Pumps, valves and other equipment handling liquids or gases have been on the industrial scene for a long time. And throughout that time, they have relied on compression packing as an effective method of sealing against fluid losses at shafts, rods and valve stems.

There is nothing complicated about the concept of compression packing: soft, pliable material pressed into rings, then compressed into the stuffing box of a pump or valve. The stuffing box is the space between the moving components and the body of the pump or valve. (See Fig. 1.) When packing has been inserted, a packing gland is then tightened against the uppermost ring, causing the packing to expand laterally against the side of the stuffing box and the rotating or reciprocating shaft. The result is a seal that prevents the leakage of fluid or gases.

Even the most highly lubricated packings, with 30-35% lubricant by volume, have an inherent disadvantage. After gland follower adjustments during operation, the lubricant is gradually lost. Most gland followers are designed so that when all the adjustment has taken place, the lubricant has been entirely squeezed out of the packing, which then must be removed and replaced.

This problem has been solved successfully through modern technology leading to the development of self-lubricating fibers and graphite ribbon. When used in compression packing, these products behave much differently than their highly lubricated counterparts. Because these modern packings do not contain significant

Shown below are some of the more common methods of compression packing installation:

There are two basic sealing functions for which compression packings are used:
1. Static seals, as in valves and expansion joints, where any motion, if it exists at all, is extremely slow and infrequent;
2. Dynamic seals, as in centrifugal or reciprocating pumps and blowers where continuous movement takes place.

The concept of packing is old, but the greatest advances in this type of sealing have taken place in the last 25 years, far outstripping accomplishments in all the previous years combined. Most of the new products are self-lubricating, and do not need externally applied lubricants except for the breaking-in period.

The following steps are the most important to assure long life and reliable performance from compression packings:
1. Select materials to meet specific sealing requirements.
2. Remember such factors as surface speeds, pressures, temperatures and the medium being handled.
3. Follow good installation and break-in procedures.
4. Establish a good program of equipment maintenance.

**HOW COMPRESSION PACKINGS WORK**

Compression packings require a fluid film between the packing itself and the moving component, whether centrifugal or reciprocating. This film can be supplied from a built-in lubricant — liquid, solid or combination — from leakage of the medium being handled, or from an external lubricant supply.

![Diagram](image)

**Fig. 1:** Typical arrangement when pump pressure at stuffing box is above atmospheric pressure, and the fluid pumped is an acceptable lubricant in itself.

**Fig. 2:**

**Fig. 3:**

Typical arrangement when pump pressure at stuffing box is below atmospheric pressure.
FLUID INLET CONNECTED TO EXTERNAL SOURCE

Fig. 4:
Typical arrangement when pump is moving slurries or other non-lubricating fluids.

amounts of lubricant, they must not be over-tightened during installation, and need very few adjustments during the life of the packing. They far outlast the older style products. In the case of valves, properly selected and used self-lubricating packings will last the life of the valve itself, because of the slow and infrequent movement involved.

TYPES OF COMPRESSION PACKING CONSTRUCTION

There are eight basic types of construction used for compression packings, involving various materials, shapes and sizes:

1) Braided Packings, available in the following types:
   a. Square braid, or square plated braid. This packing consists of yarns, rovings, ribbons and other materials which are interwoven, and run in the same direction. Cross-section is usually square, but can also be rectangular. The material is soft, and capable of carrying considerable lubricant. This packing will cause little or no harm to equipment, and is recommended for high-speed, low-pressure rotary service. It performs well on old and new equipment alike.
   b. Braid-over-braid, also known as round braid or multiple braid. These packings are formed by machines into round tubular jackets, using yarns, rovings, ribbons and other materials, alone or in combination. Sizes are increased merely by braiding one jacket over another. Finished packings can be round, square or rectangular in cross section. They are relatively dense packings, used mostly for high pressure, low speed applications like valve stems, expansion joints and groove gasketing.
   c. Braid over core. This type of packing is made by braiding one or more jackets of yarns, rovings, ribbons or other materials over a core, which can be extruded, twisted, wrapped or knitted. A wide range of densities is obtainable.
   d. Interbraid. Yarns, ribbons and other materials, alone or in combination, are formed on special machinery which criss-crosses the strands diagonally through the body of the packing. This forms an extremely light, integral packing which cannot unravel in service. There are no external jackets to wear out, no plaitts to unravel. Yarn is distributed uniformly throughout, and has better lubricant retention. This packing, even though dense, is flexible. It is recommended for pumps, agitators, valves, expansion joints and in grooves.

