	67	52	38	22	19	27	5,0
		10	**P-RV 10 S**	**WAL374073**	17,2	71	54	39	22	22	27	7,0
		12	**P-RV 12 S**	**WAL374074**	20,7	72	55	40	22	24	27	7,5
		14	**P-RV 14 S**	**WAL374075**	30,0	81	62	46	27	27	32	10,0
		16	**P-RV 16 S**	**WAL374076**	34,9	84	65	48	27	30	32	11,0
		20	**P-RV 20 S**	**WAL374077**	68,2	100	78	57	41	36	46	16,0
	250 (3626)	25	**P-RV 25 S**	**WAL374078**	94,5	105	81	57	41	46	46	18,5
		30	**P-RV 30 S**	**WAL374079**	128,5	117	91	64	50	50	55	24,0
		38	**P-RV 38 S**	**WAL374080**	234,7	128	99	67	60	60	70	29,0

L = approximate length with nuts tightened
L = Ungefährmaß bei angezogenen Überwurfmuttern
L = Ungefährmaß bei angezogenen Überwurfmuttern

Characteristics

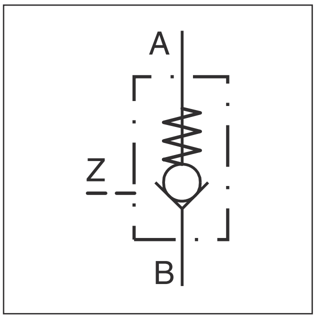
Hydraulically Pilot Operated Check Valve Series RH

Pilot operated check valves series RH allow free flow in one direction (B to A). The counter flow is blocked (A to B). By applying pilot pressure the ball can be lifted from its seat and allow flow from A to B.

Most common use:

- Keeping cylinders leak-free in position, when spool type directional control valves are used
- Return line discharge, when return flow exceeds functional limits of directional control valve at differential cylinders
- As hydraulically activated drain or circulation valve

The valves are available without and with hydraulic pre-discharging.

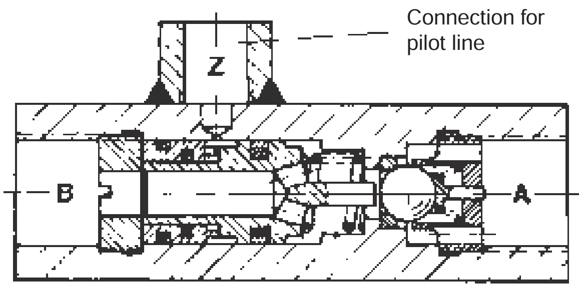


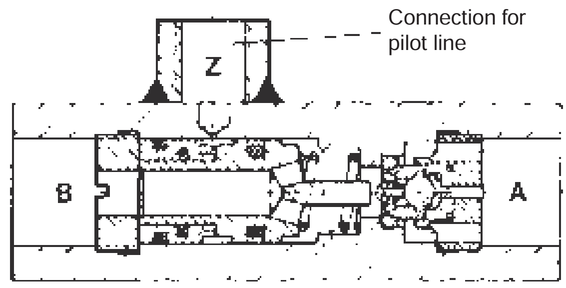
Without pre-discharging

These valves have a ball as valve element, which quickly enables the full flow cross-section proportionally during pilot operation. A metering position in the pilot port dampens the control movement of the pilot spool so that pressure shocks (unloading shocks) are mostly suppressed.

With pre-discharging

For valves with pre-discharging a spherical polished valve spool (seat valve function) is built-in instead of a ball. The additional check valve achieves a pre-opening which provides shock-free unloading of the fluid, especially at high working pressure and large volumes.





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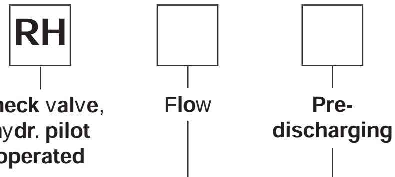
Technical data

Code	RH	1	2	3 / 3V	4 / 4V
Max. operating pressure	[bar]	700	700	500	500
Flow approx.	[l/min]	15	35	55	100
Pilot flow volume	[cm³]	0.15	0.22	0.4	1
Pipe connections DIN ISO 228/1 A, B		G 1/4	G 3/8	G 1/2	G 3/4
Pipe connections DIN ISO 228/1 Z		G 1/4	G 1/4	G 1/4	G 1/4
Weight	[kg]	0.4	0.4	0.6	1.3
Mounting		Freely suspended in the pipeline			
Mounting position		unrestricted			
Fluid		Hydraulic oil 10...68 mm²/s (ISO VG 10 to 68 as per DIN 51 519)			
Viscosity recommended	[cSt]/[mm²/s]	10...500			
Viscosity permitted	[cSt]/[mm²/s]	4...500			
Temperatures	[°C]	Fluid and ambient: -20...+80; observe viscosity range!			
$MTTF_D$ value	[years]	150			

RH UK.INDD RH 12.08.11

Ordering code



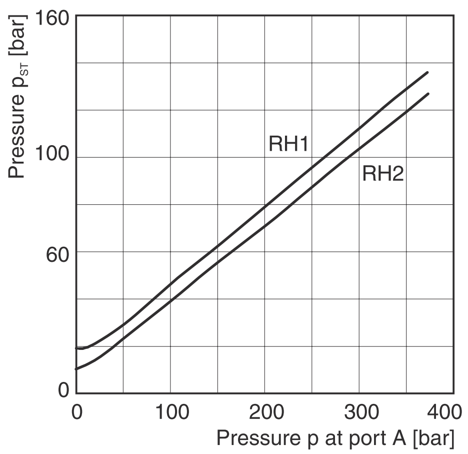
Code	Flow [l/min]
1	15
2	**35**
3	55
4	100

Code	Pre-discharging
V*	**with**
omit	**without**

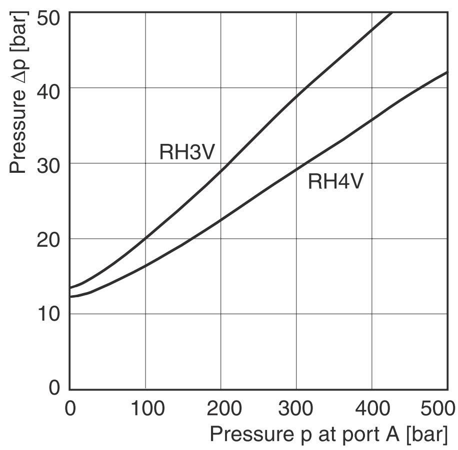
* only for sizes 3 and 4

Bold letters =
Short-term availability

Pilot pressure p_{St} for pilot operation of the main valve (p_B = 0 bar)

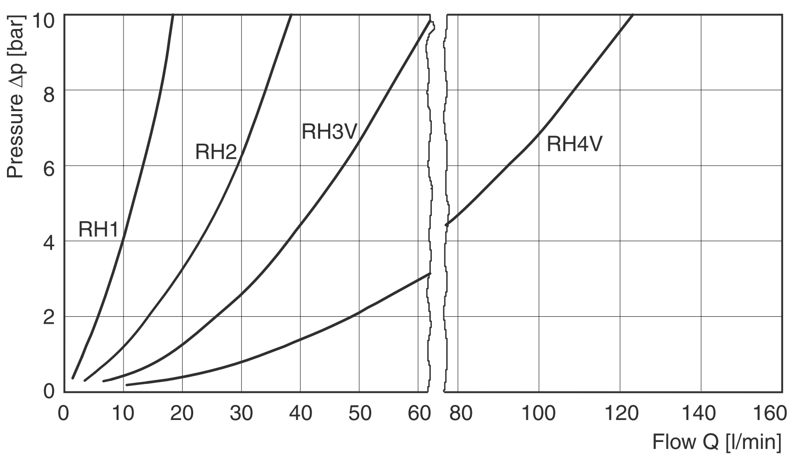


Pilot pressure p_{St} for pilot operation of pre-discharging



for keeping open	
p_{St}	$p_B + \Delta p + k$
p_B [bar]	pressure on side B
Δp [bar]	flow resistance A to B as per Δp/Q performance curve
k	10 at RH 1 and RH 2 7 at RH 3 V 8 at RH 4 V

Performance curves Δp/Q (valid for flow polarity B to A and pilot operated direction A to B)

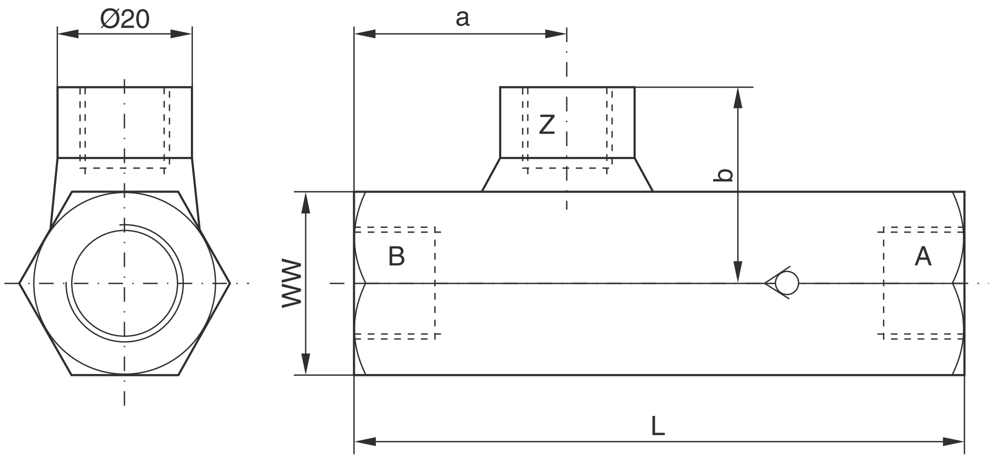


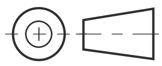
Opening pressure B to A 0.2...0.3 bar

Oil viscosity during the measurement, 60 mm²/s

For viscosities over approx. 500 mm²/s, a strong Δp-increase is to be expected for smaller types (RH1...RH3).

RH UK.INDD RH 12.08.11



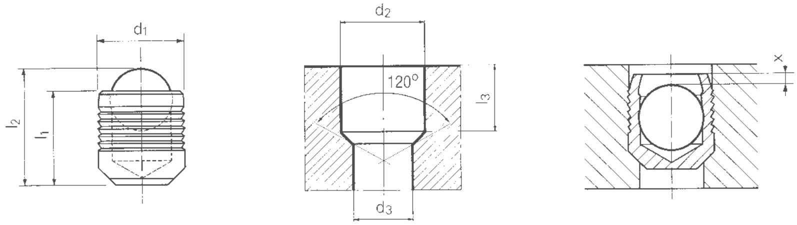


Type	Port *		L	a	b	SW
	A, B	Z				
RH 1	G 1/4	G 1/4	84	31.5	27	24
RH 2	G 3/8	G 1/4	90	32	28.5	27
RH 3 V	G 1/2	G 1/4	100	36.5	31	32
RH 4 V	G 3/4	G 1/4	126	45	35.5	41

* as per DIN 228/1, suitable for pipe connections with thread studs form B as per DIN 3852 page 2.

