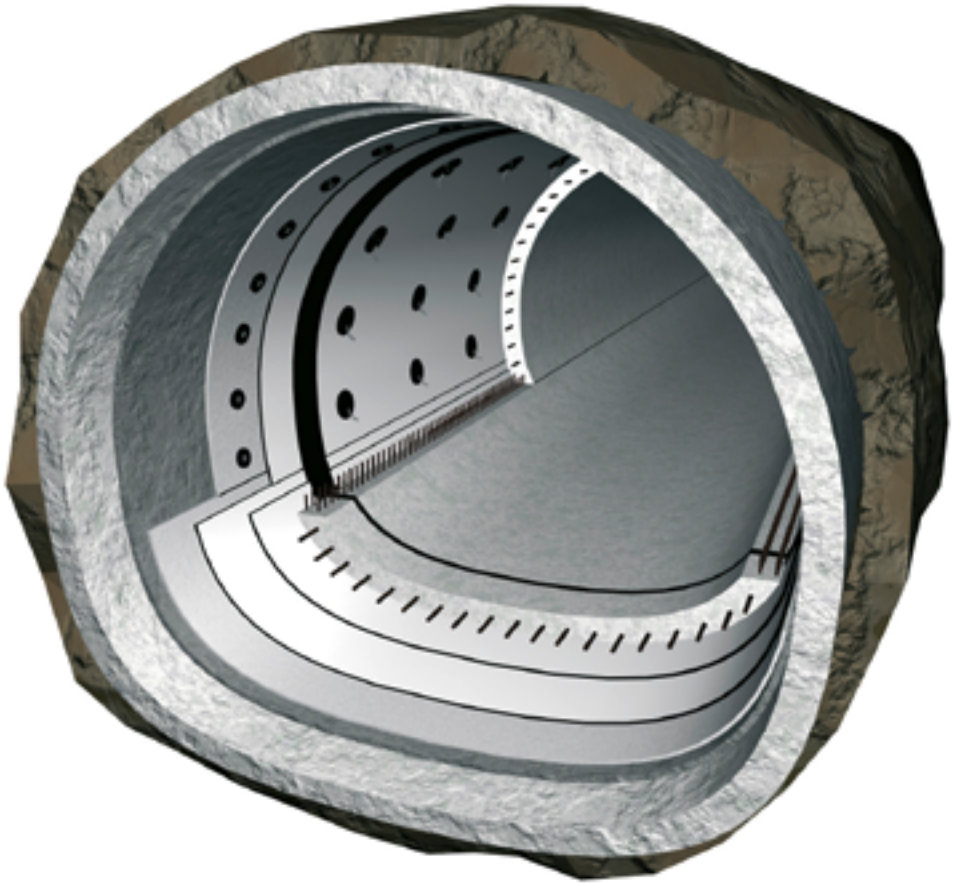
Tunnel construction

Naue

The Naue Complete Solution



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Building on sustainable ground.

Naue, the System Provider

Modern tunnels are planned with a functional service life of more than 100 years. They must be properly protected against the impact of groundwater. Therefore, there are high demands on the structure and on the waterproofing. For this reason, it is very important to supply a perfectly compatible waterproofing system. From high-quality system components “Made in Germany”, to installation by a certified installation team, Naue offers the ideal, complete solution for tunnel waterproofing.

