

Tunnel Fire Protection



A fire in a tunnel can have catastrophic consequences



Loss of human life

Structural damage

Structural failure

Fire damage

Not only is there a risk to human life but also severe damage to the tunnel structure can occur, requiring extensive repairs or even causing collapse of the tunnel.

The resulting disruption of transport links can cause serious economic or social problems such as increased traffic congestion, reduction in tourism or damage to local businesses.

Many studies have shown that the fires generated in road tunnels burn at a very high temperatures. The EU "UPTUN" Project has demonstrated that a HGV carrying an 'ordinary' load can generate a fire comparable to that from an oil tanker with temperatures over 1300°C recorded.



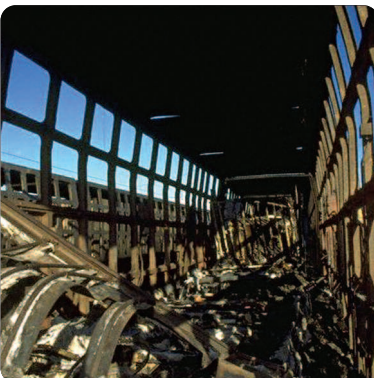
Typical tunnel fire temperatures

Car Fire : 400°C

Lorry Fire : 1000°C

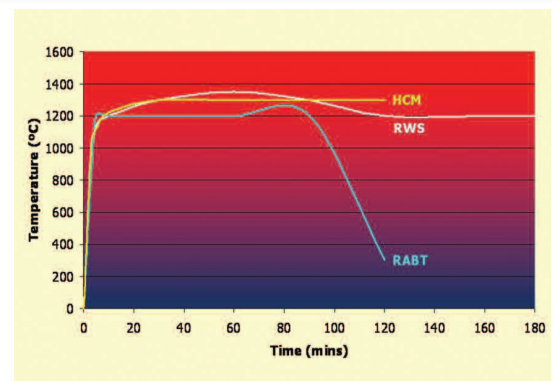
Petrol Tanker Fire : 1200°C

Large Petrol Tanker Fire : 1400°C



A number of fire curves have been developed to represent the temperatures generated in real fire situations.

Of these the RWS curve developed in Holland is the most severe and is now widely used in fire tests developed for tunnel fire protection systems.





The need for fire protection in tunnels

High-strength concrete used in tunnel linings is vulnerable at high temperatures due to either explosive spalling or over-heating of steel reinforcement bars within the lining. Collapse of the tunnel can occur or at least extensive damage, requiring lengthy repairs. Spalling can take place at temperatures as low as 200°C.

The safety of people in a tunnel during a fire is important and there is a need for fire proof refuges or escape routes. Cable trays, structural steel or fuel drainage systems all may need to be protected against fires. All these elements of the tunnel structure need an insulating fire resistant layer to provide thermal protection against temperatures above 1300°C.



Applications for FireBarrier 135 in tunnels

Full thickness is sprayed in one layer

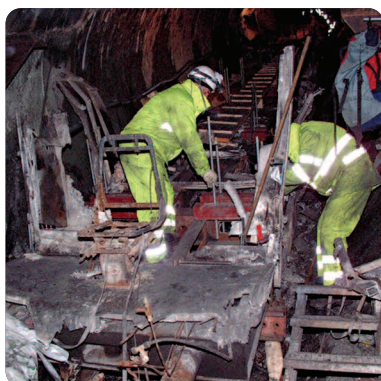
Quick drying time

High bond strength

Stable in tunnel operating environments

Proven in service

Fire tested for all fires curves used in tunnels



FireBarrier 135 - high performance fire protection in tunnels



FireBarrier 135 is a refractory cement fire protection material specially developed for the high temperatures developed in tunnel fires. It can be applied by spraying or cast into sheets.

FireBarrier 135 has many benefits

- Refractory Product - can withstand repeated exposure to 1350°C for long cycle times
- Very low spraying wastage during installation - less than 1% of weight
- Fast and easy to install - one, single layer application
- High adhesion strength - eight times greater than product weight
- High quality surface finish that can be painted



Resistant to real tunnel fire temperatures

Unlike most other products used for tunnel fire protection, FireBarrier 135 is a refractory material able to withstand repeated and prolonged exposure to high-temperature exposure.

In fire tests, when exposed repeatedly at temperatures of 1350°C FireBarrier has shown consistent performance as a protection to concrete.



