Waterstops
Trelleborg Ridderkerk BV
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Introduction

The Dutch have always had to struggle with the sea to "keep their feet dry". Special construction methods have been developed to solve various problems in ensuring a structure is watertight. Sealing problems occur especially where concrete structures are too large to be poured as one monolithic unit. Ensuring joint water tightness is therefore of paramount concern particularly for underwater and immersed structures such as tunnels under rivers and canals, basement garages and cellars, dry docks, locks, etc. For these applications special joint sealing systems have been developed to ensure watertight joints.
Use of waterstop

Many large concrete structures are too big to be poured as one monolithic unit and therefore have a number of constructions joints.

Two different types of joints can be identified:

• The work-joint which has to be watertight without having to accomodate movement between the adjacent concrete pours.
• The expansion joint which has to accommodate water pressure as well as the possible movement between the individually poured concrete sections.

In a joint three types of waterstops can be utilized.

External waterstop
The external waterstop is mounted on the wet side of a concrete structure. This type of waterstop protects the joint against ingress of mud or any other substance. This waterstop is also installed in structures where a “double tightness” system is desired, e.g. nuclear power plants or at ramps to motorway tunnels. This type of waterstop is only recommended in open structures such as tunnel roofs where air can be trapped within the joint.

Internal waterstop
The primary seal between two concrete structures is accomplished by the internal waterstop. This waterstop is always fitted roughly in the centre of the wall and bridges the expansion/movement joint in the wall. When this type of waterstop is used to seal an expansion joint, the waterstop has a central sponge at its centre. The purpose of this central section is to form a free space in the concrete, which is necessary to allow movement. The central sponge may be formed with hard rubber with a central hole or with two rectangular strips of sponge rubber at the centre, one on each side.

The sponge rubber strips, being flexible, facilitate the fixing of the waterstop into the shuttering and create at the same time a perfect seal between the sponge rubber and the shuttering. During the concrete pouring and casting process no cement slurry is able to drain off owing to shutter leakage thereby preventing honeycombing and the formation of cavities in the concrete.

The concrete quality in the area around the waterstop is critical in ensuring water-tightness.
The sponge rubber is available in different sizes, dependent on the joint width during pouring.
Expansion joint

The expansion joint is installed once the concrete structure has hardened. It’s function is to keep the joint clean and open to prevent ingress of dust and dirt which could lead to disfunction of the joint. The expansion joint needs special dimensions to ensure that it fits the joint and accommodates the joint expansion.

For detailed information about this waterstop refer to our brochure ‘Expansion Joints’.
Construction of waterstops

Waterstops are produced in different types. The waterstop type depends on the water pressure and desired water tightness of the joint.
In structures with low water pressure a solid rubber waterstop may be used.

Rubber waterstop with vulcanised steel strips
When water pressures are higher and no leakage is permitted, waterstops with steel strips vulcanized into the end bulbs of the rubber waterstop are used. Concrete does not adhere to rubber or PVC, but makes a good bond with the steel strip, providing the desired water tightness.
The steel strip also increases the path of leakage which decreases leakage problems

Injection waterstop
The waterstop with vulcanised steel strip will give absolute water tightness between the concrete and the steel strips.
However, in practice, fissures and gravel spots are caused by shrinkage in the concrete and by errors during the pouring process. The concrete in the direct vicinity of the waterstop may therefore show seepage even though the waterstop is providing the required watertightness. In practice around 10% of all joints may have this leakage through the concrete.

To eliminate this leakage, Trelleborg Ridderkerk has developed a waterstop system that allows direct injection of epoxy resin or similar into the concrete around the edges of the waterstop. For further details regarding this waterstop we refer to our special brochure ‘Injection Waterstop W9U-I’.

### Summary of standard waterstops

A summary of Trelleborg Ridderkerk standard waterstops is given in the Table below. In Appendix 1,2 and 3 you will find technical drawings of the waterstops.

