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Rubber Hydraulic Seals
Technical Manual
Trelleborg Seals

Trelleborg Seals are designed and manufactured to ensure a reliable and watertight closure for dam gates and tunnels.

Large dams worldwide, have gates within the structure to assist in controlling water flow, the effectiveness of these gates is largely determined by the performance of the rubber hydraulic seals.

Trelleborg Engineered Systems Australia is the market leader for the supply of speciality rubber seals for dam gates and similar applications.

Trelleborg Seals are also available in a variety of rubber compounds and can be supplied with Kevlar® reinforcement, fabric reinforcement or teflon coatings.

Trelleborg Engineered Systems Australia has a quality system certified to ISO9001-2000 and are committed to supplying high quality, durable products which conform to the customer’s specified requirements and operating conditions.

To ensure superior construction, all corner sections of seals are usually fully moulded with any vulcanised joins being in the less stressed straight sections.

Trelleborg Engineered Systems Australia will design and manufacture rubber seals to meet your unique requirements.

This brochure provides technical aspects of rubber hydraulic seals for dams and tunnels, and an extensive profile listing of our Seals.

For more information on sizes available for each type of seal, contact Trelleborg sales staff at tqr.info@trelleborg.com or telephone +61 (7) 3866 7444 and select option 1 from the menu.
Trelleborg Dam Gate Seals

Music Note Seals

Trelleborg Music Note seals are manufactured with either a solid or hollow bulb depending on required load deflection criteria.

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

Trelleborg Music Note seals are often used for side seals and can be supplied with a PTFE coating.

The bulb on the Music Note seal is designed to be forced against the seal seat when water pressure is applied.

Sealing can be achieved by either bulb deflection, or stem deflection. Seals under high compression loads are usually designed with bulb deflection.

Stem deflection is more suitable for:

- Low compression loads
- Sealing irregular surfaces
- Large tolerances in the gates dimensions
**Hump Seals**

Trelleborg Hump seals can be manufactured with either a single or double hump and can be supplied with a PTFE coating.

Double hump seals are usually installed for sealing against a reversal of head, such as tidal river gates.

Hump seals are commonly used for sealing the top edge of submerged vertical-lift gates and radial gates.

The seal can be supplied with a hollow profile for low hydrostatic pressures.
**Flat Seals**

Trelleborg Flat seals can be supplied with either flat, chamfered or radiused seal faces.

Chamfered and radiused seals reduce the seal’s contact area for ready compression and provide space for the rubber to displace when deflecting. Flat seals are commonly 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).
Lip Seals

Trelleborg Lip seals can be supplied with a range of different lip angles and profiles. These seals are inherently flexible, however they can only be used for movement in one plane (e.g. radial or vertical-lift gates).

Sealing is achieved by compression of the sealing lip which is activated by the water pressure.
**Trelleborg Teflon Coated Seals**

Trelleborg Engineered Systems Australia has extensive experience in manufacturing rubber seals with teflon coatings. The PTFE is bonded to the rubber seal surface during the vulcanisation process.

The inclusion of teflon on the sealing surface:

- Significantly reduces the friction coefficient
- Reduces the potential for sticking or “contact bonding” to the seal plate especially when the seal is under high compression for prolonged periods
- Assists in reducing abrasive wear and increases the life of the seal

The friction coefficient for rubber to metal is typically in the range of 0.6 to 1.4 compared to a friction for teflon to metal of typically 0.1.

The friction is dependent on the seal hardness (IRHD), the surface finish of the contact face, the average surface contact pressure, the sliding speed, and the wetness/dryness of the seal.

A plot of friction coefficient versus contact pressure for wet and dry seals (rubber and teflon-coated rubber) is shown below.

Trelleborg recommends carbon filled PTFE because of its superior U.V. resistance properties.
Trelleborg Specialty Seals

Dry Dock Seals

Trelleborg Seals for dry docks are usually designed as a lip profile with a steel baseplate vulcanised into the seal.

The seal is formed by the water pressure acting on the lip.

These seals are designed to respond to large movements in the gate’s position on a regular basis.

The steel-reinforced baseplate ensures a rigid and watertight seal to the dock wall.

Gina-type Seals

Trelleborg Gina-type seals are commonly used for providing a seal between two concrete segments on an underwater tunnel, or for sealing the temporary bulkhead at the end of the tunnel.

These seals are often subjected to high hydrostatic pressures.

The seal can be manufactured with a soft rubber nipple on the sealing face to ensure a watertight seal under low contact pressures on the irregular surface.

This nipple is designed to assist during positioning of the two concrete elements.
**Omega-type Seals**

Trelleborg Omega-type seals are commonly used for providing an internal seal between two concrete segments on an underwater tunnel.

