Sealing Systems for Immersed Applications

Trelleborg Marine & Infrastructure | 2026

Agenda

About Trelleborg

Sealing Systems for Immersed Tunnel

Engineering Insights of Fehmarn Belt Project

About Trelleborg

Trelleborg Group Facts & figures

~3
SALES IN EUR B

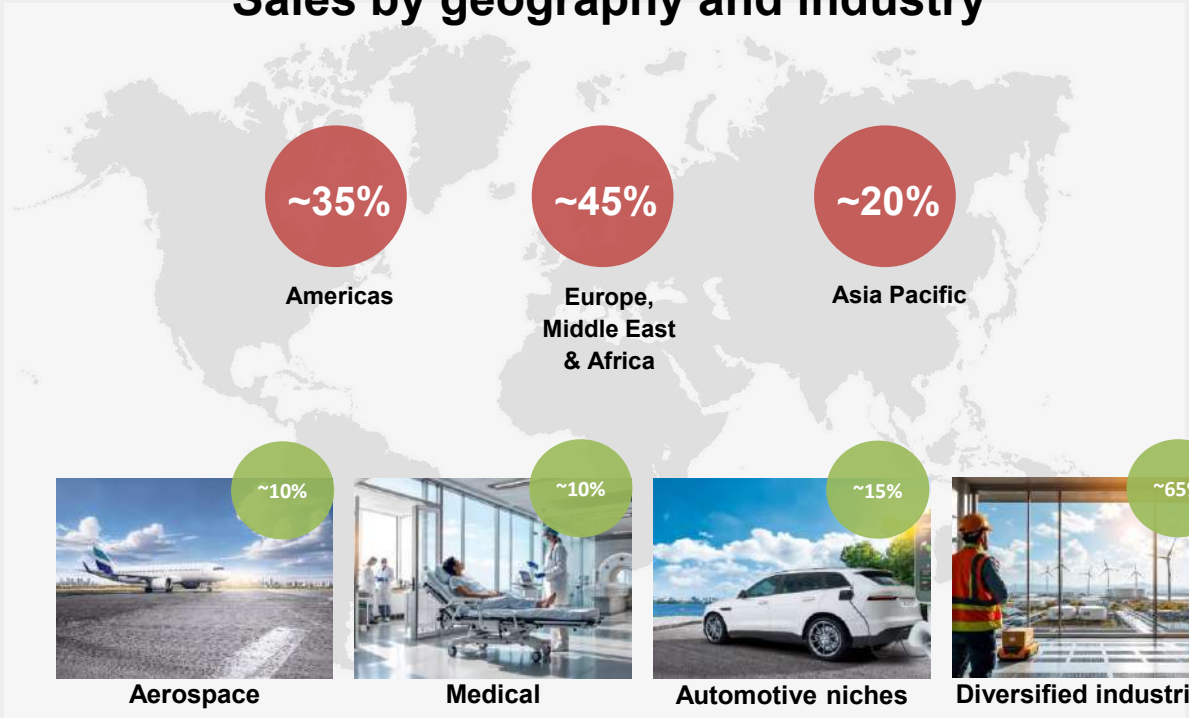
~100
MANUFACTURING SITES

1964
STOCK EXCHANGE LISTING

~35
R&D CENTERS

~40
COUNTRIES WE OPERATE IN

Sales by geography and industry



Sustainable Development

Climate

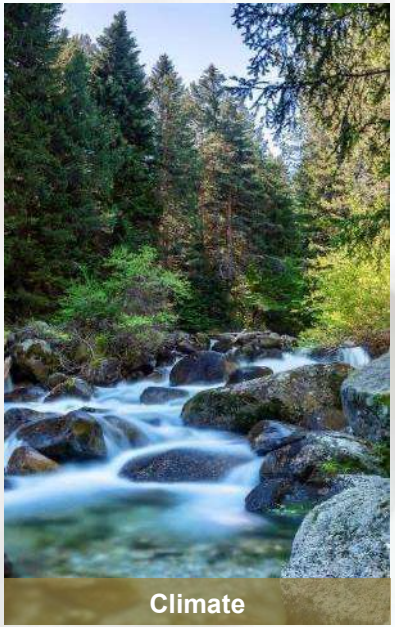
- 50% CO2 reduction by 2030
- 25% waste reduction by 2030

Circularity

- 25% biobased/recycled material in products by 2030

People

- 30% females in higher management by 2030
- 50% female applicants to open positions



TRELLEBORG

PA Infrastructure

An history long more than 140 years

1879 — Inaugurated in Ridderkerk, the Netherlands

1960s — First Immersed tunnel project to use Gina gasket and Omega seal.

1985 — Acquired by Trelleborg

2010s — Expansion towards offshore wind

today — Scaling to global footprint

Applications and Solutions

Immersed tunnels

Tunnel seals
Clamping systems
Installation services

- HZM project - China
- Shenzhong Link - China
- Oresund tunne – Sweden & Denmark
- 2nd Coentunnel - The Netherlands
- Limmerick - Ireland

Offshore Wind

Foundation seals
Airtight seals
Paid consultancy

Gwynt y Mor, DanTysk

Bearings

Jack-up vessel shock pads
Anti vibration mounts
Noise and vibration

- Disney Concert Hall -Los Angeles
- Park House, London

Water Infra

Inflatable seals
Molded seals
Bearings
Omega seals

- Ship lift, Belgium
- Mose flood barrier -Venice Italy

Dredging

- Dredging hose
- Nozzle
- Expansion joints
- Valve seal

- Boskalis, 39 floating hoses
- Palm Islands - Dubai

Special projects

Filter press membranes
Lifting bags
Oil sands hoses
Expansion joints

Qingdao Manufacturing

Position

- Manufacturing unit for all product line
- Rubber R&D center
- China sales office
- Expansion project completed 2021
- Increasing production capacity

Key products

- Fenders
- Infrastructure
- Hoses
- Docking & Mooring

SCN Fenders

Omega Seals

Hoses

AutoMoor

A Benchmark factory

Main product lines:

- Rubber Fenders
- Infrastructure & Fluid handling:
  Rubber hoses, Tunnel seals, offshore wind seals
- Docking & Mooring equipment
- Navigation & piloting products

Certified by DNV and LRQA

ISO 9001:2015

ISO 14001:2015

ISO 45001:2018

ISO 50001:2018

Compliance

Resources

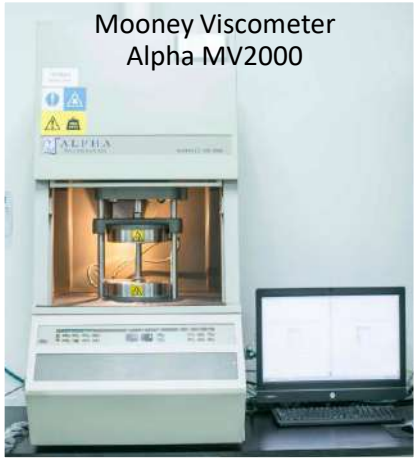
Diversity

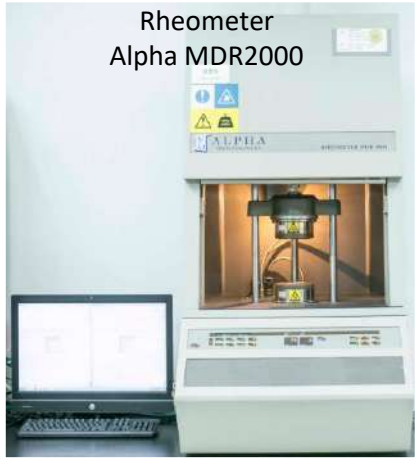
Social Engagement

Advanced Laboratory Instruments

—

For R&D and quality control





Vietnam Manufacturing

Position

- New facility in Phu My 3 Specialized Industrial Park (SIP) of Ba Ria Vung Tau
- Operations due to start in 2026
- Reinforce our production capabilities in the marine fender, marine construction, and infrastructure product lines

Key products

- Marine Construction
- Fenders
- Infrastructure
- Docking & Mooring

Sealing Systems for Immersed Tunnel


TRELLEBORG

Immersed tunnel

Project references dating back to the 1960s

Our reference list includes milestone projects around the world like:

Fehmarn Belt Denmark-Germany
Hong Kong Zhuhai Macau Tunnel
Shenzhong Link
Dalain Bay
2nd Coentunnel, The Netherlands
Limmerick, Ireland
Shatin to Central Hong Kong Tunnel
Scheldetunnel

PROJECT NAME	PROJECT TYPE	REGION	COUNTRY	CITY	YEAR	DIMA	DIMTSA
Maas tunnel Erasmus - line Rotterdam	Railway/metro	Europe	The Netherlands	Rotterdam	1981		
Wijkertunnel - The Netherlands	Road tunnel	Europe	The Netherlands	Amsterdam	1951		
Limfjords tunnel - Denmark	Road tunnel	Europe	Denmark	Aalborg	1969		
IJ-Tunnel - The Netherlands	Road tunnel	Europe	The Netherlands	Amsterdam	1957		
Hollandsche Tunnel - The Netherlands	Road tunnel	Europe	The Netherlands	Binnenstad	1959		
Benelux Tunnel - The Netherlands	Road tunnel	Europe	The Netherlands	Rotterdam	1967		
Vlaketunnel - The Netherlands	Road tunnel	Europe	The Netherlands	Dordrecht	1977		
Drecht tunnel - The Netherlands	Road tunnel	Europe	The Netherlands	Dordrecht	1974		
Kil tunnel - The Netherlands	Road tunnel	Europe	The Netherlands	Zuidelveland	1970		
Hoomtunnel - The Netherlands	Railway/metro	Europe	The Netherlands	Zaanstad	1977		
Metro tunnel - The Netherlands	Railway/metro	Europe	The Netherlands	Rotterdam	1979		05 300-70
Coolhaven tunnel - The Netherlands	Railway/metro	Europe	The Netherlands	Rotterdam	1981	150/100:130-63	
Dubbele tunnel - The Netherlands	Roads tunnel	Europe	The Netherlands	Rotterdam	1980		05 240-20
EMS tunnel - Germany	Roads tunnel	Europe	Germany	Hamburg	1985		05 340-40
Liefkenshoektunnel - Belgium	Roads tunnel	Europe	Belgium	Antwerp	1987	ETS 130-160	ETS 180220, 05 240-40, 05 300-30
Tunnel de Noord - The Netherlands	Roads tunnel	Europe	The Netherlands	Hendrik-Ido-Ambacht	1989	ETS 130-160	05 300-70
Boston Harbour tunnel - USA	Roads tunnel	North America	USA	Boston	1992	ETS 180-220	05 240-40
Piet Hein Tunnel - The Netherlands	Roads tunnel	Europe	The Netherlands	Amsterdam	1993	ETS 130-160	05 240-40
Medway Tunnel - UK	Roads tunnel	Europe	UK	Gillingham	1994	ETS 130-160	05 300-70
Wilson Tunnel - The Netherlands	Roads tunnel	Europe	The Netherlands	Limuiden	1994	ETS 130-160	05 300-70
AFM tunnel - Hong Kong Airport, China	Railway/metro	Asia	China	Hong Kong	1998		05 300-70 FM, DS 130
Jack Lynch, River Lee tunnel - Ireland	Roads tunnel	Europe	Ireland	Cork	1998	ETS 130-160	05 300-70
Oresund tunnel, Denmark-Sweden	Roads tunnel	Europe	Denmark	Copenhagen	1999	ETS 220-260	05 400-220
Metro Tunnel TM-101 - Taiwan	Railway/metro	Asia	Taiwan	Taipeh	1998		05 340-40
Tuas Bay tunnel - Singapore	Maintenance tunnel	Asia	Singapore	Singapore	1997	ETS 130-160	05 300-70
Fort Point Channel Tunnel	Roads tunnel	North America	USA	Boston	1998	ETS 180-220	05 300-70, 05 240-40
2nd Benelux Tunnel - The Netherlands	Roads tunnel	Europe	The Netherlands	Rotterdam	1998		05 360-100
Coland tunnel - The Netherlands	Roads tunnel	Europe	The Netherlands	Rotterdam	1998	ETS 130-160	05 300-70
Muni Metro TF - California, USA	Railway/metro	North America	USA	San Francisco	1999		05 240-40
MRT Chunhsiao line - Taiwan	Railway/metro	Asia	Taiwan	Taipeh	1999		05 130-35, 05 170-30
MRTA Tunnel station - Thailand	Railway/metro	Asia	Thailand	Bangkok	2000		05 240-40, 05 300-70, 05 360-100
Changheng Tunnel - China	Roads tunnel	Asia	China	Ningbo	2000	ETS 130-160	05 240-40
South Boston Piers Transitway - USA	Roads tunnel	North America	USA	Boston	2001	ETS 130-160	05 300-70
Posey/Webster Tube Retrofit - USA	Roads tunnel	North America	USA	Oakland	2001		05 300-70, 05 360-100
Taihe Road tunnel - China	Roads tunnel	Asia	China	Shanghai	2001	ETS 180-220	05 300-70
Warnowquerung tunnel - Germany	Roads tunnel	Europe	Germany	Rostock	2001	ETS 130-160	05 340-40
Sophia railtunnel - The Netherlands	Railway/metro	Europe	The Netherlands	Oud Alblas	2001		05 300-70
HSL tunnel Oude Maas - The Netherlands	Railway/metro	Europe	The Netherlands	Zwijndrecht	2005	ETS 220-260	05 360-100
HSL tunnel Dordtse Kil - The Netherlands	Railway/metro	Europe	The Netherlands	Dordrecht	2002	ETS 220-260	05 360-100
Westerscheldetunnel - The Netherlands	Roads tunnel	Europe	The Netherlands	Terneuzen	2002		05 240-40
BBC building - London, UK	Buildings	Europe	UK	London	2004		05 240-40
Choi Hung Park - Hong Kong	Buildings	Asia	China	Hong Kong	2005		05 240-40
(under construction)							
Dongsha-Zhigang Tunnel (under construction)	Roads tunnel	Asia	China	Guangzhou	-		
Kaihu Tunnel (under construction)	Roads tunnel	Asia	China	Guangzhou	-		
Tanshui Tunnel (under construction)	Roads tunnel	Asia	China	Foshan	-		
Wanghu Rd. Tnl. (under construction)	Roads tunnel	Asia	China	Guangzhou	-		
Shanghai Outing Tunnel	Roads tunnel	Asia	China	Shanghai	-		

Ongoing Projects – Immersed Tunnelling

- Fehmarnbelt Tunnel
  Fehmarn/Lolland – Denmark



- Immersion joints: Gina & Omega
- Sliding gate: Gina/Bearing
- Segment joints: Double injectable waterstop
- Portals & Ramps: Extrusion seals/Calamity gaskets
- Bulkheads: Omega's
- External seals: Extrusion seals
- Closure-joint: TBD

- Scheldetunnel
  Antwerp – Belgium



- Immersion joints: Gina & Omega
- Segment joints: Double injectable waterstop
- Portals & Ramps: Extrusion seals/Calamity gaskets
- External seals: Extrusion seals

- Khor Al Zubair Tunnel
  Bashra - Iraq


- Immersion joints: Gina & Omega
- Segment joints: Double injectable waterstop
- Portals & Ramps: Extrusion seals/Calamity gaskets
- External seals: Extrusion seals

Ongoing Projects – Immersed Tunnelling

- Blankenburg Tunnel (BAAK)
  Rotterdam - Netherlands

- Immersion joints: Gina & Omega
- Segment joints: injectable waterstop
- Portals & Ramps: Extrusion seals/Calamity gaskets
- External seals: Extrusion seals
- Closure-joint: Compression profile

Ongoing Projects – Immersed Tunnelling

Yuzhu

Ruyifang

Dongsha

Mingzhubay

Foshan Tanzhou

Dongguan Hongfu

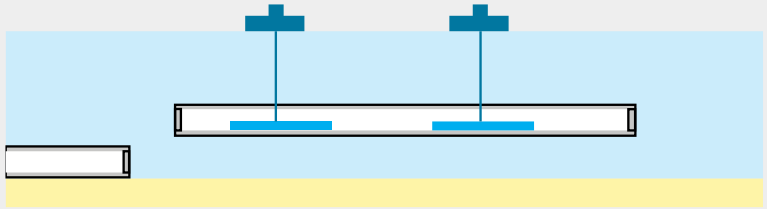
Ongoing Projects – Immersed Tunnelling

Huizhan Xi(Exhibition west)

More projects coming soon

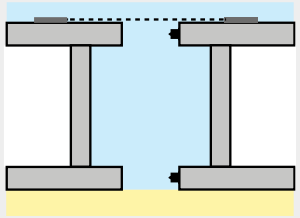
What is an immersed tunnel?

