Gate Sealing Solutions
Music Note Seals

The Rubber Company’s P seals or “Music note seals” are manufactured into two profiles, determined by the appropriate load deflection criteria, with either a solid or a hollow bulb.

The hollow profile is more suitable for low hydrostatic pressures, whereas, the solid profile is less prone to compression set.

P Seals are frequently used for side seals and can be supplied with a PTFE coating. When water pressure is applied, the bulb on the Music Note Seal is devised to be forced against the seal seat. Bulb deflection, or stem deflection accomplishes a sealant effect.

Bulb deflection is appropriate for seals under high compression loads. Whereas, stem deflection is more appropriate for: low compression loads; sealing irregular surfaces and large tolerances in the gates dimensions.
**Hump Seals**

The Rubber Company’s Hump Seals can be produced in two forms, with either a single or a double hump. The Hump Seals can be supplied with a PTFE coating.

Hump Seals are usually used for sealing the top edge of submerged vertical-lift gates and radical gates. Often, double hump seals are fitted for sealing against a reversal of head, such as tidal river gates.

For low hydrostatic pressures, the seal can be provided with a hollow profile.
Lip Seals

The Rubber Company’s Lip Seals can be manufactured to suit various lip angles and profiles. The Lip Seals are naturally flexible, nevertheless can only be used for movement in one plane (e.g. radial or vertical-lift gates).

Water pressure triggers sealing by compressing the sealing lip.
The Rubber Company’s Flat Seals can be manufactured into 3 forms, either flat, chamfered or radiused seal faces.

Commonly, flat seals are installed as bottom seals. Flat bottom seals on high head gates should project no more than the deflection required to seal (e.g. 3-5mm).

Chamfered and radiused seals decrease the seals contact zone for ready compression and provide room for the rubber to displace when deflecting.
**Teflon Coated Seals**

The Rubber Company has experience in the application of rubber seals with teflon coatings. During the vulcanisation process, the PTFE is bonded to the rubber seal surface.

Including teflon on the sealing surface results in:
- A considerably lower friction coefficient
- Reducing potential for sticking or “contact bonding” to the seal plate especially when the seal is under high compression for prolonged time periods
- Abrasive wear being reduced whereas the life of the seal being increased

In comparison with friction for teflon to metal of typically 0.1, the friction coefficient for rubber to metal is typically in the range of 0.6 to 1.4.

Shore hardness (IHRD), surface finish of the contact face, average surface contact pressure, sliding speed and the wetness/dryness of the seal will affect friction.

See table below for friction coefficient versus contact pressure for wet and dry seals.

Carbon filled PTFE offers superior U.V. resistance properties.

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**Plot of friction coefficient vs. contact pressure**
Dry Dock Seals design typically as a lip profile with a vulcanised steel baseplate.

The water exerts pressure on the lip creating the seal. These seals are intended to counter large movements in the gates position on a regular basis.

A firm and watertight seal to the dock wall is safeguarded by the steel-reinforced baseplate.

Gina-type seals are often subjected to high hydrostatic pressures. These seals are frequently used for delivering a seal between two concrete sections on an underwater tunnel, or for sealing the temporary bulkhead at the close of the tunnel.

The seal can be produced with a soft rubber nodule on the sealing face to ensure a watertight seal in low contact pressure use on the uneven surface.

Positioning of the concrete faces will be facilitated by the rubber nodule.
Omega-type Seals

Omega-type seals frequently deliver an internal seal between two concrete segments on an underwater tunnel. Typically, the seals are fabric-reinforced and exposed to great three dimensional movements.

Between the tunnel sections the seal performs as a membrane. Varying numbers of internal fabric layers depend on the maximum hydrostatic pressure and required safety factor.

To ensure a watertight seal, the seal can be designed with small ridges on the sealing face.

Typical Omega-type Seal

Inflatable Seals

A common usage for inflatable seals are sealing gates and tunnels as there are large movements or variations in the sealing face.

