



# Fire-protection in tunnels

FIRE-PROTECTION  
COMPACT  
OCTOBER 2023

**AESTUVER®**



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## Application areas



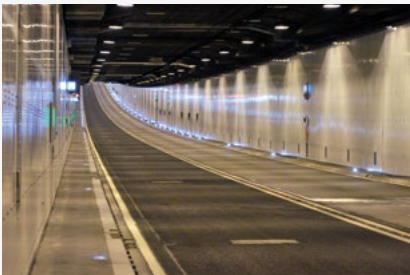
Structural fire-protection



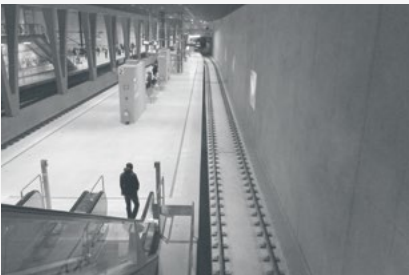
Electrical



Ventilation



Tunnels



Subway fire-protection solutions



Industry and OEM

# 01 Fire-protection in tunnels

In a society in which mobility is increasing and the volume of traffic is growing rapidly, modern, high-performance tunnels with reliable fire-protection are crucial. Increasingly long and complex tunnel systems are being planned and built, and existing tunnels modernized, in order to meet the growing requirements.

## Impact and damage

Because of the spatial limitations of a tunnel, tunnel fires render all escape, rescue and repair measures rather difficult, and are hence regarded to be the greatest risk to people, vehicles and the tunnel structure itself. High-performance fire-protection systems are therefore required to satisfy the demanding structural fire-protection requirements in tunnels. These measures reduce the risk of injury, and avoid severe fire damage to the tunnel structure and, consequently, long closures (leading to a loss of income for tunnel operators and neighboring regions).

## Integrated safety concepts

Effective safety concepts in underground transport systems are based on:

- Safe escape route design
- Fire load containment along escape and rescue routes
- Installation of efficient smoke extraction systems
- Integrity of electrical systems
- Protection of structural concrete against loss of load capacity and spalling

## Requirements for structural fire-protection systems

Requirements for structural fire-protection systems are assessed on a project-specific basis using internationally recognised time-temperature curves (see page 6-7).

The structural fire-protection system ensures that, in the event of a fire:

- No damage occurs that threatens the stability of the tunnel
- No permanent deformation of the structure occurs that restricts the usability of the tunnel
- The leak tightness of the structure is guaranteed on a continuous basis

## Cladding with Aestuver® fire-protection boards

Aestuver® fire-protection boards are used as independently fixed or directly concreted (Permanent Formwork) cladding in underground transport systems and protects the entire concrete structure and reinforcement from harmful temperatures.

The clear benefits of Aestuver® fire-protection boards for tunnel operators and transport agencies include the following:

- Use of well-established concrete types without PP fibers
- Can be cleaned using conventional cleaning processes
- Freeze-thaw-resistant and water-resistant

## Planning and project support

This brochure presents Aestuver solutions for structural fire-protection in underground transport systems. Project-specific solutions can also be formulated in cooperation with our fire-protection experts. As a reliable service provider, we pride ourselves on our direct lines of communication and close consultation.

**You can find more on the Aestuver® service portfolio on page 46–47.**



## 02 Spalling behavior of concrete in the event of fire

Fire can cause mechanical stress and chemical changes inside the structural concrete, which may decrease mechanical properties such as strength or the modulus of elasticity.

The concrete heats up from the edge areas, causing drainage and evaporation processes to take place. This causes steam pressure, leading to explosive cracking of the concrete, known as spalling or temperature shock.

This behavior becomes more marked as the strength of the structural concrete increases: the pore volume in high-strength concretes are reduced, lowering their permeability.

High-performance concretes have proven to be particularly prone to spalling. In addition, smoke can enter the concrete through hairline cracks that develop when the material is exposed to fire, accelerating the carbonatation process or introducing chlorides, for example, and corroding the reinforcing steel.

The damage to the structural concrete and subsequent fire damage in underground transport systems may have serious financial consequences for the tunnel operator, as the repair and downtime of the structure can lead to significant costs.

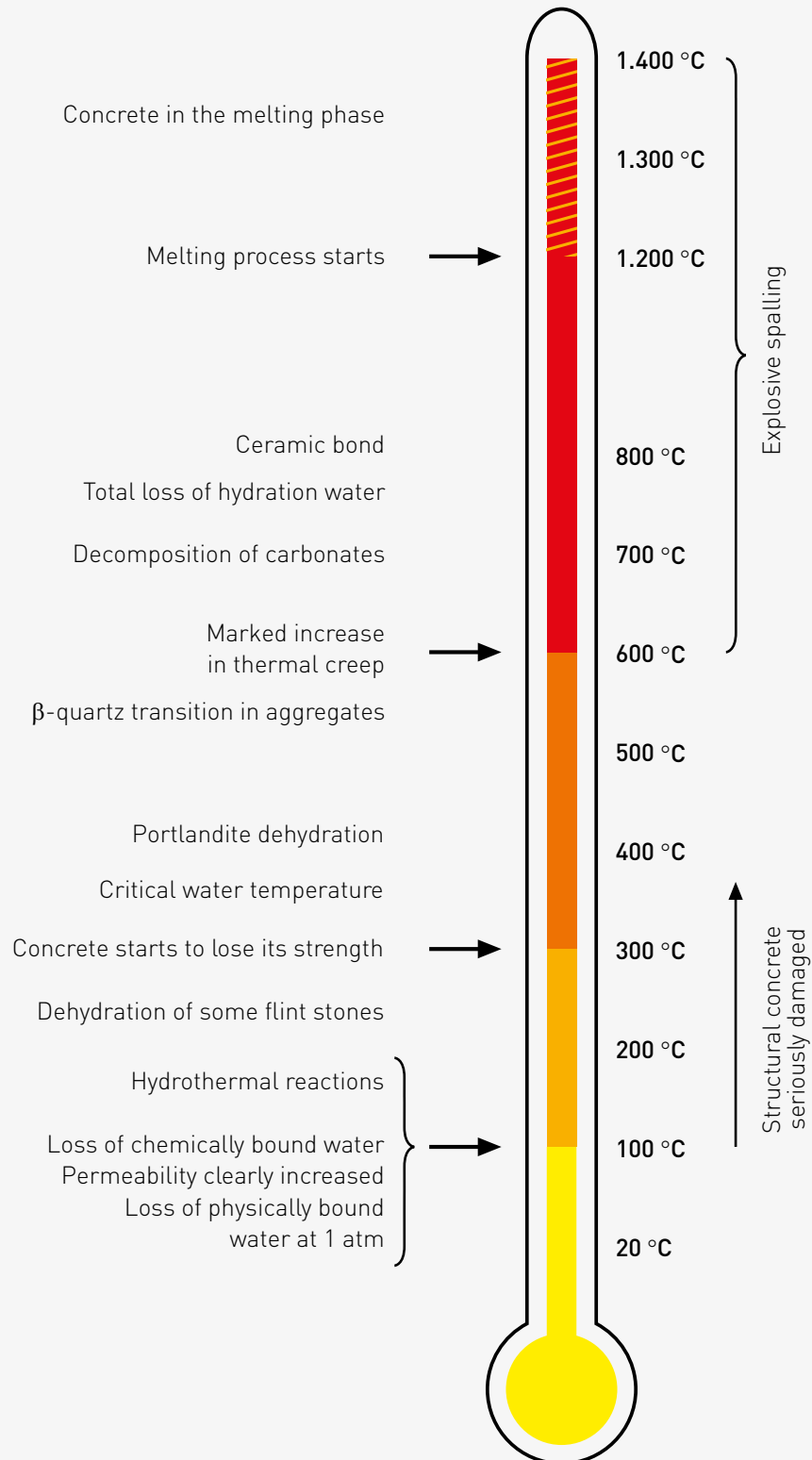
The impact on the surrounding infrastructure must also be taken into consideration – for example, if vital transport routes are unusable for long periods of time.

Passive structural fire-protection measures prevent spalling of the concrete surface and thus exposure of the load-bearing reinforcement. Aestuver® fire-protection boards keep harmful temperatures away from the concrete structural elements. This can eliminate or significantly shorten the duration of the expensive, (time- and cost-intensive) reconstruction and thus closure of the tunnel.



If the concrete is heated quickly and high thermal stresses occur, considerable damage may be caused to the concrete structural elements.

## Chemical transformation in concrete





## 03 Time-temperature curves

The impact of fires on building structures is simulated using time-temperature curves. These temperature curves form the basis for developing requirements for tunnel construction – such as the thickness of the fire-protection cladding and the design of the escape and rescue strategies in the event of fire. The aim of these specifications is to protect the tunnel structure from excessive temperatures in the event of fire.

### Including:

- Limiting the maximum temperature on the concrete surface
- Limiting the maximum temperature on the reinforcing steel

The load capacity of the concrete structure can only be guaranteed if these temperature criteria, which are defined nationally or on a project-specific basis, are met.

The observance of these requirements and the relevant structural fire-protection measures, such as cladding with Aestuver® fire-protection boards, is documented in advance with extensive fire tests.

The internationally recognized time-temperature curves are outlined below. They differ in terms of fire development, the time before the maximum temperature is reached and the duration of impact of the maximum temperature.

### ISO curve

The ISO curve (ISO 834), also called the standard fire temperature curve, is the thermal stress generally applied in component analyses/tests in the building industry. This thermal stress represents the lowest level of stress and reflects temperature requirements resulting from interior fires in buildings. The timing of the ignition, smoldering and cooling phases is not taken into account.

### ZTV-ING curve\*/RABT curve

In accordance with ZTV-ING, the ZTV-ING curve applies to road tunnels in Germany regardless of their design and the type of traffic. It is vital to ensure that, under the temperature conditions of the ZTV-ING curve, the supporting reinforcement of the tunnel structure is not heated to a temperature exceeding 300 °C and that only building materials of class A in accordance with DIN 4102 or equivalent are used. In addition, these building and general materials may not release any substances in the event of fire that are harmful to buildings or people.

### EBA curve (EUREKA)

Railroad tunnels must be designed to be self-supporting according to the state of the art and their intended use. The guideline from the EBA stipulates a fire curve defined by the German Federal Railroad Authority (Eisenbahn-Bundesamt, EBA). This fire curve is based on a temperature profile that has to allow for temperatures in the tunnel reaching 1 200 °C after just 5 minutes. The EBA fire curve simulates the time-based temperature profile of fire gases that can occur in railroad tunnel systems in the event of damage. The EBA fire curve was confirmed with fire tests on long-distance passenger train cars as part of an EU project (EUREKA EN 499).

### Hydrocarbon curve (HC)

The hydrocarbon curve is an open fire curve from the 1970s and was developed for hydrocarbon fires in industrial and offshore plants. This curve has been modified to take into account the higher fire loads in tunnels. According to the curve, the fire development is similar to a gasoline or diesel pool fire, but can also be used qualitatively for a solids fire.

### Modified hydrocarbon curve (HCM)

The modified hydrocarbon curve (HCM) was developed in France to take into account the increased safety requirements in tunnel structures, and is based on the hydrocarbon curve (HC). The HCM curve, derived from the hydrocarbon curve described previously, reaches a maximum temperature of 1 300 °C (HC curve = maximum of 1 100 °C).

The HCM curve is being used increasingly in large international infrastructure projects.

### Rijkswaterstaat curve (RWS)

The Rijkswaterstaat curve is an open fire curve based on a tanker fire with 45 000 liters of gasoline. In the modified variant, the temperature of 1 200 °C, which is reached after the fire has been burning for 2 hours, is maintained for an additional hour.

### N0, N1, N2, N3

#### According to the CETU\*\* guideline

In France, there are more far-reaching requirements for fire-protection in road tunnels, depending on the size and infrastructural importance, in accordance with the CETU\*\* guideline. There are four categories: N0, N1, N2 and N3.

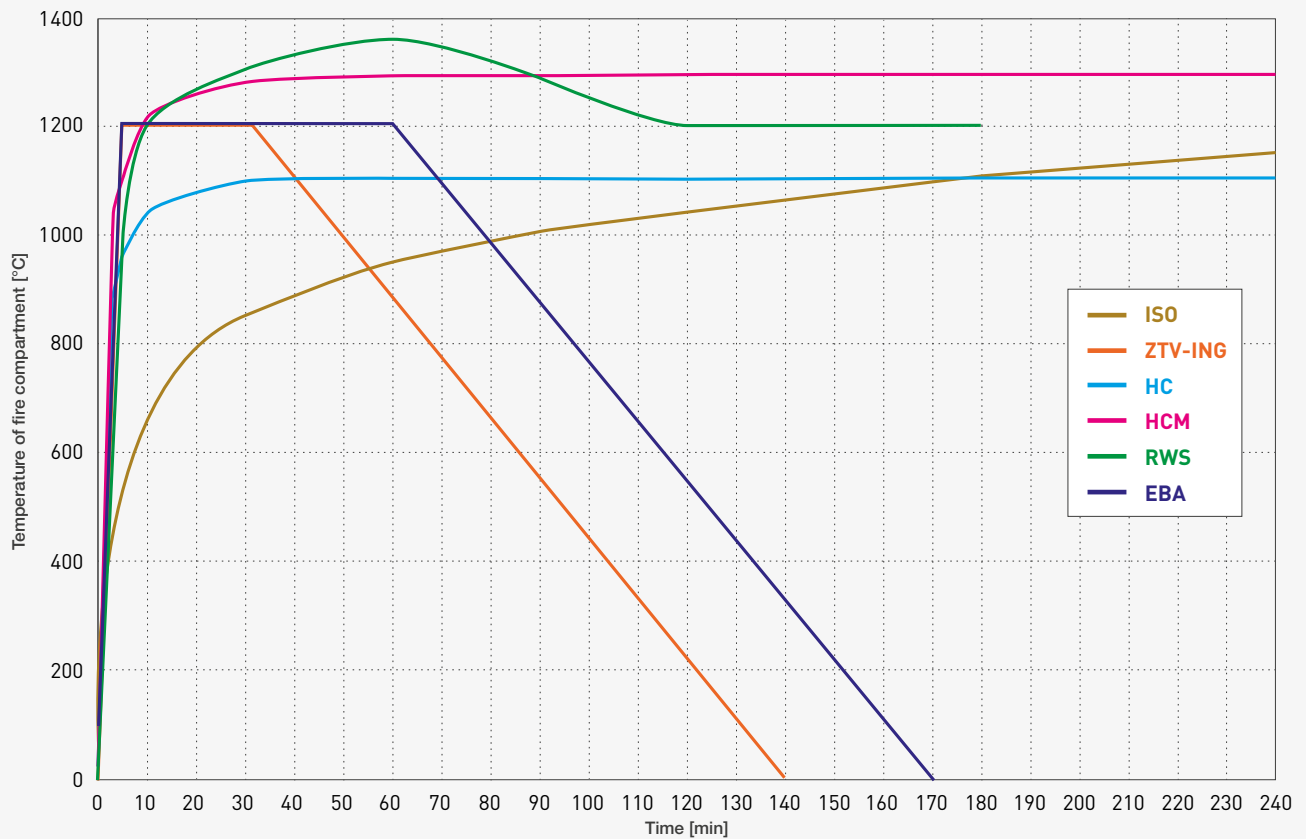
The categories represent a combination of the different time-temperature curves and have the following meanings:

- N0 = no requirement
- N1 = HCM 60 minutes and ISO 120 minutes
- N2 = HCM 120 minutes
- N3 = HCM 120 minutes and ISO 240 minutes

\* ZTV-ING: Zusätzliche Technische Vertragsbedingungen und Richtlinien für Ingenieurbauten  
(Additional Technical Terms of Contract and Guidelines for Civil Engineering Structures)

\*\* Centre d'études des tunnels

## Internationally recognised time-temperature curves



Aestuver® fire-protection boards meet or exceed the high specifications of international time-temperature curves. Further information and details on page 10–13.