1



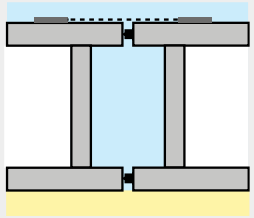
- Float elements to location
- Lower element into trench

2



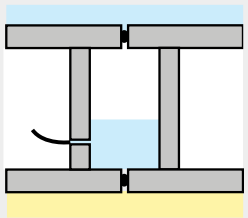
Use jacks to connect

3



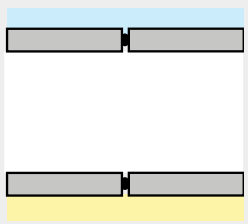
Initial compression seals

4



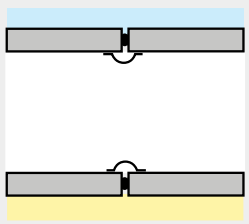
Dewatering element

5



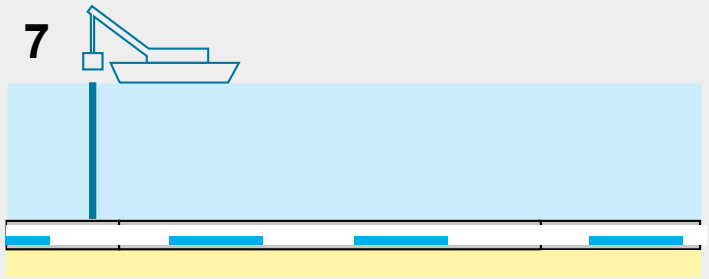
Remove bulkheads

6



Install omega seals

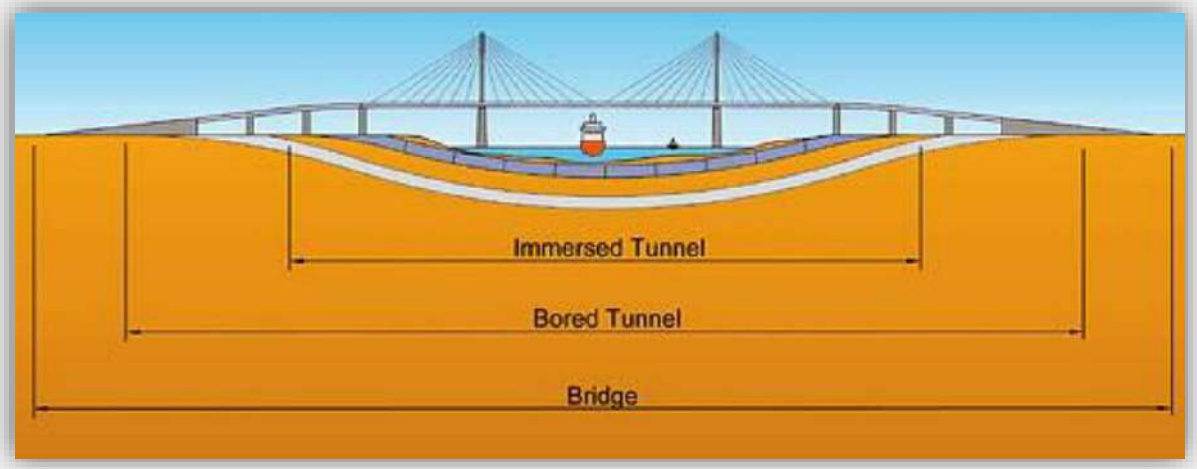
7



Back filling with sand/gravel

Why immersed tunneling

- Suitable for short shallow crossings in soft soils
- Flexible in shape and dimension (can economically suit multiple lanes)
- Suitable for short crossings
- Land reclamation opportunities

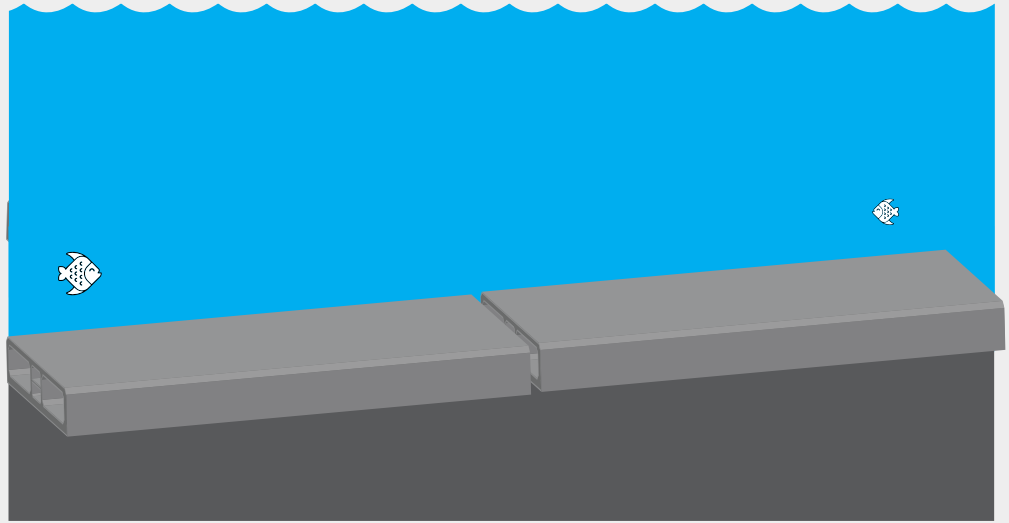


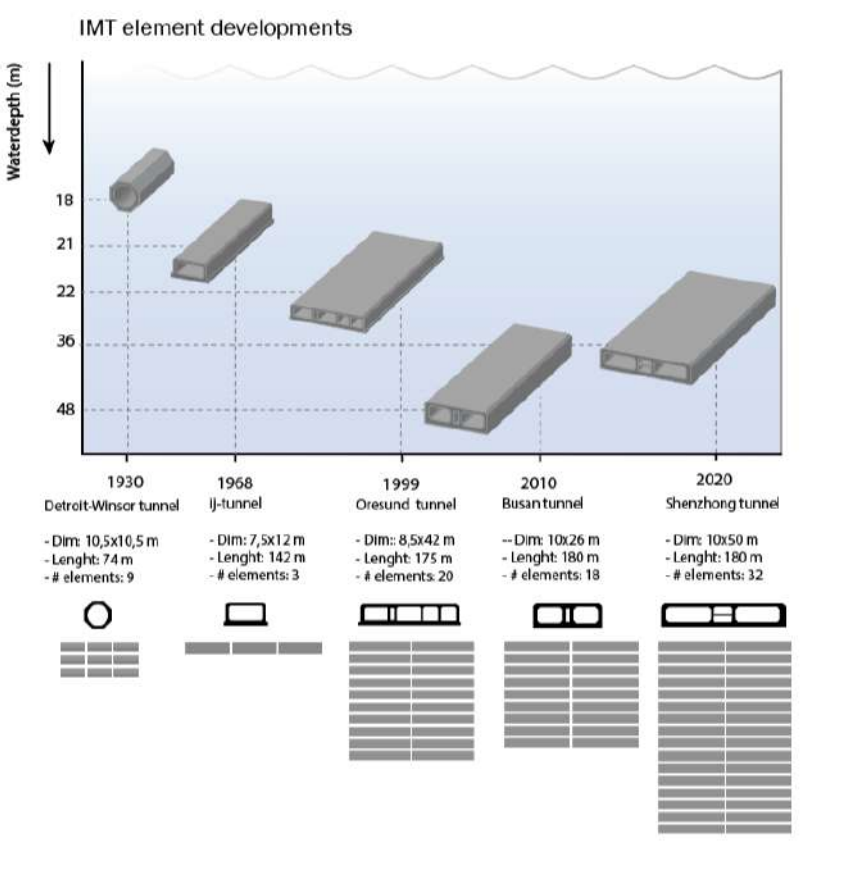
Immersed tunnel (HZMB CCCC)

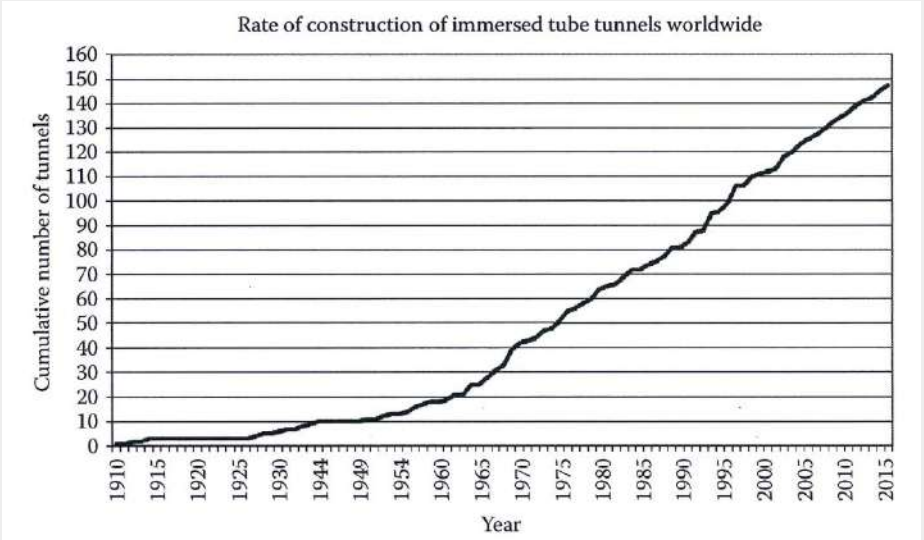
Immersed tunnel (HZMB CCCC)

IMT challenges/ joint

Seismic
Temperature
Settlement
Waterpressure
Lifetime







- **Steady increase in immersed tunnels**
- **Tendency of getting longer**
- **Major expansion in China**

Product portfolio

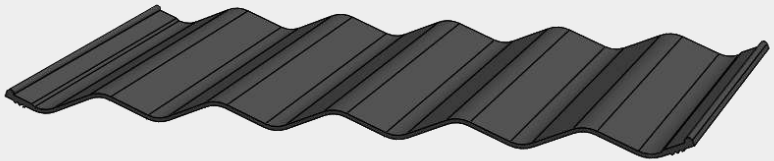
Trelleborg Immersed Tunnel Sealing Portfolio