By controlling inflation pressure of the gas or fluid above the maximum hydrostatic pressure, a good seal is achieved.

To uphold the required inflation pressure, an air compressor or water pump and automatic controls are needed.

Fabric-reinforcing the seals increases strength under high inflation pressures and improves puncture resistance.

Typical Inflatable Seal

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Waterstops

Usually, rubber waterstops uses include movement joints in underwater concrete structures, such as tunnels.

The waterstop design maintains a watertight seal under the required hydrostatic pressure and accommodates any three-dimensional movements between concrete segments.

Extreme temperature variations and creep and contraction of the concrete can produce movement of the joints.

The waterstops can be provided with steel plates vulcanised into the bulbs on either end and anchored to the concrete section for high hydrostatic pressures.

Maximum water pressure and maximum elongation of the seal defines the choice of waterstop.

<table>
<thead>
<tr>
<th>Internal Waterstop</th>
<th>External Waterstop</th>
</tr>
</thead>
</table>

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Specifying

Typically compounds of Natural Rubber, EPDM or Neoprene are moulded or extruded to create the seals.

EPDM, Neoprene or blends with Natural Rubber are recommended if the seals are to be exposed to lengthy periods of sunlight, as they are more appropriate for improved ozone resistance.

To manage with aggressive gases or fluids other synthetic rubbers can be used.

Important properties for rubber hydraulic seals are:
- High tensile strength
- High tear resistance
- Good abrasion resistance
- Low water resistance
- Exceptional weathering resistance

Natural Rubber has superior mechanical properties. A typical specification for a Natural Rubber seal is shown below.

<table>
<thead>
<tr>
<th>Test</th>
<th>Standard / Method</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardness (IRHD)</td>
<td>AS1683.15.2, ASTM D2240, BS903A.Z</td>
<td>65 ± 5</td>
</tr>
<tr>
<td>Tensile strength at failure</td>
<td>AS1683.11, ASTM D412, BS903A.Z</td>
<td>&gt; 21 MPa</td>
</tr>
<tr>
<td>Elongation at failure</td>
<td>AS1683.11, ASTM D412, BS903A.Z</td>
<td>&gt; 450%</td>
</tr>
<tr>
<td>Tensile strength after heat aging for 96 hr at 70°C</td>
<td>AS1180.3, ASTM D573, BS903A.Z</td>
<td>&gt; 80% of tensile strength before aging</td>
</tr>
<tr>
<td>Water absorption for 168 hr at 20°C</td>
<td>ASTM D471</td>
<td>&lt; 5% (by weight)</td>
</tr>
<tr>
<td>Resistance to ozone cracking for 100pphm at 20% strain at 40°C for 96hr</td>
<td>AS1683.24, ASTM D1149</td>
<td>No cracks</td>
</tr>
<tr>
<td>Compression set after 22hr at 70°C</td>
<td>AS1683.13B, ASTM D395, BS903A/6A</td>
<td>&lt; 30%</td>
</tr>
<tr>
<td>Tear Resistance</td>
<td>AS1683.12, ASTM D624, BS903A.3</td>
<td>&gt; 70 kN/m</td>
</tr>
<tr>
<td>Abrasion Resistance</td>
<td>AS1683.21, ASTM D1630, BS903A.9</td>
<td>&lt; 0.5 ml</td>
</tr>
</tbody>
</table>
Unless otherwise stated, corner sections and straight joins are fully moulded.

Deciding between a moulded and extruded seal is often a compromise between seal tolerances and tooling expenses.

An extrusion die is a more cost-effective alternative to machining a mould, if new tooling is needed to manufacture the seal.

Moulding is needed for seals with teflon coatings or non-radiused corner sections.

Below is a summary of comparisons of dimensional tolerances for rubber mouldings (Class M4) and extrusions (Class E3), as per the International Standard ISO3302.