## 04 Product properties and technical details

The outstanding mechanical properties of Aestuver® fire-protection boards open up a host of potential applications for this material. The possibilities include industrial installation to create standardized construction elements and systems, as well as individual, customized manufacturing of structures at the building site.

### Freeze-thaw and water-resistant

The boards' suitability for environments that are fully or partially exposed to weathering has been confirmed by tests carried out in accordance with the ÖBV guideline "Protective layers for enhanced fire-protection for underground transportation structures". The boards have also passed tests that verify their freeze-thaw resistance.



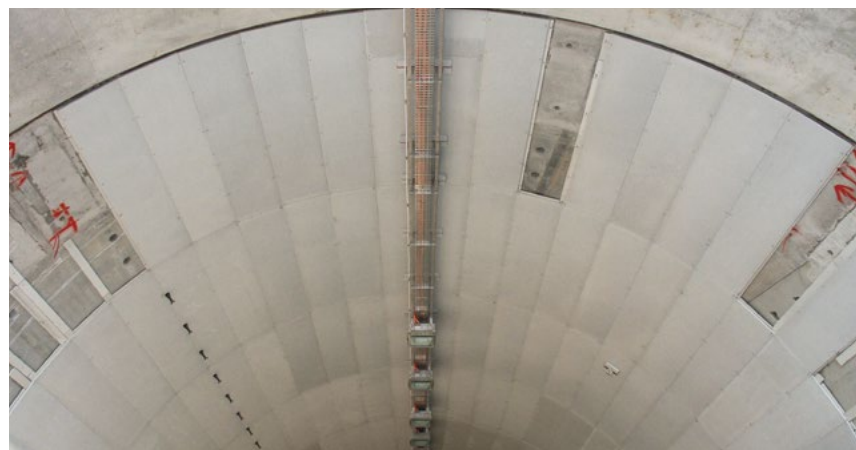
### Safe to clean and abrasion-resistant

The uniformly smooth surface allows cleaning with conventional cleaning processes, with steam and water jets, and using cleaning additives.



### Maintenance-friendly

To allow easy maintenance and inspection of the tunnel structure (concrete) and the structural joints, individual boards can be dismantled and any leaks in the concrete structure detected and repaired.





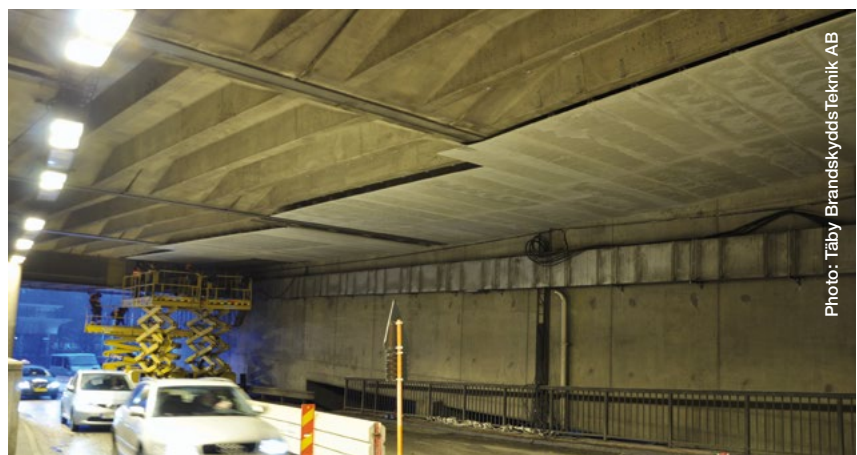
## Easy-to-handle and no risk to health

The boards can be easily machined and installed using simple, standard tools, with low dust emissions.



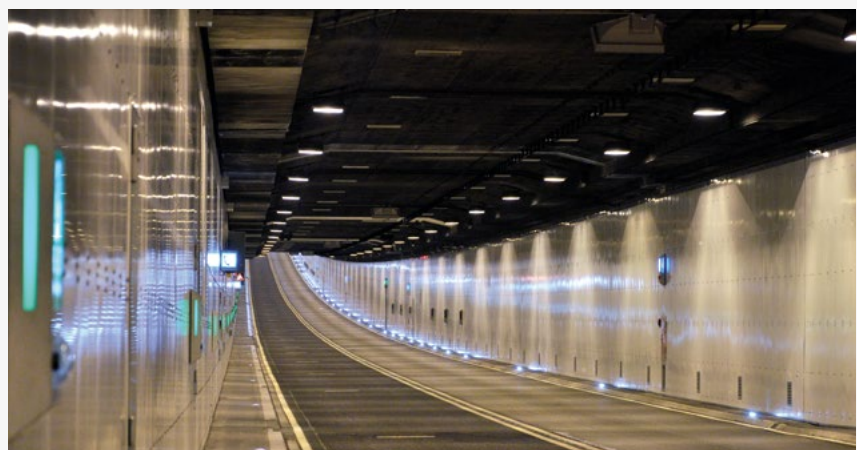
## Easy-to-assemble

The boards can be assembled with no interruption of traffic – with simple, standard tools and with no special preparation of the concrete substrate required.



## Can be coated and painted

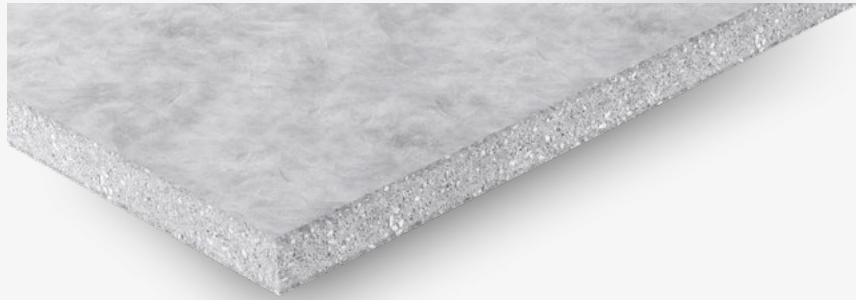
To give the interior tunnel walls an aesthetically appealing design, the smooth surface of the boards forms an ideal base for painting or coating.





## Aestuver® fire-protection board T

Cement-bonded, glass-fiber reinforced lightweight concrete board to protect concrete structures in underground transport systems against higher thermal stress.



### Characteristics

Apparent density $\rho_k$ (dry)	approx. 690–980 kg/m <sup>3</sup>
Flexural strength (based on EN 12467 $\pm 10\%$ ) <sup>1)</sup>	3.5 N/mm <sup>2</sup>
Thermal conductivity $\lambda_R$ (in accordance with DIN 12667)	0.175 W/mK
Extension / shrinkage reaction to changes in RH of air of 30 % (20 °C) (in accordance with EN 318)	$\pm 0.15\%$
Equilibrium moisture at 65 % RH of air and 20 °C air temp. (in accordance with DIN EN ISO 12570) <sup>1)</sup>	approx. 7%
Compressive strength (in accordance with EN 789) <sup>1)</sup>	9 N/mm <sup>2</sup>
Alkalinity (pH value)	approx. 12
Bending elasticity modulus in N/mm <sup>2</sup> (based on EN 12467 $\pm 10\%$ ) <sup>1)</sup>	$\geq 2000$ N/mm <sup>2</sup>
Application category with respect to intended use (in accordance with EAD 350142-00-1106)	Type 1, 2, 3, 4, 5, 6, 7, 8, 9, 10
Application category with respect to climatic conditions (in accordance with EAD 350142-00-1106)	Type X (incl. Z1, Z2, Y)

<sup>1)</sup> Value for a 20 mm board

### Dimensional tolerance at equilibrium moisture content for standard board sizes

Length, width	$\pm 1$ mm
Diagonal difference	$\leq 2$ mm
Thickness	$\pm 1$ mm

### Areas of application:

Tunnel cladding set in concrete, predominantly in new construction projects (see page 20–23)

### Assessments

European Technical Assessment	ETA-15/0531
Construction material class (in accordance with DIN EN 13501-1)	non-combustible, A1
Construction element classification for civil engineering structures	international
Tunnel fire tests in accordance with international time-temperature curves for constructions set in concrete	ZTV/EBA RWS120 RWS180 HC180 HCM120 HCM180

### Characteristics depending on board thickness

Thickness in mm	10	15	20	25	30	35	40	50	60
Surface weight per m <sup>2</sup> in kg (at 7 % humidity)	approx. 11	approx. 13	approx. 17	approx. 21	approx. 25	approx. 29	approx. 33	approx. 42	approx. 50
Apparent density $\rho_k$ in kg per m <sup>3</sup> (dry)	980	800	800	790	780	800	800	780	780

### Dimensions in mm\*

2600 × 625	✓	✓	✓	✓	✓	✓	✓	✓	✓
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\*Additional board thicknesses, lengths (up to 3000 mm), widths (up to 1250 mm) and precut sizes on request.

## Aestuver® fire-protection board Tx



Cement-bonded, glass-fiber reinforced lightweight concrete board to protect concrete structures in underground transport systems against higher thermal stress.



### Characteristics

Apparent density $\rho_k$ (dry)	800 kg/m <sup>3</sup> ± 15 %
Flexural strength (based on EN 12467 ±10 %) <sup>1)</sup>	≥ 3.1 N/mm <sup>2</sup>
Thermal conductivity $\lambda_R$ (in accordance with DIN EN 12667) <sup>1)</sup>	0.2 W/mK
Extension / shrinkage reaction to changes in RH of air of 30 % (20 °C) (in accordance with EN 318)	± 0.1 %
Equilibrium moisture at 65 % RH of air and 20 °C air temp. (in accordance with DIN EN ISO 12570) <sup>1)</sup>	approx. 3–5%
Compressive strength (in accordance with EN 789) <sup>1)</sup>	4.3 N/mm <sup>2</sup>
Alkalinity (pH value)	8–10
Bending elasticity modulus in N/mm <sup>2</sup> (based on EN 12467 ±10%) <sup>1)</sup>	2 400 N/mm <sup>2</sup>
Application category with respect to intended use (in accordance with EAD 350142-00-1106)	Type 1, 2, 3, 4, 5, 6, 7, 8, 9, 10
Application category with respect to climatic conditions (in accordance with EAD 350142-00-1106)	Type X (incl. Z1, Z2, Y)
Water vapour diffusion resistance factor $\mu$ (in accordance with EN ISO 12572) <sup>1)</sup>	12

<sup>1)</sup> Value for a 20 mm board

### Dimensional tolerance at equilibrium moisture content for standard board sizes

Length, width, thickness	± 1 mm
Diagonal difference	≤ 2 mm
Thickness	± 1 mm

**Areas of application:** For independently fixed tunnel cladding in new construction projects as well as existing structures (see page 24–35)

### Assessments

European Technical Assessment	ETA-17/0170
Construction material class (in accordance with DIN EN 13501-1)	non-combustible, A1
Construction element classification for civil engineering structures	international
Tunnel fire tests in accordance with international time-temperature curves for constructions set in concrete	RWS120 RWS180 HCM120 ISO240 NFPA 290

### Characteristics depending on board thickness

Thickness in mm	20	25	30	35
Surface weight per m <sup>2</sup> in kg (at 5 % humidity)	approx. 17	approx. 21	approx. 25	approx. 30
Apparent density $\rho_k$ in kg per m <sup>3</sup> (dry ± 15 %)	820	800	800	800

### Dimensions in mm\*

2 600 × 625	✓	✓	✓	✓
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\* Additional board thicknesses, lengths (up to 3000 mm), widths (up to 1250 mm) and precut sizes on request.



## Aestuver® fire-protection element D+2 (also available as D+2 light)

Cement-bonded, glass-fiber reinforced lightweight concrete board for escape and rescue routes.



### Characteristics

Equilibrium moisture content at 65 % RH of air and 20 °C air temp.  
(in accordance with DIN EN ISO 12570)

approx. 7 %

Alkalinity (pH value)

approx. 12

### Dimensional tolerance at equilibrium moisture content for standard board sizes <sup>3)</sup>

Length, width	± 1 mm
Thickness	± 2 mm

### Assessments

Construction material class (in accordance with DIN EN 13501-1)	non-combustible, A1
Fire resistance grade <sup>1)</sup>	I 90 and E 90

<sup>1)</sup> Examination of the complete structure required in individual cases.

### Characteristics depending on board thickness

Thickness in mm	52.5
Surface weight per m <sup>2</sup> in kg (at 5 % humidity)	47
Dimensions in mm	1 250 × 625

Other thicknesses, sizes and precut sizes on request.