MB 600 Series Sealing Plugs

HUGE STOCKS
VOLUME DISCOUNT



- **Sleeve**
  Stainless Steel
  DIN 1.4305, AISI 303
- **Hardness**
  HB = 220
- **Ball**
  Stainless Steel
  DIN 1.4301, AISI 304

Sleeve and Ball clear passivated per MIL S 5002 Aerospace quality.
Equivalent working pressure capability can be obtained when using base materials with similar mechanical characteristics. However, the appropriate installation instructions must be followed.
Anchorage between sleeve and base material is achieved when the sleeve is a minimum of HB=30 greater than the base material. If the hardness difference is less, hole roughness of 10 to 30 µm is needed to achieve indicated working pressures.

Security Range
The security range (the difference between working pressure and Test B pressure) allows for uncontrollable variations.
For instance, dynamic loading at 1 million cycles and a frequency of 3-4Hz has shown that burst pressure Test A and Test B pressure are reduced about 20% after this point.

Type	Dimensions in mm						
	d_1	l_1	l_2 -	d_2 + 0.1	d3 max.	l3 min.	x ±0.2
MB 600-030	3.0	3.6	4.6	3.0	2.2	3.4	0.4
MB 600-040	4.0	4.0	5.2	4.0	3.3	3.8	0.2
MB 600-050	5.0	5.5	7.0	5.0	4.3	5.3	0.4
MB 600-060	6.0	6.5	8.6	6.0	5.3	6.3	0.4
MB 600-070	7.0	7.5	10.1	7.0	6.4	7.3	0.4
MB 600-080	8.0	8.5	11.7	8.0	7.4	8.3	0.3
MB 600-090	9.0	10.0	13.7	9.0	8.4	9.8	0.4
MB 600-100	10.0	11.0	15.2	10.0	9.4	10.8	0.4
MB 600-120	12.0	13.0	18.0	12.0	10.6	12.8	0.4
MB 600-140	14.0	15.0	20.8	14.0	12.7	14.5	0.4

1 – Proof Pressure Test B 2 – Maximum allowable working pressure = nominal pressure

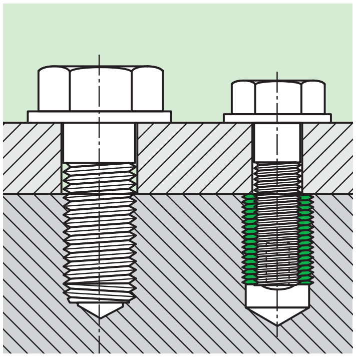
Pressure Performance

	Base Material / Minimum Hardness HB						
	High Strength Stl ETG-100 AISI 1144	Free Machining Case Hard Stl. C15 Pb	Cast Iron GG-25 DIN 1691	Ductile Cast Iron GGG-50 DIN 1693 DIN 1.0403	Aluminium Alloy Al Cu Mg 2 DIN 3.1354 AA2024	Aluminium Alloy Al Mg Si Pb DIN 3.0615 AA6262	Cast Al Alloy G-Al Si 7 Mg 3.2371 AA356-T6
	280	180	160	170	120	90	80
d1 mm	P Test B[1] Bar	P Test B[1] Bar		PW[2] Bar	PW[2] Bar	P Test B[1] Bar	PW[2] Bar
3-10	1400	1400		450	450	1200	380
12-14	1000	1000		350	350	900	280

The Ensat®– pull-out resistance due to flange cover ...

Connections using Ensat threaded inserts permit substantially smaller overall dimensions and thus pave the way for material-saving and weight-saving designs.

The illustration below shows two screw connections with equal pull-out strength.

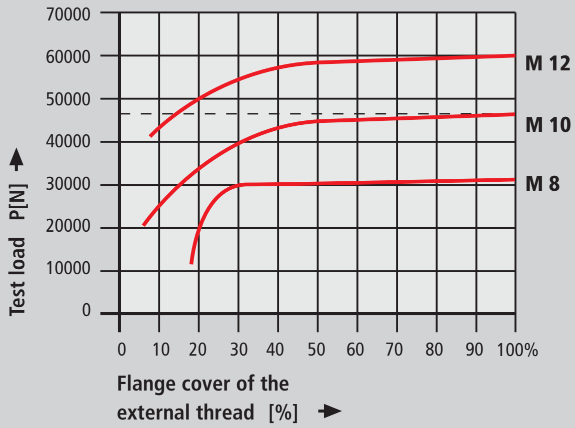


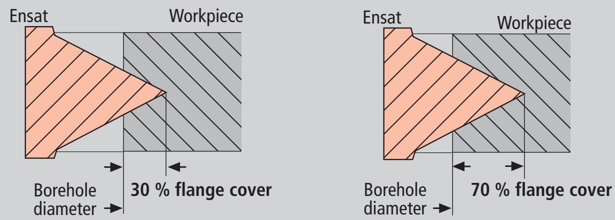
Flange cover

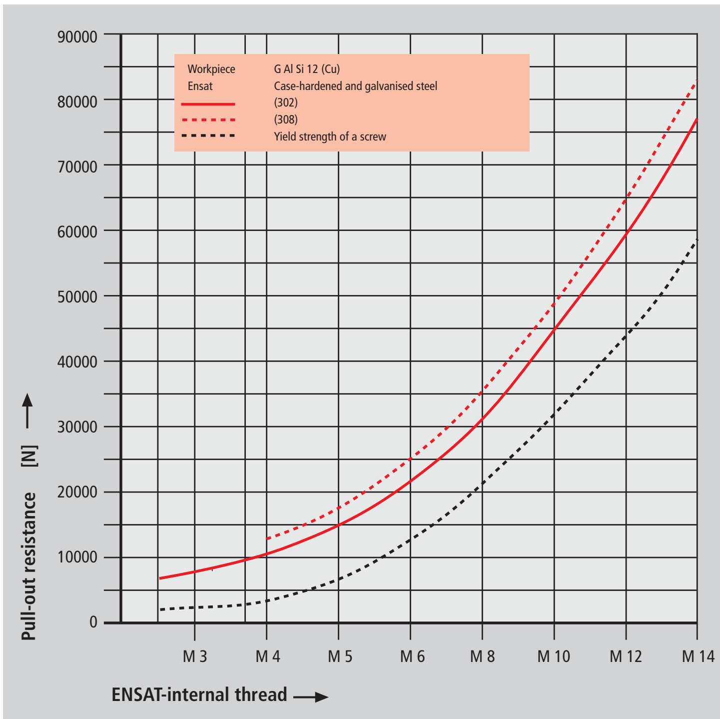
In a workpiece made of a light alloy, the Ensat 302 achieves almost maximum pull-out strength with only 30 % flange cover.

Pull-out strength

The Ensat is capable of withstanding high loads. When used in light alloys, for example, a degree of pull-out strength is achieved which far exceeds the yield strength of the mating screw 8.8.





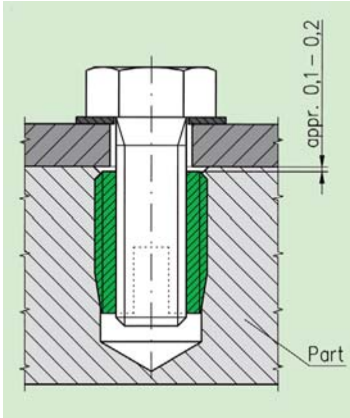


Kerb Konus

The Ensat®
in the workpiece ...

Installation recommendation

The Ensat should be processed appr. 0,1 - 0,2 mm recessed. After processing, the Ensat can be immediately subjected to load. If the component material permits subsidence of the Ensat under load, the Ensat can only execute an axial movement of 0,1 to 0,2 mm. In other words, the pretension of the screw union is largely retained, loosening of the screw connection under dynamic load is impeded.



Borehole diameter [mm]		Standard values for ENSAT 302				Standard values for ENSAT 307/308 ... 337/338			
Workpiece material: Light alloys Rm=tensile strenght [N/mm²]		R_m < 250; R_m < 300	R_m < 300; R_m < 350	R_m < 350; R_m >350	R_m >350	R_m < 300	R_m < 300; R_m < 350	R_m < 350; R_m >350	R_m >350
Ms, bronze, NF-metall				R_m >350	R_m >350			R_m >350	R_m >350
Cast iron HB = brinell hardness [N/mm²]		< 150 HB	< 150 HB; < 200 HB	< 200 HB; >200 HB	>200 HB	< 150 HB	< 150 HB; < 200 HB	< 200 HB; >200 HB	>200 HB
ENSAT internal thread	Zoll								
M2/M2,5 M3	 N° 4		4,1 4,6	4,2 4,7	4,3 4,8	- 4,6	- 4,7		- 4,8
M3,5 M4	N° 6 N° 8	5,4 5,9	5,5 6,0	5,6 6,1	5,7 6,2	5,5 6,0	5,6 6,1		5,7 6,2
M5 M6(a)	N° 10 -	7,2 8,2	7,3 8,3	7,5 8,5	7,6 8,6	7,4 -	7,5 -	7,6 -	7,7 -
M6 M8	1/4 " 5/16"	8,8 10,8	9,0 11,0	9,2 11,2	9,4 11,4	9,3 11,1	9,4 11,2	9,5 11,3	9,6 11,5
M10 M12	3/8 " 7/16"	12,8 14,8	13,0 15,0	13,2 15,2	13,4 15,4	13,1 15,0	13,2 15,1	13,3 15,2	13,5 15,4
M14 M16	1/2 " 5/8"	16,8 18,8	17,0 19,0	17,2 19,2	17,4 19,4	17,0 19,0	17,1 19,1	17,2 19,2	17,4 19,4
M18 M20/22	- 3/4"	20,8 24,8	21,0 25,0	21,2 25,2	21,4 25,4				
M24 M27 M30		28,8 32,8 34,8	29,0 33,0 35,0	29,2 33,2 35,2	29,4 33,4 35,4				
Flange cover approx.		60%	50%	40%	30%	80%	70%	60%	50%

(hatched) **Recommended borehole diameter for easy assembly. Other diameters may require lubrication.**

These specifications are only recommendations and apply to ENSAT made of steel, hardened and plated.