<table>
<thead>
<tr>
<th>Normal Dimensions (mm)</th>
<th>Moulding Tolerance (Class M4) MM +/-</th>
<th>Extrusion Tolerance (Class E3) MM +/-</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 – 6.3</td>
<td>0.50</td>
<td>0.80</td>
</tr>
<tr>
<td>6.3 – 10</td>
<td>0.70</td>
<td>1.00</td>
</tr>
<tr>
<td>10 – 16</td>
<td>0.8</td>
<td>1.3</td>
</tr>
<tr>
<td>16 – 25</td>
<td>1.00</td>
<td>1.6</td>
</tr>
<tr>
<td>25 – 40</td>
<td>1.3</td>
<td>2.00</td>
</tr>
<tr>
<td>40 – 63</td>
<td>1.6</td>
<td>2.5</td>
</tr>
<tr>
<td>63 – 100</td>
<td>2.00</td>
<td>3.2</td>
</tr>
<tr>
<td>100 – 160</td>
<td>2.5</td>
<td>-</td>
</tr>
<tr>
<td>160 -</td>
<td>1.5%</td>
<td>-</td>
</tr>
</tbody>
</table>
The Rubber Company’s Seal Design

A hardness (IRHD) of 65 is usually specified for seals. A higher hardness of 75 may be used for high head gate seals.

Under low head pressures, gate seals may have a lower hardness (e.g. 55) or hollow profile.

Summarised below are the estimated deflections for a Music Note seal with a 44.5mm bulb diameter under a load of 6 kN/m.

These estimated deflections should be used as a guide only.

<table>
<thead>
<tr>
<th>Hardness</th>
<th>Deflection for Solid Music Note Seal (44.5mm Bulb Diameter – LOAD 6kN/m)</th>
<th>Deflection for Hollow Music Note Seal with a 25mm Hole (44.5mm Bulb Diameter – LOAD 6 kN/M)</th>
</tr>
</thead>
<tbody>
<tr>
<td>55</td>
<td>7.0mm</td>
<td>16.0mm</td>
</tr>
<tr>
<td>65</td>
<td>4.0mm</td>
<td>9.0mm</td>
</tr>
<tr>
<td>75</td>
<td>2.5mm</td>
<td>5.5mm</td>
</tr>
</tbody>
</table>

Aging, number of loading cycles and temperature may alter the deflections for a given load.

To assist sealing, side and top seals rely on the water pressure.

To provide contact pressure for sealing, bottom seals rely on the weight of the gate. Fabric or Kevlar reinforcement can be offered to all seals to strengthen and harden the product; however, this will tend to decrease resilience and elasticity.

Seals should be produced as a continuous length around the perimeter of the gate with moulded corners and vulcanised joins, to ensure superior water tightness. The contact pressure acting on the seal needs to be greater than the pressure difference over the seal. Not only water loss, but gate vibration and noise and a substantial decrease in the life of the seal may result from inadequate sealing.

To avoid surface damage to the seal during compression, clamp bars, spacers and other metal edges encountering the seal should be radiused and smooth. The design of the gate should include a bracket upstream of the seal to guard against damage and jamming, if large debris is predicted.

Typically, concrete embeds the seal seat and is often stainless steel, bronze, polyethylene or some other corrosion resistant material. It is recommended that the seals do not sit directly on the concrete due to the rough and uneven surface, resulting in increased abrasion and a shorter service life.

The design of the gap between the gate and sealing strip should allow for tolerances in the gates dimensions. The seal may potentially be extruded through the gap under high hydrostatic heads, if the gap is too wide.