<table>
<thead>
<tr>
<th>Type</th>
<th>Waterstop type</th>
<th>Product description</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>W2L</td>
<td>External/internal</td>
<td>Rubber</td>
<td>Clamping</td>
</tr>
<tr>
<td>W2LS</td>
<td>External/external</td>
<td>Rubber-steel</td>
<td>Clamping</td>
</tr>
<tr>
<td>W5B</td>
<td>External</td>
<td>Rubber</td>
<td>Clamping</td>
</tr>
<tr>
<td>W10U-250</td>
<td>Internal</td>
<td>Rubber-steel</td>
<td>Internal joints</td>
</tr>
<tr>
<td>W9U</td>
<td>Internal</td>
<td>Rubber-steel</td>
<td>Internal joints</td>
</tr>
<tr>
<td>W9CU</td>
<td>Internal</td>
<td>Rubber-steel</td>
<td>Internal joints</td>
</tr>
<tr>
<td>W9U-i</td>
<td>Internal</td>
<td>Rubber-steel + injection</td>
<td>Internal joints</td>
</tr>
<tr>
<td>W9CU-i</td>
<td>Internal</td>
<td>Rubber-steel + injection</td>
<td>Internal joints</td>
</tr>
</tbody>
</table>

On request we can supply other types as well
Application Design Data
The final choice of waterstop is governed by the desired structural movement and water pressure. Both cause a tension in the rubber. In Appendix 4; graphical design data is provided for a range of waterstops. The design graphs indicate the maximum waterstop movements in the X, Y, and Z directions at a certain water pressure (in meters of water column).
Rubber quality

The standard material for the manufacture of waterstops is Styrene Butadiene Rubber (SBR).

If the SBR rubber quality is not suitable for the proposed application other rubber compounds are available. Alternative rubber compounds available are Ethylene propylene diene monomer (EPDM), Chloroprene rubber (CR), Natural rubber (NR) or Nitrile rubber (NBR).

In view of the long service life required and the fact that waterstops cannot be replaced, the rubber material has to be of a very high quality. Repair of leaking joints post the pouring of a structure using epoxy injection repair systems or similar is a costly operation so the correct choice of the rubber quality is of paramount importance. The optimal physical properties of the various alternative rubber compounds depends on the type of rubber elastomer used.

Mechanical Properties

All standard waterstops are certified through our own laboratory and will be delivered in accordance with the Dutch NEN 7030 standard. We can also supply waterstops according to German DIN 7865 standard. On request quality-test- certificates can be shown. The table below shows the NEN 7030 standard.

Table 2: Standard NEN 7030 Physical Property Requirements

<table>
<thead>
<tr>
<th>Property</th>
<th>SBR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardness (°Shore A)</td>
<td>60 ± 5</td>
</tr>
<tr>
<td>Tensile strength (N/mm²)</td>
<td>≥ 17.1</td>
</tr>
<tr>
<td>Elongation at break (%)</td>
<td>≥ 375</td>
</tr>
<tr>
<td>Tear resistance (N)</td>
<td>≥ 31.1</td>
</tr>
<tr>
<td>Change after 14 days / 70 °C</td>
<td></td>
</tr>
<tr>
<td>Tensile strength (%)</td>
<td>≤ 25</td>
</tr>
<tr>
<td>Elongation at break (%)</td>
<td>≤ 30</td>
</tr>
<tr>
<td>Hardness (° Shore A)</td>
<td>≤ 8</td>
</tr>
<tr>
<td>Compression set 72 hrs 23°C (%)</td>
<td>≤ 10</td>
</tr>
<tr>
<td>Water absorption (gr/m²)</td>
<td>≤ 30</td>
</tr>
<tr>
<td>Ozone resistance 120 hrs/25 pphm/20°C/20% tear</td>
<td>No cracks</td>
</tr>
<tr>
<td>Low temperature resistance</td>
<td></td>
</tr>
<tr>
<td>Change of hardness at 0 °C (°Shore A)</td>
<td>≤ 5</td>
</tr>
<tr>
<td>Change of hardness at -10 °C (°Shore A)</td>
<td>≤ 8</td>
</tr>
</tbody>
</table>
**Chemical resistance**
The table below summarizes the resistance and performance of various rubber compounds to a range of common chemicals. This table provides an indication of a suitable elastomer. The data is based on a temperature of 20 °C and concentrated solutions. For confirmation of a correct selection please don’t hesitate to contact us.