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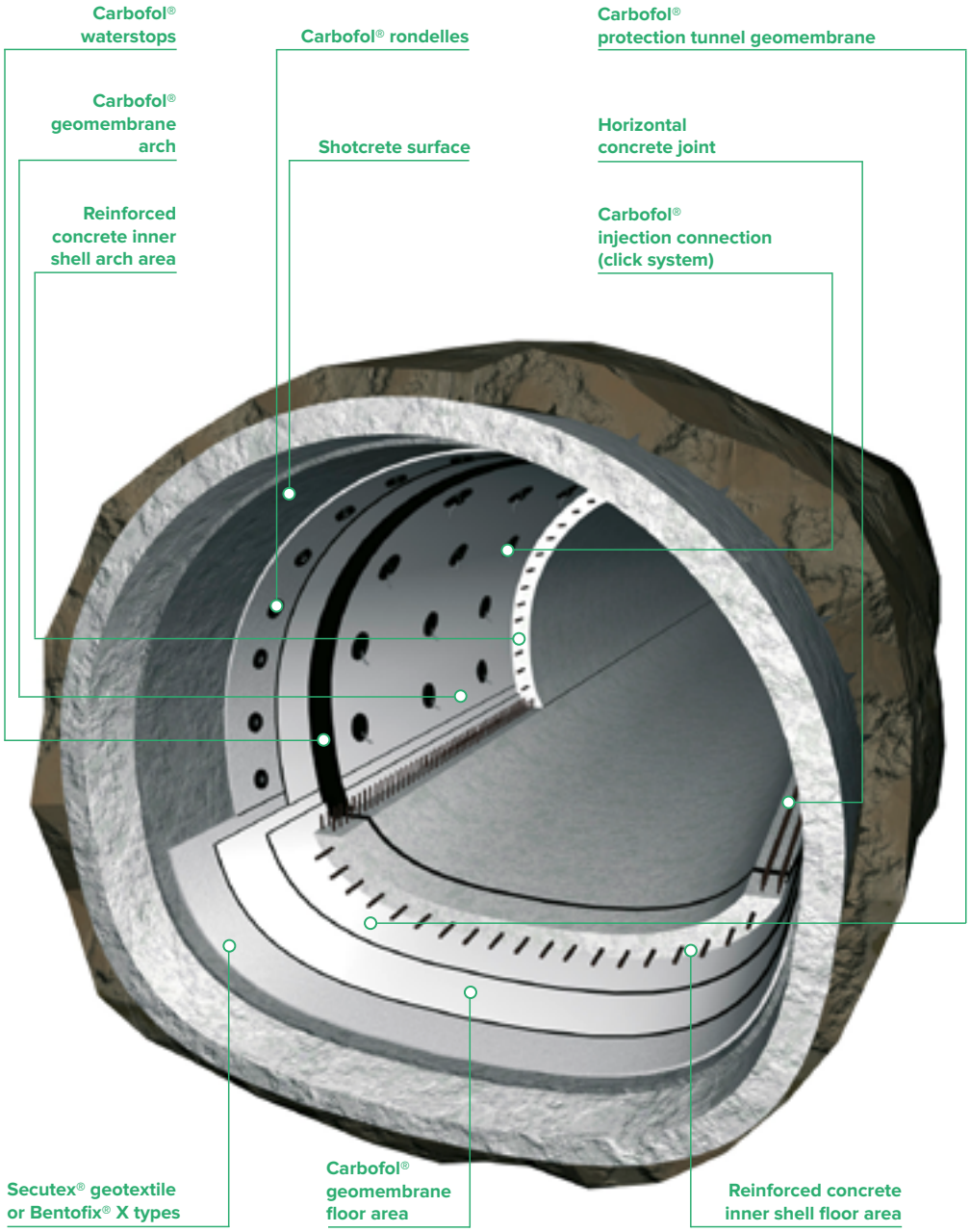
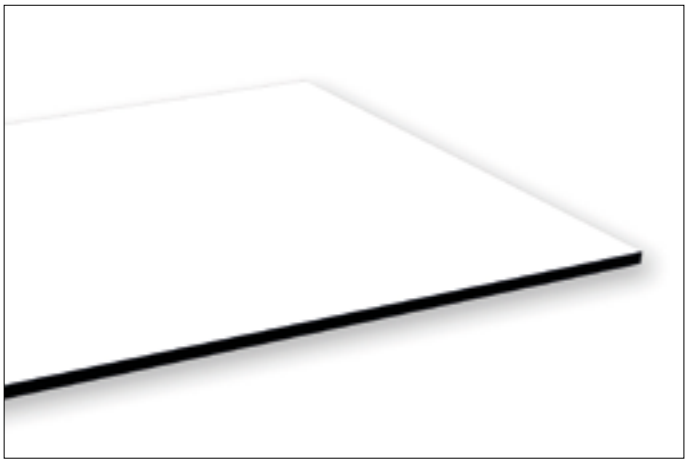

