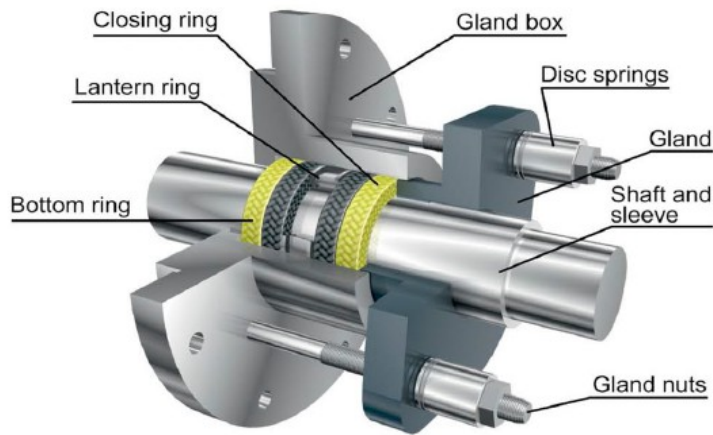


PACKING INSTALLATION INSTRUCTIONS

(Русская версия и polish version on www.sinograf.com)

Glands with soft packing are traditional and still primary means of sealing industrial equipment in rotating motion. They are characterized by simple design, low manufacturing cost, ease of assembly and disassembly, and minimal risk of sudden failure. Users may select suitable sealing material and optimise the solutions to match pressure, temperature and type of medium. Despite its seemingly outdated concept, soft packing has a number of advantages, since in the majority of cases its wear-and-tear accumulation is currently signalled, a device with an expanding leakage may continue to operate, the service can easily foresee and schedule packing replacement, the replacement is quick and downtime short, the replacement packing can be quickly delivered or is in own stock. Furthermore, soft packing's service life has radically increased through the use of high performance flexible graphite, PTFE aramid and carbon fiber based materials, which nowadays can match the durability of mechanical seals while still exceeding them in economic terms. Soft packing's durability is even greater, because in modern pump gland solutions packing protection systems are used that consist of setting a lantern ring and providing a flushing fluid inside the sealing package thereby relieving the seal and preventing penetration of solid particles. More advanced solutions include also a particle deflector, autonomous system of barrier fluid, lubricating, flushing, cooling or sometimes a seal heating system.



1. Safety considerations

Packing itself contains no substances that under normal use could be harmful to health or the environment. However, during installation security measures should be always taken as appropriate for the device's operation. Prior to packing installation the device must be switched off and disconnected from the mains, with de-pressurised system, closed valves, and it must be made sure that no moving parts would endanger the operator. If a device operates with hazardous substances, the system should be pre-flushed, and the operator should use appropriate personal protective equipment.

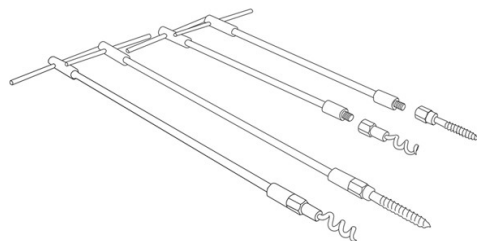
As regards waste and worn-off soft package components, it should be taken into account that polymeric materials, including PTFE, aramids, silicones and most of elastomers, are resistant to biodegradation and can last long in the environment. Therefore, this kind of waste must be handled

with care, and when dismantled must be disposed of or recycled by the packing supplier. It must never be burned or heated above 300 °C. In high temperatures they may release dioxins, furans, fluorine compounds and other harmful fumes. This also applies to seemingly safe materials, plant fibre or expanded graphite based, which, even if made of safe and natural materials, also may contain harmful compounds captured from working medium.

2. Removal of worn-off packing

When removing worn-off packing, precautions should be taken so as not to scratch or otherwise damage the gland surface. Where medium is clean

and safe, after loosening a gland the worn-off package is easily pushed out by pressure in the system. In other cases a special extractor with a corkscrew shaped tip should be used. Extractors are screwed in at least two opposing locations in the old package, so that no deadlock, and then worn rings are pulled out evenly on the corkscrewing principle. Both when dismantling, as well as installing a new packing package, it's recommended to use specialized tools to facilitate the work, minimize the risk, and save time and



money. Gland should be cleaned of corrosion and the working medium's crystallized residues. Shaft or shaft sleeve should have clean and smooth surface without carbon deposits, nicks or cracks, any unevenness and cracks can lead to very rapid wear of the packing. In an extreme case, the shaft should be welded and ground, or the shaft sleeve replaced. Newer packing solutions include a protective shaft sleeve with high hardness, which can be replaced or repeatedly grinded.