The adjacent table is used to determine the recommended bore hole diameter depending on the material of the workpiece and the Ensat type/dimension.

Example:
Light alloy workpiece
(R_m=280 N/mm²),
Internal thread M8,
recommended bore hole diameter for
Ensat®-S 302: 11,2 to 11,4 mm
Ensat®-SB 307/308: 11,2 to 11,5 mm

In case of processing problems (e.g. markedly increased screw-in torque levels) there is generally no harm in selecting diameter data in the next highest column. In case of doubt, we advise carrying out a test.

Retaining hole

The retaining hole can be simply drilled or integrated into in the casting.

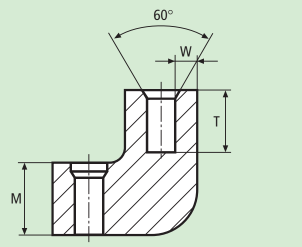
Countersinking the borehole is recommended in order to:
- Prevent the workpiece surface from being raised
- Permit screwing in to a greater depth
- Ensure improved initial cutting characteristics

Material thickness:
Length of the Ensat = smallest admissible material thickness M.

Depth of the blind hole:
Minimum depth -T see Works Standard sheets, page 7 to 20.

Borehole diameter:
Brittle, tough and hard materials call for a larger borehole than soft or elastic materials. For guideline values, see the table above.

Edge distance:
The smallest still admissible edge distance depends on the planned stress level and the elasticity of the material into which the Ensat is screwed.



Guideline values for light alloys:
W ≥ 0,2 to ≥ 0,6 E

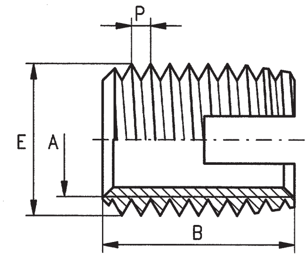
Guideline values for cast iron:
W ≥ 0,3 to ≥ 0,5 E
E = Outside diameter of the Ensat® [mm]-

Thin-walled threaded insert
self-tapping

Ensat®-SD
Works Standard
303

Application

Threaded insert Ensat with cutting slot in a special thin-walled and shortened version. Particularly suitable for plastic with thin residual walls and for light-weight constructions. These versions are designed primarily for processing on thread tapping machines, as the pitch of the outside and inside thread is identical. For processing thin-walled inserts in metal, the tensile strength / hardness of the base material is always the determining factor. In critical cases, we recommend lubricating with suitable media in order to prevent fracture of the thin-walled inserts.



Dimensions in mm

Article no.	Internal thread A	External thread E	P	Length B	Location hole diameter, non-ductile alloys, NF metals L	Minimum bore-hole depth for blind holes T
303 000 030 ...	M 3	4,5	0,5	6	4,2 bis 4,3	8
303 000 035 ...	M 3,5	5	0,6	6	4,7 bis 4,8	8
303 000 040 ...	M 4	6	0,7	6	5,6 bis 5,7	8
303 000 050 ...	M 5	7	0,8	8	6,6 bis 6,7	10
303 000 060 ...	M 6	8	1,0	10	7,5 bis 7,6	13
303 000 080 ...	M 8	10	1,25	12	9,2 bis 9,4	15
303 000 100 ...	M 10	12	1,5	15	11,2 bis 11,4	18

Example for finding the article number Self-tapping thin-walled insert Ensat-SD slot to Works Standard series 303 with internal thread A = M5 made of hardened and yellow chromated steel: Ensat-SD 303 000 050.160

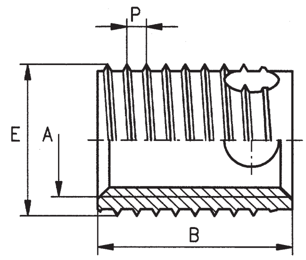
Materials, tolerances, thread, see Works Standard 302, Page 7 and 8; materials ... 400 and ... 500 on request.

Thin-walled threaded insert
self-tapping, with cutting bores

Ensat®-SBD
Works Standard
347/348

Application

Threaded insert Ensat with three cutting bores in a special thin-walled version. Particularly suitable for plastic with thin residual walls and for light-weight constructions. This version is designed primarily for processing on thread tapping machines, as the pitches of the external and internal threads are identical. For processing thin-walled inserts in metal, the tensile strength / hardness of the base material is always the determining factor. In critical cases we recommend lubricating with suitable media in order to prevent fracture of the thin-walled inserts



Dimensions in mm

Article no.	Internal thread A	External thread Special thread E	P	Length B Works Standard 347	348	Location hole diameter, non-ductile alloys, NF metals L	Minimum borehole depth for blind holes Works Standard 347	348
3.. 000 035 ...	M 3,5	5	0,6	5	8	4,7 bis 4,8	7	10
3.. 000 040 ...	M 4	6	0,7	6	8	5,6 bis 5,7	8	10
3.. 000 050 ...	M 5	6,5	0,8	7	10	6,1 bis 6,2	9	13
3.. 000 060 ...	M 6	8	1	8	12	7,5 bis 7,7	10	15
3.. 000 080 ...	M 8	10	1,25	9	14	9,4 bis 9,6	11	17
3.. 000 100 ...	M 10	12	1,5	10	18	11,2 bis 11,5	13	22
3.. 000 120 ...	M 12	14	1,75	12	22	13,2 bis 13,5	15	26

Short design Works Standard 347
Long design Works Standard 348
Materials, tolerances, thread see Works Standard 307/308, Page 10; materials ... 400 and ... 500 on request.

Kerb-Konus-Vertriebs-GmbH • P.O. Box 1663 • 92206 Amberg • Phone +49 9621 679-0 • Fax +49 9621 679444

Materiali per guarnizioni

Seals materials

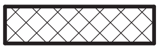
I materiali principalmente usati nella tecnica oleoidraulica e pneumatica sono elencati qui di seguito in una breve descrizione.

The materials which are mainly used in hydraulics and pneumatics are listed in the following summary.

Materiali **Materials**

Designazione della mescola **Compound designation**	**Materiale** **Material**	**Caratteristiche principali** **Main characteristics**	**Impiego** **Use**	**Applicazione** **Application**
NBR 70.80-01 NBR 72.80-01 NBR NT 70.11 NBR 78.80-01 NBR 79.80-02 NBR 80.80-01 NBR 80.80-02 NBR 85.80-01 NBR 90.80-01	Elastomero nitrile NBR Nitrile elastomer NBR	Grazie alla buona resistenza alla maggior parte degli oli e grassi a base minerale, NBR è il materiale usato più spesso nella tecnica oleoidraulica e pneumatica. NBR is the most frequently used material in hydraulics and pneumatics due to good resistance to most oils and greases with mineral oil base.	Il campo d'impiego termico si trova normalmente tra –30° e +100°C, (per breve tempo +120°C). Caratteristiche meccaniche molto buone, non resiste all'ozono. The thermal range of use is normally between –30° to +100°C, (short-term +120°C). Very good mech. values, not very resistant to ozone.	NBR è utilizzato in presenza di oli minerali e liquidi difficilmente infiammabili, HFA, HFB ed HFC. NBR is used with mineral oils and hardly inflammable fluids HFA, HFB and HFC.
FPM NT 80.7/75 FPM 85.80-01	Elastomero fluorurato FPM Fluoro elastomer FPM	FPM si distingue per la resistenza alle temperature elevate, alle intemperie ed alle sostanze chimiche. FPM is known for its high resistance to temperature, weather and chemicals.	Utilizzabile fino a +200°C. Caratteristiche meccaniche medie. Non idoneo con acqua calda e vapore. Can be used up to +200°C. Average mech. values. Poor in hot water and steam.	FPM è molto resistente a tutti i liquidi oleoidraulici a base minerale/sintetica. FPM is highly resistance in all hydraulic fluids with mineral/synth. base.
AU 80.80-01 AU 85.80-01 AU 94.80-01 AU 95.80-01 AU 95.80-02 AU 98.80-01	Poliuretano PUR Polyurethane PUR	I materiali poliuretani si distinguono per la caratteristiche meccaniche molto buone, come elevata resistenza alla trazione, all'abrasione ed all'estrusione. Polyurethane materials are known for very good mechanical values such as high tensile strength, wear- and extrusion-resistance.	Il campo d'impiego termico si trova tra –40°C e +110°C. Utilizzabile in acqua ed in fluidi contenenti acqua solo fino a +50°C. Thermal range of use is between –40°C and +110°C. Can only be used in water and aqueous media up to +50°C.	Materiale molto resistente alla pressione. È utilizzato esclusivamente con oli minerali. Highly pressure-resistant material. Used exclusively in mineral oils.
PTFE BZ.80-01 PTFE BZ.83-01	PTFE-bronzo PTFE-bronze	Resistenza alla pressione molto buona. Elevata resistenza all'abrasione, resistenza limitata alle sostanze chimiche. Very good resistance to pressure. High resistance to wear, limited resistance to chemicals.	Per elevate sollecitazioni e grandi velocità. For severe stress and high speeds.	Per impianti oleoidraulici (non in soluzioni acquose). For hydraullic plant (not in aqueous solutions).
PTFE KO.80-01 PTFE KO.83-01	PTFE-carbone PTFE-carbon	Buona resistenza alla pressione, elevata capacità lubrificante, media resistenza all'abrasione. Good pressure resistance, high degree of lubricity, average wear resistance.	Per sollecitazioni medie, anche a temperature elevate. For average stress even at high temperatures.	Per superfici d'accoppiamento tenere. Anche in fluidi poco lubrificanti. For soft reverse running surfaces. Also in media with low lubricity.
PTFE GM.80-01 PTFE GL.83-01	PTFE-vetro PTFE-vetro-MoS_2 PTFE-glass PTFE-glass-MoS_2	Buona resistenza alla pressione ed all'abrasione. Buona flessibilità. Good pressure and wear resistance. Good flexibility.	Per elevate sollecitazioni meccaniche. Non per funzionamento a secco. For high mechanical stress. Not for dry running.	Per oleoidraulica ad alta pressione, acqua, vapore. Per superfici d'accoppiamento tenere. For high-pressure hydraulics, water steam. For soft reverse running surfaces.