### Maximum permitted load <sup>2) 3)</sup>

Span = 100 cm
Step height = 82 cm
Trial subject = 100 kg

<sup>2)</sup> Findings report of MFPA Leipzig, UB III/B-06-014

<sup>3)</sup> Sample values for Aestuver® fire-protection element D+2

### Characteristics depending on board thickness

Thickness in mm	42.5
Surface weight per m <sup>2</sup> in kg (at 5 % humidity)	35.7
Dimensions in mm	1 250 × 625

Other thicknesses, sizes and precut sizes on request.  
Maximum allowable resilience on request

### Maximum permitted rolling load <sup>2) 3)</sup> D+2 D+2 light

Span = 600 mm	12.5 kN/m <sup>2</sup>	8.00 kN/m <sup>2</sup>
Span = 800 mm	7.0 kN/m <sup>2</sup>	4.50 kN/m <sup>2</sup>
Span = 950 mm	5.0 kN/m <sup>2</sup>	3.30 kN/m <sup>2</sup>
Span = 1 000 mm	4.5 kN/m <sup>2</sup>	3.00 kN/m <sup>2</sup>
Span = 1 250 mm	2.8 kN/m <sup>2</sup>	1.85 kN/m <sup>2</sup>

### Slip resistance assessment group

R 10



R 12



R 13



**Areas of application:** Cover for concrete troughs alongside track bedding, or to replace timber sleeper lining, see page 36–37

## Aestuver® fire-protection board BSP



Cement-bonded, glass-fiber reinforced lightweight concrete board for high-quality structural fire-protection

- Certified weather, frost and water resistance
- No flammable components



### Characteristics

Apparent density $\rho_k$ (dry)	approx. 625 – ca. 965 kg/m <sup>3</sup>
Thermal conductivity $\lambda_R$ (in accordance with DIN EN 12667) <sup>1)</sup>	approx. 0.21 W/mK
Specific heat capacity c	approx. 0.9 kJ/kgK
Extension / shrinkage reaction to changes in RH of air of 30 % (20 °C) (in accordance with EN 318)	± 0.1 %
Equilibrium moisture at 65 % RH of air and 20 °C air temp. (in accordance with DIN EN ISO 12570)	approx. 7 Gew.-%
Alkalinity (pH value)	approx. 12
Application category with respect to intended use (in accordance with EAD 350142-00-1106)	Type 1, 2, 3, 4, 5, 6, 7, 8, 9, 10
Application category with respect to climatic conditions (in accordance with EAD 350142-00-1106)	Type X (incl. Z1, Z2, Y)

<sup>1)</sup> Value for a 20 mm board | Details for other board thicknesses on request

### Dimensional tolerance at equilibrium moisture content for standard board sizes

Length, width	± 1 mm
Diagonal difference	≤ 2 mm
Thickness	± 1 mm

### Assessments

European Technical Assessment	ETA-11/0458
Construction material class (in accordance with DIN EN 13501-1)	non-combustible, A1
IMO FTFC part 1	non-combustible
Construction element classification	national/international

### Characteristics depending on board thickness







Thickness in mm	10	12	15	20	25	30	40	50	60
Approx. surface weight per m <sup>2</sup> in kg (at 7 % humidity)	10	10	12	15	18	22	28	34	41
Approx. apparent density $\rho_k$ in kg per m <sup>3</sup> (dry)	950	800	800	700	690	680	650	650	640
Flexural strength in N/mm <sup>2</sup> (based on EN 12467 ± 10 %) <sup>1)</sup>	5	4	3.5	3.5	3.3	2.8	2.8	2.8	2.8
Bending elasticity modulus in N/mm <sup>2</sup> (based on EN 12467 ± 10 %)	4300	4200	3450	3000	2750	2400	2250	1900	1450
Compressive strength in N/mm <sup>2</sup> (in accordance with EN 789)	20	–*	8.5	9	–*	6.5	6.5	–*	6
Water vapour diffusion resistance factor $\mu$ (in accordance with EN ISO 12572)	36	–*	25	54	–*	–*	–*	–*	25
Airborne sound insulation $R_w$ in dB (in accordance with DIN 52210)	31	–*	–*	31	–*	–*	36	–*	39

### Dimensions in mm \*\*









2600 × 1250	✓	✓	✓	✓	✓	✓	✓	✓	✓
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\* No data available | \*\* Additional board thicknesses, lengths (up to 3000 mm), widths (up to 1250 mm) and precut sizes on request.

## 05 Accessories

Article-name	Description	Quantity/ dimensions	Article-no.
Fire-protection adhesive 1300			
	Noncombustible (EN13501-1, building material class A1), solvent-free water glass adhesive with mineral fillers for sealing and joining board materials.	20 Units à 1kg	8809903
		40 Units à 1kg	8809904
Fire-protection mastic			
	Sealing compound approved in Europe and used for producing linear joint seals or fire barriers. Can be used as sealant, filler compound or coating material, as waterproofing for fire-protection joints in outdoor or wet environments, or as cable insulation.	310ml Cartridge	8061011
		580ml Film tube	8061020
Fire-protection sealant			
	Sealing compound with ETA approval for linear joint seals or fire barriers.	Project-dependent	–
Expansion joint tape			
	ETA-approved compressible joint tape, impregnated with halogen-free fire-protection additives for improving the fire-protection of joints in ceilings and walls.	16mm	8061012
		24mm	8061013
		30mm	8061014
		39mm	8061015
		49mm	8061016
		60mm	8061017
		70mm	8061018
		80mm	8061019
Powerpanel fine surface treatment			
	Lightweight, ready-to-use dispersion filler for full-surface covering, smoothing and filling.	10l	79090
DSB tape			
	Fiber-free, high-foaming intumescent material based on graphite for system components or elements and special, detailed solutions for structural fire-protection.	10mm	8062001
		20mm	8062002
		30mm	8062003
		40mm	8062004
		50mm	8062005
		to 300mm	8062006



Article-name	Description	Quantity/ dimensions	Article-no.
Joint tape T			
	Ceramic-fiber-free joint tape, guarantees outstanding thermal stability with a melting point of over 1 330 °C.	5 m	8063002
Joint cord T			
	Intumescent material with halogen-free fire-protection additives and a flexible, moisture-resistant cover hose for strengthening expansion joints in tunnel construction while ensuring fire-protection.	32 mm	8063006
		42 mm	8063007
		47 mm	8063008
Assembling mortar			
	Easy to use dry cement based mortar with glass fibre reinforcement and lightweight additives. The mortar is used to repair areas of damages and to bond corner joints of Aestuver® fire-protection boards.	8.5 kg	9703075
Repair mortar Tx			
	Aestuver™ repair mortar Tx is a cement-based dry mortar. Aestuver™ repair mortar Tx is designed to make good minor damage to Aestuver® fire-protection boards Tx	5 kg	9703076
Nail anchor			
	Threaded anchor for direct mounting of Aestuver® fire-protection boards when retrofitting in tunnel projects.	Project-dependent	–
Nail anchor with nut			
	Self-tapping metal screws for mounting Aestuver® fire-protection boards on steel base frames.	Project-dependent	–
Screws			
	Easy to install and reinsert (removable) threaded anchor for direct mounting of Aestuver® fire-protection boards when retrofitting in tunnel projects.	Project-dependent	–
Fastening screws (self drilling)			
	Self-tapping metal screws for mounting Aestuver® fire-protection boards on steel base frames.	Project-dependent	–

## 06 Installation instructions for Aestuver® fire-protection boards

### 6.1 General

#### Board storage and transport

Aestuver® fire-protection boards (including Aestuver® T and Aestuver® Tx) are packed horizontally and delivered on pallets. They should always be stored flat on a level surface. Storing them vertically can cause deformation of the panels and damage to the edges. When panels are stacked on the floor, their load capacity must be appropriate.

As they are frost- and water-resistant, the panels can be stored outdoors. The boards should be protected from excessive moisture before installation for problem-free fitting and clean surface treatment.

They can be transported horizontally by forklift or other panel transport vehicles. Single panels should always be carried upright. Tools known as panel lifters or carriers can make it easier to carry the panels manually.

The appropriate tools and working methods should be chosen to avoid damaging the edges. Furthermore, transportation and lifting equipment must be designed to avoid damage to the boards caused by bending, vibration or collision.



Aestuver® fire-protection boards are delivered on pallets to site by truck.

Single boards should always be carried upright.

If these tools are not available, workers should wear gloves. Panels are delivered to the site on pallets and can be unloaded with a forklift. They can also be shipped in a container, for example for overseas shipments.

#### Cutting and machining

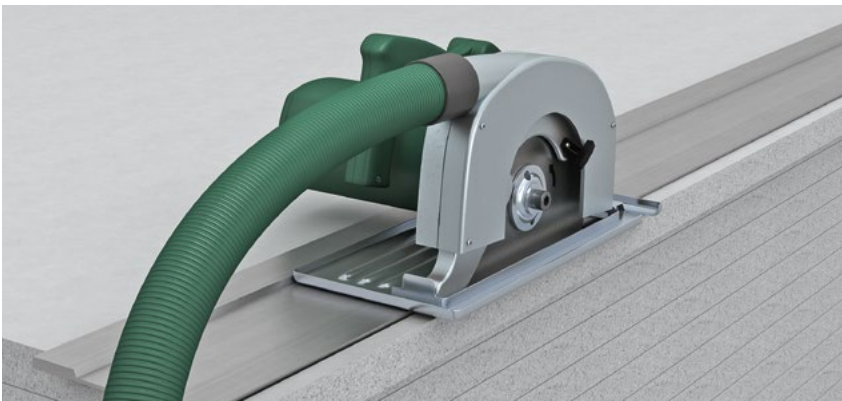
The Aestuver® fire-protection board can be cut using a conventional rail-guided circular handsaw with a dust extractor (preferably a plunge saw) or with stationary panel dividing saws. For precise, clean-edged cuts, the use of carbide-tipped saw blades with alternating teeth is recommended.

The amount of dust is reduced by using saw blades with a small number of teeth and low rotation speeds. Further processing, such as rounding and adjustments, can be performed with a jigsaw, a router or a hole saw. As is usual when cutting board materials, we recommend the use of extraction devices that continue to run on.

#### Mounting

Nail anchors or concrete screws are typically used for the direct mounting of Aestuver® fire-protection boards in tunnels. The type, size and spacing of fasteners can vary by project, however, and must always be approved by the Aestuver Application Technology team.

Backing strips can be fixed to the Aestuver® fire-protection boards using standard commercial steel staples, which makes it possible to prefabricate individual cladding elements.



Cutting Aestuver® fire-protection boards

### Joint design

Aestuver® fire-protection boards are butt-jointed (gap width  $\leq 2$  mm). Where necessary, wider gaps can be filled with Aestuver™ assembling mortar or a similar material. Approval must always be obtained from the Aestuver Application Technology team.

### Surface treatment

The smooth surface of Aestuver® fire-protection boards makes them ideal for painting or coating.

The visible side of the Aestuver® fire-protection board has a smooth surface; the alkaline base thus does not need any filling prior to final surface finishing. However, we do recommend undercoating with a base primer if the surface is to be painted or varnished. Dispersion-, resin- or acrylic-based fillers, paints and varnishes from typical commercial manufacturers can be used.

For special applications, the panel surface may need to be impregnated with alkali-resistant products. Please follow the manufacturer's instructions when applying the coating.

Panels must be dry and free of dust and grease prior to surface treatment. Coatings up to 0.5 mm thick will not infringe fire safety requirements with respect to fire resistance classification.

For esthetic reasons, fire-protection cladding in tunnel areas that are constantly exposed to weather can be coated in order to prevent uneven penetration of moisture. It is highly recommended that panels and panel edges that are exposed to water spray be coated – for example, in tunnel mouths and at entry points. The length of the area to be coated must be defined for each specific project. It depends, in particular, on the distance that melt water is carried into the tunnel. In general, it is recommended that these areas be coated up to a height of 3 meters above the surface of the roadway.

For frost and road salt resistance in road tunnels, Aestuver® fire-protection boards must be surface-coated. Appropriate solutions must be clarified on a project-specific basis and approved by the Aestuver Application Technology team.

### Repairs

Repairs to Aestuver® fire-protection boards that have sustained minor damage (surface damage, width/depth  $\leq 5$  mm) during installation must be carried out using:

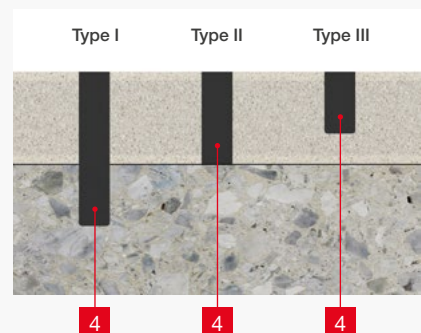
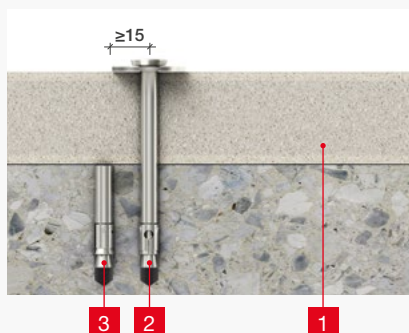
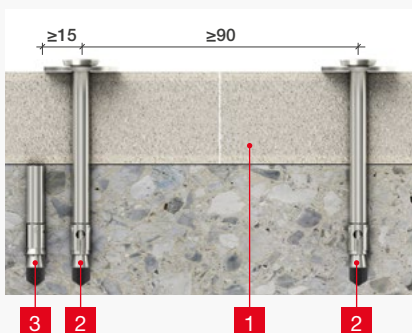
- Aestuver® fire-protection board and Aestuver® fire-protection board T:
  - Aestuver™ assembling mortar or
  - Aestuver™ fire-protection mastic
- Aestuver® fire-protection board Tx:
  - Aestuver™ repair mortar Tx or
  - Fire-protection sealant
- Damage to edges and surface (width/depth  $\leq 2$  mm):
  - no repair necessary

For environments with demanding corrosion protection requirements, the substructure and fixing must meet special quality requirements. The planning engineer must factor in these requirements when stipulating which building materials are to be used and determining appropriate protective measures.

### Filling of drill holes

In case of incorrect drillings or revised Aestuver® fire-protection boards, you can use Aestuver™ fire-protection mastic or joint mastic to fill unused drilling holes as shown as Type I / II / III (diameter: 6–20 mm). New fasteners have to be set in a distance  $\geq 15$  mm.

- 1 Aestuver® fire-protection board**  
Thickness: 30 mm  
Board directly mounted on concrete
- 2 New drilling hole with fastener**  
For example: Fischer nail anchor with washer
- 3 Old nail anchor**  
Is removed with plier
- 4 Drilling hole filled with Aestuver™ fire-protection mastic or joint mastic**  
 $\varnothing$  6–20 mm







### Cleaning

Aestuver® fire-protection boards can be cleaned using conventional cleaning methods, such as high-pressure water jets, steam jets or brushes. When using high-pressure water jets, we recommend the following distances between the nozzle and the panel surface:

- Distance  $\geq 50$  cm with 100 bar
- Distance  $\geq 20$  cm with 20 bar

Tests carried out in accordance with DIN EN ISO 11998 have confirmed the good cleanability of the boards' surface.

Aestuver® fire-protection boards require no additional coating or hydrophobic treatment for the cleaning methods listed above.

### Disposal

Aestuver® fire-protection boards are a mineral building material with no components that are dangerous to health or groundwater; it can therefore be disposed of at construction-waste landfill sites. Waste code (EWC): 170101 (concrete)

## 6.2 Installation instructions for set in concrete fire protection system

The Aestuver® fire-protection boards and backing strips must be clean, dry and free of dust.

Structural conditions in the tunnel (such as joints or integral components) must be considered in detail during planning and installation of the fire-protection boards.

A gap must be left around adjacent components in order to prevent climate variations from causing any movement of the structure or board materials.

Aestuver® fire-protection boards are installed in the shell construction with

butt joints. All butt joints are then covered with backing strips (lengthwise and crosswise).

- Width: 100 mm
- Thickness: 10 mm

Each backing strip is fixed with staples (made of rustproof steel).

- Staple spacing: approx. 50–75 mm
- Staple length: Thickness of the backing strips + board thickness – 5 mm

This protects the bottom of the panel (side that is visible in the tunnel) from being contaminated with wet cement.

The backing strips must be 50 mm from the edge of the board (centred on a joint).