Table 3: Chemical resistance

<table>
<thead>
<tr>
<th>Quality</th>
<th>SBR</th>
<th>EPDM</th>
<th>CR</th>
<th>NR</th>
<th>NBR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural gas</td>
<td>Moderate</td>
<td>Moderate</td>
<td>Excellent</td>
<td>Moderate</td>
<td>Excellent</td>
</tr>
<tr>
<td>Petroleum</td>
<td>Not</td>
<td>Not</td>
<td>Moderate</td>
<td>Not</td>
<td>Excellent</td>
</tr>
<tr>
<td>Liquefied Ammonia</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Excellent</td>
</tr>
<tr>
<td>ASTM Oil No. 1</td>
<td>Moderate</td>
<td>Not</td>
<td>Excellent</td>
<td>Not</td>
<td>Excellent</td>
</tr>
<tr>
<td>ASTM Oil No. 2</td>
<td>Not</td>
<td>Not</td>
<td>Good</td>
<td>Not</td>
<td>Excellent</td>
</tr>
<tr>
<td>ASTM Oil No. 3</td>
<td>Not</td>
<td>Not</td>
<td>Good</td>
<td>Not</td>
<td>Good</td>
</tr>
<tr>
<td>Petrol</td>
<td>Not</td>
<td>Not</td>
<td>Good</td>
<td>Not</td>
<td>Excellent</td>
</tr>
<tr>
<td>Brackish Water</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Excellent</td>
</tr>
<tr>
<td>Diesel</td>
<td>Not</td>
<td>Not</td>
<td>Good</td>
<td>Not</td>
<td>Excellent</td>
</tr>
<tr>
<td>Kerosene</td>
<td>Not</td>
<td>Not</td>
<td>Not</td>
<td>Not</td>
<td>Excellent</td>
</tr>
<tr>
<td>Air from .. till .. °Celsius</td>
<td>-15 till 70</td>
<td>-20 till 110</td>
<td>-10 till 90</td>
<td>-40 till 70</td>
<td>-20 till 70</td>
</tr>
<tr>
<td>Mineral Oil</td>
<td>Not</td>
<td>Not</td>
<td>Good</td>
<td>Not</td>
<td>Excellent</td>
</tr>
<tr>
<td>Motor Oil</td>
<td>Not</td>
<td>Not</td>
<td>Excellent</td>
<td>Not</td>
<td>Excellent</td>
</tr>
<tr>
<td>Water till .. °Celsius</td>
<td>70</td>
<td>110</td>
<td>70</td>
<td>70</td>
<td>70</td>
</tr>
<tr>
<td>Weather conditions/Ozone</td>
<td>Moderate</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Moderate</td>
<td>Moderate</td>
</tr>
<tr>
<td>Seawater</td>
<td>Moderate</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Moderate</td>
<td>Excellent</td>
</tr>
<tr>
<td>Sulphured Hydrogen</td>
<td>Not</td>
<td>Good</td>
<td>Moderate</td>
<td>Not</td>
<td>Good</td>
</tr>
</tbody>
</table>
Mounting procedure

The water tightness of the joint is often determined by the way a waterstop is installed. The waterstop is most vulnerable whilst mounting. The internal waterstop supplied with vulcanised steel strips has holes in the strips for installation purposes.

It is important to ensure that the centre of the waterstop is placed in the center of the movement/expansion joint and that the waterstop doesn’t move in relation to the joint while the concrete is poured. Waterstop movement is a particular problem when there are high concrete pressures during the concrete pour.

The concrete underneath the waterstop has to be vibrated and consolidated during the pour otherwise porosity, cavities and honey combing will occur.

When the waterstop is mounted horizontally the ends should rise upward, in order to prevent air entrapment. The number of longitudinal ridges should also be minimised to reduce the possibility of trapping air under the waterstop.

Once the waterstop has the concrete poured on one side, the other side needs to be cleaned to ensure it is free of sharp objects.
Corners/special constructions

Trelleborg Ridderkerk can supply prefabricated flat or standing corners for every desired angle. Improved joint strength and security can be achieved as factory joints can be hot vulcanised to maximized joint strength.

Any joints required to be made on site should always be made in a length of straight waterstop. A joint requires a minimum straight length of 20 cm on each side of the joint. It is recommended, where possible, to make all corners in the factory. The design of the corners and location of site joints should be resolved in consultation with the consultant and Trelleborg Ridderkerk. Site joints can be vulcanised at the construction site by Trelleborg Ridderkerk engineers. It is possible to mount internal waterstops with a radius. The minimum radius for various waterstops are shown in the following table.

Table: 4 Radius

<table>
<thead>
<tr>
<th>Waterstop</th>
<th>Radii (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>W10U-250</td>
<td>&gt; 100</td>
</tr>
<tr>
<td>W9U</td>
<td>&gt; 100</td>
</tr>
<tr>
<td>W9U-I</td>
<td>&gt; 100</td>
</tr>
<tr>
<td>W9CU</td>
<td>&gt; 150</td>
</tr>
<tr>
<td>W9CU-I</td>
<td>&gt; 150</td>
</tr>
</tbody>
</table>

Appendix 5 details all the possible styles of corners and their names.

