One of the fundamental constraints of industrial valves is tightness. For every kind of valve, two main types of tightness must be considered:

**Process/Atmosphere tightness:**
Assures the seal between the fluid region and the valve exterior, preventing leakage into the atmosphere.

**In-Line tightness:**
Assures the seal between the upstream and downstream of the valve, preventing leakage when the valve is closed.

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**PROCESS/ATMOSPHERE TIGHTNESS**

**SEALING GASKETS**

Pressure equipment is generally composed of several parts assembled together by a bolt or stud and nut connection (body, bonnet, sleeves, seat...). Each connection point creates a pathway for potential leaks, which must be eliminated by installing a sealing ring or gasket.

**Application examples:**
Certain valves are designed with a body/bonnet assembly, notably:
- Gate valves
- Slide valves
- In-line globe valves
- Ball valves (depending on type, see “Technology” chapter)
- Non-return check valves

For example, if the bonnet is connected to the upper body flange, a sealing gasket must be installed between the two parts in order to guarantee tightness between the fluid region and valve exterior. The geometry of the seal can vary depending on the design and type of gasket. The most commonly used shapes are circular or rectangular.
Sealing gaskets can also be found on valves installed at the bottom of a tank or an adapter for in-line mounting (seat gaskets), providing tightness between the tank and the valve. When required, this type of valve can be supplied with a dismountable seat (see “Options for Increased maintainability”). If such is the case, a second gasket is required to ensure tightness between the dismountable seat and the valve.

In addition to defining the shape, the choice of material and seal technology must be compatible with the service conditions (type of fluid, pressure and temperature).

The following is a list of the most frequently used gaskets:

<table>
<thead>
<tr>
<th>Type of gasket</th>
<th>Shape</th>
<th>Primary materials used (non-exhaustive)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elastomer</td>
<td>O’ring, Quad-ring</td>
<td>Nitrile, Fluoroelastomer (Viton®)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ethylene Propylene (EPDM)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Silicone</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Polyurethane</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Kalrez®</td>
</tr>
<tr>
<td>Flat</td>
<td>Circular, Rectangular</td>
<td>PTFE</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Graphite</td>
</tr>
<tr>
<td></td>
<td></td>
<td>reinforced PTFE</td>
</tr>
<tr>
<td></td>
<td></td>
<td>reinforced Graphite</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gylon®</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Klingersil®</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Novapress®</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gore-tex®</td>
</tr>
<tr>
<td>Spiral wound</td>
<td>Circular, Rectangular</td>
<td>Graphite + metal (Stainless steel,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hastelloy®, Inconel®, Titanium, Monel®...)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PTFE + metal</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mica + metal</td>
</tr>
<tr>
<td>Metallic</td>
<td>Circular, Rectangular</td>
<td>Helicofe®</td>
</tr>
<tr>
<td></td>
<td>Annular (type R)</td>
<td>Metallo plastic</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Carbon steel</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Stainless Steel</td>
</tr>
<tr>
<td></td>
<td></td>
<td>…</td>
</tr>
</tbody>
</table>
Each valve equipped with a stem or a piston can be fitted with a gland, which ensures the tightness between the process and the atmosphere. The gland, or stuffing box, consists of a stack of compressed rings (called packing) composed of one or several different materials.

The packing profiles may vary. The selection of materials used in the gland will take into account the process temperature and the chemical compatibility of the fluid.

The nature of the packing might also depend on the type of application. For example, they could be FDA approved for food applications, or PMUC certified for a nuclear application.

One qualified design against fugitive emissions (TA-Luft - ISO 15848) can consist of double gland packing with a leak detector, tightened down by self-compensating spring washers, guaranteeing a leak rate of less than $1 \times 10^{-3}$ torr.l/sec. (refer to “Standards” chapter).

The bellows seal prevents any leakage to the outside of the valve. It is integrated into the valve with one extremity welded to the end of the stem and the other welded to the stuffing box / bonnet. It provides the primary seal between the process and the atmosphere with compressible metal walls.

The “bellows procedure” eliminates any fugitive emissions that a conventional, single gland packing might let pass through. The use of a metal bellows seal is recommended to guarantee a leak rate of less than $1.10^{-7}$ Torr.l/sec. (refer to “Standards” chapter). A secondary tightness seal is assured by the stuffing box, limiting leaks to the outside in the event the metal bellows becomes damaged.

**NOTE**: A bellows seal is not adapted for fluids containing solid particles or having the tendency to crystallize.
VACUUM HOOD

In the case where a fluid is particularly dangerous or located in an environment that is highly reactive when exposed to the atmosphere, “vacuum hood” technology ensures enhanced sealing between the process and the atmosphere.

This secondary sealing system is designed to perfectly control any leakage from the gland packing that might occur due to the permeability of the packing over time. When the valve technology doesn’t allow for the installation of a metal bellows seal, or the valve is installed in a vacuum system, the vacuum hood maintains high vacuum and confines the gland.