It is advisable to start with 1,250 mm long backing strips to cover all continuous joints.

The shorter backing strips are installed on the joints between the rows of longer backing strips.

Contact Aestuver's Technical Department for further details regarding the installation of a set-in concrete fire protection system.

The smooth, printed side remains visible during the preparation process. The nonprinted side faces the interior of the tunnel (i.e., the roadway).



Fixing of backing strips on Aestuver® fire-protection board T

### 6.3 Handling instructions for retrofitted fire-protection cladding (direct mounting)

In order to mount Aestuver® fire-protection boards securely, uneven base surfaces must be smoothed out in the area of the mounting points as needed. Backing strips can be used for this purpose or, for smaller areas, Aestuver™ assembling mortar can also be used.

When installed in lining segments or round tunnels, fire-protection boards should be laid crosswise.

- Fire-protection cladding is typically installed from top to bottom.

- Before attaching the fire-protection cladding, the condition of the tunnel surface must be inspected (for leaks, cracks and load capacity, etc.).



- The drilled holes must be marked on the fire-protection board. Drilling templates can be used for marking or even for drilling the holes.



- Apply the backing strips to the printed side of the Aestuver® fire-protection board.
- Fasten each backing strip with stainless steel staples, 2–3 per backing strip (temporary fixation)



- Place the first panel in the exact position required. The nonprinted side of the Aestuver® fire-protection board should face the interior of the tunnel (i.e., the roadway).
- Drill the holes for the fasteners and extract the drilling dust.



- Install the fasteners in the base surface with appropriate fastening tools. The fasteners must be driven into the base surface to a depth at which the washer touches the panel.
  - Nail anchors: using a pneumatic hammer, or manually
  - Threaded anchors: using a pneumatic screwdriver, or manually
- All adjacent panels are butt-jointed (gap width  $\leq 2$  mm). If a tight board joint is not possible, then the fire-protection board must be trimmed to fit or replaced.

## 07 Application areas tunnels

### Details:

Fire-protection cladding set in concrete

Wall apron mounted with nail anchors

Fire-protection cladding set in concrete

Wall apron set in concrete

Backing strips

Fire-protection cladding set in concrete in the haunch region

With Aestuver™ joint tape T 1330

Fire-protection cladding set in concrete in haunch area

Without Aestuver™ joint tape T 1330

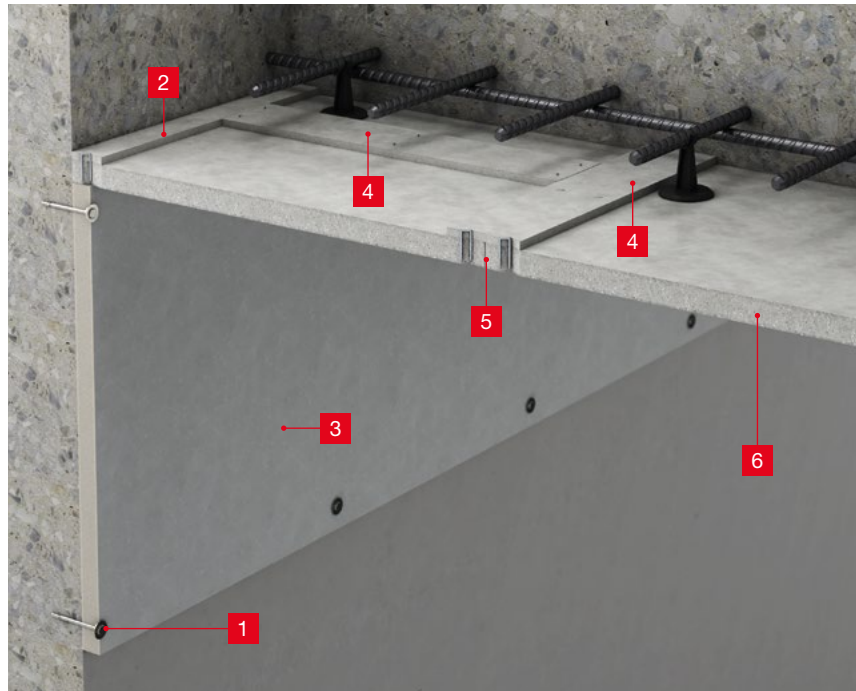




## Fire-protection cladding set in concrete – permanent formwork

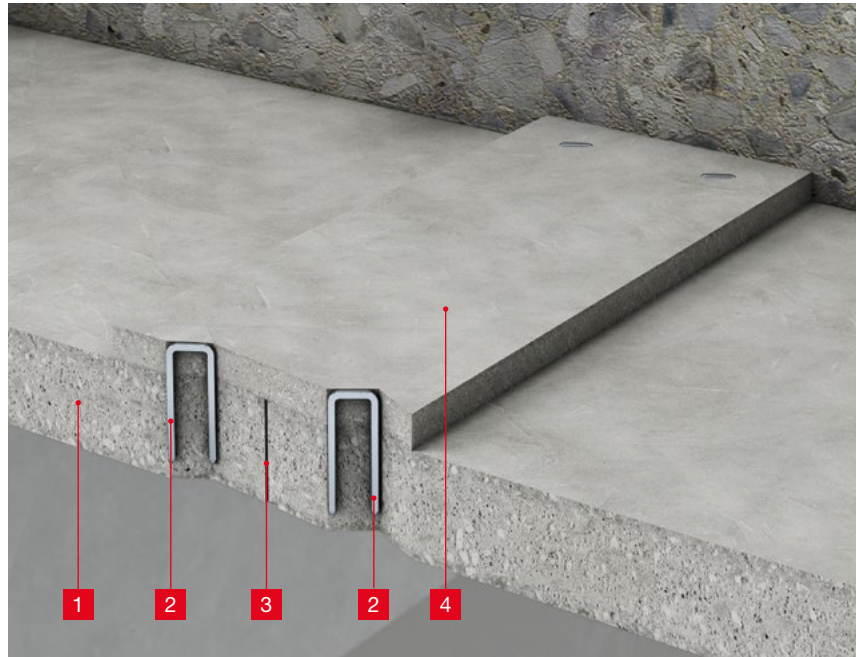
### Wall apron fixed with nail anchors

- 1 Fixing of wall apron**  
Fixings: Nail anchors with washers
- 2 Backing strips (wall fixing)**  
Aestuver® fire-protection board T  
Width: 50 mm – Thickness: 10 mm  
Fixings: Staples
- 3 Wall apron**  
Aestuver® fire-protection board Tx
- 4 Backing strips (transverse and longitudinal joints)**  
Aestuver® fire-protection board T  
Width: 100 mm – Thickness: 10 mm  
Fixings: Staples
- 5 Joints – Closely butted**
- 6 Ceiling cladding set in concrete**  
Aestuver® fire-protection board T



## Backing strips

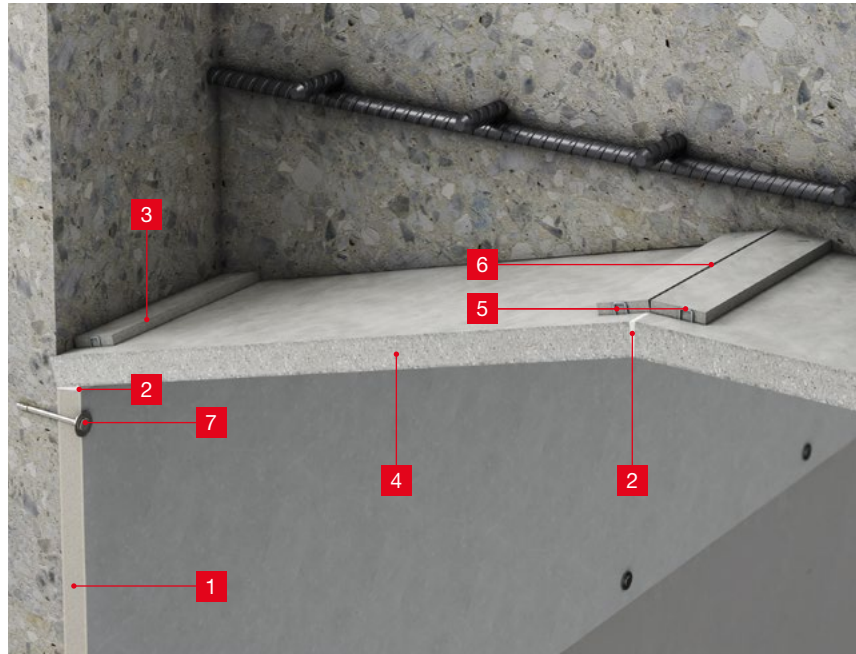
- 1 Ceiling cladding set in concrete**  
Aestuver® fire-protection board T
- 2 Fixing of backing strips**  
Fixings: Staples
- 3 Joints – Closely butted**
- 4 Backing strips (transverse and longitudinal joints)**  
Aestuver® fire-protection board T  
Width: 100 mm – Thickness: 10 mm  
Fixings: Staples



## Fire-protection cladding set in concrete in the haunch region

With Aestuvert<sup>TM</sup> joint tape T 1330

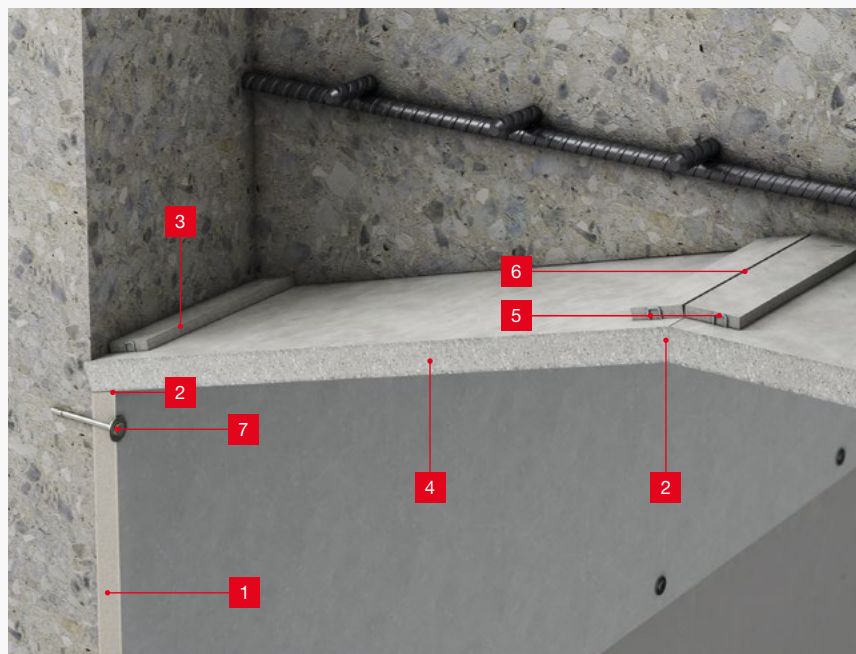
- 1 Wall apron**  
Aestuvert<sup>®</sup> fire-protection board Tx
- 2 Joints – Aestuvert<sup>TM</sup> joint tape T 1330**
- 3 Backing strips (wall fixing)**  
Aestuvert<sup>®</sup> fire-protection board T  
Width: 50 mm – Thickness: 10 mm  
Fixings: Staples
- 4 Ceiling cladding set in concrete**  
Aestuvert<sup>®</sup> fire-protection board T
- 5 Backing strips (transverse and longitudinal joints)**  
Aestuvert<sup>®</sup> fire-protection board T  
Width: 50 mm – Thickness: 10 mm  
Fixings: Staples –  
Staple spacing: ≤ 50 mm
- 6 Board joint – Closely butted**
- 7 Mounting of fire-protection cladding – Nail anchors or concrete screws with washers**



## Fire-protection cladding set in concrete in haunch area

Without Aestuvert<sup>TM</sup> joint tape T 1330

- 1 Wall apron**  
Aestuvert<sup>®</sup> fire-protection board Tx
- 2 Joints – Closely butted**
- 3 Backing strips (wall fixing)**  
Aestuvert<sup>®</sup> fire-protection board T  
Width: 50 mm – Thickness: 10 mm  
Fixings: Staples
- 4 Ceiling cladding set in concrete**  
Aestuvert<sup>®</sup> fire-protection board T
- 5 Backing strips (transverse and longitudinal joints)**  
Aestuvert<sup>®</sup> fire-protection board T  
Width: 50 mm – Thickness: 10 mm  
Fixings: Staples –  
Staple spacing: ≤ 50 mm
- 6 Board joint – Closely butted**
- 7 Mounting of fire-protection cladding – Nail anchors or concrete screws with washers**



## Details:

Fire protection cladding system for walls and ceiling (with backing strips)

Fixings: Nail anchors

Fire protection cladding system for walls and ceiling (with backing strips)

Fixings: Concrete screws

Fire protection cladding system for walls and ceiling (without backing strips)

Fixings: Nail anchors

Fire protection cladding system for walls and ceiling (on metal subframe)