Carbofol® waterstops
Carbofol® rondelles
Carbofol® protection tunnel geomembrane
Carbofol® geomembrane arch
Shotcrete surface
Horizontal concrete joint
Reinforced concrete inner shell arch area
Carbofol® injection connection (click system)
Secutex® geotextile or Bentofix® X types
Carbofol® geomembrane floor area
Reinforced concrete inner shell floor area

Carbofol® waterproofing membrane



Geomembrane

Carbofol® geomembranes (GMs) for tunnel waterproofing are manufactured from plasticiser-free polyethylene (PE) and offer high chemical resistance.

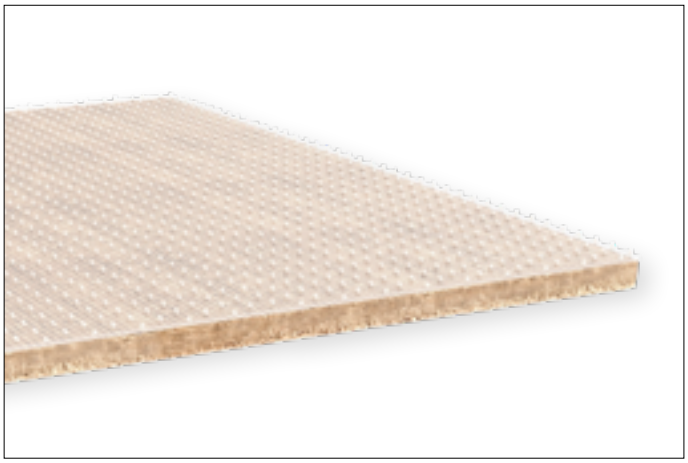
Secutex® geotextiles

Protective geotextile

Carbofol® installed

Secutex® geotextiles for tunnel construction are manufactured from polypropylene (PP) fibres. Due to a special production process, Secutex® geotextiles for tunnel construction fulfil the requirements of fire reaction class E (formerly B2). The main functions of nonwoven geotextiles in tunnel sealing systems with geomembranes are protection and drainage.

Bentofix® X types as waterproofing component



Bentonite mat

Bentofix® X type in the arch area

In some cases, certain geological conditions can increase the demands on the tunnel waterproofing system. With the use of Geosynthetic Clay Liners (GCLs; Bentofix® X types) in tunnel construction, the standard protective geotextile is replaced and, at the same time, a supplementary waterproofing component is installed.

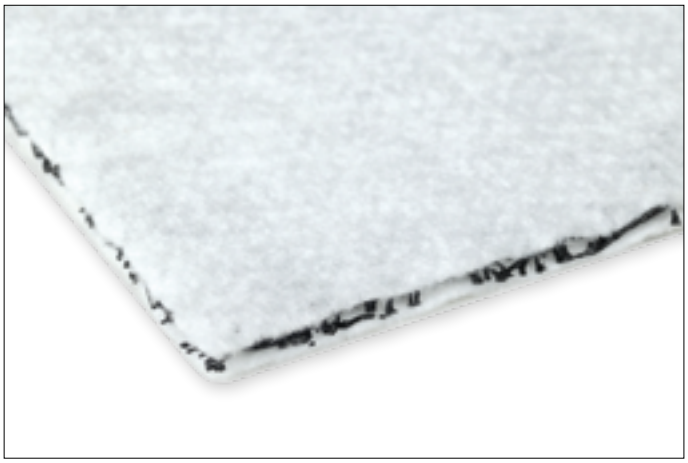
The Bentofix® X GCL used in such cases takes over the following functions:

- Protection (e.g. the tunnel protection geotextile Secutex® R 1001-B2)
- Waterproofing (additional sealing barrier in the tunnel)
- Prevention of longitudinal water flow behind the tunnel membrane

Bentofix® X GCLs can be installed as strip-shaped, radially running elements or over the entire surface of the tunnel sealing system.