Resistant to tunnel operating conditions

Extensive tests at the TNO laboratory have proven the resistance of FireBarrier 135 to environmental conditions found in tunnels. FireBarrier 135 is resistant to water jet sprays used to clean tunnel linings.

FireBarrier 135 will not spall when subjected to water hose sprays at high temperature providing safety for fire-fighting.





High quality surface finish

FireBarrier 135 can be trowelled flat to provide a high-quality surface finish that can be used as the final tunnel lining surface (with optional painting). This avoids the need for expensive secondary cladding.

High strength

FireBarrier 135 has high adhesion strength typically 8 times its weight, allowing fixings to be attached directly to it.

Like concrete, strength increases over time. Adhesion has been verified in use and in independent laboratory tests.

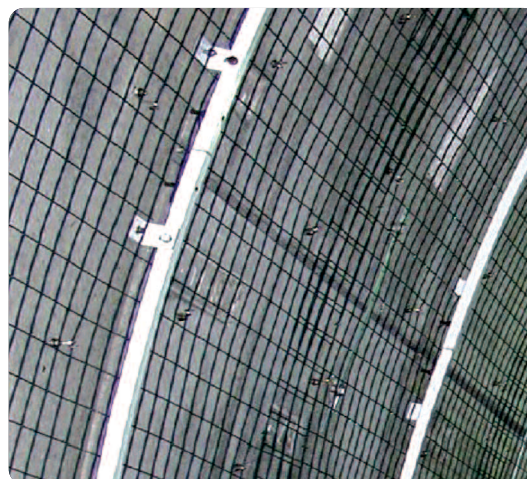
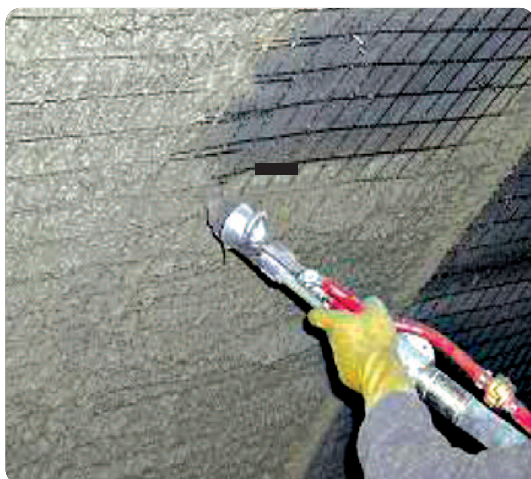


Ease of installation

FireBarrier is easy to install with virtually no wastage due to spray re-bound.

It is installed in one single layer with quick dry times.

It can be installed onto concrete or metal substrates using standard spray equipment (Putzmeister M11 or PFT G4/G5).



High adhesion strength

Verified in use

Easy to install

High quality surface finish

Virtually no wastage

Quick drying times

FireBarrier 135 is normally installed by spraying over a mesh, which is fixed to the concrete lining using "pig tail" anchors.

FireBarrier 135 - optimum fire protection around the world

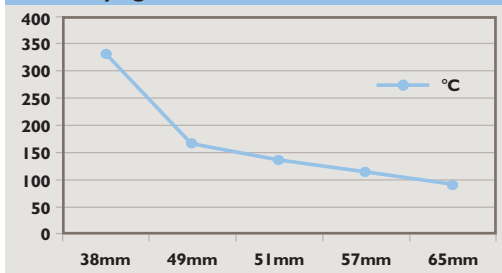


FIREMASTER®

FireBarrier 135 is one of the most extensively fire-tested products available for tunnel fire protection with numerous tests to the various fire standards in force.

Numerous tests have been carried out to the RWS and HCM high-temperature tunnel fires. In these tests FireBarrier is required to insulate the concrete substrate to below 380°C and reinforcement bars inside to below 250°C (25mm from the concrete surface). Some tests have even lower maximum temperatures allowed for the concrete as spalling temperatures vary for different concrete grades.