Omega Seal

Waterstops

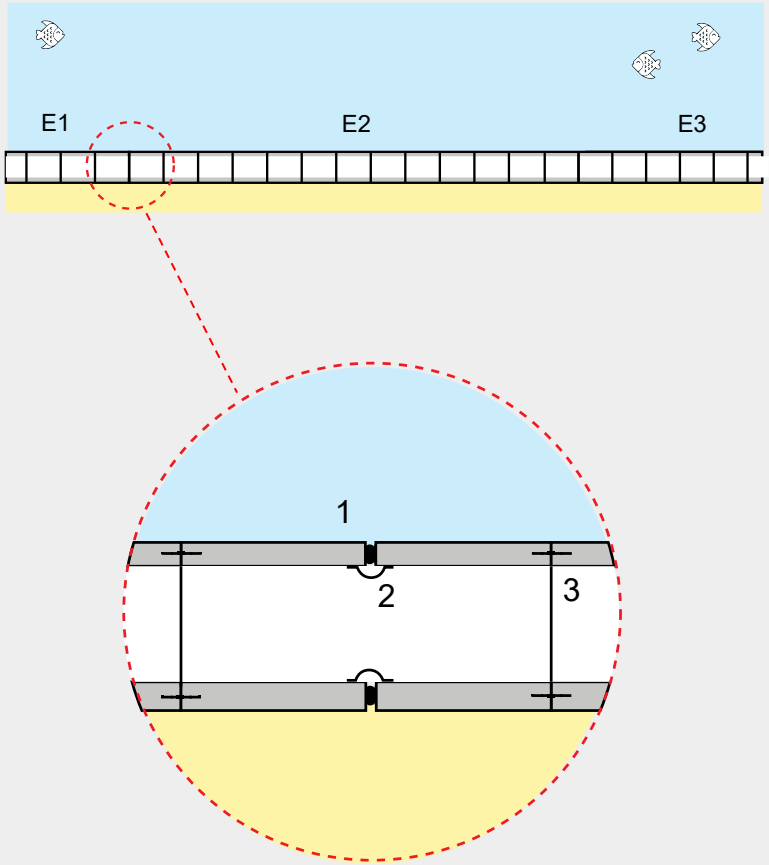
Gina Gasket

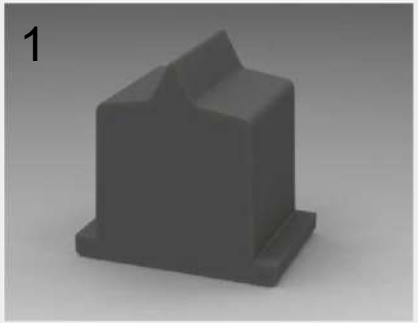
Inflatable Seal



M Seal

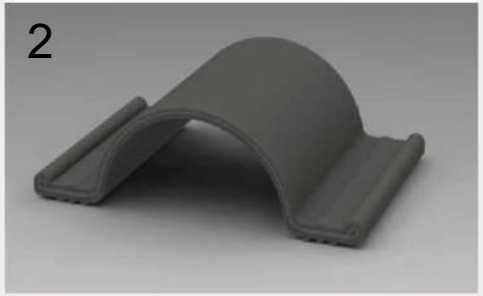
Lip Seal





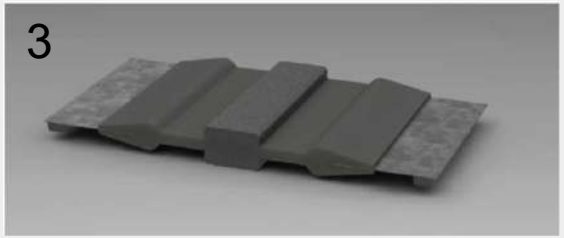
Gina

Primary seal
Immersion joint



Omega

Secondary seal
Immersion joint

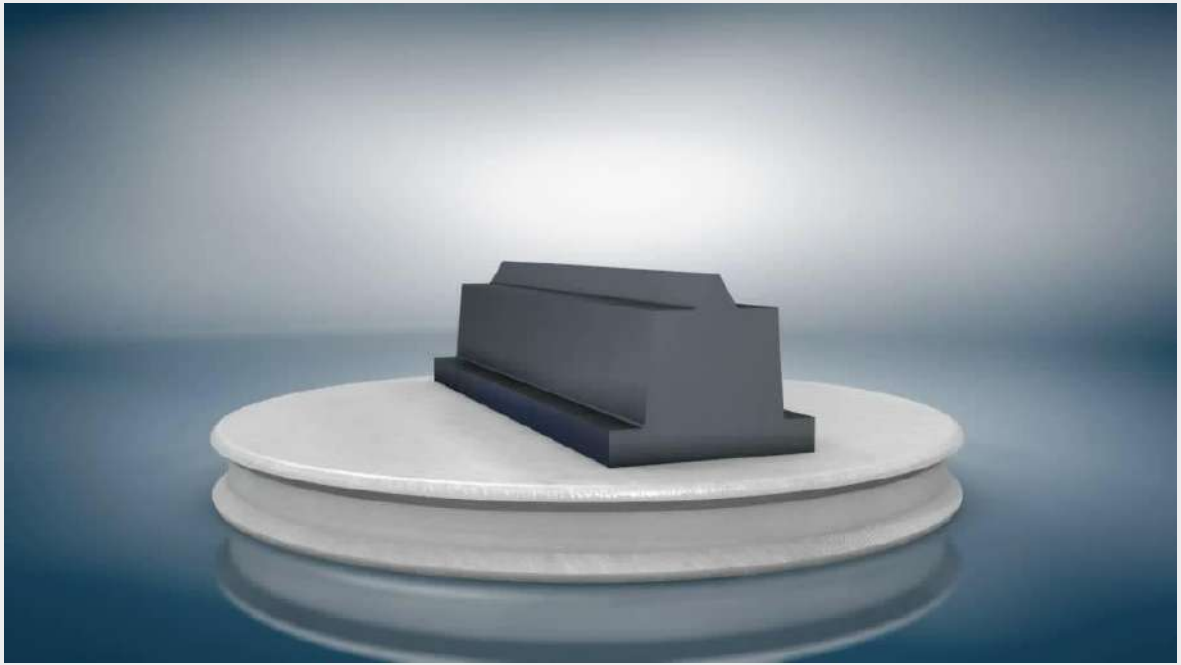


Waterstop

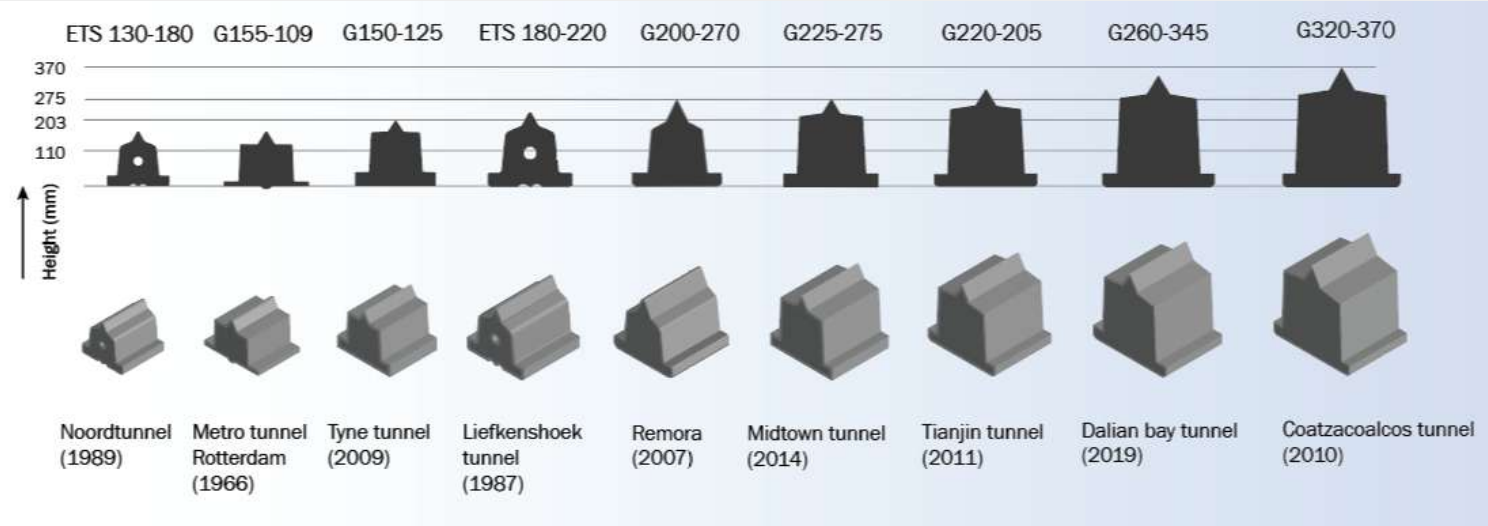
Cast-in seal
Segment joint

Gina Gasket

Gina gasket – product overview



Gina development



Gina gasket production

Applications:

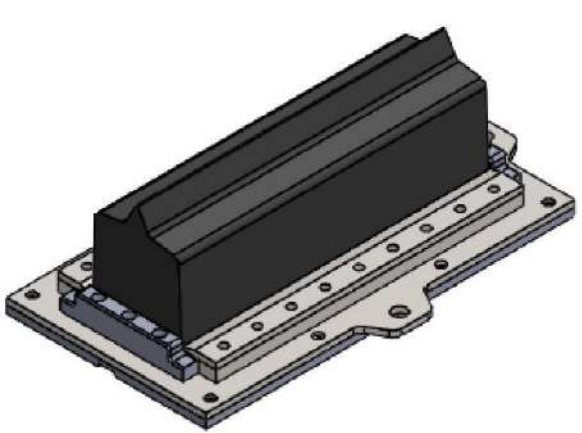
Immersion joint - large compression and shear movements

Cut & Cover joint – large compression and shear movements

Force compression test

This test is executed to validate the seals stiffness to comply to project specification

Shear testing



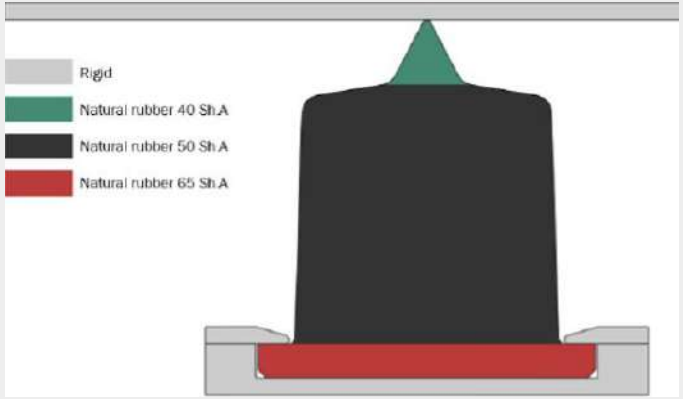
This test is executed to investigate the shear stiffness of the Gina gasket. Shear might take place in the construction during settlement of ground

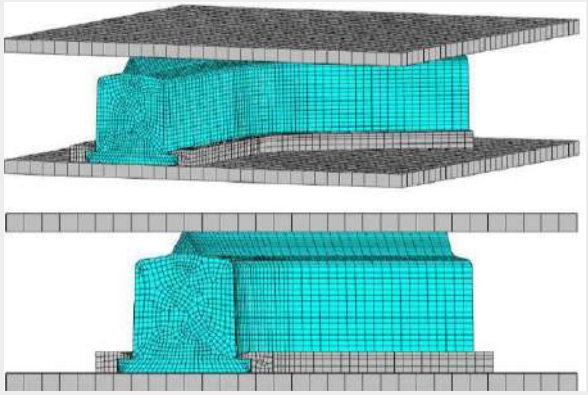
Waterpressure test

This test validates the Gina gasket regarding the project waterpressure. The Gina seal is often tested until failure to investigate its maximum capacities

Figure 9. Failure mode at 80 mm compression at 5.8 bar

FEA capabilities





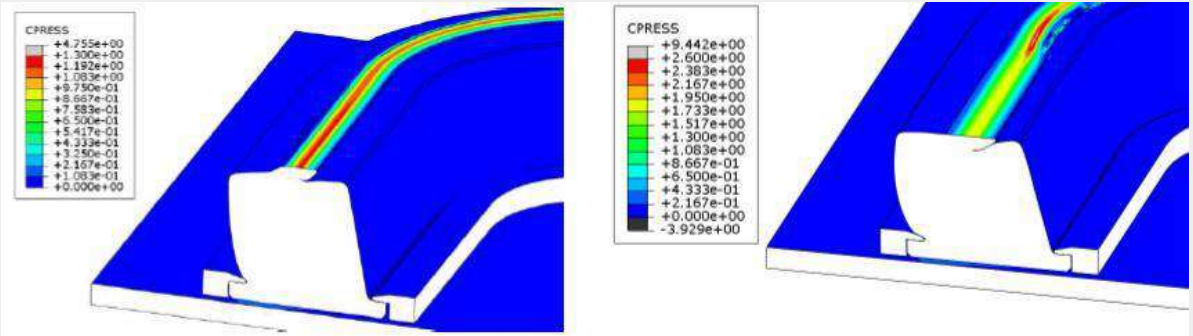


Figure 15. Load case A - contact pressure [MPa] at 1.8 [bar] pressure(Left), Load case D - contact pressure [MPa] at 3.5 [bar] pressure (Right)

Finite element analysis is used to determine gina gasket **displacement**, **contact pressure**, **internal stress** and **strain** within the material

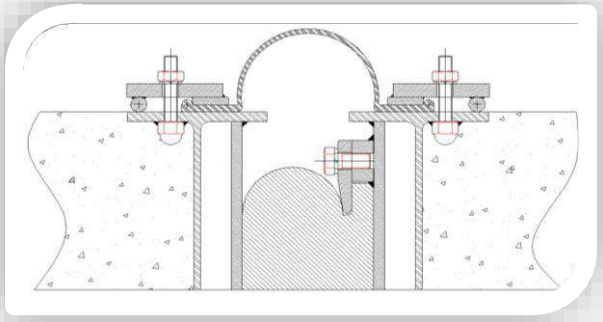
Omega seal

Omega seal – product overview

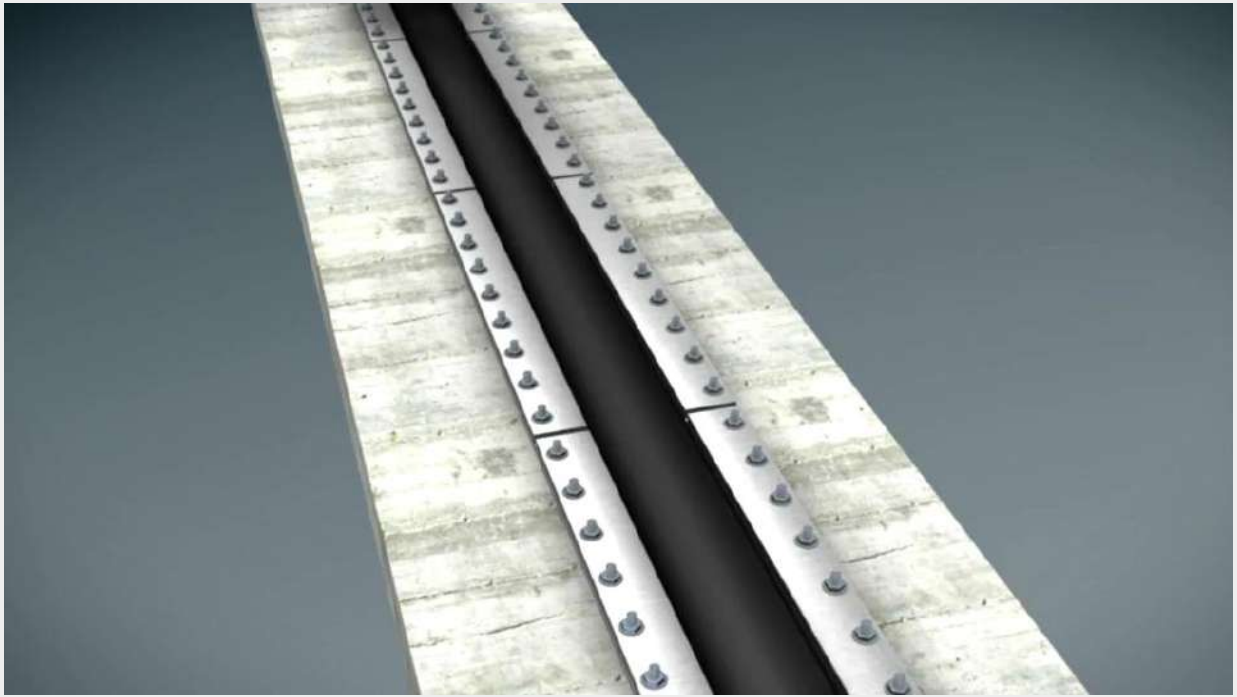
Omega seal

Applications:

- Immersion joint – Dilatation joint, large movements
- Segment joint – Secondary sealing besides waterstop
- Bored tunnel/station – Dilatation joint, large movements
- Cut & Cover – Dilatation joint, large movements



Omega gasket



Omega gasket

Omega seal installation

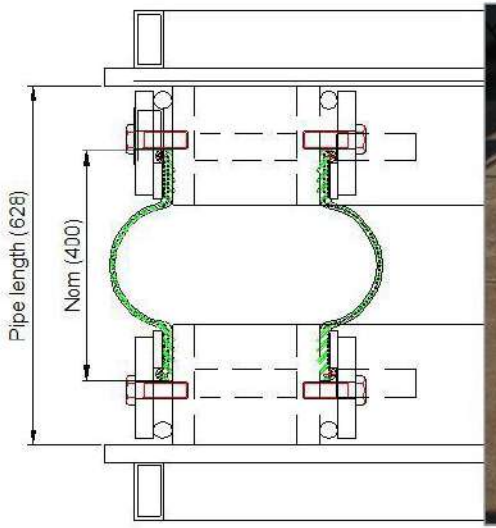
Omega seal with integrated valve

Vulkanised valve system within Omega seal has the following added values:

- Direct in-situ testing of Gina/omega combination
- Future inspection in possible due to inlet

Omega seal waterpressure test

Test setup used to validate Omega seals capacity by doing watertightness test and optimizing clamping strip and flange design



3) Results & observations

The Omega Seal has passed the test successfully until the combination of 20 mm opening above nominal and 9 bar, see table 1.

At an opening of 30 mm above the nominal or more a pressure drop occurs after some hours. Due to the wide opening in combination with the pressure the pull force on the flange becomes higher and higher. Finally the flange will slide from under its clamp, the volume of the omega arc increases and with the same amount of water it results in a pressure drop. This process stops when the pull force is equal to the friction. The pressure stays stable at a certain level. When the pressure is increased after a pressure drop to the intended level the flange will continue to slip and finally it is pulled out completely with leakage as a result.

Table 1: Omega type: 400-100 test results. Duration of all tests is a minimum of 48 hours.

Pressure / Omega	5 Bar	7,5 Bar	9 Bar
Nom – 90	V Passed	V Passed	V Passed
Nom – 60	V Passed	V Passed	V Passed
Nom – 30	V Passed	V Passed	V Passed
Nom (Width = 400 mm)	V Passed	V Passed	V Passed
Nom + 20	V Passed	V Passed	V Passed
Nom + 30	V Passed	Max 7 Bar	1 Hour
Nom + 40	V Passed	Max 6 Bar	X
Nom + 50	V Passed	X	X

4) Conclusions & recommendations

The Omega Seal is strong enough to resist 9 bar water pressure in combination with an opening of nominal plus 20 mm or smaller for 48 hours.