The complete concreting of the tunnel inner shell is important for ensuring basic functional reliability. Due to the sometimes large inner shell thicknesses and correspondingly high quantities of steel reinforcement, two options are recommended for achieving the complete concreting of the inner shell with the required pressure against the tunnel waterproofing system: either the use of self-compacting concrete or an additional concrete grouting (360°) after finalising the regular inner shell concreting. This grouting should be done no earlier than one month after concreting and before stopping the permanent lowering of the water table around the tunnel construction site.

Secudrain® drainage mats



Drainage composite

Secudrain® drainage mats for tunnel construction are made from primary polypropylene (PP). Thanks to their three-dimensional filter and pressure-stable structure, Secudrain® surface drainage systems in tunnel construction achieve a particularly reliable water drainage capacity. The main function of Secudrain® three-dimensional drainage systems in tunnel construction is permanent drainage.

Secumat® erosion control mats

Randomly oriented filament mat

Secumat® erosion control mat on a tunnel embankment

Secumat® erosion control mats are an important addition for the protection of tunnel entrances against surface-parallel erosion. The three-dimensional polypropylene (PP) fibres are UV, biologically and chemically resistant and offer permanent protection to tunnel embankments.

This artificial root structure provides reliable protection against soil erosion, especially in severe weather conditions. The main function of Secumat® 3D Mesh in tunnel construction is to provide permanent erosion protection.

Carbofol® rondelles with predetermined breaking point

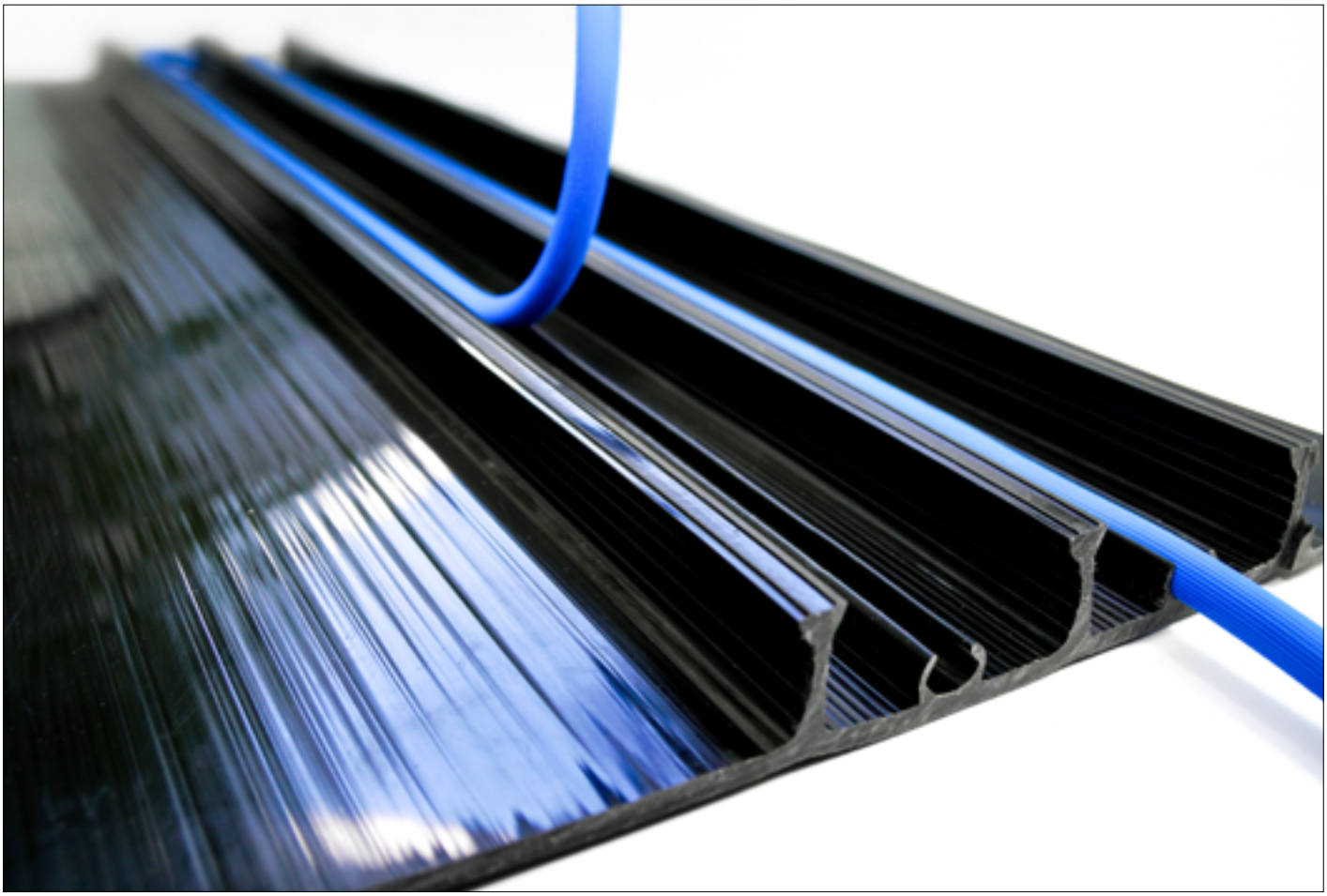
Carbofol® rondelles with a proven predetermined breaking point serve as an installation help for fixing the geomembrane to the shotcrete surface. Initially, the Carbofol® rondelles are fixed to the shotcrete layer with a nail gun. Afterwards, the geomembrane sheets are fixed to the rondelles using a hot air welding machine.