Fasce di guida LUBROSEAL® LSFC (stelo)
Fasce di guida LUBROSEAL® LKFP (pistone)



Descrizione
- fascia di guida in PTFE per stelo e pistone
- disponibile, pronta per il montaggio, tagliata a misura o a metraggio

Materiale
- elemento di tenuta:
  compound PTFE-bronzo (PTFE-BZ.83-01)
  compound PTFE-carbone (PTFE-KO.83-01)
  compound PTFE-vetro (PTFE-GL.83-01)

Funzione
- elemento di guida non metallico per steli e pistoni
- In parte per sedi normalizzate secondo ISO 10766
- l'accoppiamento dei materiali metallo/PTFE impedisce il grippaggio
- attrito ridotto
- nessun avanzamento a scatti
- buone caratteristiche di marcia in assenza di lubrificazione momentanea

Limiti d'impiego
- velocità di scorrimento: 5 m/s
- temperatura di esercizio: assegnata in dipendenza dell'elemento di tenuta dello stelo o del pistone

Temperature e pressione di esercizio
- temperatura +20 °C:
  pressione superficiale: 15 N/mm²
- temperatura +80 °C:
  pressione superficiale: 8 N/mm²
- temperatura +120 °C:
  pressione superficiale: 6 N/mm²

Il carico ammissibile di una fascia di guida si calcola moltiplicando la superficie proiettata per la pressione superficiale consentita. Nel fissare la pressione superficiale consentita si deve tenere conto dell'andamento non lineare della compressione sull'area di contatto, che risulta in corrispondenza del carico, della temperatura e delle tolleranze di fabbricazione. Con incapsulamento completo della fascia di guida in alloggiamento è consentito un carico specifico sensibilmente più alto.

Indicazioni costruttive

Finitura superficiale
Assegnata in dipendenza dell'elemento di tenuta dello stelo o del pistone.

LUBROSEAL® LSFC rods guide strips
LUBROSEAL® LKFP pistons guide strips

Description
- PTFE bar and piston guide strip
- cut ready for fitting or available as yard ware

Material
- sealing element:
  PTFE-bronze compound (PTFE-BZ.83-01)
  PTFE-carbon compound (PTFE-KO.83-01)
  PTFE-glass compound (PTFE-GL.83-01)

Function
- non-metal guide element for rods and pistons
- partly for standardised housings to ISO 10766
- metal/PTFE combination prevents «seizing»
- low friction
- no stick slip
- good running characteristics in absence of temporary lubrication

Limits on use
- running speed: 5 m/s
- working temperature: assigned to the corresponding rod or piston sealing element

Working temperature and pressure
- temperature +20 °C:
  surface pressure: 15 N/mm²
- temperature +80 °C:
  surface pressure: 8 N/mm²
- temperature +120 °C:
  surface pressure: 6 N/mm²

The permissible loading of a guide strip is computed from the projected surface multiplied by the permissible surface pressure. When determining the permissible surface pressure the non-linear pressure course across the contact range which results in accordance with load, temperature and manufacturing tolerances is taken into account. A considerably higher specific load is permitted if the guide strip is fully slotted in the groove.

Design notes

Surface finish
Will be assign to the corresponding rod- or piston seal.

Tolleranza d'accoppiamento / Allowance

Fasce di guida/Guide strips	∅ fondo sede/Groove base ∅ D/d
LUBROSEAL® LSFC (steli/rods)	H8
LUBROSEAL® LKFP (pistoni/pistons)	h8

Tipo di montaggio
Le fasce di guida sono consegnate a metraggio e quindi tagliate a misura per la lunghezza corrispondente e piazzate nella cava d'alloggiamento.

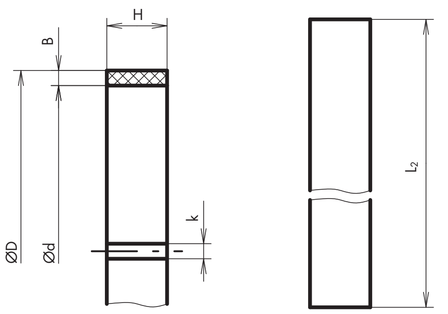
Indicazioni per il taglio delle fasce di guida in PTFE
Nel tagliare al diametro o al perimetro richiesti si deve fare attenzione che la lunghezza della fascia determinata col calcolo partendo dal diametro deve essere ridotta del valore k. L'interstizio che risulta dopo il montaggio è assolutamente necessario per compensare la dilatazione termica.
Consigliamo di tagliare le fasce con un taglio diritto. Con taglio inclinato, per esempio di 45°, non può essere escluso un danneggiamento delle punte (possono compersi).

Da questo risulta il seguente calcolo modificato della lunghezza per L_2:
– per steli: L_2 = (Ø d + B) x 3.11
– per pistoni: L_2 = (Ø D - B) x 3.11

Mounting type
Guide strips are supplied as yard ware and cut to the appropriate length and placed in the take-up groove.

Notes for cutting PTFE guide strips
When cutting to the required diameter or circumferential length, please note that the strip length computed from the diameter must be reduced of k value. The gap which occurs after fitting is vital due to heat expansion. We recommend that the strips be cut using a straight cut. If impact is at an angle, e.g. 45°, the tips may be damaged due to the strip working loose .

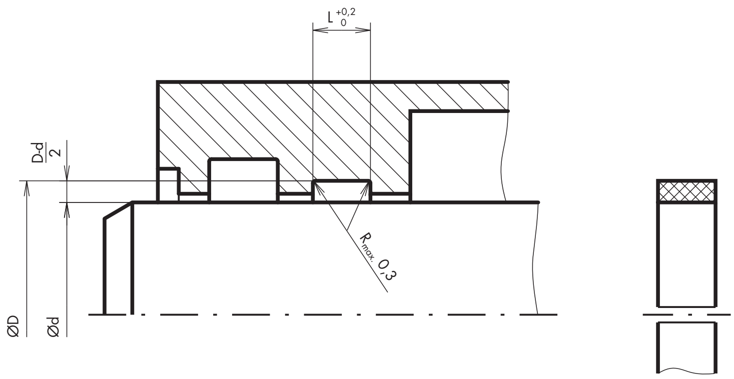
The following modified length calculation for L_2 results:
– for rods: L_2 = (Ø d + B) x 3.11
– for pistons: L_2 = (Ø D - B) x 3.11



k: interstizio per compensare la dilatazione termica
gap for bridging heat expansion

Tolleranza di fabbricazione L_2
Manufacturing tolerance L_2:
≥ 20 a/to ≤ 140 mm: 0/–0,5
> 140 a/to ≤ 250 mm: 0/–0,8
> 250 a/to ≤ 400 mm: 0/–1,0
> 400 a/to ≤ 500 mm: 0/–1,2
> oltre/over 500 mm: 0/–2,0

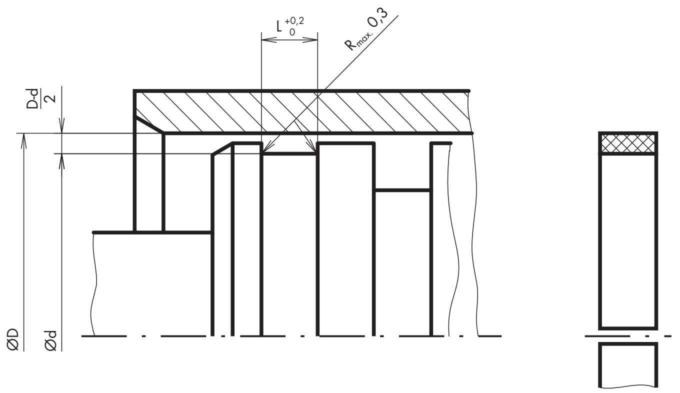
Sede di fasce di guida per steli / Housing for rods guide strips



Spessore della fascia di guida: $\frac{ØD–Ød}{2}$
Guide strip thickness:

Larghezza della fascia di guida: $L^{0}_{-0,2}$
Guide strip width:

Sede di fasce di guida per pistoni
Housing for pistons guide strips



Spessore della fascia di guida: $\frac{ØD-Ød}{2}$
Guide strip thickness:

Larghezza della fascia di guida: $L^{\ 0}_{-0,2}$
Guide strip width:

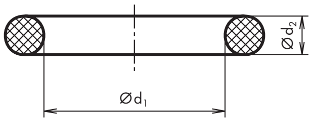
Dimensioni fasce di guida LUBROSEAL® LSFC (stelo) LUBROSEAL® LKFP (pistone)
Guide strips dimensions LUBROSEAL® LSFC (rod) LUBROSEAL® LKFP (piston)

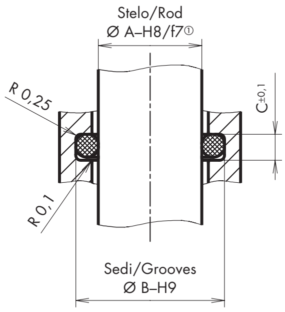
Spessore fascia Strip thickness B mm	Tolleranza Tolerance B mm	Larghezza fascia Strip width H mm	Tolleranza Tolerance H mm
Compound PTFE-bronzo (PTFE-BZ.83-01)①		**PTFE-bronze compound (PTFE-BZ.83-01)①**	
1,50	+0,02/–0,05	5,60	0/–0,2
1,50	+0,02/–0,05	8,00	0/–0,2
1,50	+0,02/–0,05	10,00	0/–0,2
1,50	+0,02/–0,05	12,00	0/–0,2
2,00	+0,02/–0,05	8,00	0/–0,2
2,00	+0,02/–0,05	10,00	0/–0,2
2,00	+0,02/–0,05	12,00	0/–0,2
2,00	+0,02/–0,05	15,00	0/–0,2
2,50	+0,02/–0,05	5,60	0/–0,2
2,50	+0,02/–0,05	6,00	0/–0,2
2,50	+0,02/–0,05	8,00	0/–0,2
2,50	+0,02/–0,05	9,70	0/–0,2
2,50	+0,02/–0,05	10,00	0/–0,2
2,50	+0,02/–0,05	12,00	0/–0,2
2,50	+0,02/–0,05	15,00	0/–0,2
2,50	+0,02/–0,05	20,00	0/–0,2
2,50	+0,02/–0,05	25,00	0/–0,2
Compound PTFE-carbone (PTFE-KO.83-01)②		**PTFE-carbon compound (PTFE-KO.83-01)②**	
2,00	+0,02/–0,05	6,00	0/–0,2
2,00	+0,02/–0,05	8,00	0/–0,2
2,00	+0,02/–0,05	10,00	0/–0,2
2,00	+0,02/–0,05	12,00	0/–0,2
2,00	+0,02/–0,05	15,00	0/–0,2
2,00	+0,02/–0,05	20,00	0/–0,2
2,00	+0,02/–0,05	25,00	0/–0,2
2,50	+0,02/–0,05	8,00	0/–0,2
2,50	+0,02/–0,05	10,00	0/–0,2
2,50	+0,02/–0,05	15,00	0/–0,2