2) Twisted packings, consisting of yarns, rovings, ribbons and other materials twisted together around a core to the desired size. When yarn or roving is used, one size of packing can be used for several sizes of stuffing boxes. For smaller stuffing boxes, the packing can be reduced in size by twisting and removing strands from a larger size. When metallic materials are used, they resist high temperatures and pressures, block the penetration of fluids, and adjust to fit irregularities of the equipment.

3) Wrapped, rolled and folded packings. These packings are formed from strips of lead, copper, aluminum, rubberized woven fabrics and other materials, which are spirally wrapped, rolled or folded upon themselves over a compressible core. Rubberized packings are light yet resilient, and effectivly resist fluid penetration. Metallic types not only resist fluid penetration, but conform to irregularities of the equipment.

4) Extruded packings. Various materials are extruded to form a blended mix in any desired cross-section, with a choice of densities and compressibility. They are sometimes provided with a skeleton jacket. They hold lubricant well, and give long service life. They also conform to irregularities in the stuffing box, and perform well in centrifugal and reciprocating pumps.

5) Laminated packings, available in several forms, including:
   a. Fabric, consisting of laminated plies, cured in slab form, from which strips or rings are cut. Packings can be produced in several types, all highly resilient.
   b. Flexible graphite. Packings rings are cut from flexible graphite sheets which are cemented together to the desired thickness, then cured at high temperatures in a form. Rings have little radial expansion under gland pressure; therefore, they must have interference fits to seal properly.

6) Bulk packings. A homogeneous material which is supplied in powdered, shredded, or fibrous form, used alone or blended with other. This is a highly conformable product which can be used to pack a variety of stuffing box sizes.

7) Die formed packings. A pre-compressed ring form in which many compression packing materials can be supplied to provide controlled density and size.

8) Flexible graphite tape packings. Silt into various widths from sheet that is produced by extruding and calendaring natural flake graphite. This product is available in thickness of .005" through .030" with a nominal density of 70 pounds/foot. When used as a compression packing, the slit tape is normally corrugated or embossed to improve its ability to be made into rings. It can be die formed or compressed in the stuffing box to form endless, true labyrinth packing rings. It is a high-chemically inert, has good thermal conductivity, and can be used in temperatures ranging from -400°F to +550°F in nonoxidizing atmospheres.
SYMPTOMS AND CAUSES OF PACKING FAILURE

Premature failure of packings can occur for a variety of reasons. The following table will help you spot the symptoms of failure, and pinpoint the probable cause. If you find your packing not performing as it should, remove and examine the old packing. Do not throw it away. It can often provide valuable clues about the condition of the equipment.