In situations where stresses are applied to the installed membrane during concreting, the predetermined breaking point of the rondelles will open, allowing the membrane to move and protecting it against damage.

Carbofol® rondelle

Carbofol® waterstops with injection hose channel

Carbofol® waterstops are used in tunnel construction for sealing block and construction joints, dividing the waterproofing into grouting fields and as a connection at the termination of the membrane waterproofing system. The Carbofol® tunnel membrane and the Carbofol® waterstops are made of the same material, ensuring a perfect weld between both system parts. To achieve complete concreting also between the waterstop bars, injection tubes must be installed in between. For easy and safe installation of the injection tubes, special injection hose holders are provided between the waterstop bars.



Carbofol® waterstops with integrated injection hose holders

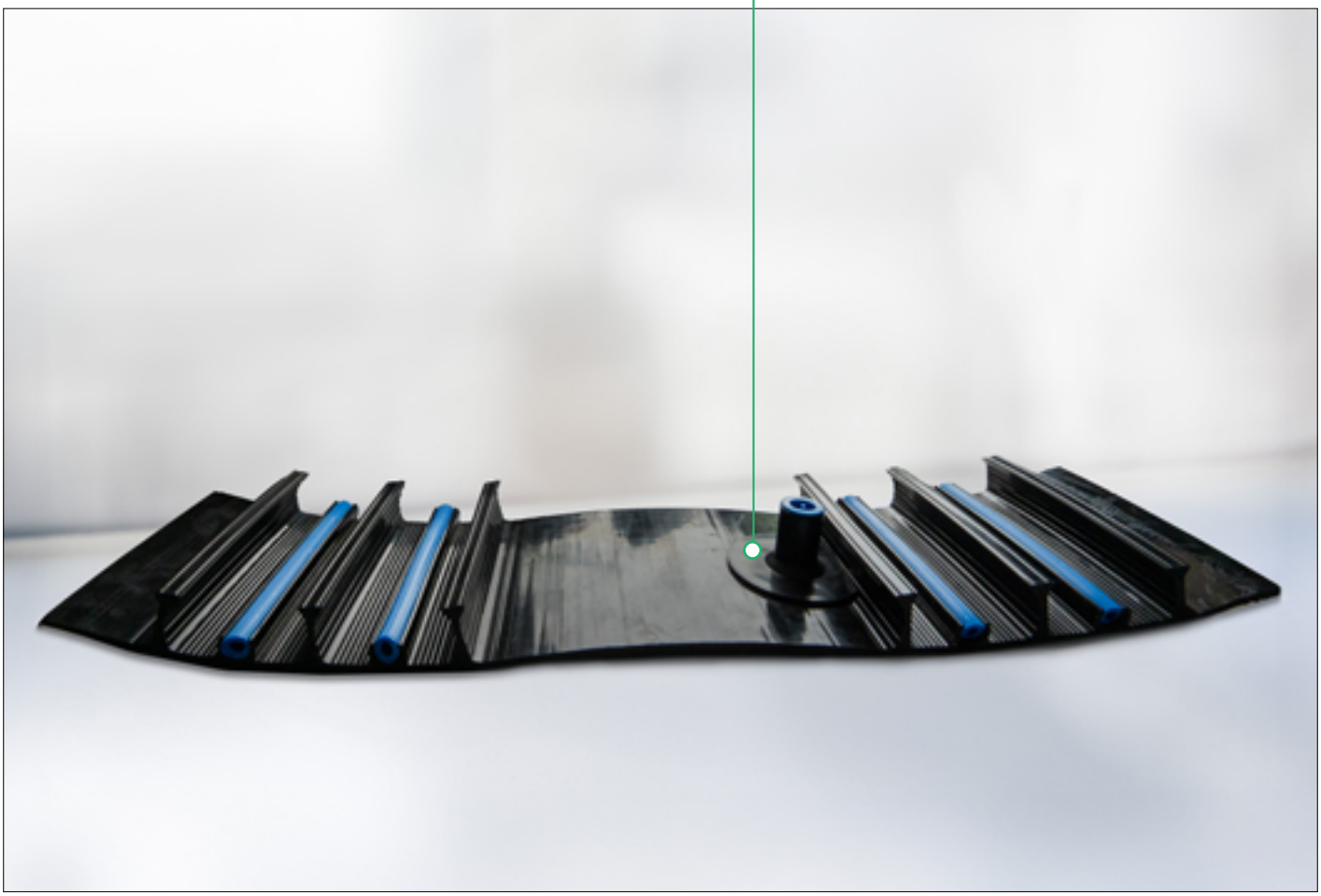
Carbofol® air venting part

Carbofol® waterstops are usually welded on both sides to the Carbofol® tunnel membrane. The concreting pressure pushes the air between the two welds towards the arch area, where it should escape.

A solution for this is the installation of the Carbofol® air venting part in the arch area.

The specially developed solution allows air to vent without allowing any concrete or liquids to enter.

Detail of the air venting part



Carbofol® air venting part

Carbofol® injection connection (click system)