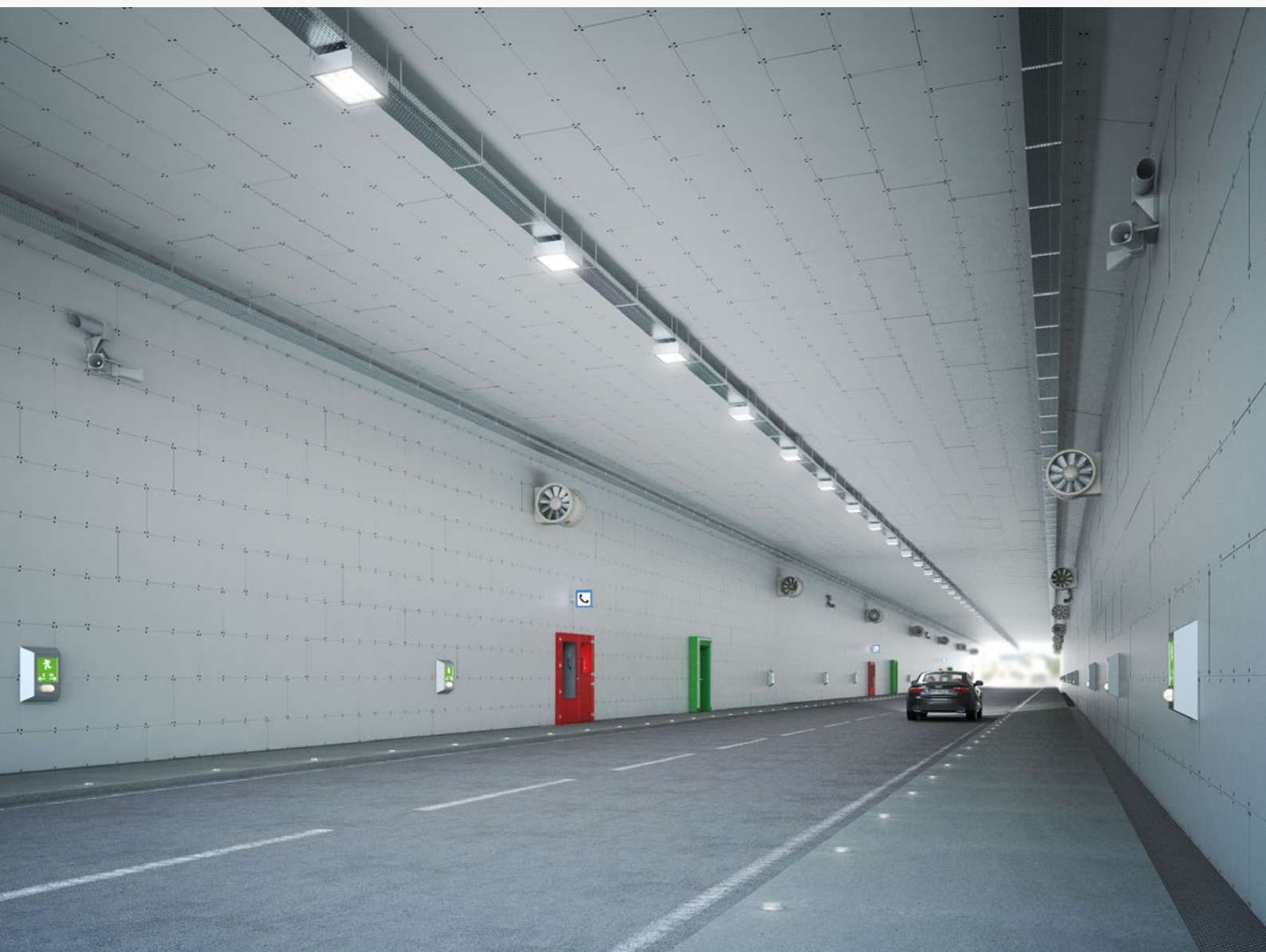
Fixings: Metal screws

Fixing elements for tunnel technology

Penetration of fire-protection board for tunnel technology

Joint tolerance

Height tolerance

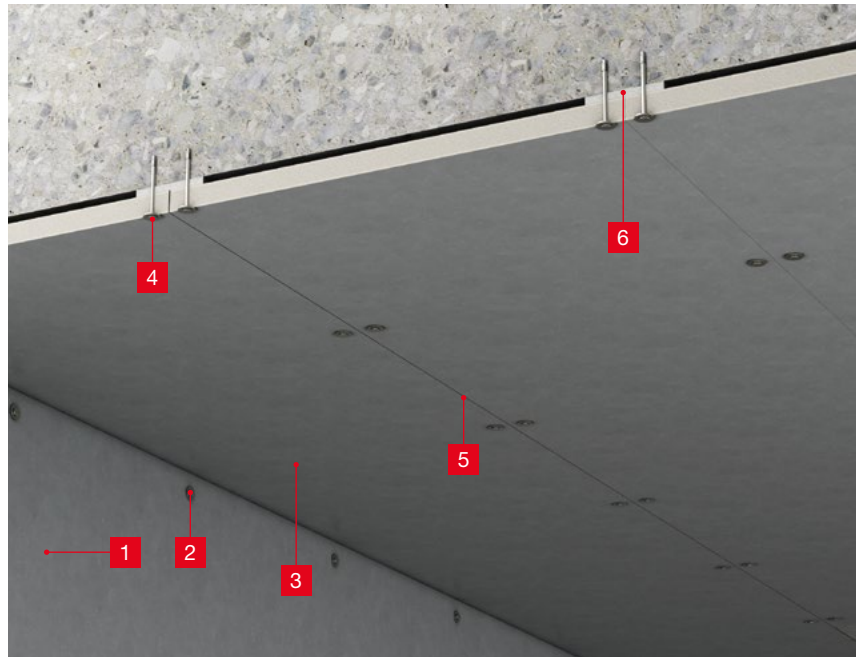




## Fire protection cladding system for walls and ceiling (with backing strips)

Fixings: Nail anchors

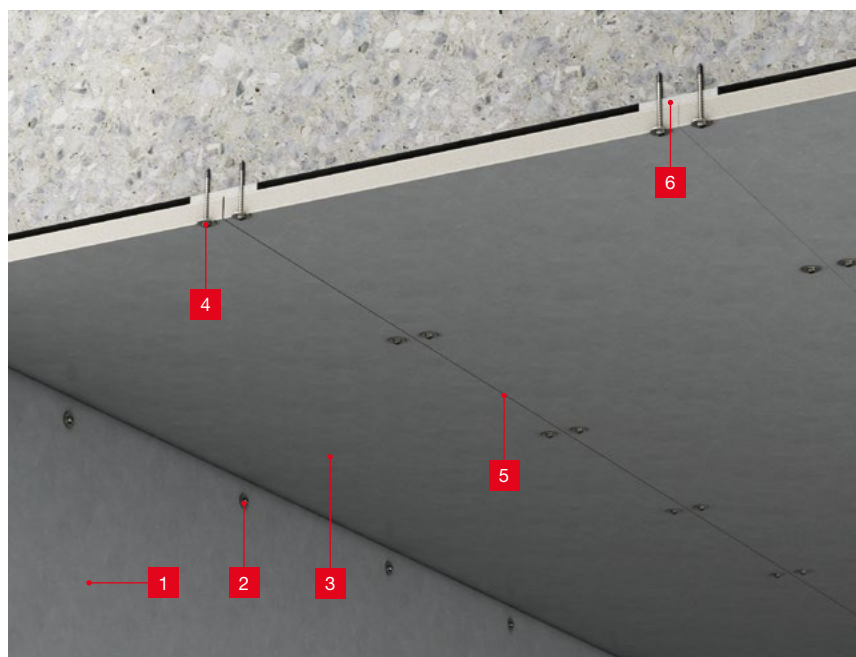
- 1 Wall apron**  
Aestuver® fire-protection board Tx
- 2 Fixing of wall apron**  
Fixings: Nail anchors with washers
- 3 Independently fitted ceiling cladding**  
Aestuver® fire-protection board Tx
- 4 Fixing of fire-protection cladding**  
Fixings: Nail anchors with washers
- 5 Joints – Closely butted**
- 6 Backing strips (transverse and longitudinal joints)**  
Aestuver® fire-protection board T  
Width: 100mm – Thickness: 10mm



## Fire protection cladding system for walls and ceiling (with backing strips)

Fixings: Concrete screws

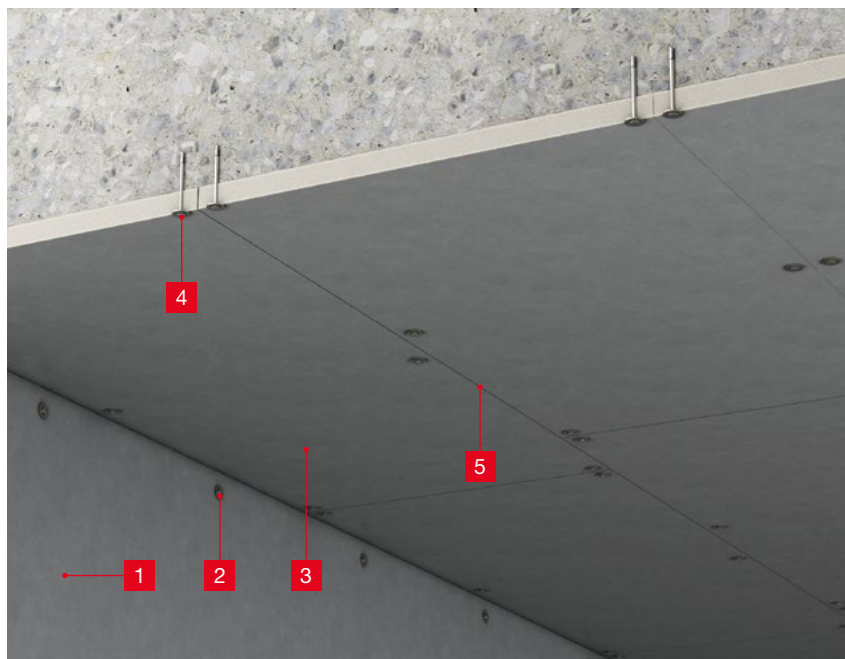
- 1 Wall apron**  
Aestuver® fire-protection board Tx
- 2 Fixing of wall apron**  
Fixings: Concrete screws with washers
- 3 Independently fitted ceiling cladding**  
Aestuver® fire-protection board Tx
- 4 Fixing of fire-protection cladding**  
Fixings: Concrete screws with washers
- 5 Joints – Closely butted**
- 6 Backing strips (transverse and longitudinal joints)**  
Aestuver® fire-protection board T  
Width: 100mm – Thickness: 10mm



## Fire protection cladding system for walls and ceiling (without backing strips)

Fixings: Nail anchors

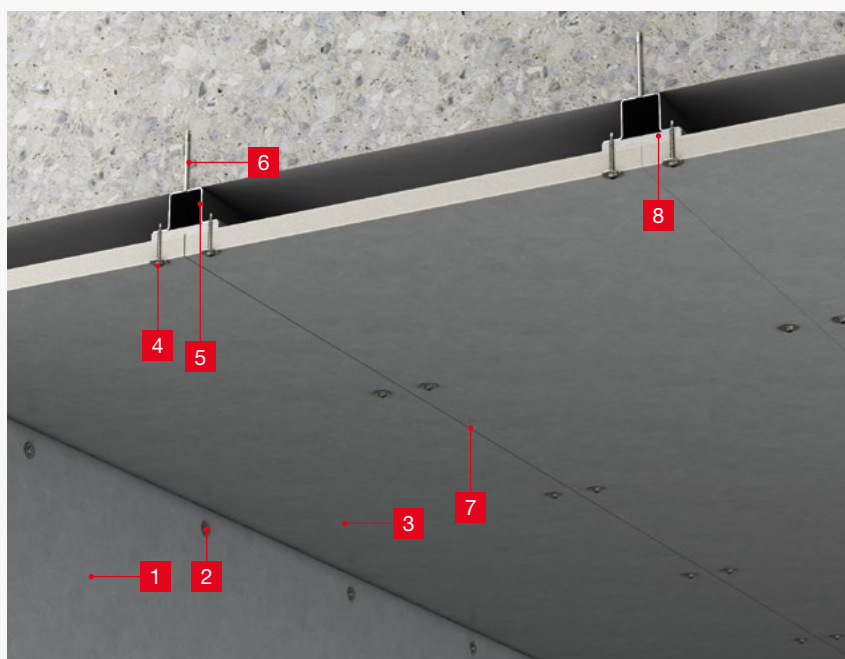
- 1 Wall apron**  
Aestuver® fire-protection board Tx
- 2 Fixing of wall apron**  
Fixings: Nail anchors with washers
- 3 Independently fitted ceiling cladding**  
Aestuver® fire-protection board Tx  
Format: 1 300 × 625 mm
- 4 Fixing of fire-protection cladding**  
Fixings: Nail anchors with washers
- 5 Joints – Closely butted**



## Fire protection cladding system for walls and ceiling (on metal subframe)

Fixings: Metal screws

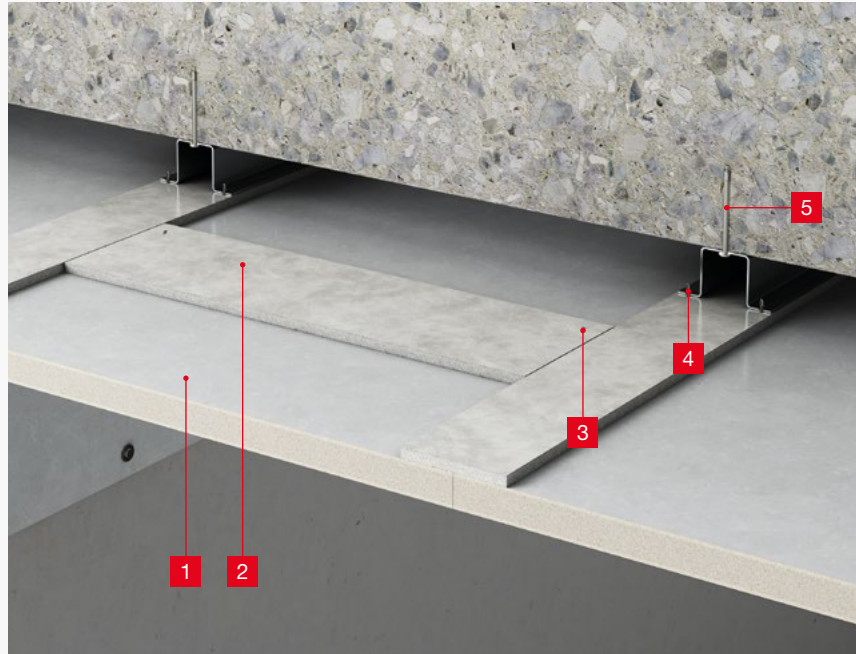
- 1 Wall apron**  
Aestuver® fire-protection board Tx
- 2 Fixing of wall apron**  
Fixings: Nail anchors with washers
- 3 Independently fitted ceiling cladding on substructure**  
Aestuver® fire-protection board Tx
- 4 Fixing of fire-protection cladding**  
Fixings: Screws with drill points and washers
- 5 Metal substructure**
- 6 Fixing of metal substructure**  
Fixings: Nail anchors
- 7 Joints – Closely butted**
- 8 Backing strips (transverse and longitudinal joints)**  
Aestuver® fire-protection board T  
Width: 100mm – Thickness: 10mm



## Fire protection cladding system for walls and ceiling (on metal subframe)

Fixings: Metal screws

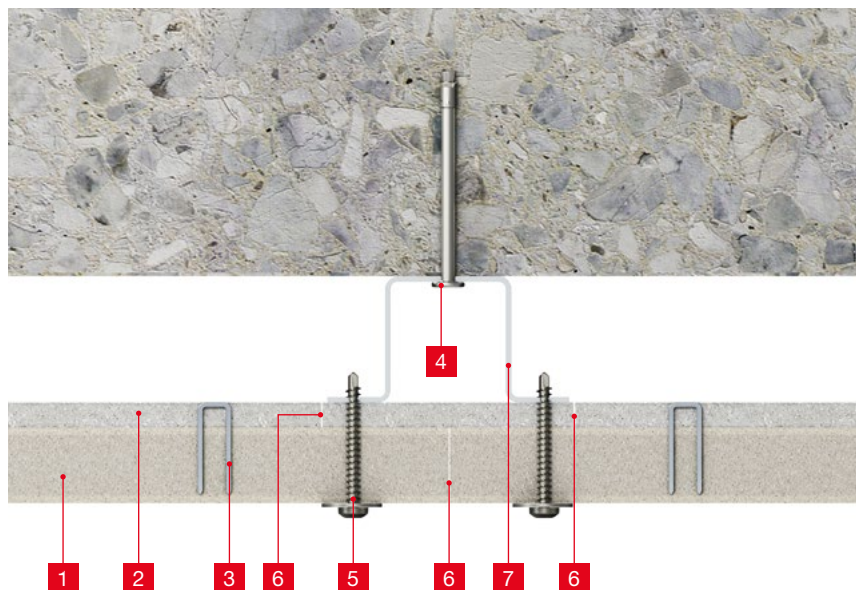
- 1** Independently fitted ceiling cladding on substructure  
Aestuver® fire-protection board Tx
- 2** Backing strips (transverse and longitudinal joints)  
Aestuver® fire-protection board T  
Width: 100 mm – Thickness: 10 mm
- 3** Fixing of backing strips (transverse joints)  
Fixings: Staples
- 4** Fixing of fire-protection cladding  
Fixings: Screws with drill points and washers
- 5** Fixing of metal substructure  
Fixings: Nail anchors