Concrete interface temperatures with varying thicknesses of FireBarrier 135



Test laboratory and test report reference number	Test duration (mins)	Compress. strength of concrete substrate	Fire curve type	Thickness of concrete substrate (mm)	Thickness of FB 135 used (mm)	Temperature at interface of concrete and FB 135 (°C)	Temperature of steel reinforcement bars (°C)	Temperature of concrete cold face (°C)
CSI DC02/016/F02	120	B35	HCM	150mm	28mm	289	123	50
CSI DC02/006/F02	120	B35	HCM	150mm	32mm	282	122	39
TNO 2005-CVB-R-0024	120	B50	HCM	200mm	28mm	345	135	56
TNO 2005-CVB-R-0024	120	B50	HCM	200mm	35mm	275	118	35
TNO 98-CVB-R-1182	120	B35	RWS	150mm	38mm	334	209	Not Measured
TNO 98-CVB-R-1182	120	B35	RWS	150mm	51mm	136	113	Not Measured
SINTEF 22N008,02.C	134	B70	RWS	400mm	49mm	167	N/A	18
SINTEF 22N008,02.D	125	B76	RWS	400mm	57mm	113	N/A	18
CSI DC02/006/F05	240	B35	ISO 834	150mm	28mm	348	189	55
CSTB France ¹ RS06-186 A	132	B30	HCM	180mm	28mm	334	148	43
SP Sweden P801874	120	C35/45 Pre-stressed to 12.9 MPa	RWS	600 (2 slabs each 3.6m x 1.22m)	36mm	230 285	85 ² 65 ²	Not Measured
SwRi, USA	120	6000psa	RWS	150mm	36mm	272	174	Not Measured
MFPA Austria P3.2/13-032	170		RABT	250mm	30mm	245 (max over 170 mins)	90 (100 at end of test)	Not Measured
NFTC PR China	180	C30	Hydrocarbon	150mm	24mm	361	237	Not Measured
NFTC PR China	230	C30	RABT	150mm	28mm	242 max	175 max	Not Measured

Versatility

FireBarrier 135 can also be cast into sheet form and installed as a dry board or shape for applications where spraying is not convenient.

Efficient

FireBarrier is an efficient insulation at high temperature with low thickness requirements to meet fire protection performance.

- 1 Tested as a floor with fire above to simulate the floor of an escape passage
- 2 Reinforcing rods placed 75mm from concrete lining surface

FireBarrier 135 - Versatility in fire protection of tunnels

There is a FireBarrier solution for every fire situation in a tunnel.

Project: El-Azhar Tunnel (Cairo · Egypt) : 1999 - 2000

Requirement: Fire Protection of Main Concrete tunnel structure 2 hours RWS fire curve

Application: Thickness Applied: 47mm in one single layer

Volume: 57000m² of FireBarrier 135 applied (3442 Tonnes)



Project: Mont Blanc Tunnel (France · Italy) : 2001

Requirement: Fire Protection of Escape Refuges 2 hours HCM and 4 hours ISO fire curves

Application: Thickness Applied: 42mm in one single layer onto Bioclima 30 bricks

Volume: 1700m² of FireBarrier 135 applied (110 Tonnes)



Project: Bjørvika Tunnel, Oslo, Norway : 2009

Requirement: Immersed road tunnel two hours RWS fire protection with fire testing required on large pre-stressed roof sections. Washable surface, high adhesion strength

Application: FireBarrier 135 in one single layer 36mm thick. Custom designed fire rated expansion joint seal system between segments

Volume: 50,000 m² installed. 5,000 linear metres of expansion joint seal system



Project: St Marie Aux Mines Tunnel France : 2007 - 2008

Requirement: Escape passage located under roof of ventilation shaft. Fire protection required for the floor of the ventilation shaft to prevent fire spread to escape way underneath. 2 hours protection required against HCM high-rise hydrocarbon fire

Application: 28mm of FireBarrier 135 spray-applied to floor of ventilation shaft. Design proven by special fire test of floor section : built at CSTB fire test laboratory France



Project: Lecco Tunnel (Italy) : 2005

Requirement: Fire Protection of Tunnel Roof, Ventilation ducts and Escape passages 2 hours HCM fire curve, 4 hours ISO curve

Application: 28mm in one single layer for concrete exposed to HCM curve for 120 minutes. 12mm in one single layer for concrete exposed to ISO 834 curve for 2 hours. 35mm for steel sections exposed to HCM fire curve for 2 hours

Volume: 40000m² of FireBarrier 135 applied (1148 tonnes)



Project: Verla Di Giovo Tunnel (Italy) : 2005

Requirement: Fire Protection of steel bulkhead forming air ventilation shaft 2 hours Hydrocarbon fire curve (1100°C)

Application: Thickness Applied: 44mm average in one single layer (30mm to 58mm on corrugated steel bulkhead)

Volume: 5500m² FireBarrier 135 installed (330 tonnes)



Morgan Advanced Materials

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Morgan Advanced Materials is a global materials engineering company which designs and manufactures a wide range of high specification products with extraordinary properties, across multiple sectors and geographies.

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MANUFACTURING LOCATIONS