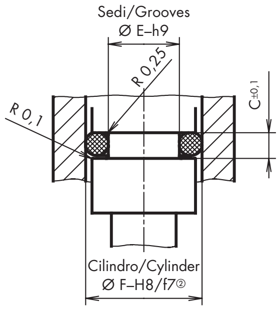
Materiale:
① elemento di tenuta:
compound PTFE-bronzo (PTFE-BZ.83-01)
② elemento di tenuta:
compound PTFE-carbografite (PTFE-KO.83-01)
③ elemento di tenuta:
compound PTFE-vetro (PTFE-GL.83-01)

Material:
① sealing element:
PTFE-bronze compound (PTFE-BZ.83-01)
② sealing element:
PTFE-carbon compound (PTFE-KO.83-01)
③ sealing element:
PTFE-glass compound (PTFE-GL.83-01)

O-Ring e dimensionamento delle sedi / O-Ring and dimensions of grooves







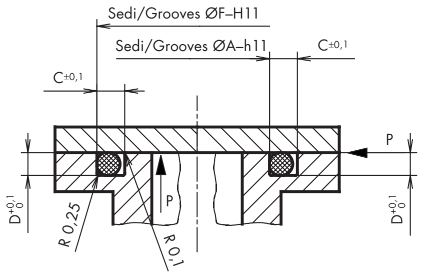
N° rif. Ref. no.	Norma Standard Code AS/BS	Dimensioni O-Ring / O-Ring dimensions Ø d_1	Ø d_2	A Ø ext.	Sconsigliabile per tenute dinamiche/Unsuitable for dynamic applications — Sede nel supporto / Groove in housing A	B Idr./Hydr.	B Pneum.③	C	Sede nello stelo / Groove in piston F	E Idr./Hydr.	E Pneum.③	C
		mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm
ORM 0225-25		22,5	2,5	27,5								
ORM 0230-25		23,0	2,5	28,0								
ORM 0235-25		23,5	2,5	28,5								
ORM 0240-25		24,0	2,5	29,0								
ORM 0245-25		24,5	2,5	29,5								
ORM 0250-25		25,0	2,5	30,0								
ORM 0260-25		26,0	2,5	31,0								
ORM 0270-25		27,0	2,5	32,0								
ORM 0275-25		27,5	2,5	32,5								
ORM 0280-25		28,0	2,5	33,0								
ORM 0290-25		29,0	2,5	34,0								
ORM 0295-25		29,5	2,5	34,5								
ORM 0300-25		30,0	2,5	35,0								
ORM 0310-25		31,0	2,5	36,0								
ORM 0320-25		32,0	2,5	37,0								
ORM 0330-25		33,0	2,5	38,0								
ORM 0340-25		34,0	2,5	39,0								
ORM 0350-25		35,0	2,5	40,0								
ORM 0360-25		36,0	2,5	41,0								
ORM 0370-25		37,0	2,5	42,0								
ORM 0380-25		38,0	2,5	43,0								
ORM 0390-25		39,0	2,5	44,0								
ORM 0400-25		40,0	2,5	45,0								
ORM 0410-25		41,0	2,5	46,0								
ORM 0420-25		42,0	2,5	47,0								
ORM 0430-25		43,0	2,5	48,0								
ORM 0440-25		44,0	2,5	49,0								
ORM 0450-25		45,0	2,5	50,0								
ORM 0460-25		46,0	2,5	51,0								
ORM 0470-25		47,0	2,5	52,0								
ORM 0480-25		48,0	2,5	53,0								
ORM 0490-25		49,0	2,5	54,0								
ORM 0500-25		50,0	2,5	55,0								
ORM 0510-25		51,0	2,5	56,0								
ORM 0520-25		52,0	2,5	57,0								
ORM 0530-25		53,0	2,5	58,0								
ORM 0540-25		54,0	2,5	59,0								
ORM 0550-25		55,0	2,5	60,0								
ORM 0560-25		56,0	2,5	61,0								
ORM 0570-25		57,0	2,5	62,0								
ORM 0580-25		58,0	2,5	63,0								
ORM 0590-25		59,0	2,5	64,0								

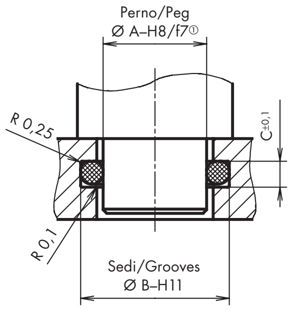
① oltre 100 bar accoppiamento Ø A: H7/g6
② oltre 100 bar accoppiamento Ø F: H7/g6
③ vedi pagina 96

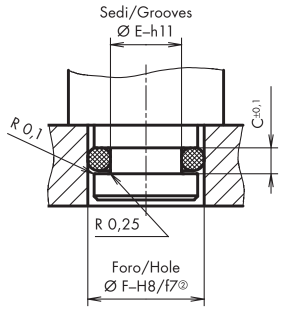
① from 100 bar and Ø A clearance: H7/g6
② from 100 bar and Ø F clearance: H7/g6
③ see page 96

Avvertimento:
Le dimensioni degli O-Ring senza raccomandazione di montaggio non sono previste per l'impiego dinamico.

Note:
O-Ring dimensions without a mounting recommendation are not suitable for dynamic applications.





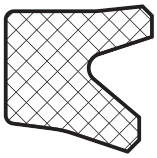


Tenute statiche/Static applications

Pressione interna Internal press.			**Pressione esterna External press.**	**Sede nel supporto Groove in house**			**Sede nel perno Groove in peg**		
F	**C**	**D**	**A**	**A**	**B**	**C**	**F**	**E**	**C**
mm	mm	mm	mm	mm	mm	mm	mm	mm	mm
27,5	3,3	1,9	22,5	22,5	26,5	3,3	27,5	23,5	3,3
28,0	3,3	1,9	23,0	23,0	27,0	3,3	28,0	24,0	3,3
28,5	3,3	1,9	23,5	23,5	27,5	3,3	28,5	24,5	3,3
29,0	3,3	1,9	24,0	24,0	28,0	3,3	29,0	25,0	3,3
29,5	3,3	1,9	24,5	24,5	28,5	3,3	29,5	25,5	3,3
30,0	3,3	1,9	25,0	25,0	29,0	3,3	30,0	26,0	3,3
31,0	3,3	1,9	26,0	26,0	30,0	3,3	31,0	27,0	3,3
32,0	3,3	1,9	27,0	27,0	31,0	3,3	32,0	28,0	3,3
32,5	3,3	1,9	27,5	27,5	31,5	3,3	32,5	28,5	3,3
33,0	3,3	1,9	28,0	28,0	32,0	3,3	33,0	29,0	3,3
34,0	3,3	1,9	29,0	29,0	33,0	3,3	34,0	30,0	3,3
34,5	3,3	1,9	29,5	29,5	33,5	3,3	34,5	30,5	3,3
35,0	3,3	1,9	30,0	30,0	34,0	3,3	35,0	31,0	3,3
36,0	3,3	1,9	31,0	31,0	35,0	3,3	36,0	32,0	3,3
37,0	3,3	1,9	32,0	32,0	36,0	3,3	37,0	33,0	3,3
38,0	3,3	1,9	33,0	33,0	37,0	3,3	38,0	34,0	3,3
39,0	3,3	1,9	34,0	34,0	38,0	3,3	39,0	35,0	3,3
40,0	3,3	1,9	35,0	35,0	39,0	3,3	40,0	36,0	3,3
41,0	3,3	1,9	36,0	36,0	40,0	3,3	41,0	37,0	3,3
42,0	3,3	1,9	37,0	37,0	41,0	3,3	42,0	38,0	3,3
43,0	3,3	1,9	38,0	38,0	42,0	3,3	43,0	39,0	3,3
44,0	3,3	1,9	39,0	39,0	43,0	3,3	44,0	40,0	3,3
45,0	3,3	1,9	40,0	40,0	44,0	3,3	45,0	41,0	3,3
46,0	3,3	1,9	41,0	41,0	45,0	3,3	46,0	42,0	3,3
47,0	3,3	1,9	42,0	42,0	46,0	3,3	47,0	43,0	3,3
48,0	3,3	1,9	43,0	43,0	47,0	3,3	48,0	44,0	3,3
49,0	3,3	1,9	44,0	44,0	48,0	3,3	49,0	45,0	3,3
50,0	3,3	1,9	45,0	45,0	49,0	3,3	50,0	46,0	3,3
51,0	3,3	1,9	46,0	46,0	50,0	3,3	51,0	47,0	3,3
52,0	3,3	1,9	47,0	47,0	51,0	3,3	52,0	48,0	3,3
53,0	3,3	1,9	48,0	48,0	52,0	3,3	53,0	49,0	3,3
54,0	3,3	1,9	49,0	49,0	53,0	3,3	54,0	50,0	3,3
55,0	3,3	1,9	50,0	50,0	54,0	3,3	55,0	51,0	3,3
56,0	3,3	1,9	51,0	51,0	55,0	3,3	56,0	52,0	3,3
57,0	3,3	1,9	52,0	52,0	56,0	3,3	57,0	53,0	3,3
58,0	3,3	1,9	53,0	53,0	57,0	3,3	58,0	54,0	3,3
59,0	3,3	1,9	54,0	54,0	58,0	3,3	59,0	55,0	3,3
60,0	3,3	1,9	55,0	55,0	59,0	3,3	60,0	56,0	3,3
61,0	3,3	1,9	56,0	56,0	60,0	3,3	61,0	57,0	3,3
62,0	3,3	1,9	57,0	57,0	61,0	3,3	62,0	58,0	3,3
63,0	3,3	1,9	58,0	58,0	62,0	3,3	63,0	59,0	3,3
64,0	3,3	1,9	59,0	59,0	63,0	3,3	64,0	60,0	3,3

Guarnizione per stelo LUBROSEAL® LT20C

LUBROSEAL® LT20C rod seal



Descrizione
– guarnizione con profilo asimmetrico
– labbro di tenuta arretrato sul diametro interno
– labbro statico esterno con accoppiamento preciso bloccato leggero

Materiale
– elemento di tenuta:
poliuretano PUR (AU 95.80-01)
durezza: 95 Shore A

Funzione
– guarnizione a semplice effetto per stelo
– in parte per sedi normalizzate secondo ISO 5597
– indicata anche come guarnizione secondaria in un sistema di tenuta

Limiti d'impiego
– pressione: max. 40 MPa
– velocità di scorrimento: 0,5 m/s (anche maggiore, se usata come guarnizione secondaria)
– temperatura di esercizio:
  – oli idraulici HL, HLP: –30 a +110 °C
  – liquidi HFA, HFB: +5 a +50 °C
  – liquidi HFC: –30 a +40 °C
  – acqua: +5 a +50 °C
  – HETG (oli di colza): –30 a +60 °C
  – HEES (esteri sintetici): –30 a +80 °C
  – HEPG (glicole): –30 a +50 °C
  – grassi minerali: –40 a +110 °C