At certain combinations of opening, above nominal plus 20 mm, and pressure the flange of the omega seal tend to slip from under the clamping strip.

Under all test conditions the Omega Seal did not fail on its plies or rubber body. Also the vulcanized corners and joints did not fail or showed a sign of abnormal deformation.

It is recommended to prevent an opening of the omega seal larger than nominal opening plus 20 mm. This is feasible by installing the omega seal with a pre-compression.

In order to reduce the chance of slip of the omega flange it is recommended to install with the highest possible torque. As usual please retighten the bolts at least 1 day later to compensate the relaxation effect of the rubber and later if possible.

TB ED 2007-160a
Trelleborg Baldor BV
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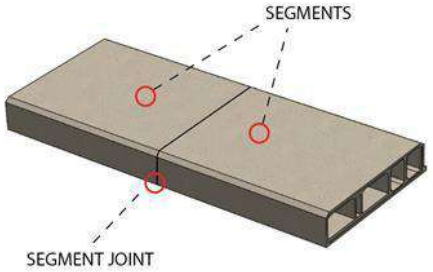
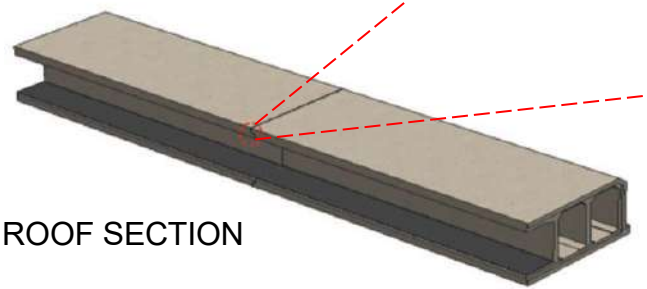
Segmental joints

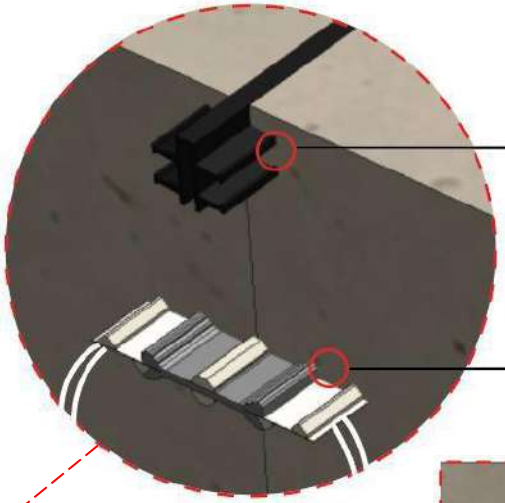
SEGMENT JOINTS, CUT&COVER

In both the immersed elements as in cut&cover elements, segment joints can be found. These concrete structures contain a multitude of adjacent concrete parts that are poured onto each other. The following seals are implemented in order to keep these segments watertight.



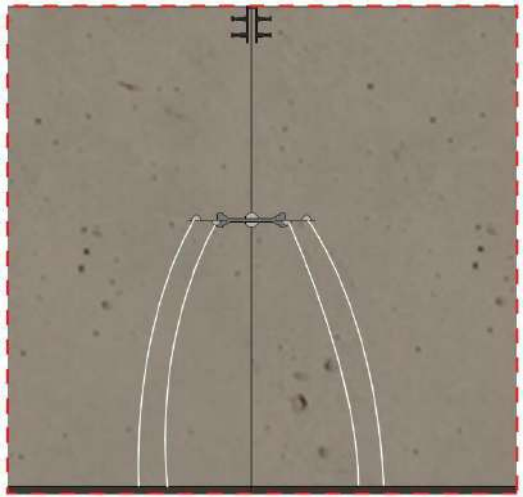


ROOF SECTION

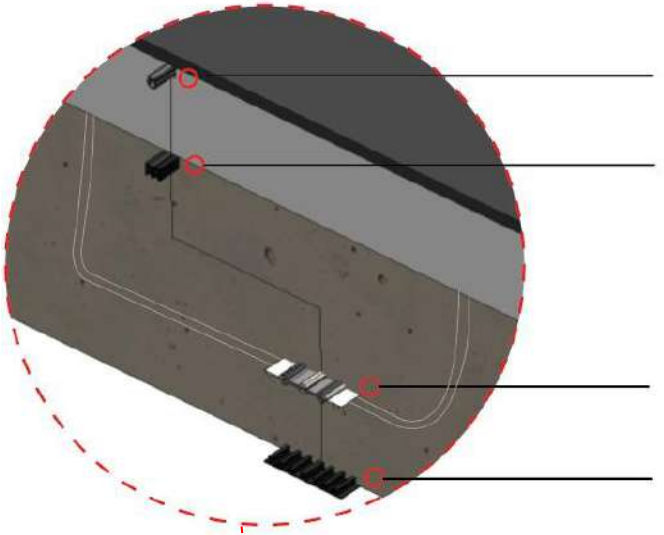


VFV 10/3 SEAL
This seal is casted in concrete and protects the waterstop from the outside environment

NEW DOUBLE INJECTABLE WATERSTOP
This multiple injectable waterstop prevents water ingress within the adjacent concrete segments



SEGMENT JOINTS, CUT&COVER

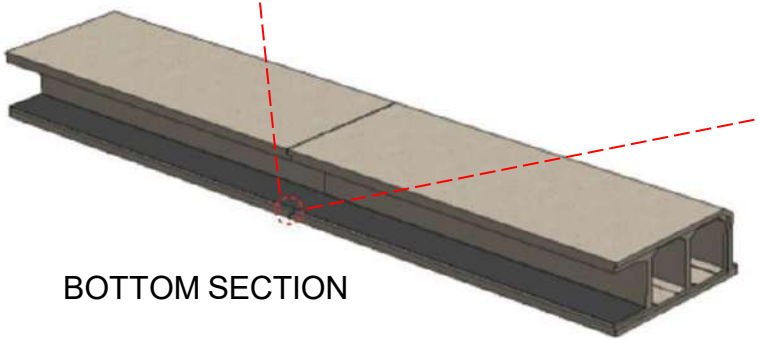


CALAMITY ECS 45/44CJ SEAL
This seal has as main pupose to prevent oil like materials from entering the segment joint

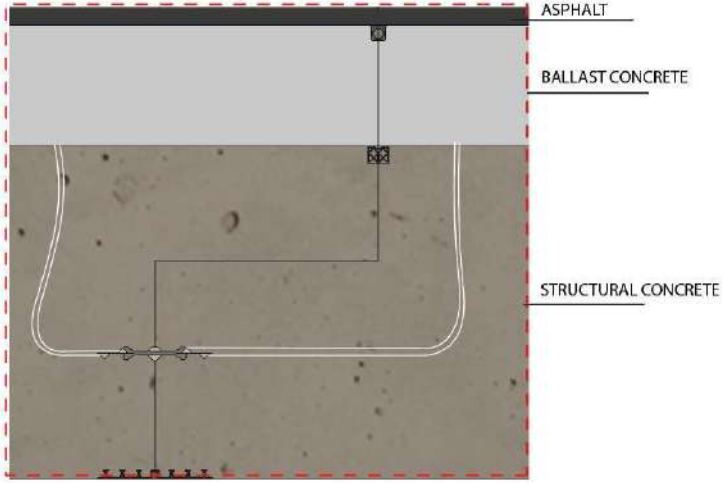
ACME 20A/30V SEAL
This compression seal is casted in concrete and protects the waterstop from the outside environment

NEW DOUBLE INJECTABLE WATERSTOP
This multiple injectable waterstop prevents water ingress within the adjacent concrete segments

AM 350 SEAL
This seal functions to protect the waterstop from ground entering the segment joint



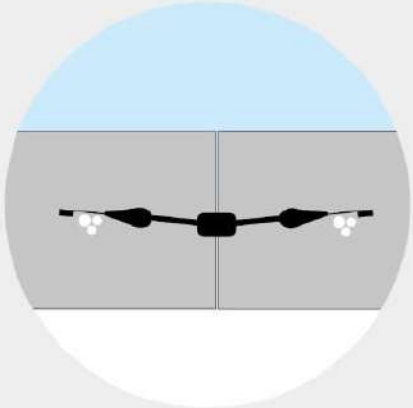
BOTTOM SECTION



Waterstops

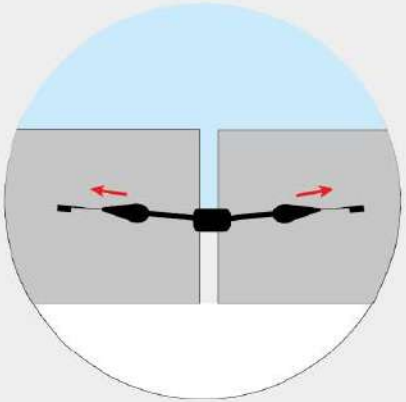
The waterstop is a casted-in rubber profile that can withstrand large deformation and waterpressure

Challenges within waterstops



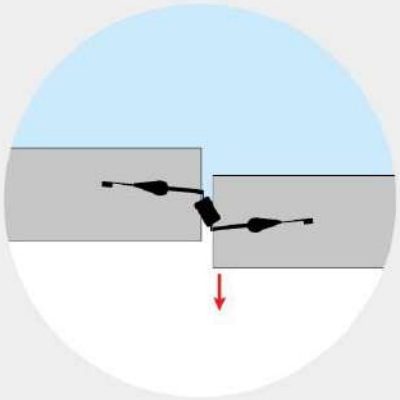
Transport & installation

Air entrapment
Difficulty of installation
Damage during transport
Time consuming injection



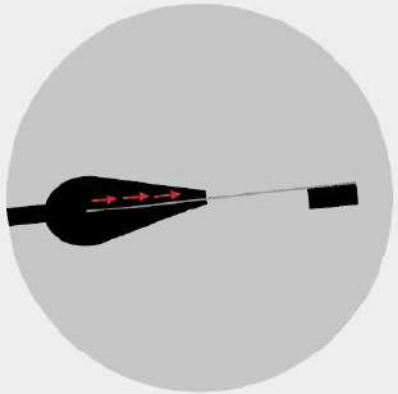
Concrete expansion & shrinkage

Elongation at break



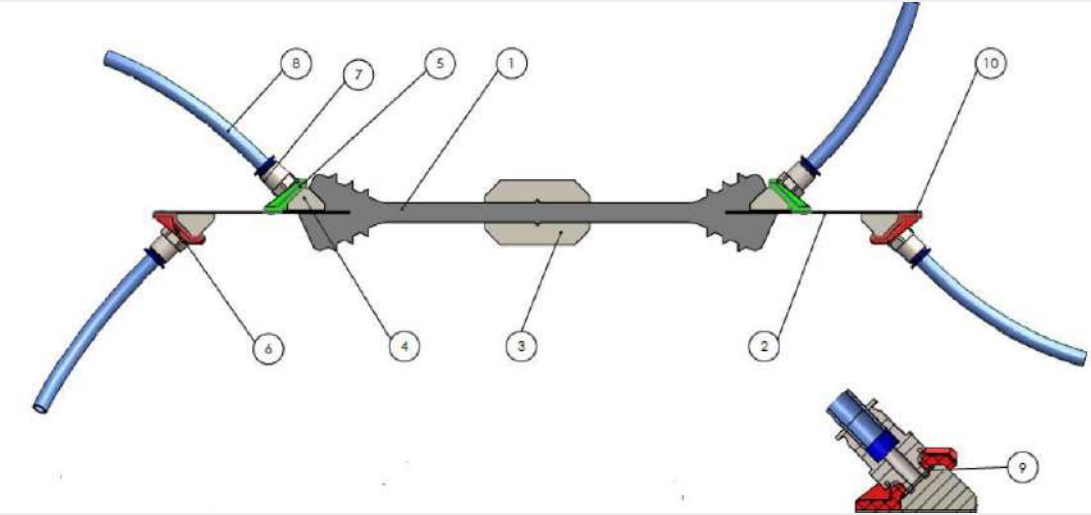
Large settlements

Tearing of material



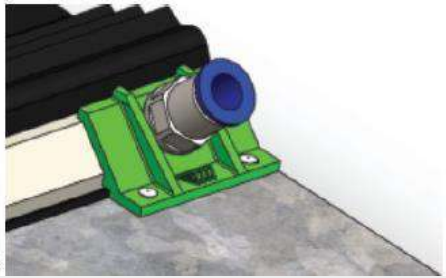
Metal rubber bonding

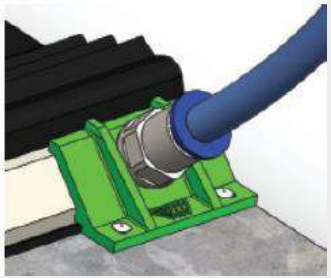
New Waterstop (W29 series)



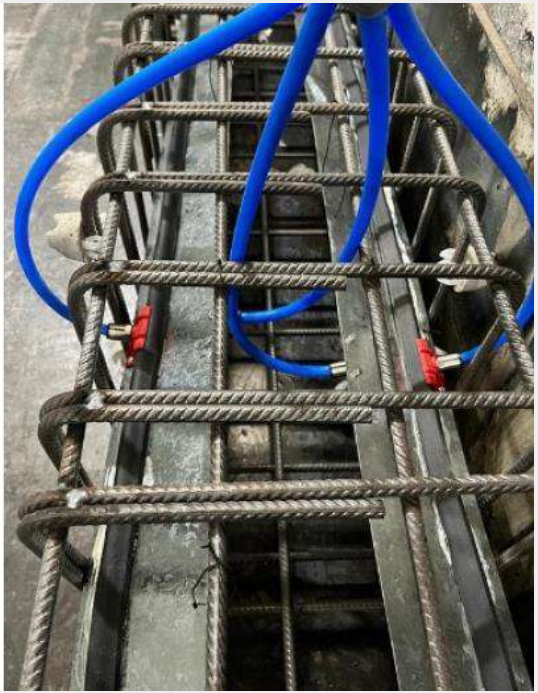
The **W29 waterstop** is Trelleborg newest waterstop with the following advantages:

- Flexible plug-and-play hoses for reliable and easy installation
- Longer epoxy distance of **6 meter**





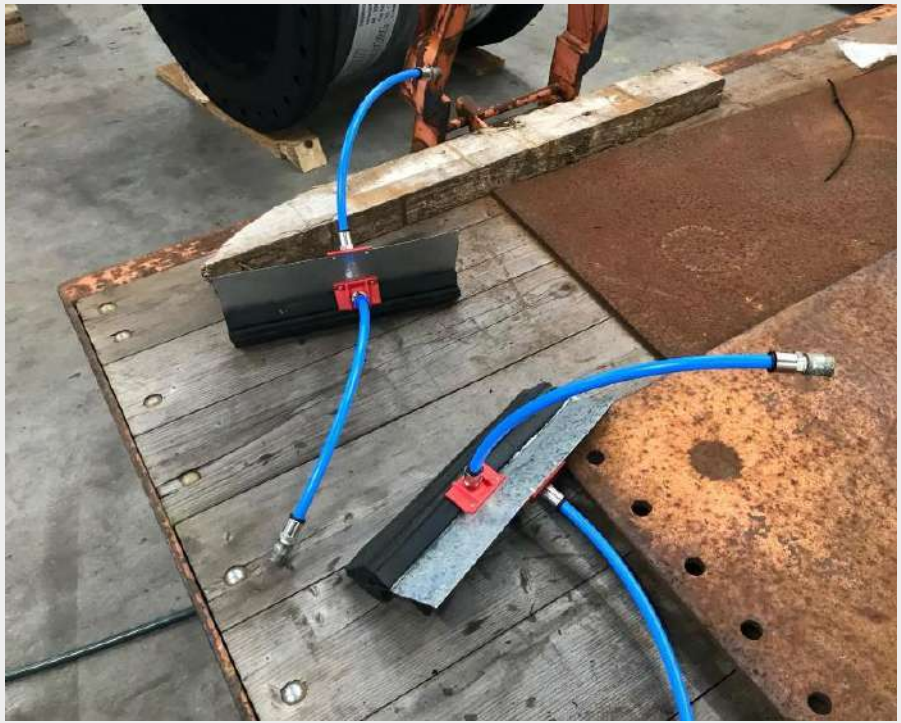
Injection system testing

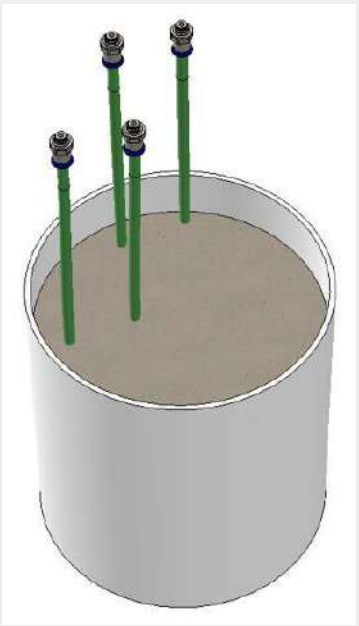


Concrete beam injection

The test validates that the epoxy distance is at least 6 meters from injection point

Concete test - 4 bar





A pressure vessel is used to simulate 4 bars of concrete pressure

Waterstop water tightness test

INTRODUCTION
In accordance with the technical spec 330-D-SSA-007_rev0 a cycle test has to be done with the waterstops types W9Ui and W9CUi. This document contains our proposal of the test method.