3. Gland inspection

Quality and condition of the surfaces dynamically mating with packing has a significant impact on the packing wear rate. Because glands without the protective shaft sleeves are already rare, the term "shaft" will mean both a shaft and a shaft with a sleeve. Requirements for the shaft are similar to those for plain bearings, i.e. surface roughness in the fine grinding level $Ra \leq 0,63$. Roughness of the remaining elements of the interface with packing does not matter, surface quality at the precise machining finish $Ra \leq 5$ level is sufficient. To avoid excessive shaft abrasion, suitable surface hardness of 60 HRC should be provided. For packing with a low friction coefficient, such as those PTFE based, these requirements are lower, and for flexible graphite the minimum hardness is not required at all, because the shaft is covered with a graphoid film, and friction from the shaft transforms into laminar friction inside the graphite, like in greases. However, any kind of packing can absorb abrasive particles from the medium flow and thus indirectly wear the shaft.

The gap between the shaft and housing should not exceed the assumed standards, or at least of 0,5 mm. For particularly worn-out devices, wherein this value may be exceeded, sealing rings can be used, made of packing with high mechanical strength, or packing reinforced in its corners with carbon or aramid. Shaft runout should be kept in the standard range and not exceed 0,1 mm or 1/100 of the packing width.

4. General rules for packing selection

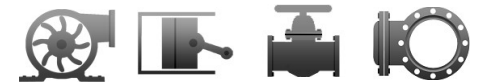
Issues related to packing selection for specific operating conditions can be divided into two groups. The first group are the parameters which are treated arbitrarily, such as service type and degree of its aggressiveness pH, temperature range and the right size. It should be must also taken into account the fact that some media can react with, or possibly dissolve, the packing components. These criteria must be strictly observed, otherwise the packing will be destroyed or worn-off very quickly.

When choosing a packing in terms of temperature resistance one should be aware that the allowable operating temperature is not equivalent to the service temperature. Due to friction, a gland operates at a temperature than the medium, and thus a margin should be taken of at least 50 °C. Where there is high pressure or high rotation, or possibly when gland operates on insufficient leakage, the temperature margin should be even greater.

The second group are the parameters to a large extent relative, such as pressure, linear velocity and application type. This parameter group differentiates packings primarily in terms of strength and substantially does not determines the acceptable ranges of application. Soft packing material

structure is not destroyed under the influence of only one of these factors, and only their concurrent action causes wear. So it is good, in assessing a material's suitability for gland packing, to employ dynamic load factor - pV , i.e. product of the velocity and pressure, which might concurrently occur in the application, without causing too rapid degradation. The high pV coefficient is a high result mechanical strength of the packing, good heat conductivity and low friction and indicates susceptibility to wear rate of different types of sealant under similar operating conditions.

Another criterion that determines the packing selection is the type of application. In this case, specific conditions of the device's operation should take into account, such as high shaft speed in centrifugal pumps, high friction area in piston pumps, high pressure in valves, or large radial stresses in mixers. For most packings the limits are defined of operating parameters for a specific application type, e.g. maximum pressure in centrifugal pumps, in reciprocating, in valves and in static conditions.



Also referred to application type are sanitary requirements for the packing material. In the food, pharmaceutical, and cosmetic industries most of the installations must meet high quality requirements imposed by standards and directives, including European Commission Regulation (EC) No 10/2011 on health standards for materials intended for contact with food. In such cases the materials should be used that have been tested on migration into simulants and have a Health Quality Certificate 10/2011. One can be guided by Polish NIH and/or US FDA certificates, or similar, but they are not sufficient criteria to meet current regulations on the EU market.

5. Ring preparation

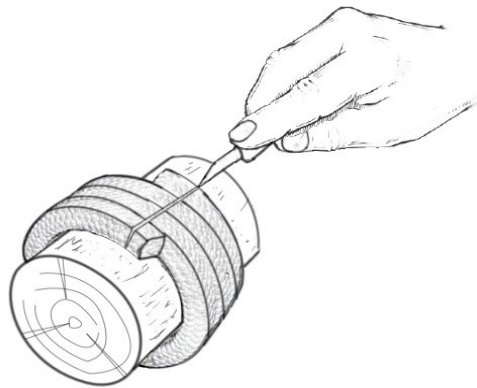
Packing size should be so selected that after its formation the ring can be freely inserted into the gland's working gap, and at the same time does not leave too much clearance. In general, device manufacturers indicate the packing size and quantity required for replacement. This also can be easily determined by direct measurement of the gland's working gap or the shaft diameter and the inner diameter of the stuffing box. Half of the difference between these diameters is the size of the gap. Final packing dimension should take into account a margin for the twist and a slight installation clearance, generally 10 - 20% of the thickness, but this depends greatly on the packing type and mechanic skills. Most packings are produced in size range from 4x4mm to 30x30mm with the progress of about 20%, giving it ample opportunity to adjust the size because of good flexibility. Whenever in doubt, a size lower in the same line should be chosen, because it is much easier to compensate for excessive installation clearance by pressing the gland than to repair assembly damage to ill-fitting rings.