Applicazione non prevista per:
– liquidi HFD

Description
– packing ring with asymmetrical profile
– sealing lip restored to original position at internal diameter
– static outer lip with wringing fit

Material
– sealing element:
polyurethan PUR (AU 95.80-01)
hardness: 95 Shore A

Function
– rod seal with simple effect
– partly for standard housing acc. ISO 5597
– also suitable as secondary seal inside a sealing system

Limits on use
– pressure: max. 40 MPa
– running speed: 0,5 m/s (higher still if used as secondary seal)
– service temperature:
  – hydraulic oils HL, HLP: –30 to +110 °C
  – HFA, HFB fluids: +5 to +50 °C
  – HFC fluids: –30 to +40 °C
  – water: +5 to +50 °C
  – HETG (colza oils): –30 to +60 °C
  – HEES (synth. ester): –30 to +80 °C
  – HEPG (glycols): –30 to +50 °C
  – mineral-based greases: –40 to +110 °C

Application is not provided for:
– HFD fluids

Indicazioni costruttive

Design notes

Finitura superficiale **Surface finish**

	Rugosità/Surface roughness			Classe di rugosità Roughness class
	R_a	R_t	R_z	
	μm	μm	μm	
superficie di scorrimento/sliding surface	≤ 0,3	≤ 2,5	≤ 1,25	N4/N5
fondo della sede/groove base	≤ 1,6	≤ 6,3	≤ 6,3	N7
fianchi della sede/groove sides	≤ 3	≤ 15	≤ 10	N8

fattore di portanza t_p > 50% fino a max. 90% con 0,5 R_t profile bearing length ratio t_p > 50% to max. 90% at 0,5 R_t

Dimensioni dell'interstizio in funzione della pressione **Interstice dimensions depending on pressure**

Larghezza profilo/Profile width	Dimensioni max. ammissibili dell'interstizio/Max. permissible interstice dimensions			
B	16 MPa	26 MPa	32 MPa	40 MPa
mm	mm	mm	mm	mm
≤ 5	0,5	0,4	0,35	–
> 5 a/to ≤ 7,5	0,55	0,45	0,4	0,35
> 7,5 a/to ≤ 12,5	0,6	0,5	0,45	0,4
> 12,5	0,65	0,55	0,45	0,4

Tolleranza d'accoppiamento / Allowance

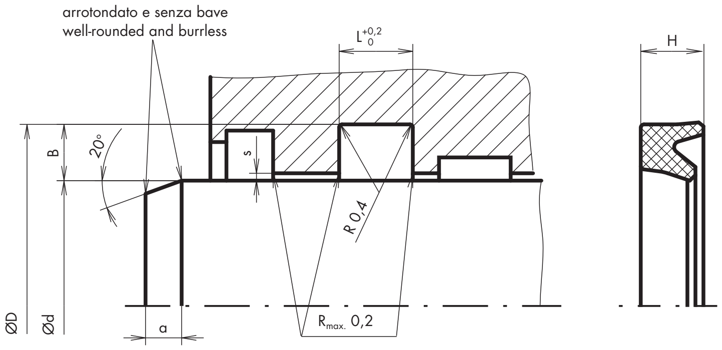
Ø nominale Nominal Ø d mm	Fondo della sede-Ø Groove base Ø D	Ø stelo Rod Ø d
≤200	H11	f8
>200	H10	f7

Tipo di montaggio / Mounting type

– vedi colonna «Tipo di montaggio» nella tabella delle dimensioni

– see column «Mounting type» in the dimensions table

Sede / Housing



Dimensioni LUBROSEAL® LT20C / Dimensions LUBROSEAL® LT20C

Cod. art. Art. no.	Sede secondo Housing acc. ISO 5597	Ø stelo Rod Ø d mm	Fondo della sede-Ø Groove base Ø D mm	Altezza guarnizione Seal height H mm	Larghezza sede Groove width L mm	Larghezza profilo Profile width B mm	Smussatura Chamfer a mm	Tipo di montaggio② Mounting type②
11.6330.0010	•	8,00	16,00	5,70	6,30	4,00	3,50	–
.0020		8,00	16,00	8,20	9,00	4,00	3,50	–
.0030	•	10,00	18,00	5,70	6,30	4,00	3,50	–
.0040	•	10,00	20,00	7,30	8,00	5,00	4,00	–
.0060	•	12,00	20,00	5,70	6,30	4,00	3,50	–
.0070	•	12,00	22,00	7,30	8,00	5,00	4,50	–
.0080		12,00	22,00	8,20	9,00	5,00	4,50	–
.0090	•	14,00	24,00	7,30	8,00	5,00	4,50	–
.0100		14,00	24,00	8,20	9,00	5,00	4,50	–
.0110		15,00	25,00	8,20	9,00	5,00	4,50	–
.0120	•	16,00	24,00	5,70	6,30	4,00	4,00	–
.0130	•	16,00	26,00	7,30	8,00	5,00	4,50	–
.0140		16,00	26,00	8,20	9,00	5,00	4,50	–
.0150		18,00	26,00	8,20	9,00	4,00	4,00	–
.0160	•	18,00	28,00	7,30	8,00	5,00	4,50	–
.0170		18,00	28,00	8,20	9,00	5,00	4,50	–
.0180	•	20,00	28,00	5,70	6,30	4,00	4,00	–

① consegna in breve tempo
② h: a mano
w: con utensile di montaggio
– (senza indice): prevedere sede accessibile assialmente

① available in short time
② h: by hand
w: with mounting tool
– (without index): provide housing accessible in the axial direction

Materiale:
– elemento di tenuta:
poliuretano PUR (AU 95.80-01)
Durezza: 95 Shore A
Pressione: 40 MPa
Velocità di scorrimento: 0,5 m/s (anche maggiore come guarnizione secondaria)
Temperatura di esercizio: –40 a +110 °C (secondo il fluido)

Material:
– sealing element:
polyurethan PUR (AU 95.80-01)
Hardness: 95 Shore A
Pressure: 40 MPa
Running speed: 0,5 m/s (higher still if used as secondary seal)
Working temperature: –40 to +110 °C (depending on medium)

Dimensioni LUBROSEAL® LT20C

Dimensions LUBROSEAL® LT20C

Cod. art. / Art. no.	Sede secondo / Housing acc. ISO 5597	∅ stelo / Rod ∅ d mm	Fondo della sede-∅ / Groove base ∅ D mm	Altezza guarnizione / Seal height H mm	Larghezza sede / Groove width L mm	Larghezza profilo / Profile width B mm	Smussatura / Chamfer a mm	Tipo di montaggio② / Mounting type②
11.6330.0190	●	20,00	30,00	7,30	8,00	5,00	4,50	–
.0200		20,00	30,00	8,20	9,00	5,00	4,50	–
.0210		22,00	30,00	8,20	9,00	4,00	4,00	–
.0220	●	22,00	32,00	7,30	8,00	5,00	4,50	–
.0230		22,00	32,00	8,20	9,00	5,00	4,50	–
.0240	●	25,00	33,00	5,70	6,30	4,00	4,00	w
.0250	●	25,00	35,00	7,30	8,00	5,00	4,50	–
.0260		25,00	35,00	8,20	9,00	5,00	4,50	–
.0270		25,00	40,00	10,00	11,00	7,50	5,50	–
.0290	●	28,00	38,00	7,30	8,00	5,00	4,50	–
.0300		28,00	38,00	8,20	9,00	5,00	4,50	–
.0320		30,00	38,00	8,20	9,00	4,00	4,00	w
.0330		30,00	40,00	10,00	11,00	5,00	4,50	w
.0340		30,00	45,00	10,00	11,00	7,50	5,50	–
.0350	●	32,00	42,00	7,30	8,00	5,00	4,50	w
.0360		32,00	42,00	10,00	11,00	5,00	4,50	w
.0370		32,00	47,00	10,00	11,00	7,50	5,50	–
.0380		35,00	45,00	10,00	11,00	5,00	4,50	w
.0390		35,00	50,00	10,00	11,00	7,50	5,50	–
.0400	●	36,00	46,00	7,30	8,00	5,00	4,50	w
.0410		36,00	46,00	10,00	11,00	5,00	4,50	w
.0420		40,00	48,00	8,20	9,00	4,00	4,00	h
.0430	●	40,00	50,00	7,30	8,00	5,00	4,50	w
.0440		40,00	50,00	8,20	9,00	5,00	4,50	w
.0450		40,00	50,00	10,00	11,00	5,00	4,50	w
.0460		40,00	55,00	10,00	11,00	7,50	5,50	–
.0470		42,00	52,00	10,00	11,00	5,00	4,50	w
.0480		45,00	53,00	8,20	9,00	4,00	4,00	h
.0490	●	45,00	55,00	7,30	8,00	5,00	4,50	w
.0500		45,00	55,00	10,00	11,00	5,00	4,50	w
.0510		45,00	60,00	10,00	11,00	7,50	5,50	–
.0520		50,00	58,00	8,20	9,00	4,00	4,00	h
.0530	●	50,00	60,00	7,30	8,00	5,00	4,50	h
.0540		50,00	60,00	10,00	11,00	5,00	4,50	h
.0560		50,00	65,00	10,00	11,00	7,50	5,50	w
.0570	●	50,00	65,00	11,40	12,50	7,50	5,50	w
.0580		50,00	70,00	11,40	13,00	10,00	6,00	–
.0590		55,00	63,00	8,20	9,00	4,00	4,50	h
.0600		55,00	65,00	10,00	11,00	5,00	4,50	h
.0620		55,00	70,00	11,40	13,00	7,50	5,50	w
.0630		56,00	66,00	8,20	9,00	5,00	4,50	h
.0640	●	56,00	71,00	11,40	12,50	7,50	5,50	w
.0650		56,00	71,00	11,40	13,00	7,50	5,50	w
.0660		60,00	70,00	10,00	11,00	5,00	4,50	h
.0670		60,00	70,00	11,80	13,00	5,00	4,50	w
.0680		60,00	75,00	11,40	12,50	7,50	5,50	w

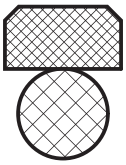
① consegna in breve tempo
② h: a mano
w: con utensile di montaggio
– (senza indice): prevedere sede accessibile assialmente

① available in short time
② h: by hand
w: with mounting tool
– (without index): provide housing accessible in the axial direction