TEST EQUIPMENT
The product that will be tested is the Waterstop types W9Ui and W9CUi, see appendix.

The test rig is built up with a Waterstop, W9Ui or W9Cui, and two concrete blocks. The waterstop is vulcanised as a closed ring with diameter 500 mm. This closed ring is casted in two concrete blocks which can move from each other in axial direction. For making 200 cycles, an electric steered valve and electric waterpump is used. Each cycle starts with an axial opening of 0 mm and a waterpressure of 0 bar. One cycle takes at about 1,5 minutes. A mechanical counter shows quantity of cycles which has been done.

Figure left: Testequipment and concrete blocks
Figure right: Waterstop ring casted only in lower concrete block yet

TEST METHOD
The Waterstops W9Ui and W9CUi will be tested by pumping them up in 200 cycles continually to the same waterpressure. The waterstop W9Ui will be deformed until 30 mm opening, the waterstop W9CUi will be deformed until 45 mm opening, with respect to the nominal position. The water pressure will be increased to 5 bar.

RESULTS
The water tightness and the water pressure will be checked during the test.

Table: Result of cycle test W9Ui with an actual waterpressure of 5 bar and 1,5 times the actual waterpressure is 7,5 bar

	Axial opening	30 mm / 5 bar	21 mm / 7,5 bar
W9Ui	Result	Passed / Failed	Passed / Failed

Table: Result of cycle test W9CUi with an actual waterpressure of 5 bar and 1,5 times the actual waterpressure is 7,5 bar

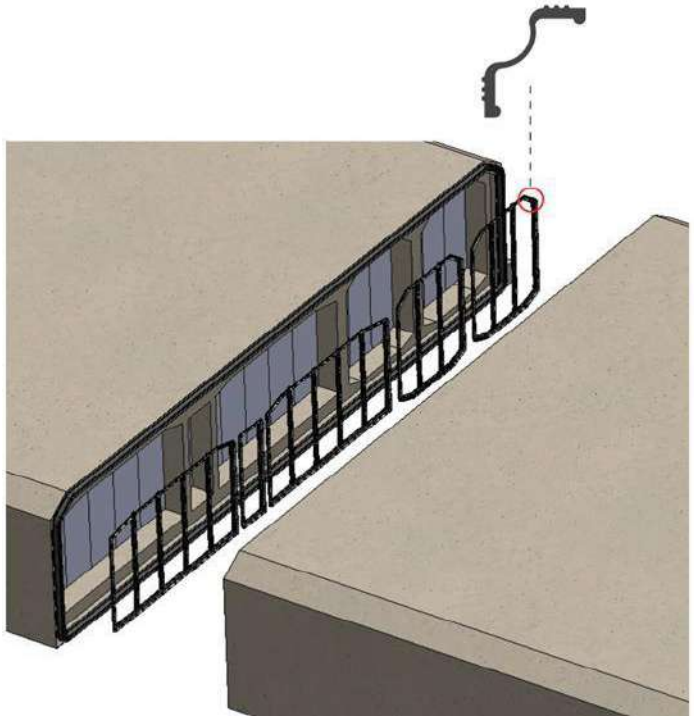
	Axial opening	45 mm / 5 bar	51 mm / 7,5 bar
W9CUi	Result	Passed / Failed	Passed / Failed

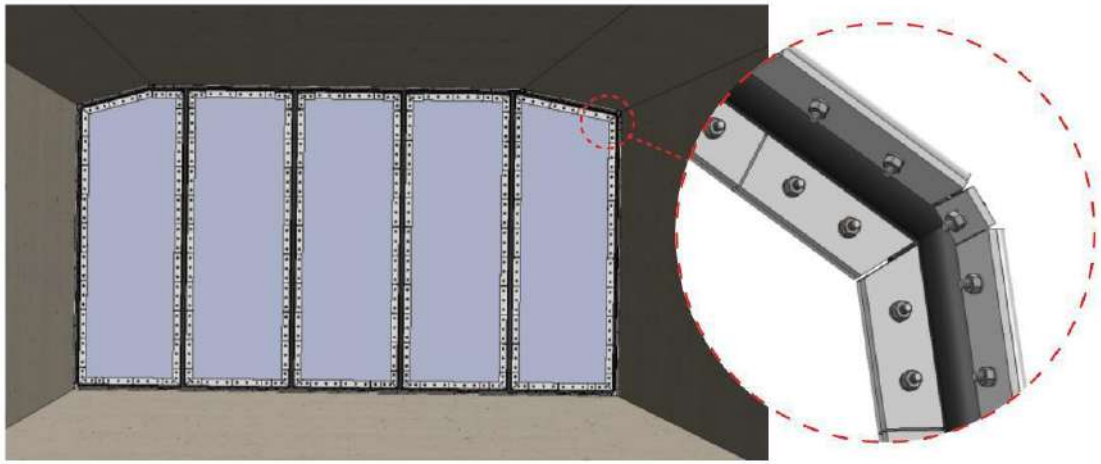
Succes of seal also depends installation and casting conditions.

Bulkhead seal

BULKHEAD

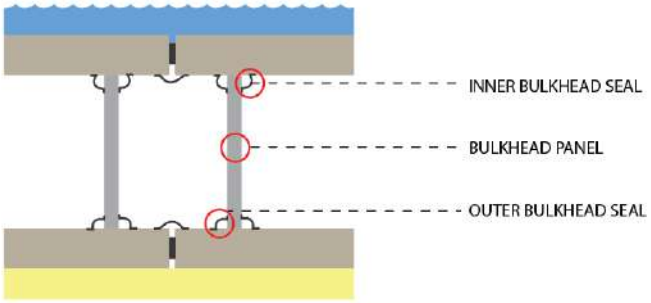
Bulkhead panels are used to prevent water from entering the tunnel elements during immersion. These panels will be removed after the immersion joints are activated





BULKHEAD SEAL

Membrane frame that makes the reusable bulkhead panels watertight. Each of the 5 tunnel galleries are sealed with a bulkhead seal.



CLAMPING SYSTEM

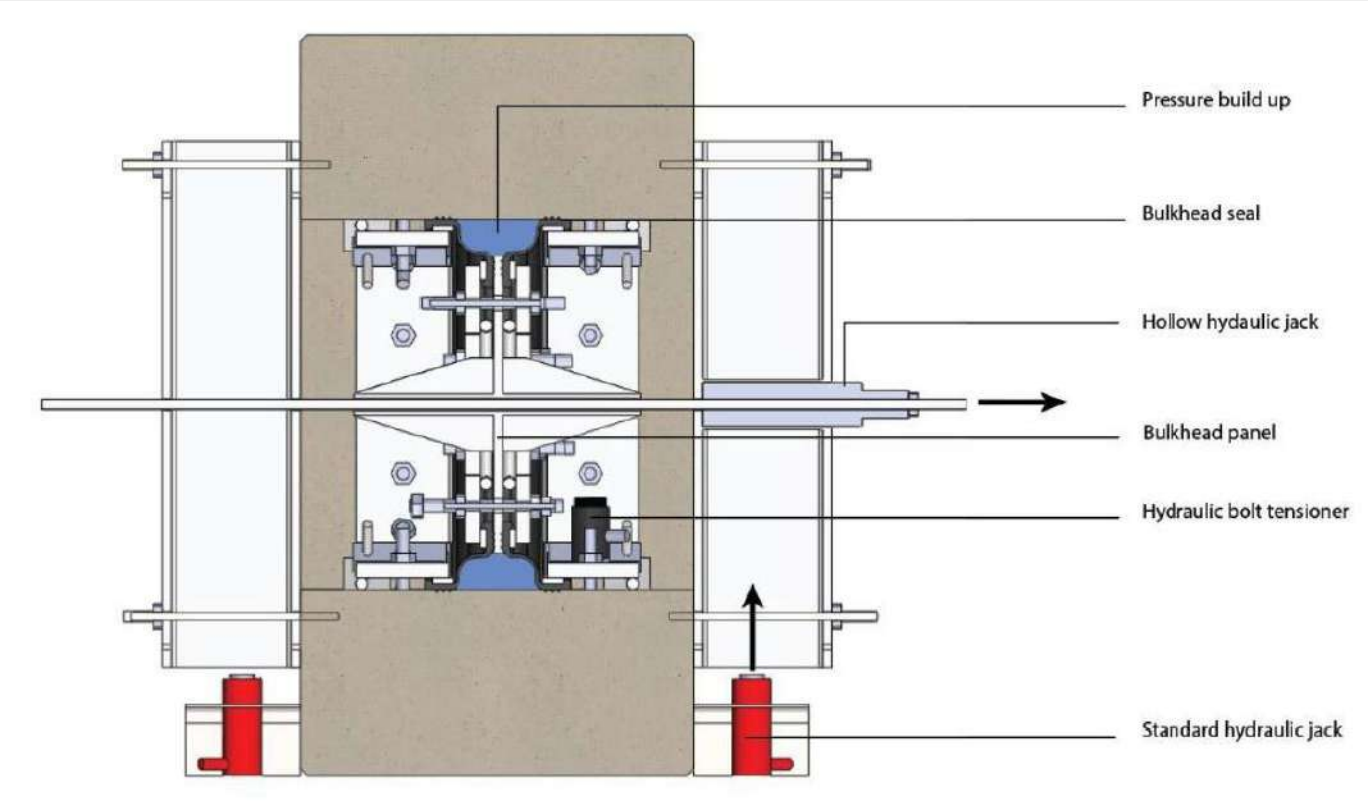
The steel clamping system fixates the bulkhead frames into position. Trelleborg is able to design and manufacture these steel components alongside the bulkhead frames in order to create a fully integrated water defence system.

Location of the bulkhead seal

Bulkhead seal watertightness test

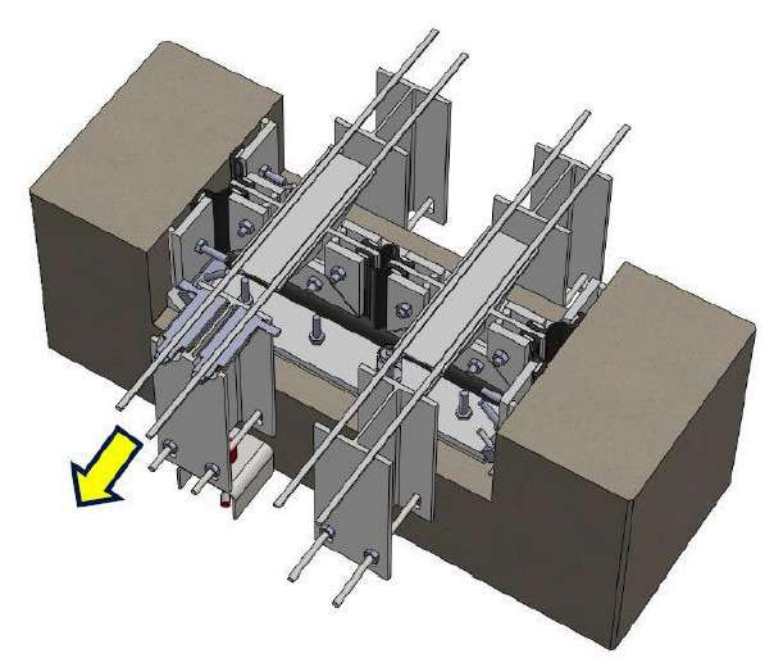
The test simulates bulkhead-door movement by using horizonal and vertical hydraulic jacking systems. Water pressure is added behind the seal to simulate project waterpressure

Test setup

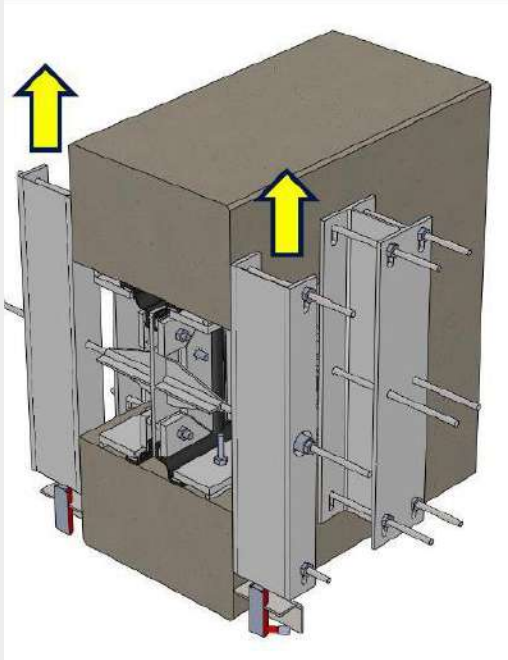

Pressure build up
Bulkhead seal
Hollow hydaulic jack
Bulkhead panel
Hydraulic bolt tensioner
Standard hydraulic jack