In order to better match packing's profile, it can be slightly rolled out with a cylindrical tool without detriment to its properties, even if the profile will adopt a slightly rectangular shape. It's good to slightly roll out aramid or carbon fibre based packing to a trapezoidal shape, so that after rolling it in a ring and installing the packaging turn offset the trapeze and aligns the profile. This will cause a greater pressure on the perimeter, and eliminate free space between packing rolls on the gland's outside, and most importantly will relieve the shaft surface. This montage reduces

sleeve's wear, accommodates lubricating film on the shaft and consequently prolongs the packing's service life in the case of application of a packing with high mechanical strength. Packing rings can be trimmed in several ways:

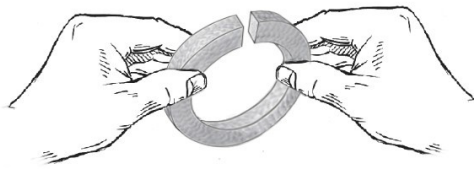
- by wrapping the packing around the shaft with the same diameter as the required one,
- using an instrument with a slider and computing scale,
- by cutting sections based on theoretical calculations.

Unfortunately, this method is most difficult and unreliable because the length of a section is not calculated by a simple formula, and packing's after-turn compression should be always taken into account, which varies depending on packing material and structure. A reliable method is to wrap the packing around a shaft, the diameter of which can be easily adjusted to the required one by wrapping a sheet of cardboard or flexible plastic around it. The roll should be slightly larger than the actual shaft diameter, so that the rings' trim is slightly oversized and consequently the installation play is between the shaft and the package. Packing on the shaft can be easily cut either at right angles or obliquely. Cutting at 45° angle is important for better seal of the lock ring, which is recommended for valves. Unfortunately cutting at right angles after rolling the ring does not produce exact contact of the lock surface. To remedy this, after marking the cut location and removing the packing from the shaft, each section should be cut at a slight slant on both sides. Depending on the packing structure and shaft diameter, to obtain proper bevel, the cut should be tilted by ca. 10° to 20° respective to the right angle.



However, the fastest and very precise method of section preparation is to use an instrument with a slider and computing scale. The instrument determines the section lengths based on the calculation slider principle, it takes into account the shaft diameter and packing size and defines cut locations taking into account the bevel for accurate lock setup. Packing should be cut with a sharp knife with a safe handle, by one decisive stroke. In order to maintain the blade's performance it should be sharpened periodically to facilitate cutting. Many packings include, however, hard fibre or metal reinforcement, and some of them are made of aramid fibres, which are used also for ballistic cloth. For these reasons, cutting them is extremely difficult and normal tools quickly

blunt. The ideal solution to this problem is to use a guillotine trimmer for packing, which not only enables easy and precise cutting of every packing type, but also measures section lengths and sets proper cut angle.



6. Installation of rings

Correctly trimmed packing section should be rolled into a ring, so that its both ends match and form a tight lock without space. The first step is to insert the ring's connection into the chamber, and then gently slide the remainder in. It should be made sure that the ring is properly seated, by pushing it with the gland or a special tool in the form of a roll of flexible plastic. Persistent resistance and the degree of the pressing tool caving verify the ring's proper settlement. Locks of each ring have to be each time moved by a certain angle, so as to distribute them evenly in the whole space and level formation of the package's weak points. To ensure gland's proper conduct, once the last ring is set, a place should remain, high at least at half the packing thickness.

Rings should be arranged closer to the packing box, with a slight clearance left at the interface with shaft. This aims at directing more pressure to the packing box's outer wall, and at relieving the shaft at start up. This facilitates liquid film formation and reduction in friction on the shaft, and prevents the risk of the whole package's rotation. Packing assumes its ultimate fit and form at its start-up and initial compression of the whole package.



7. Gland starting and adjusting

Once all rings are seated in the chamber, set up the gland and slightly tighten the screws. After releasing the shut-off valves and flooding, start the pump. In the first phase after start, the package should enable continuous leak of the pumped medium. At this time, the packing's volume is

increasing due to the medium's absorption. This results with initial self-sealing by thickening of the packing and producing a gradual pressure in the shaft slot. For proper packing operation the leak is necessary, if it's stopped, loosen the gland to get the leak back.

After an hour the gland should be gradually and evenly tightened. Gland screws should be tightened gradually in intervals of several minutes, constantly keeping the drip. Repeat the process until it leaks at rate of 60 drops per minute or more, but the resulting leak may be largely dependent on the type of medium, pressure, temperature, shaft runout, and the packing type. Gland temperature cannot unnaturally increase at this, maximum increase of 50 °C above the medium temperature is allowed, otherwise the pump must be stopped, the gland loosened, and the start up process repeated.