<table>
<thead>
<tr>
<th>SYMPTOMS OF PACKING FAILURE</th>
<th>POSSIBLE CAUSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excessive reduction in cross section of packing directly beneath rod, shaft or plunger</td>
<td>Rod or plunger out of alignment, and in the case of the rod or shaft, bearings may be badly worn, causing shaft to whip</td>
</tr>
<tr>
<td>Excessive reduction in thickness of packing directly over, or on either side of rod or shaft</td>
<td>Bottom of stuffing box badly worn, with packing being extruded into the system</td>
</tr>
<tr>
<td>Whole ring or part of ring missing from set</td>
<td>Rings roiling with shaft, or loose in box. Packing too small</td>
</tr>
<tr>
<td>Wear on outside of one or more rings</td>
<td>Rings cut too short or too long, depending on style of material used, causing packing under pressure to be deformed.</td>
</tr>
<tr>
<td>Axial bulge in one or more rings</td>
<td>Adjacent rings cut too short or too long, depending on style of material used, causing packing under pressure to be deformed.</td>
</tr>
<tr>
<td>Packings extrude between rod or shaft and the gland follower</td>
<td>Excessive gland bolt pressure and/or too much clearance between rod or shaft and gland follower</td>
</tr>
<tr>
<td>Rings next to gland follower badly damaged, but bottom rings in fair condition</td>
<td>Improper installation of packings and excessive gland bolt pressure.</td>
</tr>
<tr>
<td>Wearing surface of rings dried and charred with rest of packing in good condition</td>
<td>High temperature and lack of adequate lubrication</td>
</tr>
<tr>
<td>Innermost ring deteriorated</td>
<td>Packing incompatible with fluid handled.</td>
</tr>
</tbody>
</table>

HOW TO INSTALL PACKINGS

PACKING THE PUMP CORRECTLY

The importance of packing the pump correctly cannot be overemphasized. Many packing failures are due to incorrect installation of the packing. The following steps have been devised to ensure effective installation of packings on pumps:

1) REMOVE ALL THE OLD PACKING FROM THE STUFFING BOX. Clean box and shaft thoroughly and examine shaft or sleeve for wear and scoring. Replace shaft or sleeve if wear is excessive.

2) USE THE CORRECT CROSS-SECTION OF PACKING OR DIE-FORMED RINGS. To determine the correct packing size, measure the diameter of the shaft (inside the stuffing box area if possible) and then measure the diameter of the stuffing box (to give the O.D. of the ring). Subtract the I.D. measurement from the O.D. measurement and divide by two. The result is the required size.

3) WHEN USING COIL OR SPIRAL PACKING, ALWAYS CUT THE PACKING INTO SEPARATE RINGS. Never wind a coil of packing into a stuffing box. Rings can be cut with butt (square), bias or diagonal joints, depending on the method used for cutting. The following illustration shows these methods of preparing bulk packing. The best way to cut packing rings is to cut them on a mandrel with the same diameter as the shaft in the stuffing box area. If there is no shaft wear, rings can be cut on the shaft outside the stuffing box.

CUT...DON'T WIND

BUTT JOINT

SINE JOINT

Hold the packing tightly on the mandrel, but do not stretch excessively. Cut the ring and insert into the stuffing box, making certain it fits the packing space properly. Each additional ring can be cut in the same manner, or the first ring can be used as a master from which the balance of the rings are cut. If the butt cut rings are cut on a flat surface, be certain that the side of the master rings, and not the O.D. or I.D. surface, is laid on the rings to be cut. This is necessary so that the end of the rings can be reproduced.

When cutting diagonal joints, use a maple mitre board so that each successive ring can be cut at the correct angle.

It is necessary that the rings be cut to the correct size. Otherwise, service life is reduced. This is where die-cut rings are of great advantage, as they give you the exact size ring for the I.D. of the shaft and the O.D. of the stuffing box. There is no waste due to incorrectly cut rings.

4) INSTALL ONE RING AT A TIME. Make sure it is clean, and has not picked up any dirt in handling. If desired lubricate the shaft and the inside of the stuffing box.

Seat rings firmly (except PTFE filament and graphite yarn packings, which should be snugged up very gently, then tightened gradually after the pump is on stream). Joints of successive rings should be staggered and kept at least 90°
apart. Each individual ring should be firmly seated with a lapping tool. When enough rings have been individually seated so that the seal of the gland will reach them, individual lapping should be supplemented by the gland.