Moving bulkhead panels

Use hollow jacks to generate axial displacement to move panel



Use jacks to generate vertical displacement to move panel



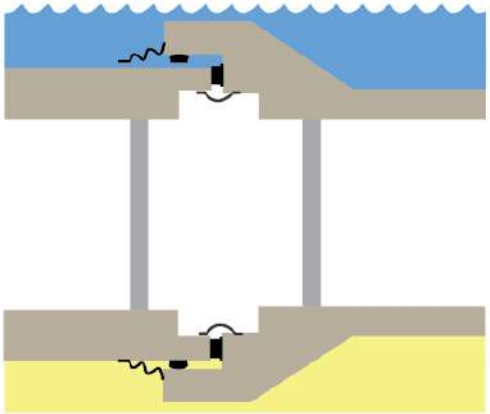
Bulkhead seal in production

Bulkhead seal as installed in Fehmarnbelt tunnel

Closure joint

Type of closure joints

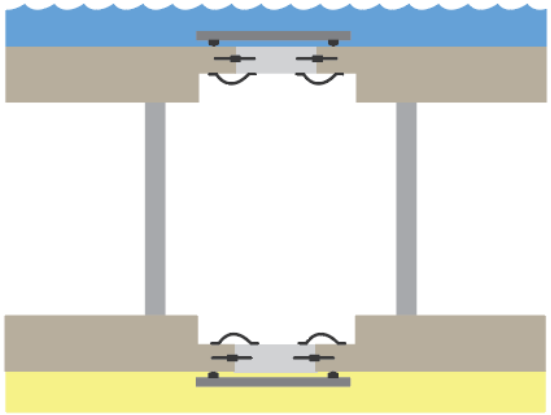
Closure joint - Sleeve joint design



Inlcudes seals:

- M-seal
- Gina seal
- Omega seal
- Inflatable seal (PS-seal)
- Lipseal

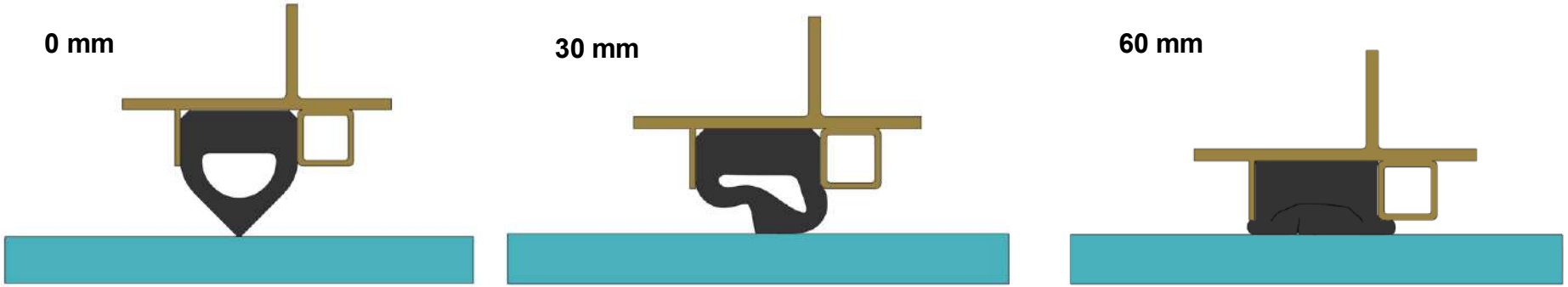
Closure joint - Panel joint design

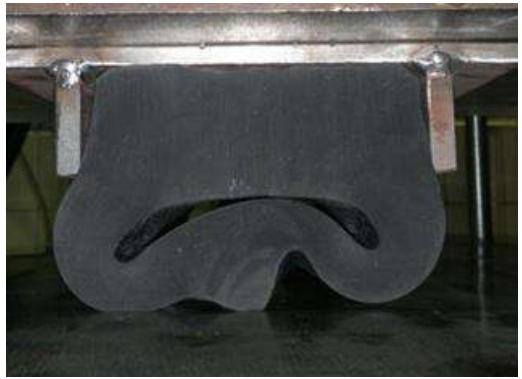


Includes seals:

- ECS 125/135 seal
- Waterstop
- Omega seal

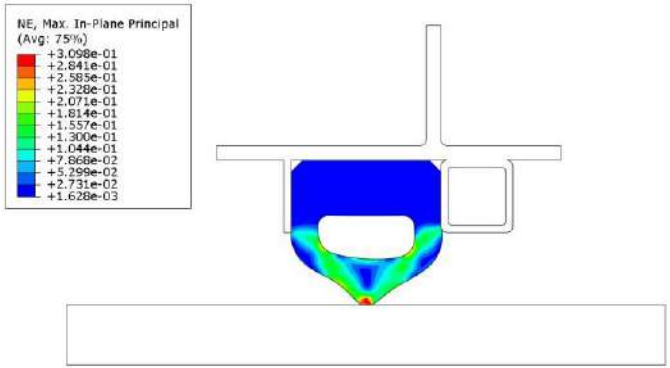
Closure join – panel joint design



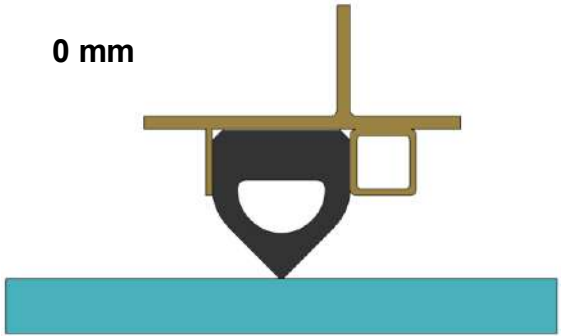


FEA of closure joint

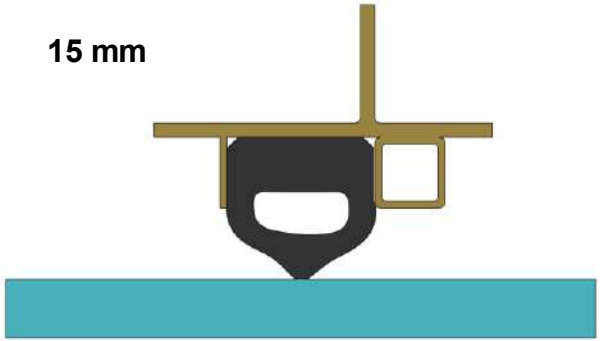
Finite element analysis is used to determine closure joint seals **displacement**, **contact pressure**, **internal stress** and **strain** within the material



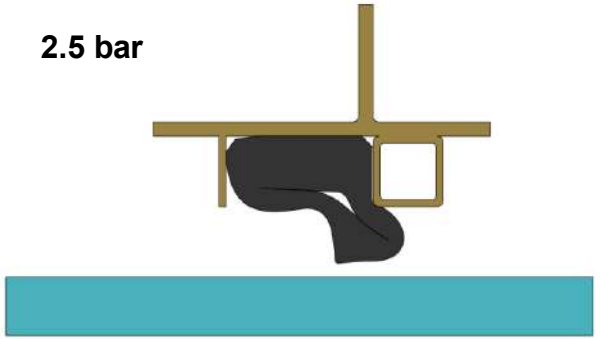
0 mm



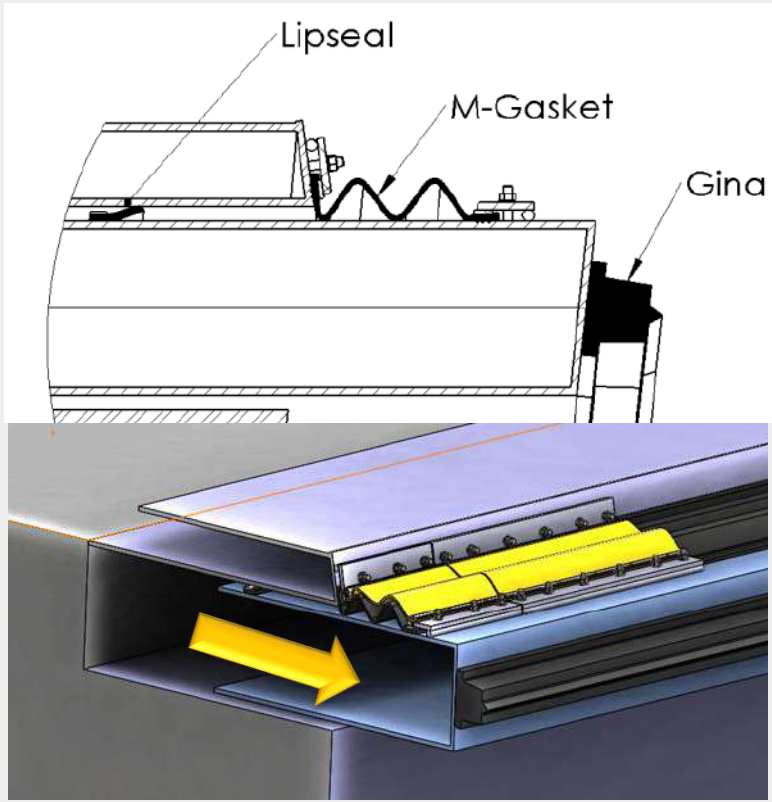
15 mm



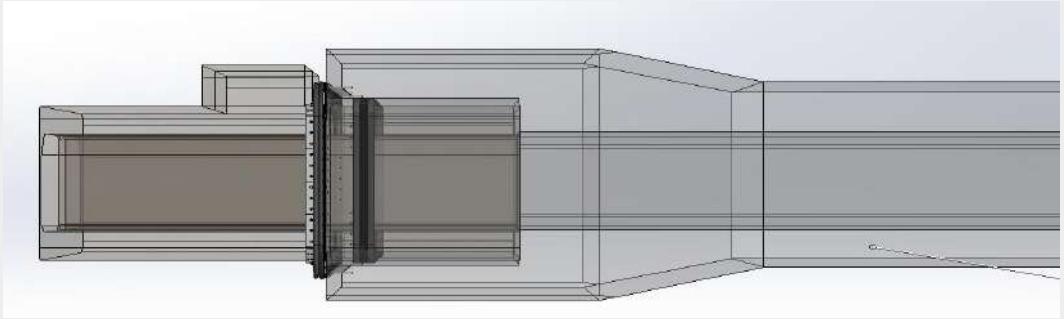
2.5 bar

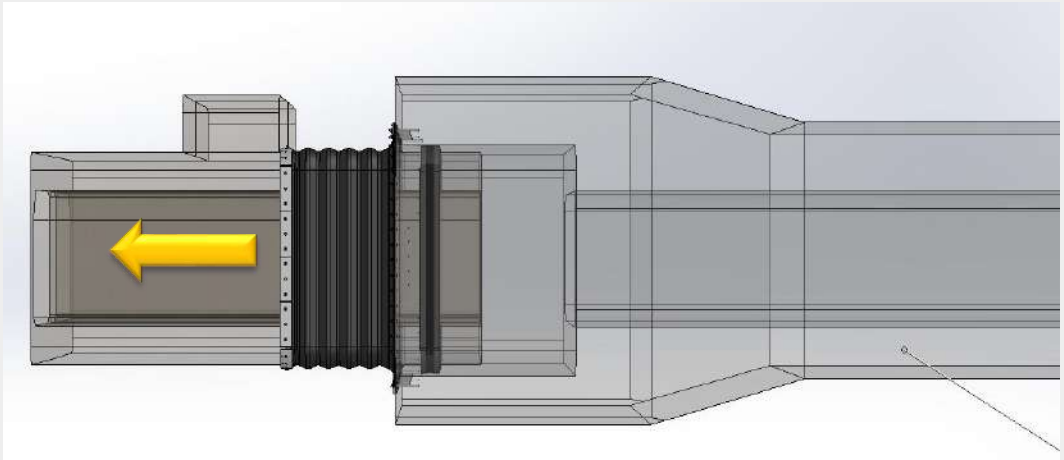


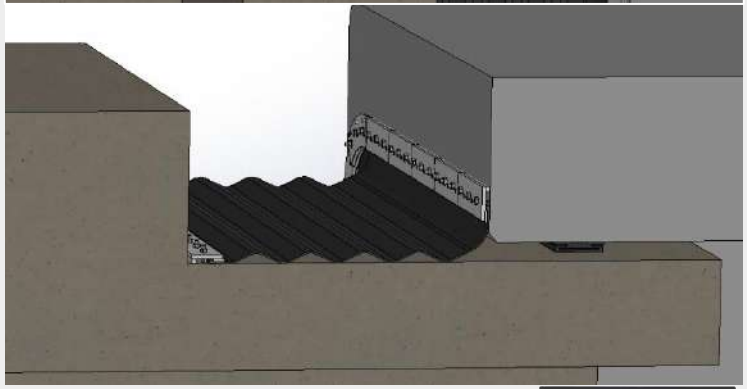
Wedge joint design - HZMB closure joint element



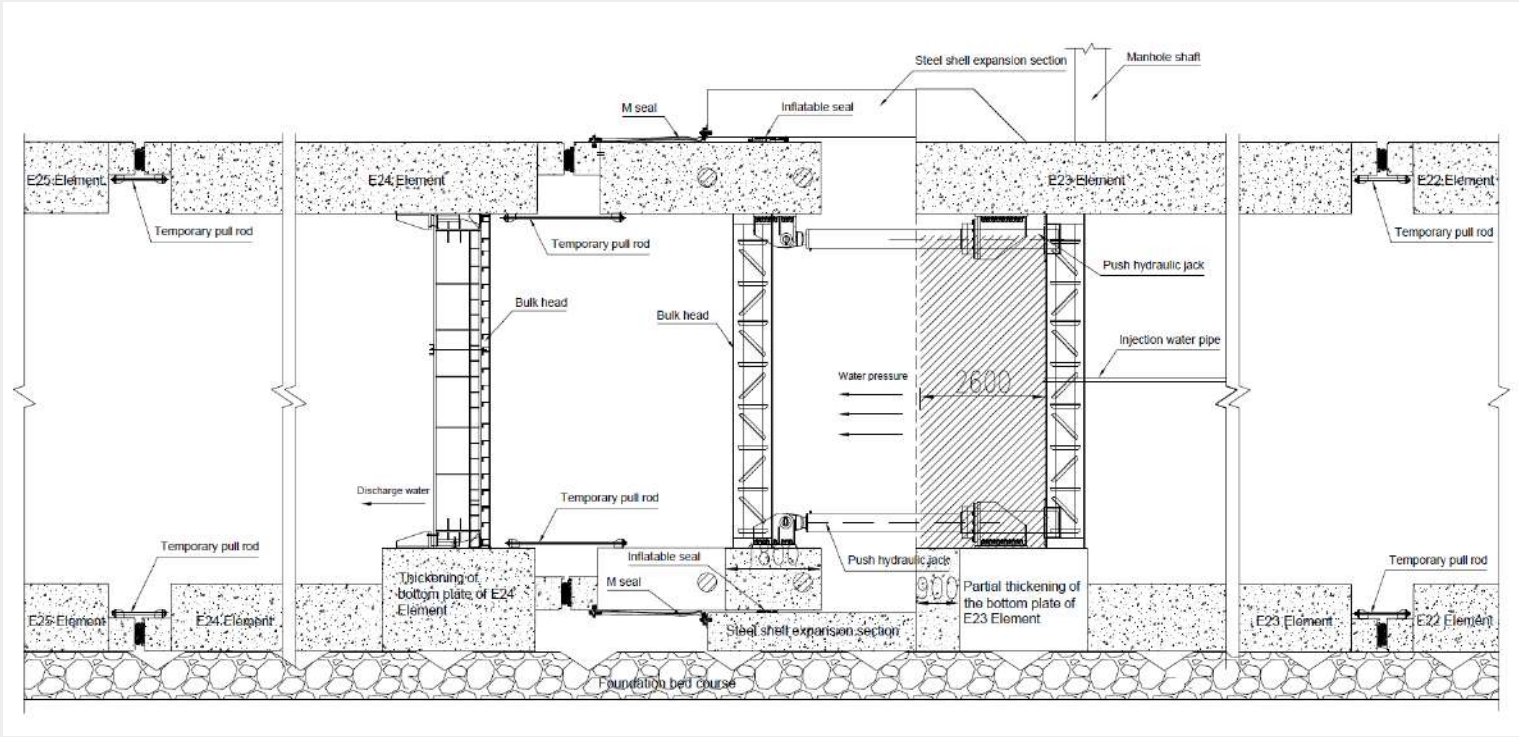
Cut&Cover jacking-out sleeve joint design – Dalian Bay closure joint element