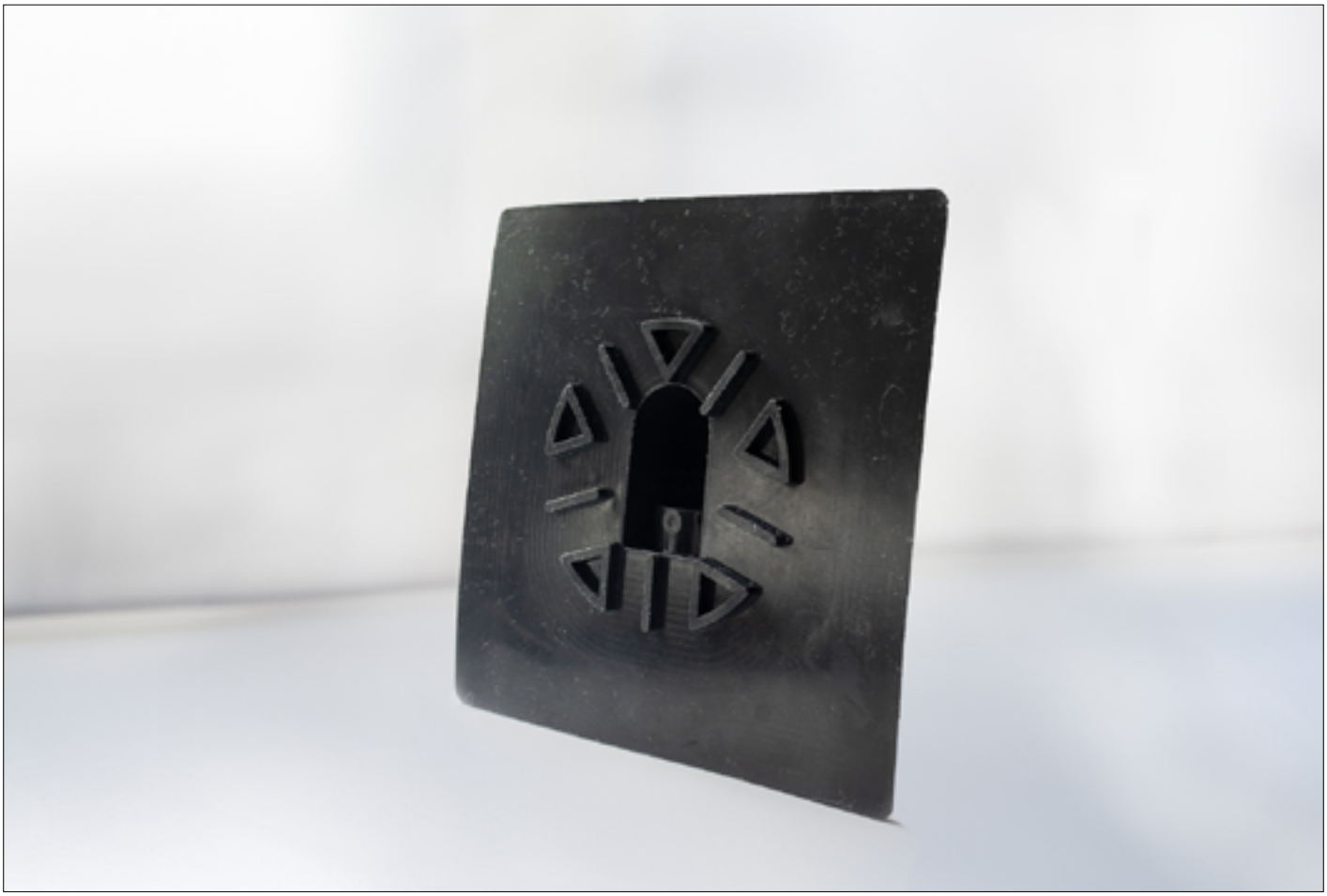
Injection connection – top view

For undrained tunnels with high water pressure, an additional testing and injection system must be installed.

The function of this system is to test and, in the case of damage, to repair the waterproofing. It also offers the excellent possibility of extended circumferential grouting (360°).

The injection connections are quickly and securely connected to the grouting hoses by using the Carbofol® click system.