## Fire protection cladding system for walls and ceiling (on metal subframe)

Without Aestuver™ joint tape T 1330

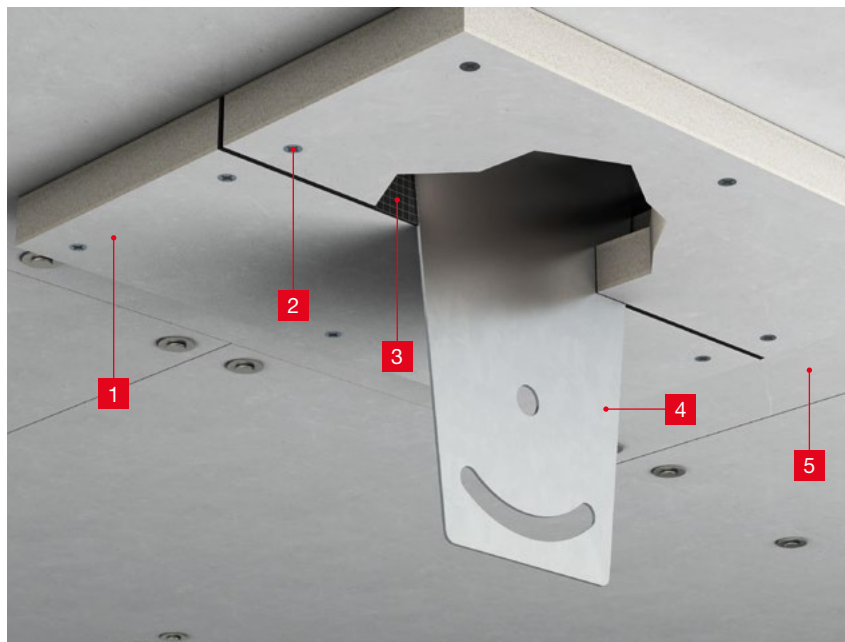
- 1** Independently fitted ceiling cladding on substructure  
Aestuver® fire-protection board Tx
- 2** Backing strips (transverse and longitudinal joints)  
Aestuver® fire-protection board T  
Width: 100 mm – Thickness: 10 mm
- 3** Fixing of backing strips (transverse and longitudinal joints)  
Fixings: Staples
- 4** Fixing of metal substructure  
Fixings: Nail anchors
- 5** Fixing of fire-protection cladding  
Fixings: Screws and washers
- 6** Joints – Closely butted
- 7** Metal substructure





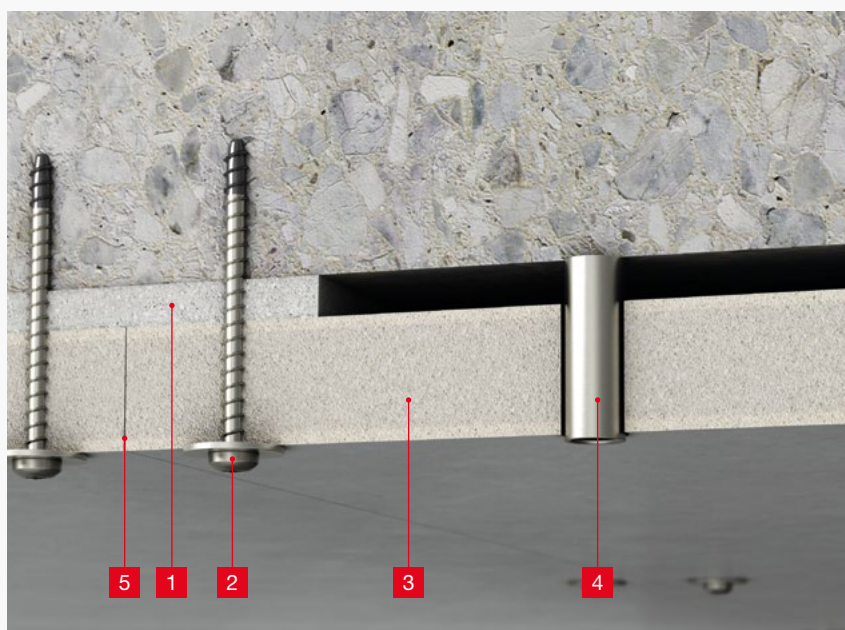
## Fixing elements for tunnel technology

- 1 Double-layer board**  
Aestuver® fire-protection board Tx
- 2 Fixing of double-layer board**  
Fixings: Drywall screws
- 3 Joints**  
Aestuver™ joint tape DSB
- 4 Fixing elements for tunnel technology**
- 5 Subsequently fixed ceiling cladding**  
Aestuver® fire-protection board Tx



## Penetration of fire-protection board for tunnel technology

- 1 Backing strips**  
Aestuver® fire-protection board T
- 2 Fixing of fire-protection cladding**  
Fixings: Concrete screws with washers
- 3 Subsequently fixed ceiling cladding**  
Aestuver® fire-protection board Tx
- 4 Stainless-steel sleeve (as spacer to receive fixings used in tunnel technology)**
- 5 Joints – Closely butted**

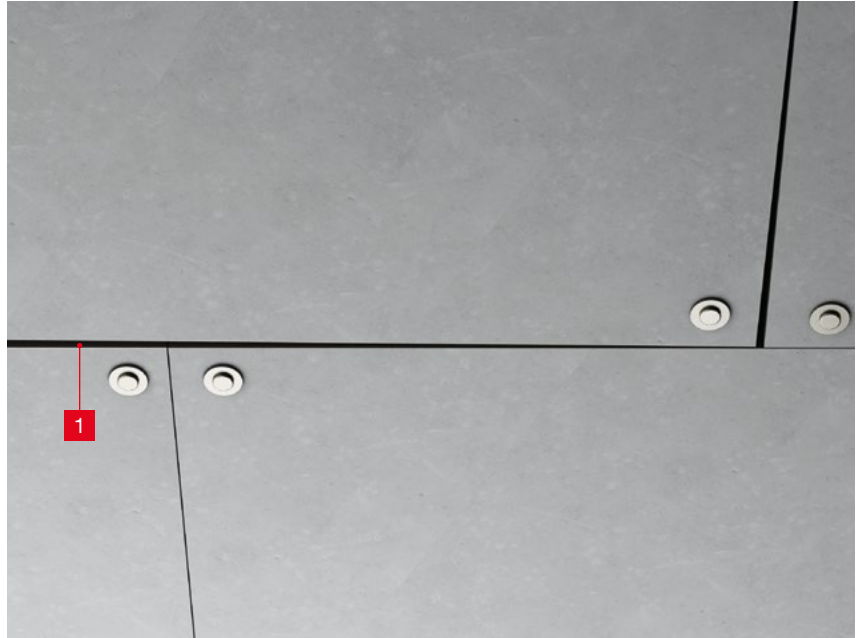


Penetration of the fire-protection cladding to support additional loads should be tested and evaluated on a project-by-project basis.



## Joint tolerance

- 1 Joint tolerance**  
Maximum: 2 mm



## Height tolerance

- 1 Height tolerance**  
Maximum: 3 mm



## Details:

### Retrofitted lining segment cladding (with backing strips)

Mounting: Concrete screws

### Transition between rectangular and lining segment tunnel (with backing strips)

Mounting: Nail anchors

### Penetration and mounting elements for tunnel technology

### Penetration of lining segment cladding for load suspension

Aestuver also offers design solutions to prevent the formation icicles in rock tunnels. The international fire-protection project team will be happy to answer any questions you may have.



## Retrofitted lining segment cladding (with backing strips)

Mounting: Concrete screws

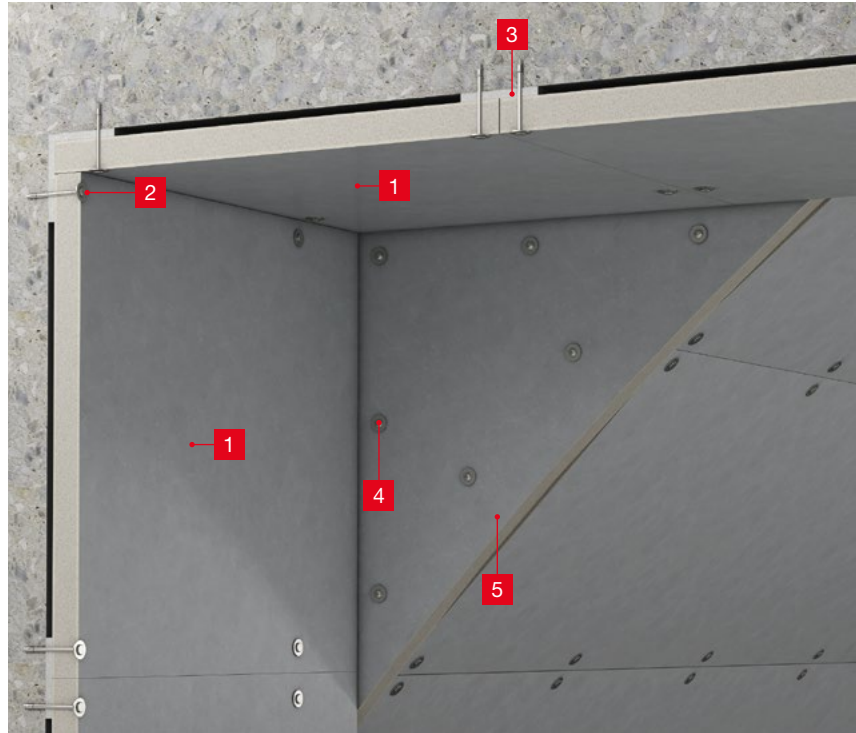
- 1 Lining segment cladding**  
Aestuver® fire-protection board Tx
- 2 Mounting of fire-protection cladding**  
Mounting: Concrete screws
- 3 Joints – Closely butted**
- 4 Backing strips (transverse and longitudinal joints)**  
Aestuver® fire-protection board T  
Width: 100mm – Thickness: 10mm



## Transition between rectangular and lining segment tunnel (with backing strips)

Mounting: Nail anchors

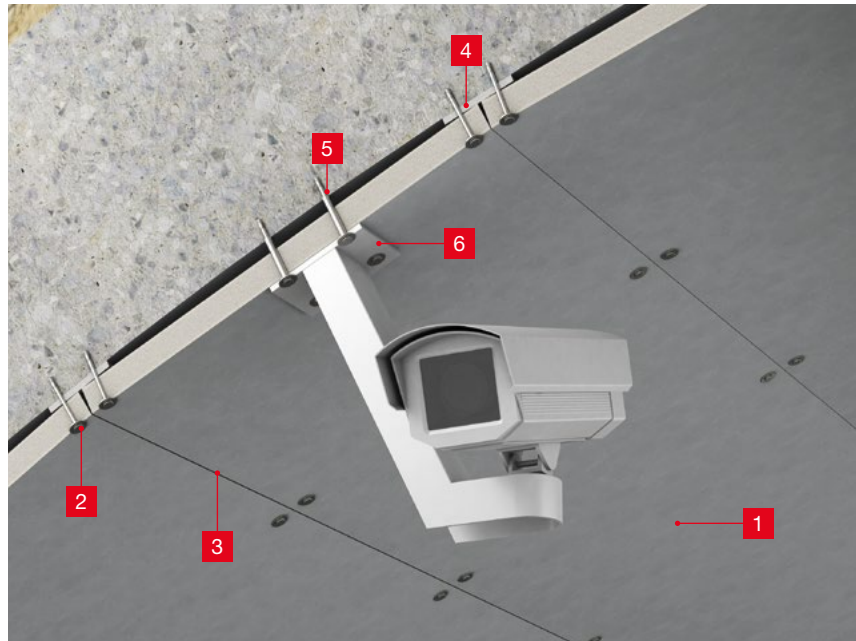
- 1 Retrofitted ceiling lining and wall apron mounting**  
Aestuver® fire-protection board Tx
- 2 Mounting of wall apron and ceiling lining**  
Mounting: Nail anchors with washers
- 3 Backing strips (transverse and longitudinal joints)**  
Aestuver® fire-protection board T  
Width: 100 mm – Thickness: 10 mm
- 4 Mounting of fire-protection cladding in the transition area**  
Mounting: Nail anchors with washers
- 5 Mounting of fire-protection cladding in the transition area on lining segment cladding (board in board edge)**  
Mounting: Drywall screws with washers





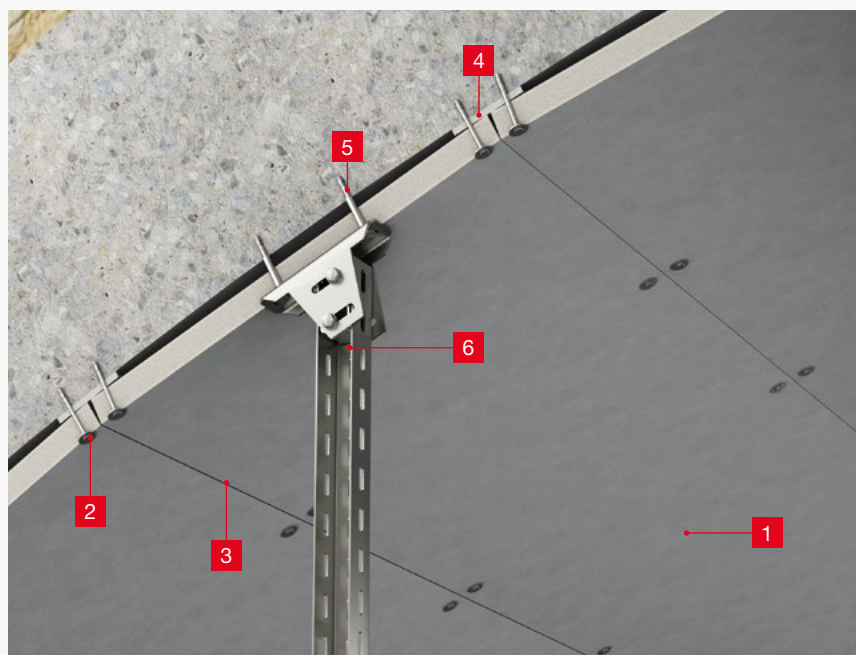
## Penetration and mounting elements for tunnel technology