If gland is equipped with a system of barrier and/or coolant fluid or lubricant, which is an increasingly common practice of manufacturers of dirty and/or hazardous medium pumps and pumps operated in suction mode, remove all debris from supply ducts and lines, and check their patency. Package should include a special lantern ring, usually between 2 or 3 packing rolls, placed so as to ensure free flow of medium from the input opening in the packing body. Barrier fluid pressure only slightly exceeds the medium pressure and every dirt can easily clog the ducts. Flushing ring has to maintain a certain distance and patency of the duct between the packing's both parts, and if it underperforms or is excessively worn, it should be replaced.

Throughout packing service life the leak/ drip should be controlled and accordingly adjusted. Particular attention should be paid in the event of changes in pump's operating parameters, if the pressure drops, the drip may be interrupted, and packing temperature rapidly increase, which will ultimately lead to seizure and damage to the package. Total package's wear in one operating cycle should not exceed 50% of its initial height. A package so worn out should be replaced. Setting new rings in order to prolong service life is not recommended. Packing makes most harm in the final period of operation, when its structure is degenerated and contains a lot of particulates and wear products captured with medium.

8. Packing installation in valves

Seal tightness requirements are higher in glands in industrial fittings. In this case, almost complete tightness is expected, whereas in pumps a small leakage is intentionally allowed. The movable member of fitting seal node performs relatively slow rotation or axial motion and due to the small friction energy higher gland pressures can be applied, and, consequently, the gland operates virtually with no leak. At the same time, however, the increased pressure with sometimes significant gaps between the gland's spindle and housing can cause sealant extrusion of through the gaps. Therefore, sealing packages used in valves should have a more compact structure or special metal reinforcement.

In power plants fittings steam pressure can be up to 300 bar at temperature up to 650 °C. Such high operating parameters significantly limit the range of materials used for graphite-metal seals, the installation of which requires a slightly different procedure. In order to properly install seals in fittings, properly trimmed rings should be prepared and

set in the packing box, as is the case in pumps with that oblique cut provides a better seal of locks on the rings. Press the gland until resistance is clearly felt, at the same time unscrew the valve spindle so as to determine the possibility of the valve's adjustment. Graphite packing with initial density 1,1 g/cm³ should be compressed to density at least 1,4 g/cm³, that's why after filling the box the gland should be pressed and the package compressed to 70% of its original volume, or, possibly, 1 or 2 packing rings might be added sealant and the compression operation repeated. Static pressure up to 70% of the original package height takes into account the installation play of 10% resulting from the difference between packing size and the actual size of the gland's working gap, and if the play increases, also the static pressure must increase, e.g. with installation play 20% the required static pressure increases to 60%. If a valve gland is originally provided with disc springs, the correct gland pressure should be achieved after closing the disc springs. It's good to use rolls of composite sealant braided with HTR metal mesh or of carbon fibre. After installing the valve in the process line the leak should be checked, and after one day the operation the gland should be tightened, even if there has been no leak.

A common practice is to use ready-made packages of preformed flexible graphite rings with density 1,4 - 1,6 g/cm³. In this case there is no need for packing pre-compression and it is enough to press the gland after the ring package installation with proper force specified by the valve manufacturer, or applied by the disc springs. Generally graphite packing in a valve requires pressure of 60 to 120 N/mm² and it's easy to estimate the bolts tension dividing this value by the horizontal cross-sectional area of the sealing ring.

Flexible graphite rings may also be made in-house of graphite tape (ribbed tape preferably), which after winding onto the valve spindle has to be compressed with the gland to density above 1,4 g/cm³. Graphite tape gets this dense upon application and release of pressure 30 - 50 N/mm. Tape quantity used for a ring should be so selected that, once formed, the ring has square cross-section.

Where low pressure valves, water and gas fittings, all kinds of gate valves and plumbing equipment are sealed, anywhere where operating conditions are not so extreme as in power plant fittings, more types of sealing materials may be used. Many suppliers differentiate between valve and pump packings, but as regards these seals it can be assumed that any pump packing can also serve as valve packing, the general selection criterion for is the pressure, temperature and resistance to specific media. Low pressure fitting seals are also leak-free, but the sealing package does not require pre-compression, as in the case of flexible graphite. Gland has to be so tightened at start up as to stop the leak completely, and then, after some time, the screws should be re-tighten to gain some pressure margin.

As regards fittings, much higher gland pressures should be always applied than in pumps, generally 2 or even 3 times the medium pressure. In practice it is known that higher contact pressure gives more reliable seal without the need for adjustment in the long term but, unfortunately, the seal under such conditions wears more quickly. These aspects depend largely on the type of sealant and operators' skills. Maintenance staff's experience and expertise in specifics of the maintained equipment is an invaluable best practice of packing installation and cannot be substituted with even the most detailed instructions.