Undersea jacking-out sleeve design – Shenzhong link closure joint element



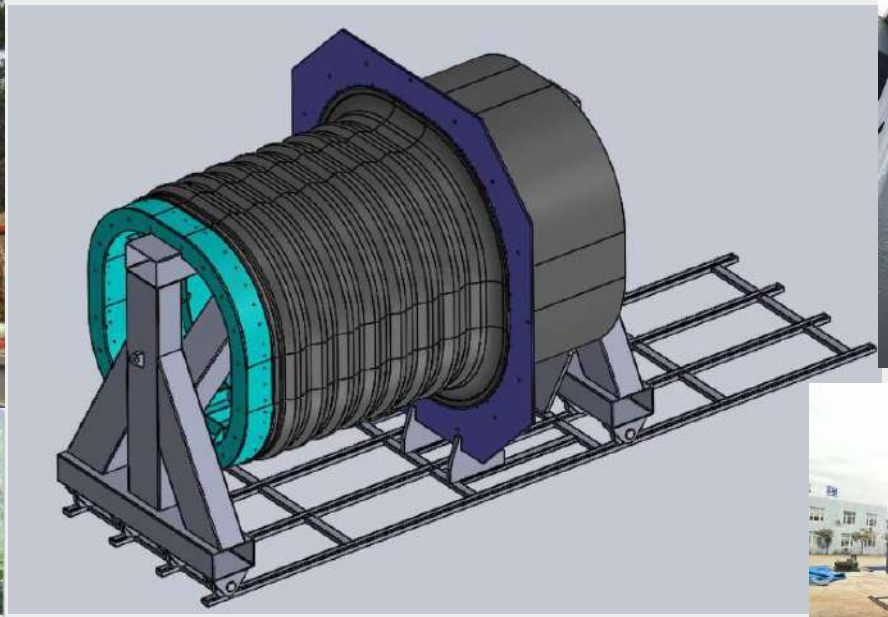
Dalian & HZMB closure joint development

M Seal Production – Shenzhong link closure joint

M-seal sliding test – Dalian Bay closure joint

A mockup was produced for testing purposes

M-seal pressure and sliding test – Shenzhong link closure joint



Dalian inflatable seal

An inflatable seal is used as secondary sealing system

Shenzhong Link inflatable seal

Installation and on-site test – Dalian Bay closure joint

Installation and on-site test – Shenzhong link closure joint

Pin & catch system

FEA of rubber mantle design to determine stiffness

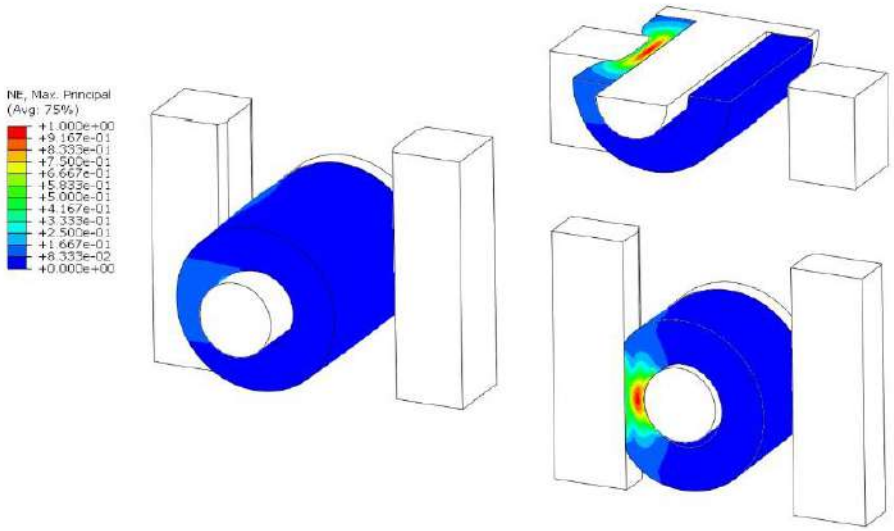


Figure 12: Simulated maximum principal strain [mm/mm] at 200 mm sleeve compression

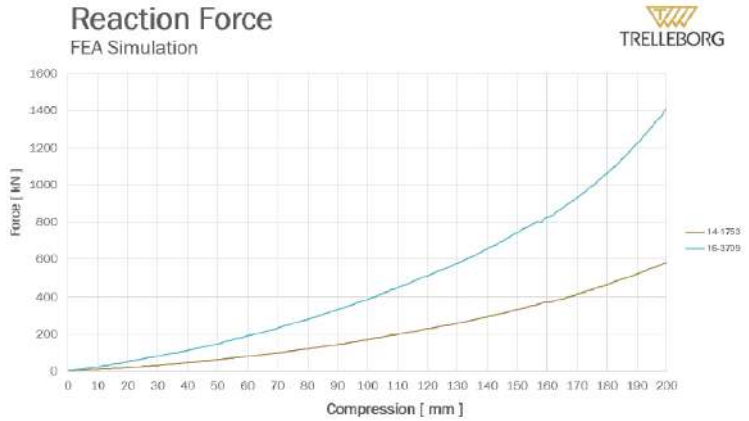
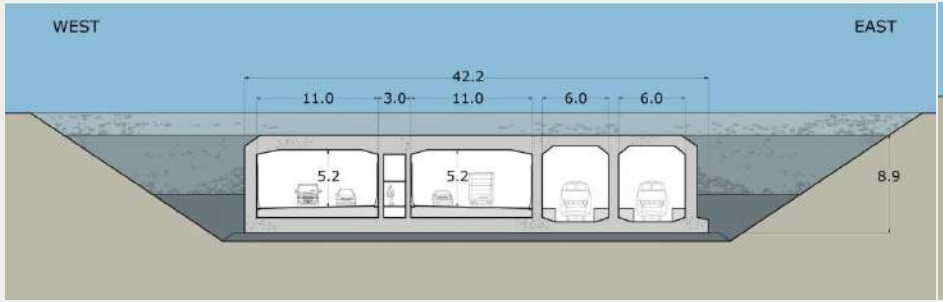
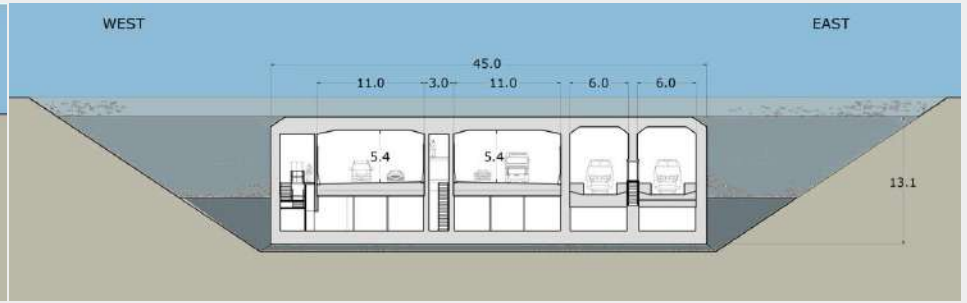


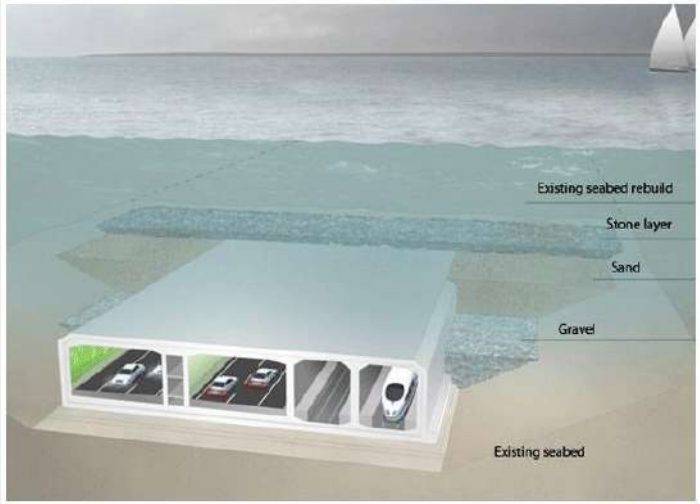
Figure 4: Simulated reaction force for ~40 Sh.A (14-1753) and ~60 Sh.A (16-3709) rubber hardness

Fehmarnbelt Tunnel

Tunnel Cross Section





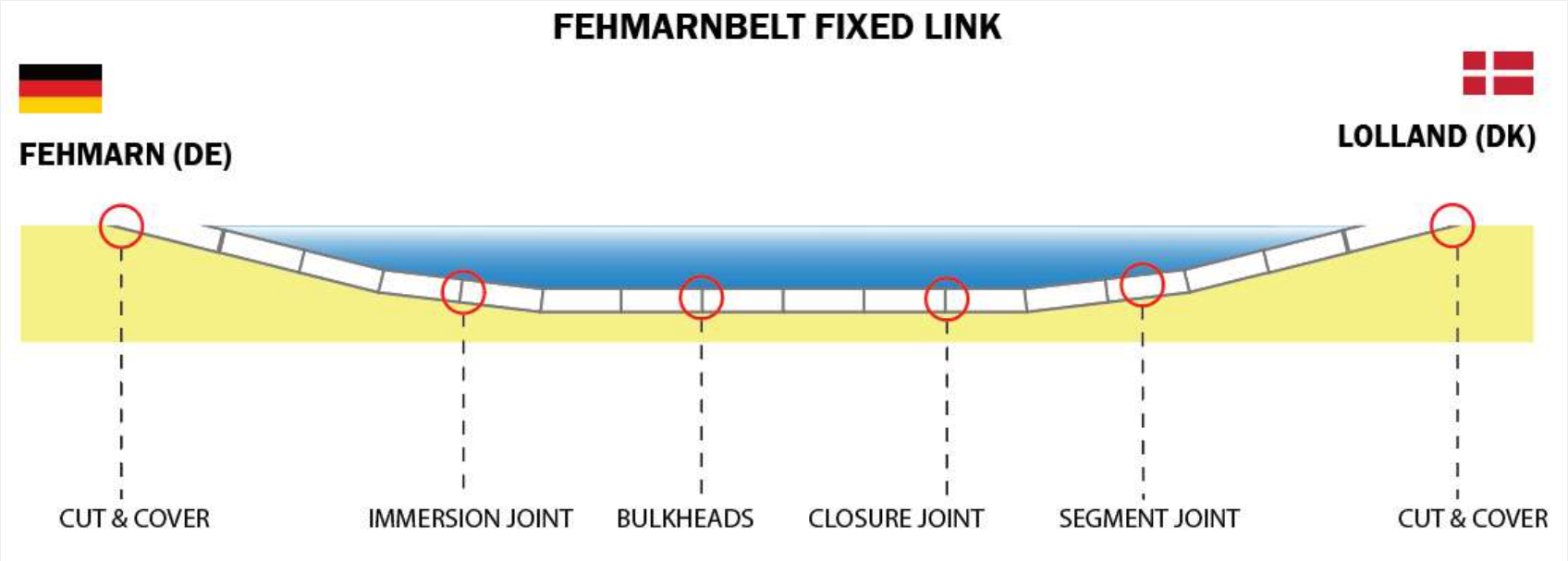


Tunnel element prefabrication dry dock

Specialized tunnel element prefabrication plant:
Location: Lolland Island, Denmark;
Total area of 1.5 million ㎡ equivalent to 200 football fields;
Largest prefabrication plant in the world;
Six production lines;
Put into operation by the end of 2022 and fully put into operation in 2023;
One week per segmental section pouring;
9 weeks per element poring.

The constructor plans to complete the prefabrication of a total of 89 concrete elements within four years, and the first batch of element will be ready by the end of 2023 or the beginning of 2024. The hauling and sinking of concrete element will be carried out in the middle of the whole construction period, and will be completed by the end of 2027 or 2028.
After that, the project will start the construction inside the tunnel, including the laying of railway and highway in the tunnel, and the installation of ventilation, lighting, signal and other equipment. It is expected to be completed in the middle of 2029.

Overview of Trelleborg Solutions – Fehmarnbelt



- ACME 20V/30A
- ECS 45/44CJ
- AM350
- NEW DOUBLE INJECTABLE WATERSTOP

- GINA
- GINA SPECIAL ELEMENT
- OMEGA
- CLAMPING SYSTEM

- BULKHEAD SEAL
- CLAMPING SYSTEM

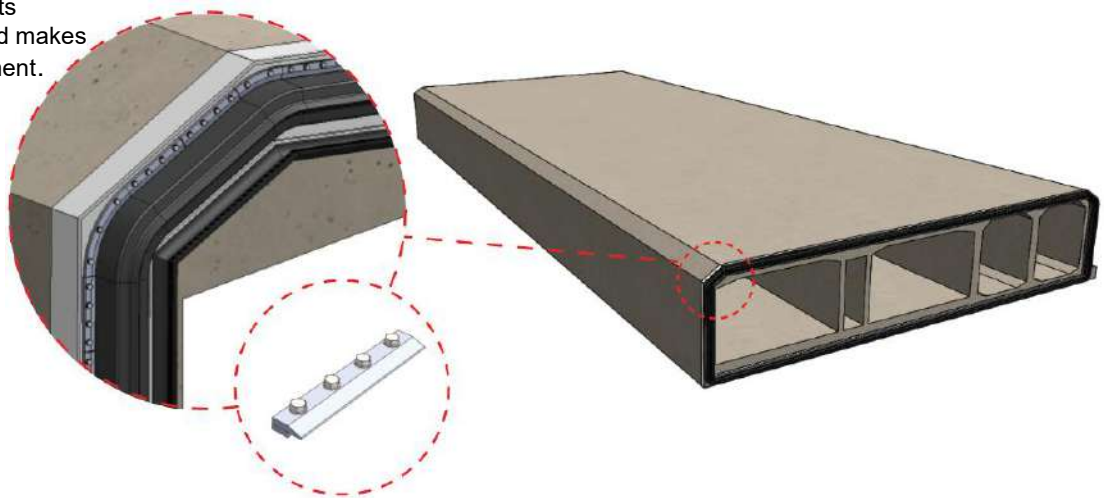
- TBD

- ACME 20V/30V
- ECS 45/44CJ
- AM350
- NEW DOUBLE INJECTABLE WATERSTOP

- ACME 20V/30V
- ECS 45/44CJ
- AM350
- NEW DOUBLE INJECTABLE WATERSTOP

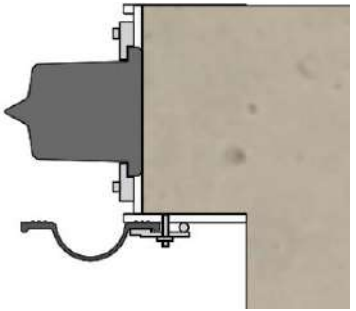
IMMERSION JOINT

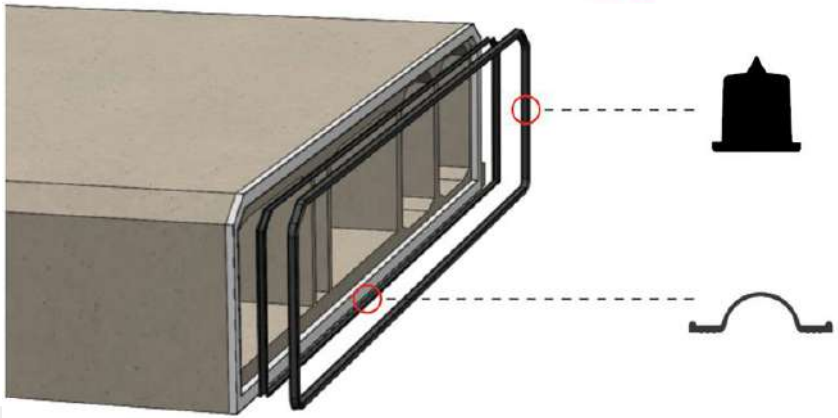
This permanent joint connects adjacent tunnel elements and makes the tunnel resilient to movement.