These seals are usually fabric-reinforced and subjected to large three dimensional movements. The seal acts as a membrane mounted over the area between the tunnel sections. The number of internal fabric layers is dependent on the maximum hydrostatic pressure and required safety factor.

The seal can be designed with small ridges on the sealing face to ensure a watertight seal.

**Inflatable Seals**

Trelleborg Inflatable seals are commonly used for sealing gates and tunnels where there are large movements or variations in the sealing face.

Sealing is obtained by controlling the inflation pressure of the gas or fluid above the maximum hydrostatic pressure. An air compressor or water pump and automatic controls are required to maintain the required inflation pressure.

These seals can be fabric-reinforced to provide increased strength under high inflation pressures and to improve puncture resistance.
**Waterstops**

Trelleborg Rubber Waterstops are commonly used in movement joints in underwater concrete structures, such as tunnels.

The waterstop is designed to maintain a watertight seal under the required hydrostatic pressure and accommodate any three-dimensional movements between the concrete sections.

Movement of these joints can result from extreme temperature fluctuations and creep and contraction of the concrete.

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

The choice of waterstop is determined by the maximum water pressure and maximum elongation of the seal.
Trelleborg Seals are moulded, or extruded, usually from compounds of Natural Rubber, EPDM or Neoprene.

Natural Rubber has superior mechanical properties.

If the seals are to be exposed to extended periods of sunlight then we recommend EPDM, Neoprene or blends with Natural Rubber for increased ozone resistance.

Other synthetic rubbers can be used to cope with aggressive gases or fluids.

In general, rubber hydraulic seals should have high tensile strength, high tear resistance, good abrasion resistance, low water resistance and excellent weathering resistance.

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>
Trelleborg Corner sections and straight joins are fully moulded, unless otherwise specified.

Finished seals are visually inspected for compliance with the customer’s requirements and our stringent workmanship standards.

The choice between a moulded and extruded seal is often a compromise between seal tolerances and tooling costs.

If new tooling is required to manufacture the seal then an extrusion die is a cheaper alternative to machining a mould.

Seals with teflon coatings or non-radiused corner sections must be moulded.

A comparison of dimensional tolerances for rubber mouldings (Class M4) and extrusions (Class E3), as per the International Standard ISO3302, is summarised below.

<table>
<thead>
<tr>
<th>NOMINAL DIMENSIONS MM</th>
<th>MOULDING TOLERANCE (CLASS M4)MM+/1</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>
### Trelleborg Seal Design

Trelleborg Seals are normally specified to have a Hardness (IRHD) of 65. High head gate seals may have a higher hardness (e.g. 75).

Gate seals under low head pressures may have a lower hardness (e.g. 55) or a hollow profile.

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

These estimated deflections are based on laboratory tests and should be used as a guide only.

<table>
<thead>
<tr>
<th>HARDNESS (IRHD)</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>7.0 mm</td>
<td>16.0 mm</td>
</tr>
<tr>
<td>65</td>
<td>4.0 mm</td>
<td>9.0 mm</td>
</tr>
<tr>
<td>75</td>
<td>2.5 mm</td>
<td>5.5 mm</td>
</tr>
</tbody>
</table>

Deflections for a given load may vary due to aging, number of loading cycles and temperature. Rubber seals tend to be slightly stiffer during the initial couple of load tests.

Side and top seals rely on the water pressure to aid sealing.

Bottom seals rely on the weight of the gate to provide contact pressure for sealing. All seals can be provided with fabric or kevlar reinforcement to strengthen and stiffen the product, however this will tend to reduce elasticity and resilience.

To ensure superior watertightness, seals should be manufactured as a continuous length around the perimeter of the gate with moulded corners and vulcanised joins. Ensure the contact pressure acting on the seal is greater than the pressure difference over the seal. Inadequate sealing will not only result in water loss but may cause gate vibration and noise and a substantial decrease in the life of the seal.

Clamp bars, spacers and other metal edges coming in contact with the seal should be radiused and smooth to avoid surface damage to the seal during compression. If large debris is anticipated, the gate should be designed with a bracket upstream of the seal to protect against damage and jamming.

The seal seat is usually embedded in concrete and is often stainless steel, bronze, polyethylene or some other corrosion resistant material. It is not recommended that seals sit directly on the concrete due to the rough and uneven surface, which will result in increased abrasion and a shorter service life.

The gap between the gate and sealing strip should be designed to allow for tolerances in the gate’s dimensions. If the gap is too wide, the seal may potentially be extruded through the gap under high hydrostatic heads.
Storage and Handling

Trelleborg Seals are specially packaged to withstand damage during transportation. Rubber seals should be handled and stored carefully in the correct manner.