Materiale:
– elemento di tenuta:
poliuretano PUR (AU 95.80-01)
Durezza: 95 Shore A
Pressione: 40 MPa
Velocità di scorrimento: 0,5 m/s (anche maggiore come guarnizione secondaria)
Temperatura di esercizio: –40 a +110 °C (secondo il fluido)

Material:
– sealing element:
polyurethan PUR (AU 95.80-01)
Hardness: 95 Shore A
Pressure: 40 MPa
Running speed: 0,5 m/s (higher still if used as secondary seal)
Working temperature: –40 to +110 °C (depending on medium)

Guarnizione per pistone LUBROSEAL® LOMKP



Descrizione
- guarnizione composita
- costituito da un anello in PTFE ed un O-Ring come elemento di pre-compressione

Materiale
- anello in PTFE :
  compound PTFE-bronzo (PTFE-BZ.80-01)
  Su richiesta:
  – compound PTFE-vetro-MoS_2 (PTFE-GM.80-01)
- NORMATEC® O-Ring:
  elastomero nitrile (NBR NT 70.11)
  durezza: 70 Shore A
  Su richiesta:
  – fluoro elastomero (FPM NT 80.7/75)
  durezza: 75 Shore A

Funzione
- guarnizione a doppio effetto per pistone
- le sedi di alloggiamento sono idonee a sostenere brusche variazioni della pressione con relativa compensazione
- elevata tenuta alla pressione
- elevata resistenza all'abrasione
- attrito limitato

Limiti d'impiego
- pressione: max. 40 MPa
- velocità di scorrimento: 5 m/s
- temperatura di esercizio:
  - oli idraulici HL, HLP:
    PTFE-bronzo/NBR: –30 a +100 °C
    PTFE-bronzo/FPM: –10 a +200 °C
    PTFE-vetro-MoS_2/NBR: –30 a +100 °C
  - liquidi HFA, HFB:
    PTFE-vetro-MoS_2/NBR: +5 a +60 °C
  - liquidi HFC:
    PTFE-vetro-MoS_2/NBR: –30 a +60 °C
  - liquidi HFD:
    PTFE-bronzo/FPM: –10 a +200 °C
  - Acqua:
    PTFE-vetro-MoS_2/NBR: +5 a +100 °C
  - HETG (oli di colza):
    PTFE-bronzo/NBR: –30 a +80 °C
    PTFE-bronzo/FPM: –10 a +80 °C
    PTFE-vetro-MoS_2/NBR: –30 a +80 °C
  - HEES (esteri sintetici):
    PTFE-bronzo/NBR: –30 a +80 °C
    PTFE-bronzo/FPM: –10 a +100 °C
    PTFE-vetro-MoS_2/NBR: –30 a +80 °C
  - HEPG (glicole):
    PTFE-bronzo/NBR: –30 a +60 °C
    PTFE-bronzo/FPM: –10 a +80 °C
    PTFE-vetro-MoS_2/NBR: –30 a +60 °C

LUBROSEAL® LOMKP piston seal

Description
- composite seal
- comprising a PTFE profile ring with an O-Ring as a prestressing element

Material
- PTFE ring:
  PTFE-bronze compound (PTFE-BZ.80-01)
  Upon request:
  – PTFE-glass MoS_2 compound (PTFE-GM.80-01)
- NORMATEC® O-Ring:
  nitrile elastomer (NBR NT 70.11)
  hardness: 70 Shore A
  Upon request:
  – fluoro elastomer (FPM NT 80.7/75)
  hardness: 75 Shore A

Function
- double effect piston seal
- pressure compensation grooves are provided for fast pressure change
- high resistance to abrasion
- high resistance to pressure
- low friction

Limits on use
- pressure: max. 40 MPa
- running speed: 5 m/s
- working temperature:
  - hydraulic oils HL, HLP:
    PTFE bronze/NBR: –30 to +100 °C
    PTFE bronze/FPM: –10 to +200 °C
    PTFE-glass-MoS_2/NBR: –30 to +100 °C
  - HFA, HFB fluids:
    PTFE-glass-MoS_2/NBR: +5 to +60 °C
  - HFC fluids:
    PTFE-glass-MoS_2/NBR: –30 to +60 °C
  - HFD fluids:
    PTFE bronze/FPM: –10 to +200 °C
  - water:
    PTFE-glass-MoS_2/NBR: +5 to +100 °C
  - HETG (colza oils):
    PTFE bronze/NBR: –30 to +80 °C
    PTFE bronze/FPM: –10 to +80 °C
    PTFE-glass-MoS_2/NBR: –30 to +80 °C
  - HEES (synth. ester):
    PTFE bronze/NBR: –30 to +80 °C
    PTFE bronze/FPM: –10 to +100 °C
    PTFE-glass-MoS_2/NBR: –30 to +80 °C
  - HEPG (glycols):
    PTFE bronze/NBR: –30 a +60 °C
    PTFE bronze/FPM: –10 a +80 °C
    PTFE-glass-MoS_2/NBR: –30 to +60 °C

– grassi minerali:
PTFE-bronzo/NBR: –30 a +100 °C
PTFE-bronzo/FPM: –10 a +200 °C
PTFE-vetro-MoS_2/NBR: –30 a +100 °C

– mineral-based greases:
PTFE bronze/NBR: –30 to +100 °C
PTFE bronze/FPM: –10 to +200 °C
PTFE-glass-MoS_2/NBR: –30 to +100 °C

Indicazioni costruttive / Design notes

Scelta del materiale / Material selection

		PTFE-bronzo/NBR PTFE bronze/NBR	PTFE-bronzo/FPM PTFE-bronze/FPM	PTFE-vetro-MoS_2/NBR PTFE-glass-MoS_2/NBR
oleoidraulica/oil hydraulic	–30 a/to +100 °C	●	○	◉
	–10 a/to +200 °C	○	●	○
corsa breve, alta frequenza/short stroke, high frequency		○	○	●
idraulica ad acqua/water hydraulic		○	○	●
superficie di scorrimento tenera/soft sliding surface		○	○	●

● idoneo / suitable
◉ possibile / possible
○ non idoneo / not suitable

Finitura superficiale / Surface finish

	Rugosità/Surface roughness R_a	R_t	R_z	Classe di rugosità / Roughness class
	µm	µm	µm	
superficie di scorrimento/sliding surface	≤ 0,3	≤ 2,5	≤ 1,25	N4/N5
fondo della sede/groove base	≤ 1,6	≤ 6,3	≤ 6,3	N7
fianchi della sede/groove sides	≤ 3	≤ 15	≤ 10	N8

fattore di portanza t_p > 50% fino a max. 90% con 0,5 R_t
profile bearing length ratio t_p > 50% to max. 90% at 0,5 R_t

Dimensioni dell'interstizio in funzione della pressione / Interstice dimensions depending on pressure

Larghezza sede / Groove width L	Larghezza profilo / Profile width B	Dimensioni max. ammissibili dell'interstizio / Max. permissible interstice dimensions 16 MPa	26 MPa	32 MPa	40 MPa
mm	mm	mm	mm	mm	mm
2,2	2,45	0,35	0,3	–	–
3,2	3,75	0,4	0,35	–	–
4,2	5,5	0,5	0,4	0,3	–
6,3	7,75	0,55	0,45	0,4	0,35
8,1	10,5	0,6	0,5	0,45	0,45
8,1	12,25	0,7	0,6	0,55	0,5

Tolleranza d'accoppiamento / Allowance

∅ nominale/Nominal ∅	16 MPa		26 MPa		32 MPa		40 MPa	
D	D	d	D	d	D	d	D	d
mm								
8 a/to ≤ 500	H8	h8	H8	h8	H8	h8	H8	h8
> 500 a/to ≤ 1000	H8	h7	H8	h7	H8	h7	H8	h7

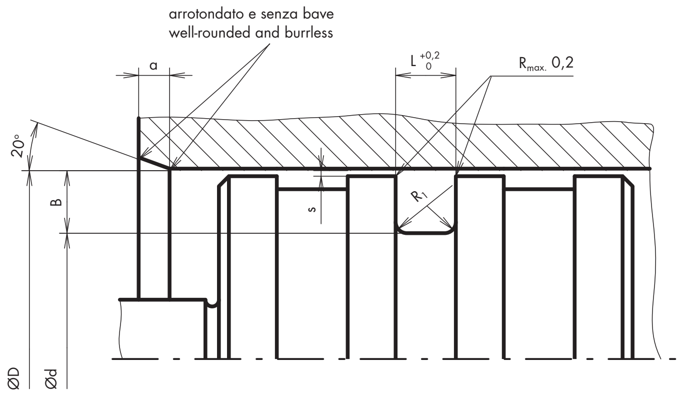
Tipo di montaggio

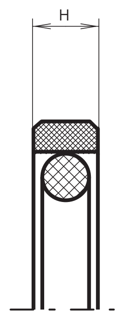
La guarnizione compatta su pistone LUBROSEAL® LOMKP è indicata per cave chiuse. Il montaggio richiede tuttavia un'attenzione particolare.

Mounting type

The LUBROSEAL® LOMKP compact piston seal is suitabe for closed grooves as a matter of course, although the seal must be fitted with great care.