The 90° connection design allows problem-free installation, even with nearby reinforcement. The injection connection part is designed with spacer elements on the underside to keep a distance between the connection part and the membrane. With this, a high flow rate of the injection material is ensured.



Injection connection – bottom view

Carbofol® swellable ring system

Carbofol® swellable ring seal

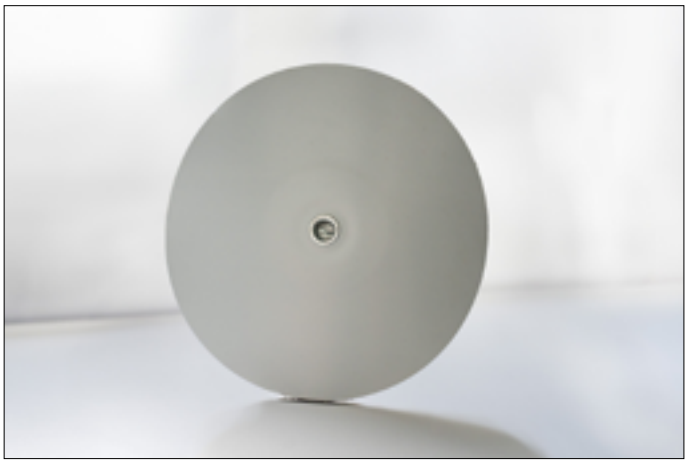
Injection hose installation through the tunnel concrete inner shell could cause water flow around the hoses. This can be reliably prevented by the specially designed Carbofol® swellable ring seals.