- 1 Lining segment cladding**  
Aestuver® fire-protection board Tx
- 2 Mounting of fire-protection cladding**  
Mounting: Nail anchors with washers
- 3 Joints – Closely butted**
- 4 Backing strips (transverse and longitudinal joints)**  
Aestuver® fire-protection board T  
Width: 100 mm – Thickness: 10 mm
- 5 Stainless-steel sleeve (as spacer to receive fixings used in tunnel technology)**
- 6 Various load suspensions**  
e.g., for traffic cameras



## Penetration of lining segment cladding for load suspension

- 1 Lining segment cladding**  
Aestuver® fire-protection board Tx
- 2 Mounting of fire-protection cladding**  
Mounting: Nail anchors with washers
- 3 Joints – Closely butted**
- 4 Backing strips (transverse and longitudinal joints)**  
Aestuver® fire-protection board T  
Width: 100 mm – Thickness: 10 mm
- 5 Stainless-steel sleeve (as spacer to receive fixings used in tunnel technology)**
- 6 Various load suspensions**  
e.g., for traffic cameras



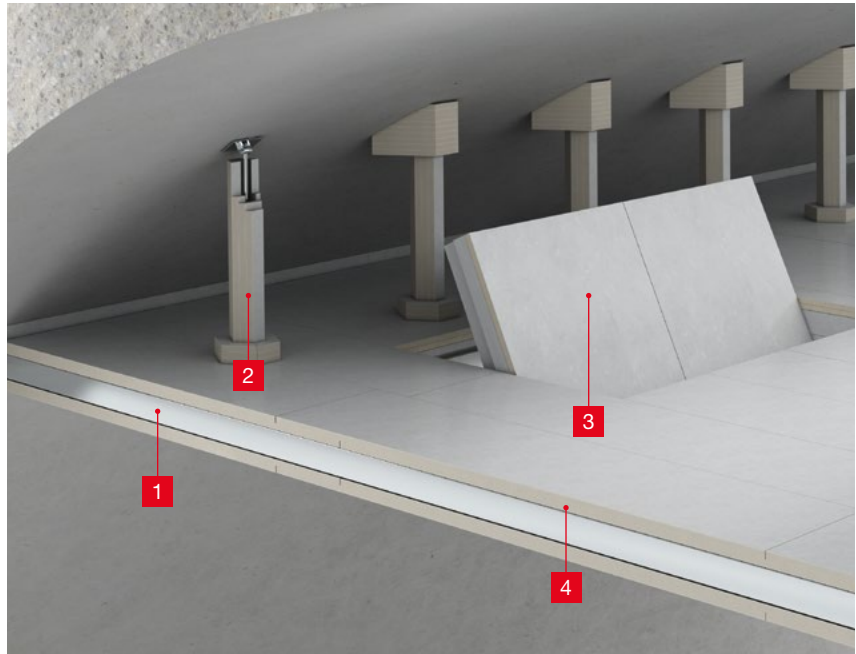
**Detail:**

Independently fixed smoke extraction layer



## Independently fixed smoke extraction layer

- 1 Smoke extraction layer**  
Aestuver® fire-protection board Tx  
(double-sided, double-layered)
- 2 Fire-protection cladding for  
hanger rods**  
Aestuver® fire-protection board Tx
- 3 Smoke extraction doors**  
Aestuver® fire-protection board Tx
- 4 Supporting structure**





**Details:**

Escape route between tracks (Indoor and outdoor)

Cable-trough cover (Indoor and outdoor)

Walkable cover on cable channels

**Advantages:**

- Durable and supports live loads (permissible traffic load of up to 12.5 kN/m<sup>2</sup>)
- Low weight makes installation and repair quick and easy
- Proven water and freeze-thaw resistance (see page 8)





## Escape and access routes in the rail area (Indoor and outdoor)

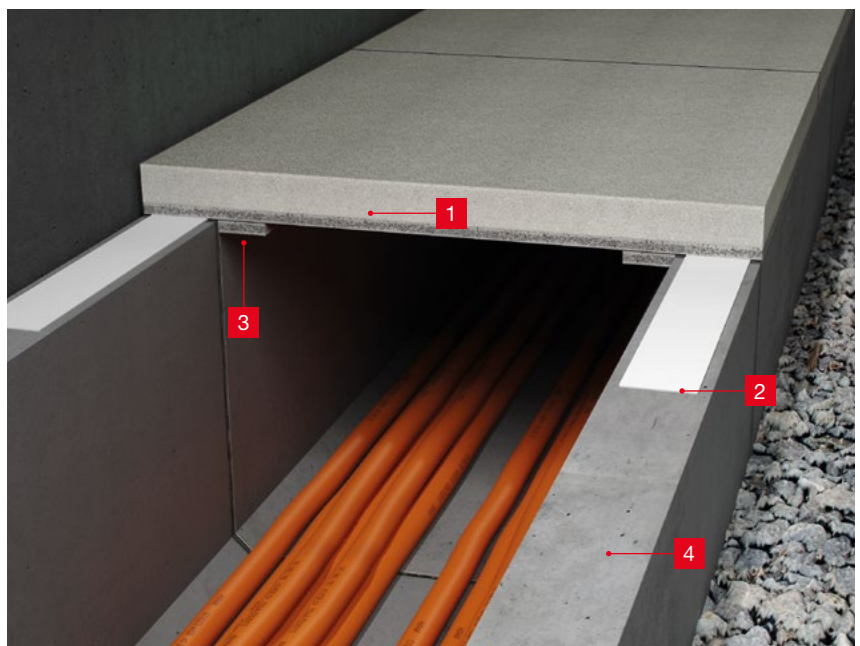
- 1 Escape route between tracks**  
 Aestuver® fire-protection element D+2  
 • with optional antislip coating R10 to R13



## Cable-trough cover (Indoor and outdoor)

Walkable cover on cable channels

- 1 Cable-trough cover**  
 Aestuver® fire-protection element D+2  
 • with optional antislip coating R10 to R13
- 2 Aestuver™ sealing strip (optional)**
- 3 Preassembled panel strips to secure against movement (optional)**
- 4 Concrete cable channel**



A fire resistance duration of 90 minutes can be guaranteed for fire loads (in the cable trough).

## Details:

### Expansion joint with Aestuvert<sup>TM</sup> joint cord T

Fire-protection cladding set in concrete

### Expansion joint with Aestuvert<sup>TM</sup> joint cord T

Independently fixed fire-protection cladding

### Expansion joint with sliding cover detail

Fire-protection cladding set in concrete (Version 1)

### Expansion joint with sliding cover detail

Fire-protection cladding set in concrete (Version 2)

### Expansion joint with sliding cover detail

Independently fixed fire-protection cladding

### Expansion joint with joint compound

Independently fixed fire-protection cladding

### Expansion joint with joint compound

Retrofitted fire-protection cladding

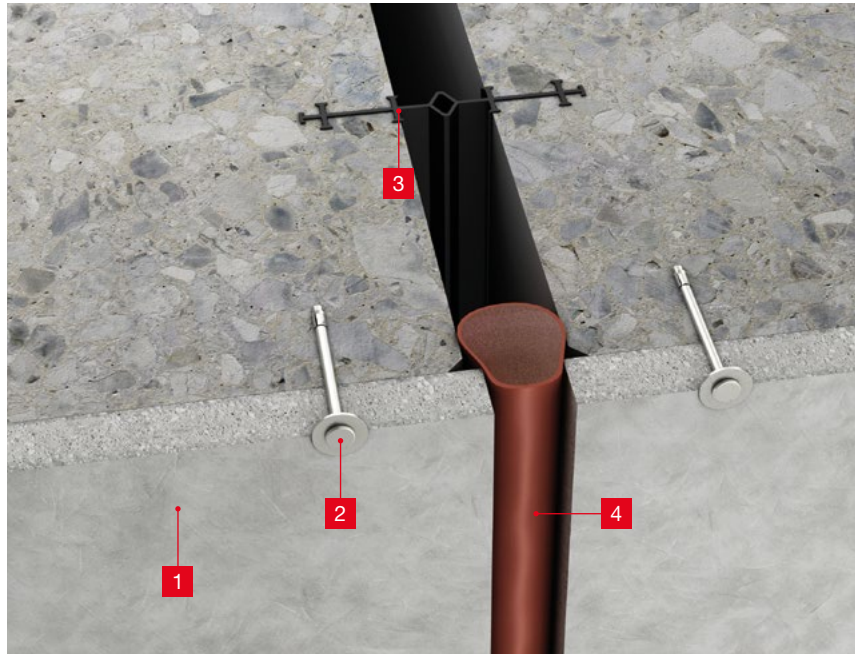


## Expansion joint with Aestuvert<sup>TM</sup> joint cord T

Fire-protection cladding set in concrete

- 1** Fire-protection cladding set in concrete  
Aestuvert<sup>®</sup> fire-protection board T
- 2** Fixing of fire-protection cladding  
Fixings: Nail anchors
- 3** Tunnel sealing\*
- 4** Fire-protection joint  
Aestuvert<sup>TM</sup> joint cord T

\* To protect the tunnel sealing, a noncombustible mineral wool can be integrated (optional).

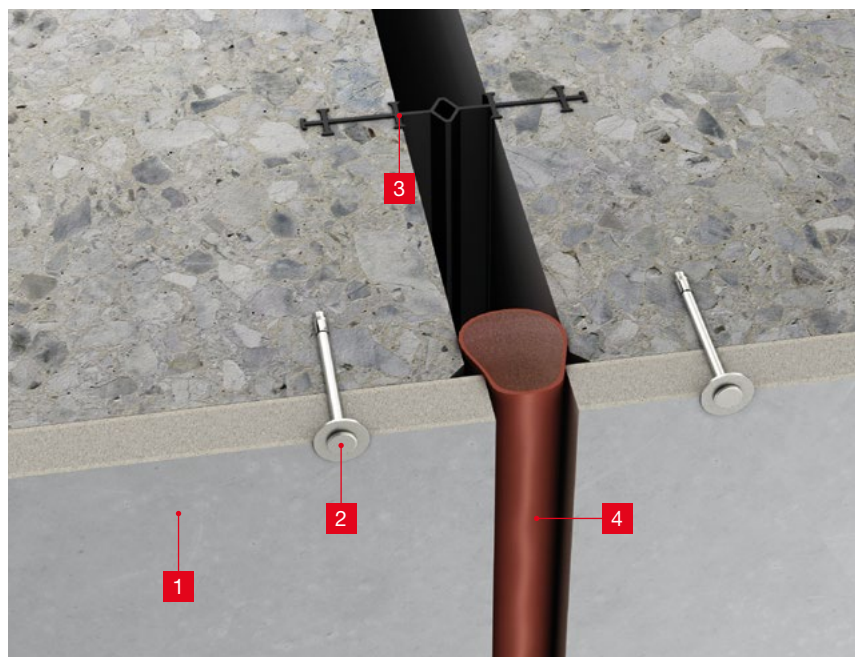


## Expansion joint with Aestuvert<sup>TM</sup> joint cord T

Independently fixed fire-protection cladding

- 1** Independently fixed fire-protection cladding  
Aestuvert<sup>®</sup> fire-protection board Tx
- 2** Fixing of fire-protection cladding  
Fixings: Nail anchors
- 3** Tunnel sealing\*
- 4** Fire-protection joint  
Aestuvert<sup>TM</sup> joint cord T

\* To protect the tunnel sealing, a noncombustible mineral wool can be integrated (optional).



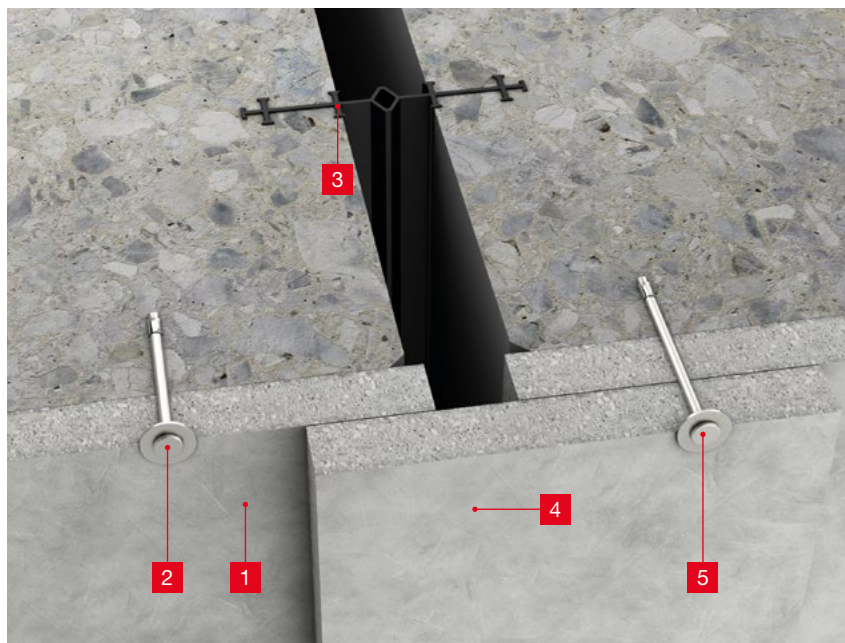


## Expansion joint with sliding cover detail

### Fire-protection cladding set in concrete (Version 1)

- 1 Fire-protection cladding set in concrete**  
Aestuver® fire-protection board T
- 2 Fixing of fire-protection cladding**  
Fixings: Nail anchors
- 3 Tunnel sealing\***
- 4 Expansion joint cover**  
Aestuver® fire-protection board T
- 5 Fixing of slide structure**  
Fixings: Nail anchors

\* To protect the tunnel sealing, a noncombustible mineral wool can be integrated (optional).