LIP SEAL WELD JOINTS

Additionally, in the case where a fluid is dangerous or located in an environment that is highly reactive when exposed to the atmosphere, the technique of “lip seal” welded joints guarantees absolute tightness between the process and the atmosphere.

A lip seal weld is formed by the fusion of two metallic “lips” and is generally used in conjunction with a metal bellows or a vacuum hood.

Lip seal weld joints are used in all cases where:

- It is necessary to provide a highly secure connection (hazardous fluid, disastrous consequences in the event of an accidental production shut-down)
- It is critical to be able to disassemble the valve.

Distinctive Features

- Can be reused up to 5 times (provided certain precautions are taken during disassembly)
- Typically made of the same material as the flanges or piping.
- Primarily used in combination with a bellows or a vacuum hood.
- Diverse lip profiles
- An additional seal can be added between the two lips
IN-LINE TIGHTNESS SYSTEMS (SEAT / OBTURATOR)

1. Soft seal (radial)
As in a gland or stuffing box, packing rings provide a radial seal on the outside diameter of the piston. The lantern ring compresses the seat packing rings (upper packing). It is in contact with the lower gland packing at one extremity and the upper packing at the other. When the valve is in the open position, the fluid is in contact with the upper packing and passes across the lantern ring.

Distinctive Features
- Tightness achieved by seat packing
- Teflon® / Metal (possible to have graphite or glass reinforced teflon) for a maximum operating temperature of 180°C
- Graphite / Metal for maximum operating temperatures of 650°C
- Easy, quick and economical maintenance
- Polished piston (to avoid damaging packing during valve operation)
- Adapted for operating temperatures ranging from -100°C / + 650°C (subject to specific evaluation based on actual operating conditions and materials used)

2. Metal-to-metal seal
In this case, in-line tightness is achieved when the piston is in direct contact with the seat. Due to a reduced contact surface (conical connection with dissimilar angles: cone/cone or cone/edge), this tightness system is better adapted for abrasive or viscous fluids and slurries with solid particles.

Distinctive Features
- Slightly more maintenance than a soft sealed valve (reworking of sealing surfaces on the seat and piston)
- Long life tightness system
- Fire safe design
- Possibility to apply hard coatings: Stellite, chrome carbide, etc.
- Fit for severe operating temperatures ranging between -196°C / +800°C (subject to specific evaluation based on actual operating conditions and materials used)

3. Dual sealing system
The “Dual Sealing System”, combines the advantages of the soft seal and the metal to metal seal. This technology considerably enhances the life of the tightness system.

Distinctive Features
- Tightness achieved with both soft seal and metal to metal contact
- Polished piston (so that fluid does not stick to the seating surface)
- Primary sealing ring (soft seal) also has scraper function
- Generally designed with dismountable seat for simplified maintenance (see chapter “Options for Improved Maintenance”)
- For operating temperatures ranging between - 40°C / + 180°C (subject to specific evaluation based on actual operating conditions and materials used)
1 Soft seat

The soft seat tightness system applicable to globe valves can be the object of a specific design: the disc can be made of two parts. A flexible sealing gasket is installed on the bottom part and the top part is threaded into the bottom part to maintain and compress the sealing gasket in place. It is also possible to have a single piece disc design where a PTFE seal is crimped into place.

Distinctive Features
- The tightness achieved as a result of sealing ring/gasket.
- Teflon® / Metal (possibility to have glass or graphite reinforced Teflon) for operating temperatures up to 180°C maximum.
- Graphite / Metal for operating temperatures up to 650°C
- Simplified maintenance (changing out the sealing ring)
- Valid for both in-line and tank bottom globe valves
- Recommended for pneumatically actuated valves
- Adapted for operating temperatures ranging from -40°C / + 650°C (subject to case study based on actual operating conditions and materials used)

2 Metal-to-metal seal

In this case, in-line tightness is made as a result of two metal parts in contact: disc and seat. The disc can either be integrated into the same part as the stem (one-piece disc/stem) or be threaded to the stem (ball and socket like connection).

Distinctive Features
- Sealing surface cone/cone or cone/edge
- Fine machining finish (fluid does not adhere to sealing surfaces)
- Fire Safe design
- Possibility to apply hard coatings: Stellite®, chrome carbide, etc.
- Long life tightness system
- Applicable for disc opening into valve body (lowering disc) or opening outside of valve body (rising disc)
TIGHTNESS APPLICABLE TO BALL VALVES

1. Soft seat

The ball is the (closing element) that sections off the fluid line. It is lodged between two soft, elastic seats that guarantee the tightness between upstream and downstream. This tightness system makes ball valves a good solution for high and low pressure processes. In the case of low pressures, the seal is ensured by the elasticity of the 2 seats equally compressed on both sides. On the other hand, for applications involving high pressures, the obturator displaces slightly and butts against the downstream seat (called the piston effect), ensuring tight shut-off.