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

Installation Methods

There are various methods of installing Trelleborg Seals. Seals can be supplied as complete sets with moulded corners, or as separate moulded corners and straight sections to be joined onsite during installation. The seal should be installed to seal with the action of the water pressure, not rely entirely on mechanical compression.

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It is strongly recommended that holes are drilled on site, preferably with a tube drill (socket-type drill).

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

Install seals as a complete unit, if possible. If there are any variations in the length then this discrepancy can be taken up by either compressing or stretching the entire length of the seal.

Temporarily clamp the seal in position prior to marking the location of the bolt holes.

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 snugly.

Bolts through Music Note and Lip seals should incorporate spacers.

Bolt holes are a frequent source of leakage and should therefore be fitted with nylon or rubber washers.

Variations in bolt tensions on the seal clamping plate can cause undulations in the seal.
Onsite Joins

Options for joining Trelleborg Seals onsite include:-

(a) Cold vulcanised join using an appropriate adhesive  
(b) Hot vulcanised join using an electrically heated mould

The latter option is expensive due to the high tooling costs, but is recommended for seals under high hydrostatic pressures requiring high strength bonds. Electrically heated moulds can be supplied for more commonly used sizes. If you are interested in investigating the option of hot vulcanised joins then contact a Trelleborg Engineered Systems Australia representative. We can arrange for an onsite technician to assist in making hot vulcanised joins.

It is recommended that the following materials are used to complete a cold vulcanised join:-

- Cold vulcanising adhesive (e.g. SC2000)  
- Toothless saw sharpened to a knife edge  
- Mitre box for ensuring a straight, uniform cut  
- Disc sander or coarse emery paper  
- Rubber dust (optional)  
- Cleaning solvent such as acetone  
- Small paintbrush

The recommended procedure for completing the cold vulcanised join 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. Match the ends of the two sections to check for an accurate fit.

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 in 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.
Recent Projects
Australia

• New Southern Railway (NSW) - Waterstops and Gina-type Seals
• Kununurra Diversion Dam (WA) - Lip and Flat Seals
• Hume Dam Note Seals (NSW) - Music Note Seals
• Cataract Dam (NSW) - Music Note Seals
• Snowy Mountains Hydroelectric Scheme (NSW) - Specialty Gate Seals
• Hydroelectric Scheme (Tasmania) - Specialty Gate and Inflatable Seals
• Swanbank Power Station (QLD) - Discharge Valve Seals
• Wyangala Dam (NSW) - Gate Seals
• Eildon Reservoir (VIC) - Bulkhead Seals
• Royal Pines Resort (QLD) - Lock Gate Seals
• Boobegan Creek (QLD) - Lock and Weir Gate Seals
• Stanwell Power Station (QLD) - Expansion Bag Assemblies
• Sunwater Queensland - Butterfly Valve Seals with Kevlar®
• NRG Gladstone (QLD) - Music Note Seals
• Melbourne Water, Paterson Lakes - Gate Seals
• Wivenhoe Dam (QLD) - Bulkhead, Hump Seals with PTFE
### Overseas

<table>
<thead>
<tr>
<th>Location</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>London Underground</td>
<td>Fabric-reinforced Omega-type Seals</td>
</tr>
<tr>
<td>Rosyth Royal Dockyard (England)</td>
<td>Dry dock Seals</td>
</tr>
<tr>
<td>Devonport Royal Dockyard (England)</td>
<td>Dry dock Seals</td>
</tr>
<tr>
<td>Tanggari II Hydro-electric (Indonesia)</td>
<td>Music Note Seals</td>
</tr>
<tr>
<td>Hong Kong Harbour</td>
<td>Gina-type Seals</td>
</tr>
<tr>
<td>Lumut Power Station (Kuala Lumpur)</td>
<td>Specialty Tunnel Seals</td>
</tr>
<tr>
<td>Bouwdienst Rijkswaterstaat</td>
<td>Specialty Lip Seals</td>
</tr>
<tr>
<td>Devonport Royal Navy Dockyard</td>
<td>Spare set Dry Dock Seals</td>
</tr>
<tr>
<td>Ruacana Hydro Namibia</td>
<td>Music Note Seals with PTFE</td>
</tr>
<tr>
<td>Victoria Dock, Cape Town South Africa</td>
<td>Dry Dock Seals</td>
</tr>
<tr>
<td>Auckland, New Zealand Devonport RNZN Dock</td>
<td>Floating Dock Gate Seals</td>
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