## Expansion joint with sliding cover detail

### Fire-protection cladding set in concrete (Version 2)

- 1 Fire-protection cladding set in concrete**  
Aestuver® fire-protection board T
- 2 Additional fixing in the expansion joint area**  
Fixings: Nail anchors
- 3 Expansion joint cover**  
Aestuver® fire-protection board T
- 4 Fixing support for expansion joint cover**  
Fixings: Aestuver™ screws



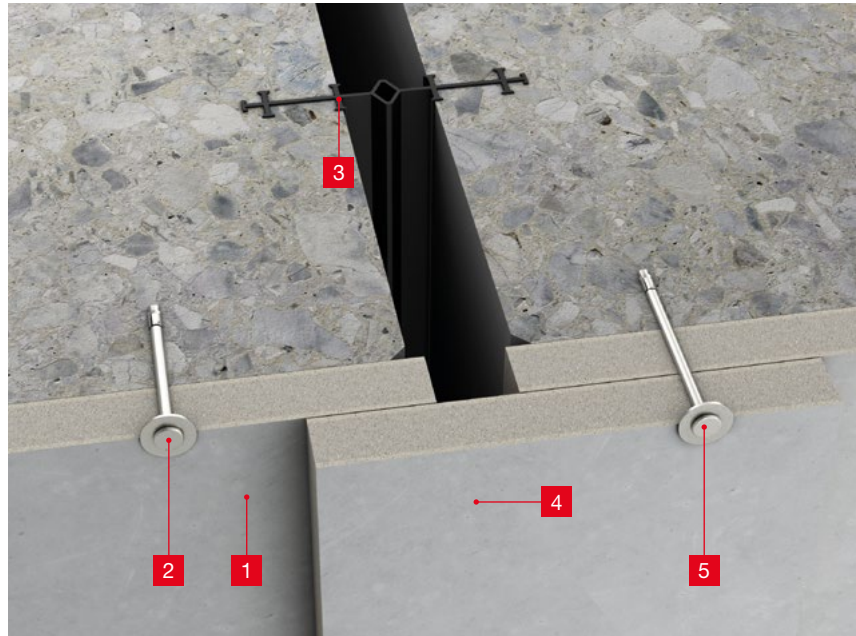


## Expansion joint with sliding cover detail

### Independently fitted fire-protection cladding

- 1** Independently fitted fire-protection cladding  
Aestuver® fire-protection board Tx
- 2** Fixing of fire-protection cladding  
Fixings: Nail anchors
- 3** Tunnel sealing\*
- 4** Expansion joint cover  
Aestuver® fire-protection board Tx
- 5** Fixing of slide structure  
Fixings: Nail anchors

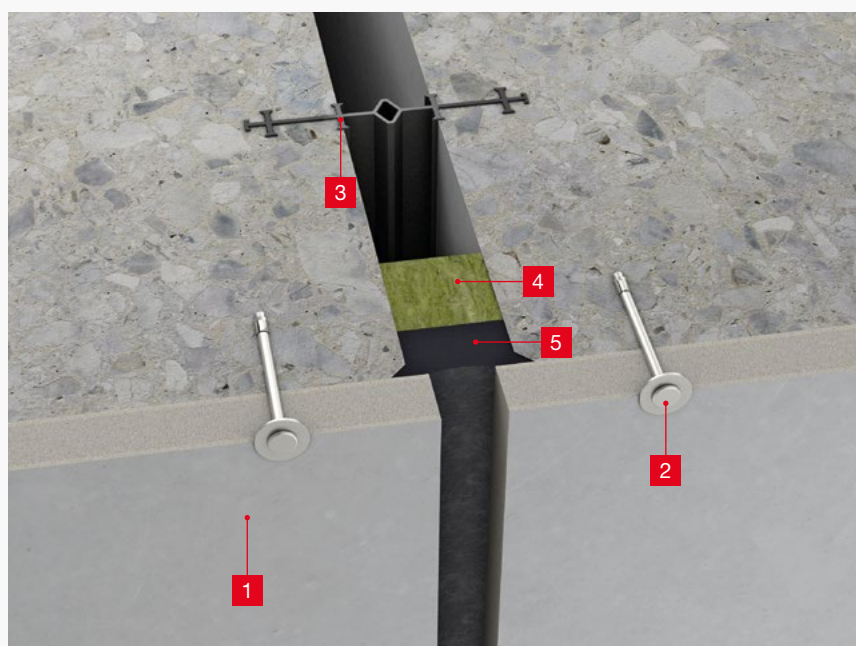
\* To protect the tunnel sealing, a noncombustible mineral wool can be integrated (optional).



## Expansion joint with joint compound

### Independently fitted fire-protection cladding

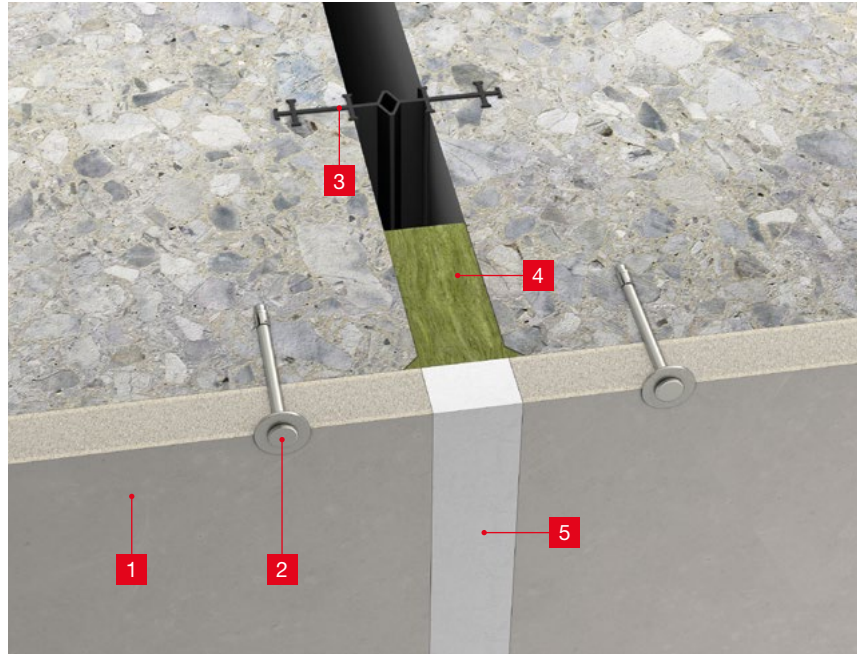
- 1** Independently fitted fire-protection cladding  
Aestuver® fire-protection board Tx
- 2** Additional fixing in the expansion joint area  
Fixings: Nail anchors
- 3** Tunnel sealing
- 4** Joint backing  
Mineral wool
- 5** Fire-protection joints  
Fire-protection sealant



## Expansion joint with joint compound

### Retrofitted fire-protection cladding

- 1 Retrofitted fitted fire-protection cladding**  
Aestuver® fire-protection board Tx
- 2 Additional fixing in the expansion joint area**  
Fixings: Nail anchors
- 3 Tunnel seal**
- 4 Joint backing**  
Mineral wool
- 5 Fire-protection joints**  
Aestuver™ fire-protection mastic



**Detail:**

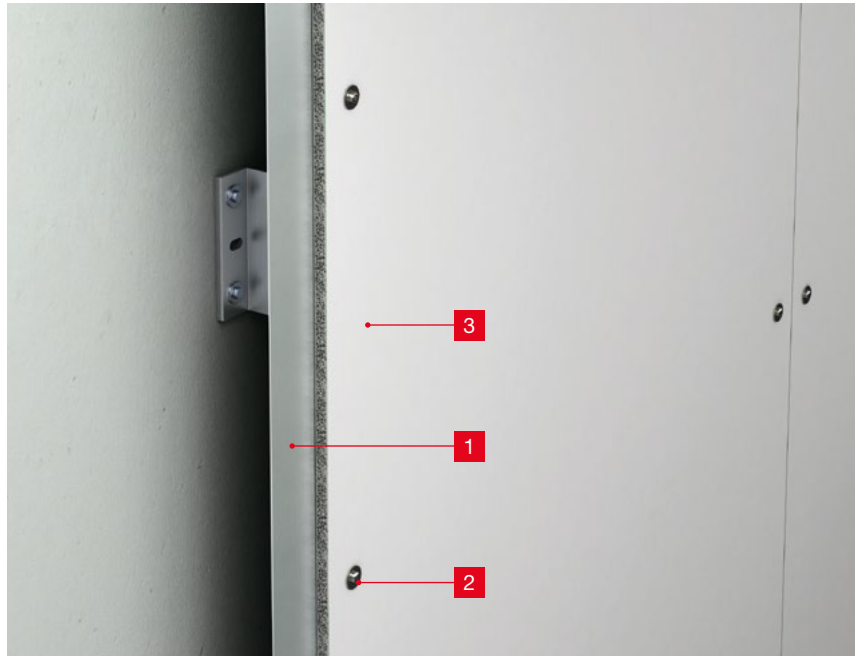
Design applications fermacell® Powerpanel HD





## Design applications fermacell® Powerpanel HD

- 1 Metal substructure
- 2 Fixing
- 3 Wall lining  
fermacell® Powerpanel HD





## 08 References

Optimal solutions make for satisfied customers.

This excerpt from our list of references contains just some examples of the many international tunnel projects in which Aestuver® fire-protection boards and products have been used with great success.

Additional, current references can be found on our web page:  
[www.aestuver.com](http://www.aestuver.com)

Project	Location	Year	Requirement
<b>Aestuver® fire-protection board Tx</b>			
Pians-Quadratsch Tunnel	Pians and Quadratsch, Austria	2018	HCM60 / ISO 120 / HCM 120
Port de Hal Tunnel	Brussels, Belgium	2018	HCM120 / ISO 240
Sachseln Tunnel (A8)	Sachseln, Switzerland	2018	ISO 120
Tuen Mun – Chek Lap Kok Link Northern Connection Sub-sea Tunnel Section	Hong Kong, China	2018	RWS 120
Keilaniemi Tunnel, Espoo	Espoo, Finland	2017	HCM 120
E18 Ekeberg and Svardtals	Oslo, Norway	2017	HC 120
Wilten Tunnel	Innsbruck, Austria	2016	RWS 120
Abu Dhabi Airport Tunnel	Abu Dhabi, United Arab Emirates	2016	RWS 120
<b>Aestuver® fire-protection board T</b>			
Konrad Adenauer Tunnel	Berlin, Germany	2016	ZTV-Curve
Slowacki Tunnel, Gdansk	Gdansk, Poland	2014-2015	HC-Curve
De groene Loper (Avenue 2)	Maastricht, Netherlands	2013-2014	RWS-Curve
Elbtunnel	Hamburg, Germany	2005-2012	ZTV-Curve
<b>Aestuver® fire-protection board</b>			
Copenhagen Cityring	Copenhagen, Denmark	2017	ISO 180
Binyanei HaUma Railway Station	Jerusalem, Israel	2015	EUREKA/ISO-Curve
Odenplan Underground Railway Station	Stockholm, Sweden	2014	ISO-Curve
Airport Tunnel Berlin Tegel	Berlin, Germany	2008	E 90
<b>fermacell® Powerpanel HD</b>			
Citybanan Tunnel	Stockholm, Sweden	2014-2015	Construction material class A1, water-resistant
Wagenladungsstrasse Stuttgart (Stuttgart 21)	Stuttgart, Germany	2013-2014	Construction material class A1, water-resistant

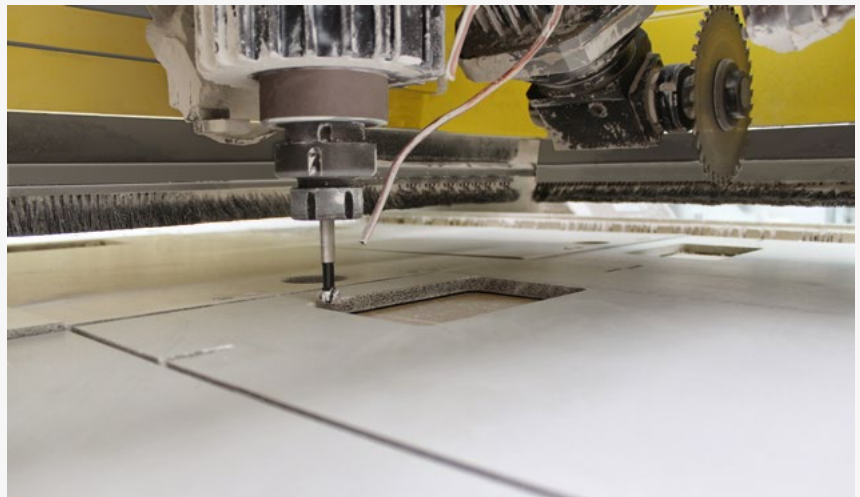
## 09 Aestuver<sup>®</sup> services

Aestuver<sup>®</sup> offers its partners and customers individual advice that is fair, needs-based and personalised. Besides tailor-made/bespoke products, we also offer extensive services at no cost. Aestuver<sup>®</sup> sees itself as a supplier of integrated system solutions: from planning to installation and beyond.

### In-house prefabrication of construction elements

In our construction element production facilities, Aestuver<sup>®</sup> fire-protection boards are cut to customer requirements and machined using state-of-the-art equipment.

- Precision-cut board blanks
- Prefabricated fire-protection construction elements for all areas of application
- Holes or cutouts
- Customer-specific packaging



### Logistics

#### Service Center |

**Telephone: +49 211 54236-200 or**

**e-mail: [auftraege@jameshardie.com](mailto:auftraege@jameshardie.com)**

Our sophisticated logistics concept guarantees just-in-time delivery to either your building site, production facility or any other location. You will be kept updated with the status of your order at all times and our Service Center employees will be happy to answer any questions you may have concerning ordering, delivery and unloading at the building site.

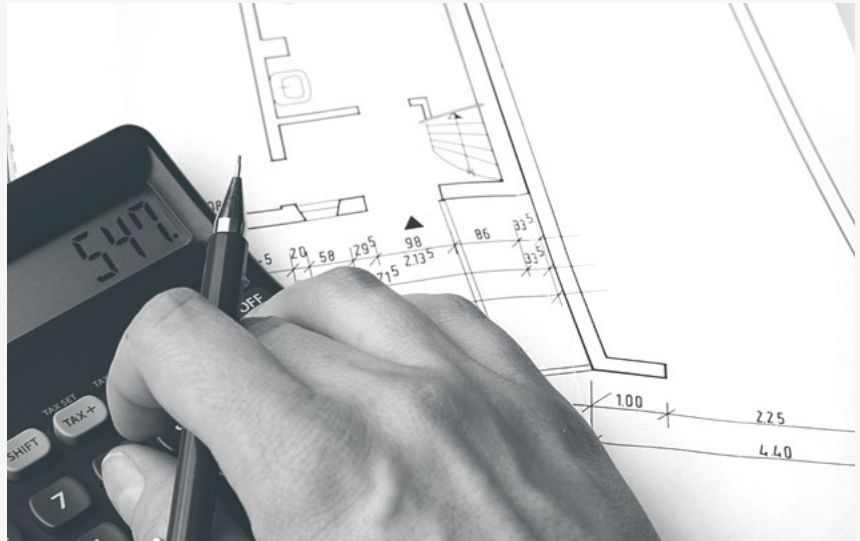


## Planning and project support

**e-mail:** [aestuver@jameshardie.com](mailto:aestuver@jameshardie.com) |

**Subject:** Tunnel fire-protection

Planning to construct or already building a property? Searching for the right solution? We offer you free planning assistance and tailor-made system solutions for your building projects. A team of experienced engineers from Application Technology and Research and Development will assist you in solving individual challenges, so please take advantage of our many years of experience and expertise.



## Technical customer service at the building site

**e-mail:** [aestuver@jameshardie.com](mailto:aestuver@jameshardie.com) |

**Subject:** Tunnel fire-protection

Our competent technical customer service team will be on hand to assist you at the building site. Whether you require assistance in design, planning or implementation, we can help.



## Exploratory tunnel-fire tests

**e-mail:** [aestuver@jameshardie.com](mailto:aestuver@jameshardie.com) |

**Subject:** Tunnel fire-protection

Exploratory tunnel-fire tests can be performed in a modern, on-site furnace on both large and small scales, as required by the project.





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The most recent edition applies. Should you require additional information, please contact our customer service.

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