Trelleborg Ridderkerk also has various solutions for:

- connections between different types of waterstops
- connections between waterstop and sheet piling
- vulcanised steel endstrip
Appendix 1. Internal waterstops

W10U-250

W9U

W9U-I

W9CU

W9CU-I
Appendix 2. External waterstops

AM 250

AM 350
Appendix 3. Application Design Data - Waterstops

Application data W9U & W9Ui
SLS conditions

Application data W9CU & W9CUi
SLS conditions
Application Design Data – Waterstops

Application Data W10U
SLS conditions

Application Data W10U
ULS conditions
### Appendix 5. Corner constructions

<table>
<thead>
<tr>
<th>Diagram</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Flat cross" /></td>
<td>Flat cross</td>
</tr>
<tr>
<td><img src="image" alt="Flat T joint" /></td>
<td>Flat T joint</td>
</tr>
<tr>
<td><img src="image" alt="Straight joint" /></td>
<td>Straight joint</td>
</tr>
<tr>
<td><img src="image" alt="Flat corner joint" /></td>
<td>Flat corner joint</td>
</tr>
<tr>
<td><img src="image" alt="Standing cross" /></td>
<td>Standing cross</td>
</tr>
<tr>
<td><img src="image" alt="Standing T joint" /></td>
<td>Standing T joint</td>
</tr>
<tr>
<td><img src="image" alt="Standing corner joint" /></td>
<td>Standing corner joint</td>
</tr>
</tbody>
</table>
Clamping joints

Introduction
In new constructions waterstops are poured halfway in the concrete. When a watertight sealing is desired between two existing structures or between an existing and a new structure, a different type of waterstop is needed.

Trelleborg has a number of different waterstops (or clamping joints) in its program for this purpose. The choice for one of these waterstops depends on the circumstances such as permissible movement, water pressure and type of construction.
**Area of application**

The clamping joints can be applied when a watertight sealing is desired between two existing structures or between an existing and a new structure.

**Two existing structures**

**Flat surface**

For sealing a flat joint the W5B can be applied.

**Corner surface**

For sealing a corner joint the W5L can be applied.

**Existing and a new structures**

For sealing this joint the W2L can be applied.

The choice for a specific type of waterstop depends on water pressure, type of structures, clamping system and movement. For a definite choice of clamping system please contact our office.
Clamping/pressure strips

The clamping joints are mounted to the existing structures with clamping or pressure strips.

These strips are attached to the wall with bolts and anchors, for the choice of the right fasteners we advice to consult the supplier.

In relation to the clamping device, there are two types.

**Pressure strips**

**Clamping strips**

The choice for a specific type of clamping device depends on water pressure, type of waterstop and movement. In general the clamping strip is better for more heavy conditions. This because no holes in the waterstop are needed and the anchors have a bigger distance to the concrete edge.

For the correct choice of clamp, please contact our office.
Plastic mass / S40

As a result off a rough surface leakage can appear between the concrete or steel surface and the rubber waterstop.

To prevent this a flexible material is put between the concrete or steel surface and the waterstop. We recommend S40 (rubber-concrete kit) or plastic mass (unvulcanised strip off rubber). By filling all small gaps and holes a perfect sealing is accomplished.

Mounting procedure

Preparation
Before mounting the clamping joint following preparations must be made.
• attach fasteners (bolts/anchors) onto the existing wall (according to supplier’s instructions);
• check the bolt length;
• check if the clamping strips fit (including corner strips);
• check if the bolts and nuts fit properly;
• clean the mounting surface;
• when using clamping strips mark the bolt positions and make holes with a hollow drill;
• when using plastic mass, attach it with solution to the clamping surface of the waterstop.

Mounting procedure
• apply waterstop;
• mounting corner strips;
• mounting other strips from corner to the centre;
• tighten nuts with the correct torque;
• tighten nuts again next day with the right torque because of relaxation rubber.

Note
In some cases it is better to adjust the waterstop on the construction site because of narrow tolerances. These specialised activities can be done by a Trelleborg engineer.
Corners

Trelleborg can supply prefab-corners for the waterstops in every angle desired as well flat corners or standing corners. A 100% bonding is guaranteed because all constructions are hot-vulcanised in our factory.

A connection between two constructions is always made in straight lengths. The minimum length to make a connection is 20 cm on each side. It is recommended to make connections in the factory. The composition of the construction depends on the type of work and can be established in consultation with Trelleborg. The additional straight connections can be vulcanised on the construction site by Trelleborg engineers.
Appendix 1. Product drawing