5) **AFTER THE LAST RING IS INSTALLED**, take up bolts finger tight or very slightly snugged up. Do not jam the packing into place by excessive gland loading. Start pump, and take up bolts until leakage is decreased to a tolerable minimum. Make sure gland bolts are taken up evenly. **STOPPING LEAKAGE ENTIRELY AT THIS POINT WILL CAUSE THE PACKING TO BURN UP.**

6) **ALLOW PACKING TO LEAK FREELY WHEN STARTING UP A NEWLY PACKED PUMP.** Excessive leakage during the first hour of operation will result in a better packing job over a longer period of time. Take up gradually on the gland as the packing seats, until leakage is reduced to a tolerable level.

7) **NEVER TRY TO STOP LEAKAGE ENTIRELY, UNLESS PACKING MANUFACTURER INDICATES THAT IT IS SAFE TO DO SO.**

8) **WHEN SPECIFIED BY THE PUMP MANUFACTURER, PROVIDE MEANS OF LUBRICATING THE SHAFT AND PACKING THROUGH THE LANTERN RING BY SUPPLYING WATER, OIL, GREASE OR LIQUID HANDLED IN THE PUMP.** Fittings for this purpose are standard on many pumps.

9) **IF THE STUFFING BOX HAS A LANTERN RING (SEE ILLUSTRATION ABOVE),** make sure that the lantern ring, as installed, is slightly behind the fluid inlet so that it will move under the inlet as follower pressure is applied.

10) **REPLACE PACKING WHEN LEAKAGE CANNOT BE CONTROLLED BY FURTHER TAKEUP ON THE FOLLOWER GLAND.**

On both centrifugal and reciprocating pumps, about 70% of wear is on the outer two packings nearest the gland. However, each additional rings does throttle some fluid pressure. On most machines, there must be enough rings so if one fails, another does the sealing, and the machine need not be shut down.

The mechanical pressure curve above shows eight packing rings. The first five rings do the majority of the sealing. The bottom three do little sealing, but are needed to fill the available space. The advantage of using fewer rings is less rod wear. Also, the stuffing box design is simpler and takes less material. But, wear isn't the only problem. With high temperatures, high pressures, corrosive chemicals, or abrasive particles in the fluid, more rings may be the only solution for some services. In such cases, the bottom ring contacting the fluid may have the most wear from these severe service conditions.

**Packing Valves Correctly**

As with pump packing, the first step in getting the most out of a valve packing is correct installation. Here is the correct way to pack valves.

1) **CAREFULLY PERFORM ALL OPERATIONS LISTED UNDER PUMP PACKING, STEPS 1-5.** Rings used on valves and expansion joints are generally cut with a diagonal joint. Illustrated below. In preparing diagonal cut (45°) rings, be sure that the first ring is cut carefully, and then tested on the stem.

2) **BRING THE FOLLOWER DOWN ON THE PACKING TO THE POINT WHERE HEAVY RESISTANCE TO WRENCHING IS FELT.** During this time, turn valve stem back and forth to determine ease of turning. Do not torque down to the point where the stem won't turn.

3) **AFTER THE VALVE HAS BEEN ON THE LINE A DAY OR SO, EVEN IF NO LEAKAGE EXISTS, THE FOLLOWER SHOULD BE TIGHTENED SLIGHTLY.** Obviously if leakage is occurring, the follower must be tightened.

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### 1. HOW TO CALCULATE A PACKING'S TRUE VALUE

CAUTION: Other than proper selection of the right packing, valve received is determined by the length of the packing you get per dollar spent, rather than by weight alone. Density of the material, then, has a direct effect on the value of the product.

For instance:

\[
\text{Cost of Packing} = \frac{\text{Density of Packing} A \times \text{Relative value of Packing A}}{\text{Density of Packing} B \times \text{Relative value of Packing B}}
\]

### 2. HOW TO CALCULATE LENGTH PER POUND OF PACKING

\[
\text{Length} = \frac{144}{\text{Density} \times \text{(cross section)}^2}
\]

### 3. HOW TO CALCULATE MATERIAL COST OF A DIE-FORMED RING

Cost per ring = \(0.0055 \times \text{price} \times \text{density} \times \text{height} \times (\text{OD}^2 - \text{ID}^2)\)

(Labor charges are usually added to the price of a die-formed ring.)