Carbofol® swellable ring seals are made of swellable plastic that expands upon contact with water. This component is also designed to avoid restriction of the injection hoses by preventing inward compression.

Carbofol® swellable ring seal with injection hose

Carbofol® ME Anchor

Carbofol® ME Anchor – bottom view



Carbofol® ME Anchor – top view

Carbofol® tunnel sealing with Carbofol® ME Anchor

Especially in pressurised water-bearing tunnels with large and/or complex cross-sections, significant inner shell thicknesses, and high reinforcement content, additional fixings are needed for the safe positioning of the reinforcement.

An innovative solution here is the use of penetration-free Carbofol® ME anchors. The reinforcement fixing does not reduce the waterproofing function in any way.

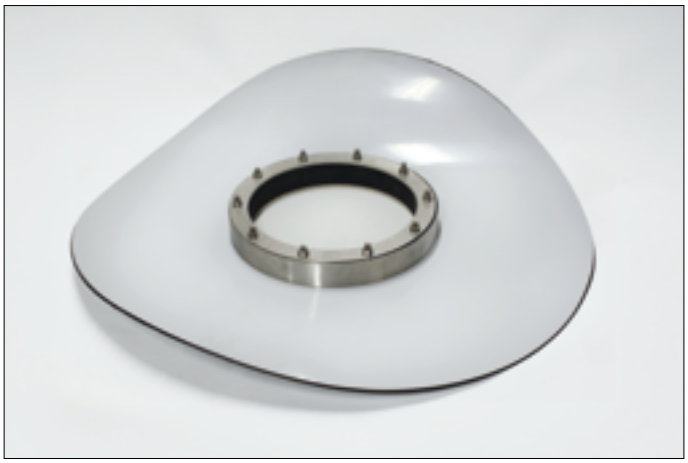
Carbofol® ME Flange

Carbofol® ME Flange

If technically necessary, long, high-tensile-strength steel bar anchorages will be used.

As an alternative to the Carbofol® ME anchor, the Carbofol® ME flange penetration seal can be used; it is water pressure-tight.

Carbofol® ME press flange connection



Carbofol® ME press flange connection

The connection of the Carbofol® tunnel waterproofing membrane to pipes of any material can be performed quickly and securely with the Carbofol® ME press flange connection, which is water pressure-tight.

Project-specific material sizing

Due to different tunnel cross-sections and tunnel sealing systems, different roll lengths and material widths are often required.

The Naue manufacturing process allows the necessary material lengths and widths to be optimally matched to the demands of virtually any tunnel project.

Project-specific Carbofol® material sizing

Installation by a certified specialist

The professional and successful installation of tunnel waterproofing systems requires a high degree of professional competence and experience.

Once installed, the waterproofing system needs to undergo a strict quality control procedure performed by a certified company. The Arbeitskreis Tunnelabdichtung e.V. (Association for Tunnel Waterproofing) provides appropriate quality control procedures and requirements for specialist tunnel waterproofing companies. Naue is a full member of this association and is certified according to its high standards.

URKUNDE

CERTIFICATE
Qualified installer for tunnel waterproofing systems, regularly tested by STUVA e. V.

Naue
Sealing GmbH & Co. KG

Kreuzbreite 29 · 31675 Bückeburg

Die oben genannte Firma erfüllt die
The above mentioned company fulfill completely

Überwachungsordnung des
the monitoring requirements of the

Arbeitskreises Tunnelabdichtung e.V.
Association of Tunnel waterproofing e. V.

und ist berechtigt das
and is authorized to hold this

Überwachungszeichen
Certificate

Krefeld, Dezember 2023

Vorsitzender
Überwachungsausschuss

Vorsitzender
Vorstand

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