Distinctive Features
- Seating surface contact is "cone/sphere"
- Sealing by flexible seats and floating ball
- Teflon® / Metal (possibility to have glass or graphite reinforced Teflon) for operating temperatures up to 180°C maximum.
- Graphite / Metal for operating temperatures up to 650°C

2. Metal-to-metal seal

The ball is lodged between two metal seats that section off the fluid line. In order to guarantee the minimum contact pressure the seats are "pushed" against the ball with a system of springs. The continual wearing from the metal/metal contact between the seats and the ball is a constraint for long term tightness.

Distinctive Features
- Seating surface contact is "cone / ball"
- Sealing tightness with metal seats
- Possibility to apply hard coatings: Stellite®, chrome carbide, etc.
- Fire Safe design
- Applicable to different design types (3-piece, split body, end entry & top entry...see "Technology" chapter)
- Possibility to have self-compensating seats to ensure tightness even with wearing (high operating cycles)

TIGHTNESS APPLICABLE TO GATE VALVES

1. Metal-to-metal seal

Gate valves are known for their long life as a result of a simple, yet performant tightness system. The discs, generally oblique (see "Technology" chapter), are wedged together for an oblique seal. In order to ensure tight shut-off of a slurry or under high pressure, a system with a parallel carriage is better adapted (parallel discs and seats).

Distinctive Features
- Seating angle, parallel or oblique (see "Technology" chapter)
- Fire Safe design
- Long life tightness system
- Required tightening force is independent of operating pressure
- Appropriate for severe service, with temperatures ranging from -196°C to +800°C
- Possibility to apply hard coatings: Stellite®, chrome carbide, etc.
1 Soft seat

The soft seal tightness system applicable to slide valves could have the following particular design: seat packing maintained and pressed against the gate by the grooves in the seat rings. Springs can be added to load the seats and provide bi-directional tightness as well as ensure tightness as the seat packings wear over time.

Distinctive Features
- Sealing contact surfaces flat/flat
- Seat packings maintained in grooves in the seating surfaces
- Possibility to have self-adjusting seat/seal guaranteeing tightness as seals wear
- Teflon® / Metal (possibility to have glass or graphite reinforced Teflon) for operating temperatures up to 180°C maximum.
- Graphite / Metal for operating temperatures up to 650°C
- Simplified maintenance, fast and easy to change out seat packings
- Possibility to apply hard coatings to gate: Stellite®, chrome carbide, etc.

2 Metal-to-metal seal

The metal-to-metal tightness system for slide gate valves is the solution most adapted to slurries, viscous, adhesive and abrasive fluids. The slide gate and seats are lapped and polished to guarantee a perfect plane to plane contact over the entire length of the slide.

Distinctive Features
- Sealing contact surfaces flat/flat on entire length of slide
- Adapted for powders, viscous, sticky and abrasive fluids as well as high temperatures
- Fire safe design
- Appropriate for severe service, with temperatures ranging from -196°C to +800°C (subject to case study based on actual operating conditions and materials used)
- Possibility to apply hard coatings to seats and slide gate: Stellite®, chrome carbide, etc.
TIGHTNESS APPLICABLE TO BUTTERFLY VALVES

1 Soft seat

The soft seal tightness system applicable to butterfly valves could have the following specific design: a shutter made up of two parts. A flexible gasket is installed on the first part, and the second part (the “tightening ring”), is bolted to the first part to maintain and compress the flexible gasket.

Depending on the application, a one-piece shutter design where the tightness is made by a flexible o-ring mounted on the diameter could be a simple solution offering an easy and cheaper maintenance.

Distinctive Features
- Tightness made by sealing gasket or flexible o-ring
- Reinforced Teflon® / Teflon® (glass, graphite, etc.) for a maximum operating temperature of 180°C
- Graphite/Metal for a maximum operating temperature of 650°C, oring gasket for maximum operating temperatures between 180°C and 200°C

2 Metal-to-metal seal

The metal-to-metal tightness system applicable to butterfly valves is compatible with the majority of fluids, notably difficult fluids (high temperature, high pressure). To avoid eventual wearing between the two metal parts (disc and metal seat) when the valve is operated, the design is generally oriented towards a double or triple offset solution.

Distinctive Features
- Sealing surface cone/edge
- Fire Safe design
- Adapted for adhesive, viscous fluids and high temperatures
- Dismountable seat for rapid maintenance
- Possibility to apply hard coatings: Stellite®, chrome carbide, etc.
- Appropriate for severe service, with temperatures ranging from -196°C to +800°C (subject to case study based on actual operating conditions and materials used)

This list of tightness systems is not exhaustive and describes the main tightness systems in industrial valve technologies.