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# Material Safety and Storage

During transportation, the seals are specially packed to withstand damage. Careful storage and handling of the Rubber Seals is important.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>1.</td>
<td>Avoid exposure to direct sunlight and high concentrations of ozone</td>
</tr>
<tr>
<td>2.</td>
<td>Preferably store in a cool room, free of UV radiation and significant temperature variations</td>
</tr>
<tr>
<td>3.</td>
<td>Preferably store flat in the relaxed position (unrolled and straight)</td>
</tr>
<tr>
<td>4.</td>
<td>Store without other objects loaded on top</td>
</tr>
<tr>
<td>5.</td>
<td>Avoid bending or rolling the delivered seals in tighter coils, especially Teflon-coated seals</td>
</tr>
<tr>
<td>6.</td>
<td>Avoid seals meeting sharp objects</td>
</tr>
<tr>
<td>7.</td>
<td>Store under dry conditions away from oils, chemicals etc.</td>
</tr>
<tr>
<td>8.</td>
<td>Avoid exposing seals to extreme temperatures</td>
</tr>
<tr>
<td>9.</td>
<td>Ensure seals are not resting on abrasive surfaces</td>
</tr>
<tr>
<td>10.</td>
<td>If seals are stored outside provide a cover to exclude light, however ensure free circulation of air</td>
</tr>
<tr>
<td>11.</td>
<td>If seals are stored in their rolled position, unroll at least 72 hours prior to installation</td>
</tr>
<tr>
<td>12.</td>
<td>Seals with PTFE should <strong>NOT</strong> be bent or folded in any way and <strong>MUST</strong> be stored out of sunlight in cool dry storage until installed.</td>
</tr>
</tbody>
</table>

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Installation of Seals

Methods

Seals can be installed in numerous methods. Seals can be supplied as complete sets with moulded corners, or as separate moulded corners and straight sections to be joined onsite during installation. Water pressure will facilitate the sealing performance.

Effective Seal Design

It is strongly recommended that holes are drilled on site, preferably with a tube drill.

The location of predrilled holes can tend to alter slightly when delivered to site, especially when there are significant climatic changes.

If possible, install seals as a complete unit. Any disparities in the length can be taken up by either compressing or stretching the entire length of the seal.

Before marking the location of the bolt holes, momentarily clamp the seal in position.

Unclamp the seal and drill the holes with a water-lubricated tube drill. Replace the seals on the gate, clamp in position and tighten the bolts securely.

Bolts through Music Note and Lip seals should incorporate spacers.

Bolt holes should be fitted with nylon or rubber washers, as are common sources of leakage.

Undulations in the seal can be caused by disparities in bolt tensions on the seal clamping plate.
Onsite Joins

For joining Seals the choices are a:
  a. Cold vulcanised join using an appropriate adhesive
  b. Hot vulcanised join using an electrically heated mould

A hot vulcanised join using an electrically heated mould is recommended for seals under high hydrostatic pressures requiring high strength bonds, but is more expensive due to elevated tooling expenses. For more commonly used sizes, electrically heated moulds can be supplied.

The following materials are recommended to complete a cold vulcanised join:
  ❖ Cold vulcanising adhesive
  ❖ Toothless saw sharpened to a knife edge
  ❖ Mitre box for ensuring a straight, uniform cut
  ❖ Disc sander or coarse emery paper
  ❖ Rubber dust
  ❖ Cleaning solvent such as acetone
  ❖ Small paintbrush

For completing the cold vulcanised join the recommended procedure is:
1. Place the seal in the mitre box and make a skived cut at an angle of approximately 30 degrees to the seal profile. If a mitre box is not available then a butt join should be made at right angles. To check for an accurate fit, match the ends of the two sections.
2. The surfaces to be joined should be roughened with the disc sander or coarse emery paper, then cleaned with acetone.
3. Mix a small quantity of the adhesive. Apply the first coat to the cleaned surfaces to be joined with the small paint brush and allow to dry. Do not allow the two surfaces to come into contact.
4. Apply a second coat of adhesive and allow to touch dry. Place the two edges together and clamp in position.
5. If there are any gaps across the join, then mix the rubber dust with a small amount of adhesive to form a paste. Spread the paste into the gaps and allow to dry.

Mitre Box for Straight Joins

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