Sede **Housing**





Dimensioni LUBROSEAL® LOMKP — Dimensions LUBROSEAL® LOMKP

Cod. art. / Art. no.	Ø alesaggio / Borehole Ø D mm	Ø fondo sede / Groove base Ø d mm	Altezza guarnizione / Seal height H mm	Larghezza sede / Groove width L mm	Larghezza profilo / Profile width B mm	Smussatura / Chamfer a mm	Raggio / Radius R_1 mm	Combinazione di materiali / Material combination PTFE bronzo/ PTFE bronze
11.5903.0010	8,00	3,10	2,00	2,20	2,45	3,00	0,30	con/with NBR
.0020	10,00	5,10	2,00	2,20	2,45	3,00	0,30	con/with NBR
.0030	12,00	7,10	2,00	2,20	2,45	3,00	0,30	con/with NBR
.0040	15,00	7,50	3,00	3,20	3,75	4,50	0,50	con/with NBR
.0050	16,00	8,50	3,00	3,20	3,75	4,50	0,50	con/with NBR
.0060	18,00	10,50	3,00	3,20	3,75	4,50	0,50	con/with NBR
.0070	20,00	12,50	3,00	3,20	3,75	4,50	0,50	con/with NBR
.0080	22,00	14,50	3,00	3,20	3,75	4,50	0,50	con/with NBR
.0100	25,00	17,50	3,00	3,20	3,75	4,50	0,50	con/with NBR
.0110	28,00	20,50	3,00	3,20	3,75	4,50	0,50	con/with NBR
.0120	30,00	22,50	3,00	3,20	3,75	4,50	0,50	con/with NBR
.0130	32,00	24,50	3,00	3,20	3,75	4,50	0,50	con/with NBR
.0140	35,00	27,50	3,00	3,20	3,75	4,50	0,50	con/with NBR
.0150	36,00	28,50	3,00	3,20	3,75	4,50	0,50	con/with NBR
.0160	40,00	29,00	4,00	4,20	5,50	6,00	0,80	con/with NBR
.0170	42,00	31,00	4,00	4,20	5,50	6,00	0,80	con/with NBR
.0180	45,00	34,00	4,00	4,20	5,50	6,00	0,80	con/with NBR
.0190	50,00	39,00	4,00	4,20	5,50	6,00	0,80	con/with NBR
.0200	55,00	44,00	4,00	4,20	5,50	6,00	0,80	con/with NBR
.0210	56,00	45,00	4,00	4,20	5,50	6,00	0,80	con/with NBR
.0220	60,00	49,00	4,00	4,20	5,50	6,00	0,80	con/with NBR
.0230	63,00	52,00	4,00	4,20	5,50	6,00	0,80	con/with NBR
.0240	65,00	54,00	4,00	4,20	5,50	6,00	0,80	con/with NBR
.0250	70,00	59,00	4,00	4,20	5,50	6,00	0,80	con/with NBR
.0270	75,00	64,00	4,00	4,20	5,50	6,00	0,80	con/with NBR
.0290	80,00	64,50	5,90	6,30	7,75	8,00	1,20	con/with NBR
.0310	85,00	69,50	5,90	6,30	7,75	8,00	1,20	con/with NBR
.0330	90,00	74,50	5,90	6,30	7,75	8,00	1,20	con/with NBR
.0350	95,00	79,50	5,90	6,30	7,75	8,00	1,20	con/with NBR
.0370	100,00	84,50	5,90	6,30	7,75	8,00	1,20	con/with NBR
.0390	105,00	89,50	5,90	6,30	7,75	8,00	1,20	con/with NBR
.0410	110,00	94,50	5,90	6,30	7,75	8,00	1,20	con/with NBR

Materiale:
– elemento di tenuta:
compound PTFE-bronzo (PTFE-BZ.80-01)
– NORMATEC® O-Ring:
NORMATEC® NBR (NT 70.11)
Pressione: 40 MPa
Velocità di scorrimento: 5 m/s
Temperatura di esercizio: –30 a +100 °C (secondo il fluido)

Material:
– sealing element:
PTFE bronze compound (PTFE-BZ.80-01)
– NORMATEC® O-Ring:
NORMATEC® NBR (NT 70.11)
Pressure: 40 MPa
Running speed: 5 m/s
Working temperature: –30 to +100 °C (depending on medium)

Tolleranza d'accoppiamento / Allowance

Fasce di guida/Guide strips	∅ fondo sede/Groove base ∅ D/d
LUBROSEAL® LSFC (steli/rods)	H8
LUBROSEAL® LKFP (pistoni/pistons)	h8

Tipo di montaggio

Le fasce di guida sono consegnate a metraggio e quindi tagliate a misura per la lunghezza corrispondente e piazzate nella cava d'alloggiamento.

Indicazioni per il taglio delle fasce di guida in PTFE

Nel tagliare al diametro o al perimetro richiesti si deve fare attenzione che la lunghezza della fascia determinata col calcolo partendo dal diametro deve essere ridotta del valore k. L'interstizio che risulta dopo il montaggio è assolutamente necessario per compensare la dilatazione termica.
Consigliamo di tagliare le fasce con un taglio diritto. Con taglio inclinato, per esempio di 45°, non può essere escluso un danneggiamento delle punte (possono compersi).

Da questo risulta il seguente calcolo modificato della lunghezza per L_2:
– per steli: L_2 = (Ø d + B) x 3.11
– per pistoni: L_2 = (Ø D - B) x 3.11

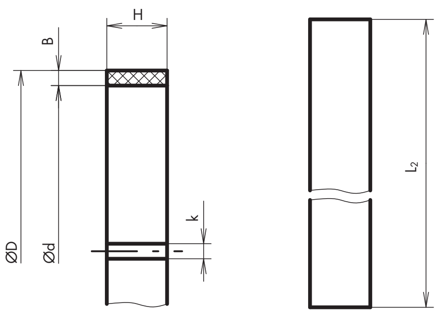
Mounting type

Guide strips are supplied as yard ware and cut to the appropriate length and placed in the take-up groove.

Notes for cutting PTFE guide strips

When cutting to the required diameter or circumferential length, please note that the strip length computed from the diameter must be reduced of k value. The gap which occurs after fitting is vital due to heat expansion. We recommend that the strips be cut using a straight cut. If impact is at an angle, e.g. 45°, the tips may be damaged due to the strip working loose .

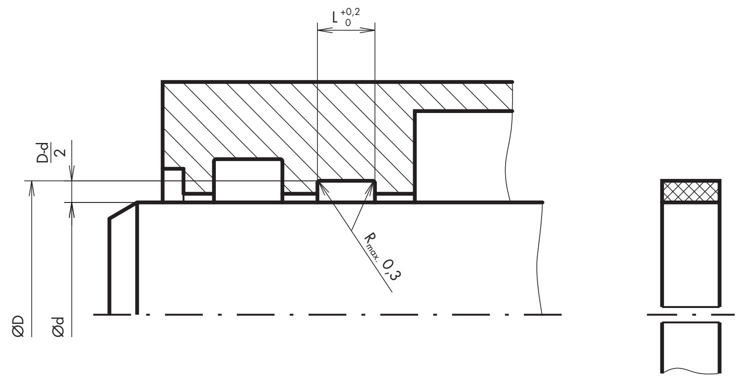
The following modified length calculation for L_2 results:
– for rods: L_2 = (Ø d + B) x 3.11
– for pistons: L_2 = (Ø D - B) x 3.11



k: interstizio per compensare la dilatazione termica
gap for bridging heat expansion

Tolleranza di fabbricazione L_2
Manufacturing tolerance L_2:
≥20 a/to ≤140 mm: 0/–0,5
>140 a/to ≤250 mm: 0/–0,8
>250 a/to ≤400 mm: 0/–1,0
>400 a/to ≤500 mm: 0/–1,2
>oltre/over 500 mm: 0/–2,0

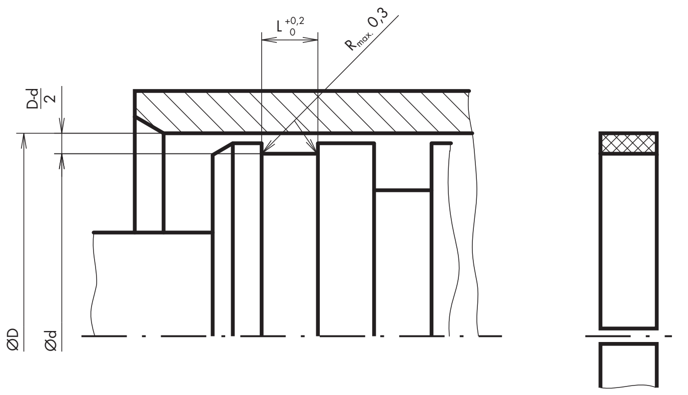
Sede di fasce di guida per steli / Housing for rods guide strips



Spessore della fascia di guida: / Guide strip thickness: $\frac{ØD-Ød}{2}$

Larghezza della fascia di guida: / Guide strip width: $L^{0}_{-0,2}$

Sede di fasce di guida per pistoni / Housing for pistons guide strips



Spessore della fascia di guida: / Guide strip thickness: $\frac{ØD-Ød}{2}$

Larghezza della fascia di guida: / Guide strip width: $L^{\,0}_{-0,2}$

Dimensioni fasce di guida LUBROSEAL® LSFC (stelo) LUBROSEAL® LKFP (pistone) / Guide strips dimensions LUBROSEAL® LSFC (rod) LUBROSEAL® LKFP (piston)

Spessore fascia Strip thickness B mm	Tolleranza Tolerance B mm	Larghezza fascia Strip width H mm	Tolleranza Tolerance H mm
Compound PTFE-bronzo (PTFE-BZ.83-01) ①		**PTFE-bronze compound (PTFE-BZ.83-01)** ①	
1,50	+0,02/–0,05	5,60	0/–0,2
1,50	+0,02/–0,05	8,00	0/–0,2
1,50	+0,02/–0,05	10,00	0/–0,2
1,50	+0,02/–0,05	12,00	0/–0,2
2,00	+0,02/–0,05	8,00	0/–0,2
2,00	+0,02/–0,05	10,00	0/–0,2
2,00	+0,02/–0,05	12,00	0/–0,2
2,00	+0,02/–0,05	15,00	0/–0,2
2,50	+0,02/–0,05	5,60	0/–0,2
2,50	+0,02/–0,05	6,00	0/–0,2
2,50	+0,02/–0,05	8,00	0/–0,2
2,50	+0,02/–0,05	9,70	0/–0,2
2,50	+0,02/–0,05	10,00	0/–0,2
2,50	+0,02/–0,05	12,00	0/–0,2
2,50	+0,02/–0,05	15,00	0/–0,2
2,50	+0,02/–0,05	20,00	0/–0,2
2,50	+0,02/–0,05	25,00	0/–0,2
Compound PTFE-carbone (PTFE-KO.83-01) ②		**PTFE-carbon compound (PTFE-KO.83-01)** ②	
2,00	+0,02/–0,05	6,00	0/–0,2
2,00	+0,02/–0,05	8,00	0/–0,2
2,00	+0,02/–0,05	10,00	0/–0,2
2,00	+0,02/–0,05	12,00	0/–0,2
2,00	+0,02/–0,05	15,00	0/–0,2
2,00	+0,02/–0,05	20,00	0/–0,2
2,00	+0,02/–0,05	25,00	0/–0,2
2,50	+0,02/–0,05	8,00	0/–0,2
2,50	+0,02/–0,05	10,00	0/–0,2
2,50	+0,02/–0,05	15,00	0/–0,2

Materiale:
① elemento di tenuta:
compound PTFE-bronzo (PTFE-BZ.83-01)
② elemento di tenuta:
compound PTFE-carbografite (PTFE-KO.83-01)
③ elemento di tenuta:
compound PTFE-vetro (PTFE-GL.83-01)

Material:
① sealing element:
PTFE-bronze compound (PTFE-BZ.83-01)
② sealing element:
PTFE-carbon compound (PTFE-KO.83-01)
③ sealing element:
PTFE-glass compound (PTFE-GL.83-01)