CLAMPING SYSTEM

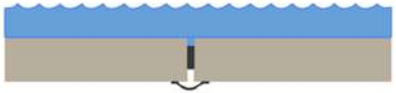
The steel clamping system fixates the Gina and omega seal. Trelleborg is able to design and supply these steel components alongside the seals in order to create a fully integrated water defence system.





GINA GASKET

Compression seal that functions as primary water defence

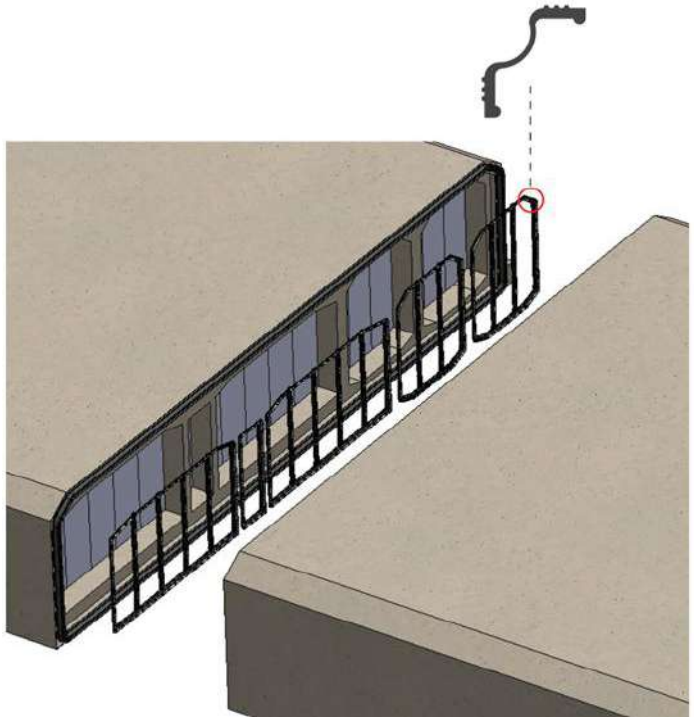


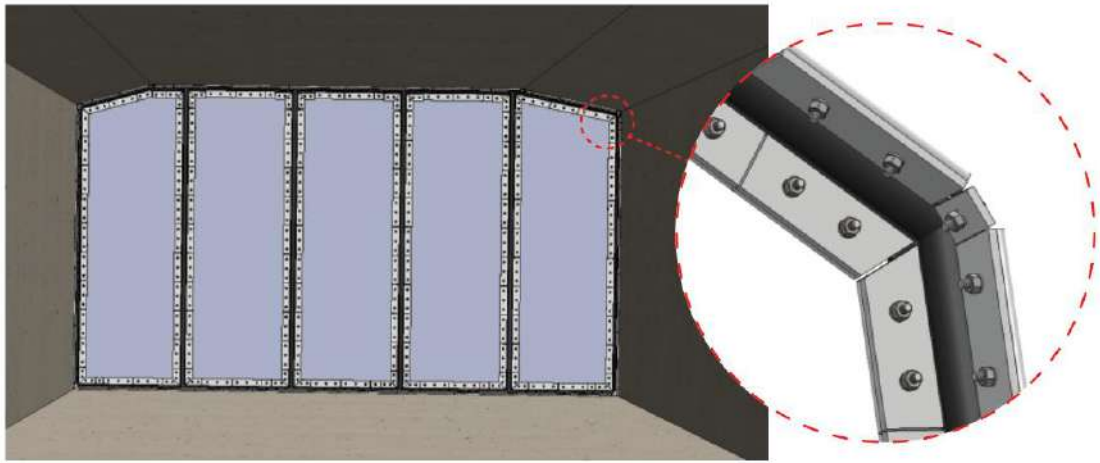
OMEGA SEAL

Membrane seal that functions as secondary water defence

BULKHEAD

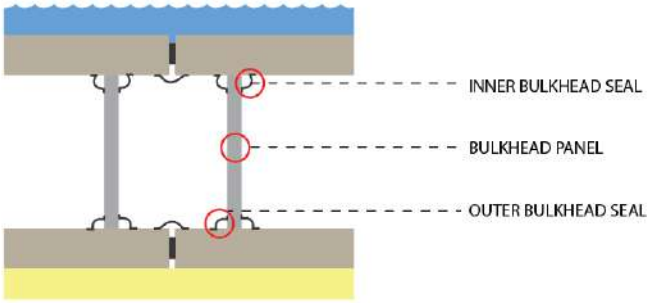
Bulkhead panels are used to prevent water from entering the tunnel elements during immersion. These panels will be removed after the immersion joints are activated





BULKHEAD SEAL

Membrane frame that makes the reusable bulkhead panels watertight. Each of the 5 tunnel galleries are sealed with a bulkhead seal.

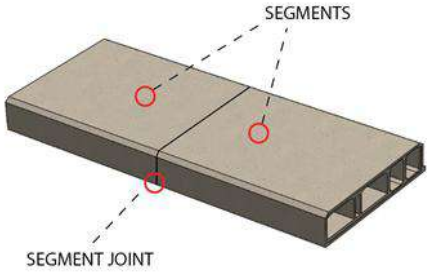


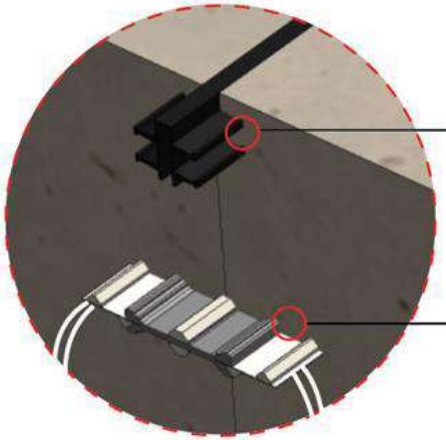
CLAMPING SYSTEM

The steel clamping system fixates the bulkhead frames into position. Trelleborg is able to design and supply these steel components alongside the bulkhead frames in order to create a fully integrated water defence system.

SEGMENT JOINTS, CUT&COVER

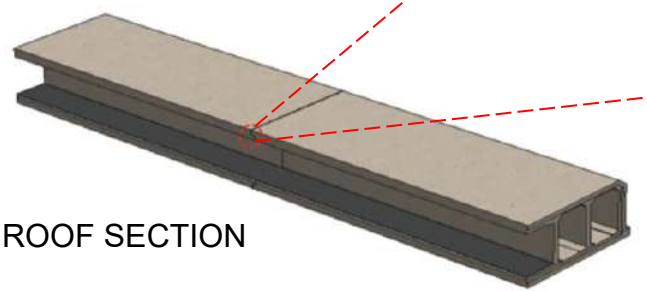
In both the immersed elements as in cut & cover elements, segment joints can be found. These concrete structures contain a multitude of adjacent concrete parts that are poured onto each other. The following seals are implemented in order to keep these segments watertight.



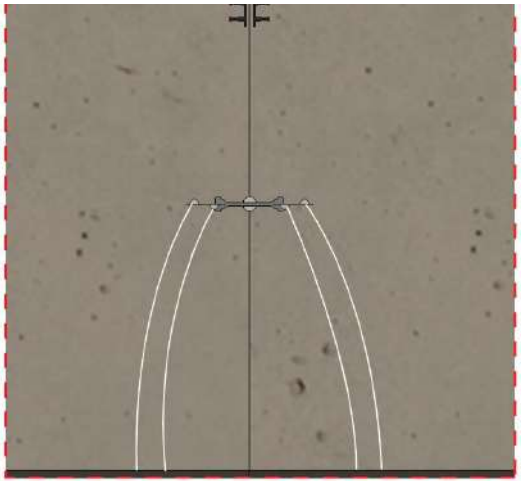


VFV 10/3 SEAL
This seal is casted in concrete and protects the waterstop from the outside environment

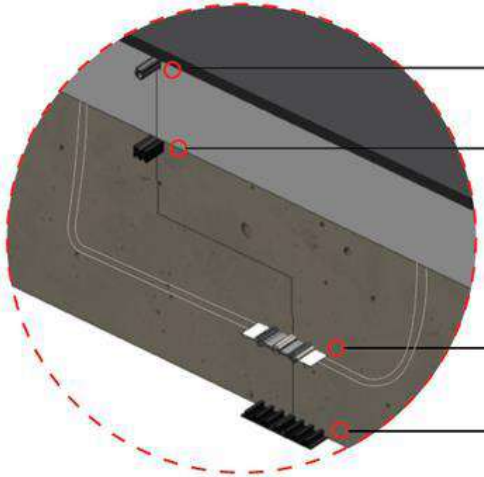
NEW DOUBLE INJECTABLE WATERSTOP (PATENTED)
This multiple injectable waterstop prevents water ingress within the adjacent concrete segments



ROOF SECTION



SEGMENT JOINTS, CUT&COVER

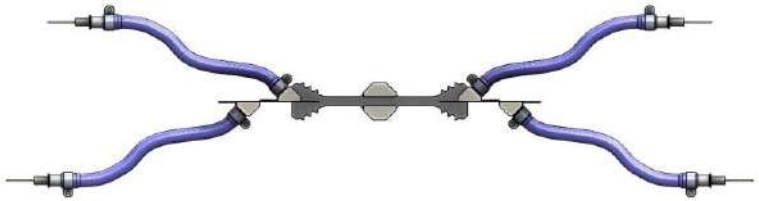


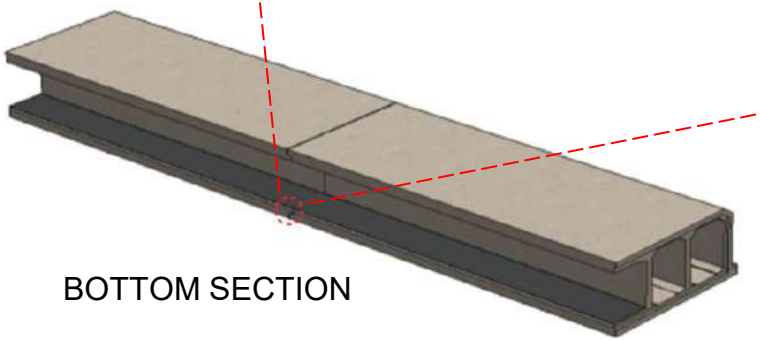
CALAMITY ECS 45/44CJ SEAL
This seal has as main pupose to prevent oil like materials from entering the segment joint

ACME 20A/30V SEAL
This compression seal is casted in concrete and protects the waterstop from the outside environment

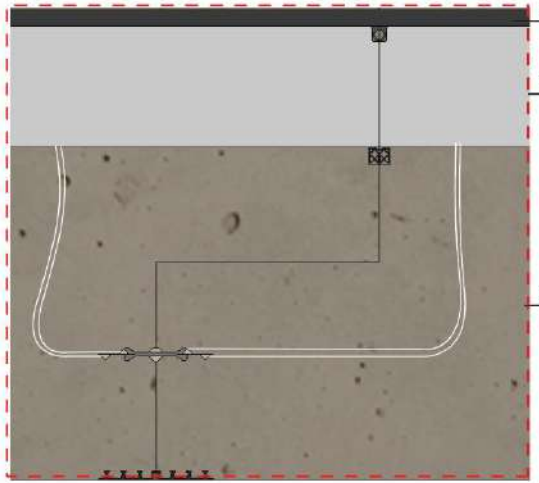
NEW DOUBLE INJECTABLE WATERSTOP (PATENTED)
This multiple injectable waterstop prevents water ingress within the adjacent concrete segments

AM 350 SEAL
This seal functions to protect the waterstop from ground entering the segment joint





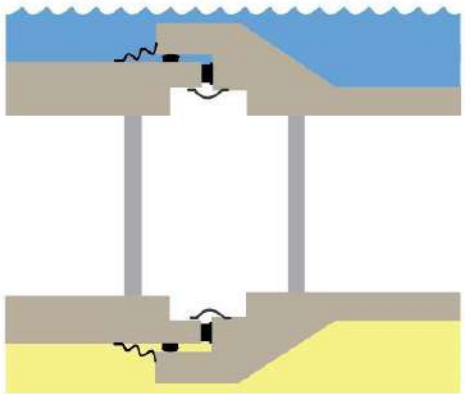
BOTTOM SECTION



CLOSURE JOINT

The closure joint is the last element that is placed within the tunnel construction. This joint has to accommodate large tolerances. Trelleborg Infrastructure has a vast amount of experience in developing seals for various types of closure joints, such as seals for 2nd Coen Tunnel, Dalian Bay, HZMB and Shenzhong link tunnel.

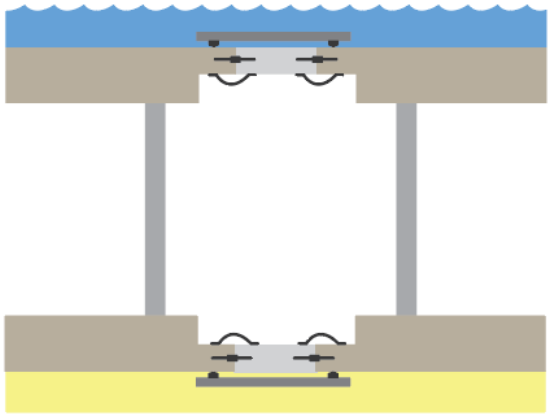
Closure joint - Sleeve joint design



Includes seals:

- M-seal
- Gina seal
- Omega seal
- Inflatable seal (PS-seal)
- Lipseal

Closure joint - Panel joint design



Includes seals:

- ECS 125/135 seal
- Waterstop
- Omega seal

Dry Dock Door – Cast-in yard Rødby

- Single Gina gasket
- Less fixation material on door vs traditional approach
- Easy installation with less steel required
- No leakage, no auxiliary pumps required
  - Reduces cost of fuel
  - Reduces Co2 emissions
  - Sustainable solution
- No maintenance requires
- Proven concept
  - Saipem, Murmansk (200m) under construction
  - Saipem, Kazachstan (120m)
  - Mariehamm, Finland (55m)
  - US Navy, Corpus Christy USA (90m)
  - Landskrona Shipyard, Sweden (75m)
  - Several Super Yacht yards (40m-50m)
  - Ruyifang Immersed Tunnel, Guangzhou China (64.5m)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