

# ▶ Tested for total safety ▶▶

The proven solution for tunnel ventilation systems





## ► The art of handling air ► ►

**TROX fully understands the art of handling air like no other company.** Founded in 1951, TROX has been developing sophisticated engineering solutions including fire and smoke protection products for many years. With extensive research and development facilities, TROX is a leader in the development of ventilation system technology.

**TROX is a reputable global manufacturer of ventilation products** with an annual turnover in excess of USD500 million. The TROX Group has 25 subsidiary companies in 22 countries and 14 production sites in 12 countries located all over the world. The company is committed to continuous quality improvement with efficient and customer-oriented manufacturing facilities that guarantee reliability, quality and timely delivery.

**The company's competence** in fire and smoke protection technology and know-how is unique in this industry. For decades TROX has been developing products and systems to improve fire and smoke protection in places where mechanical ventilation is needed. This includes underground transportation systems, offshore oil and gas facilities, power stations and commercial buildings. TROX therefore offers its customers tested and proven fire and smoke dampers of the highest quality incorporating numerous other advantages.

**TROX is a certified company** and an active member of the “Studiengesellschaft für unterirdische Verkehrsanlagen e.V.” (STUVA) (Research Association for Underground Transportation Facilities). STUVA is involved in independent research and dissemination of scientific knowledge with regards to safety for underground transportation systems.



**The TROX International Centre** of Fire Protection Centre is the new testing, research and development centre for the TROX Group. This is a state-of-the-art fire test laboratory equipped with a unique combination furnace suited for vertical and horizontal fire damper tests that can be conducted in accordance with national and international standards or project specific requirements. The size of the furnace is suitable for carrying out large-scale tunnel damper fire tests.



*The International Center Fire Protection (ICB) in Neukirchen-Vluyn, Germany, opened in 2009.*

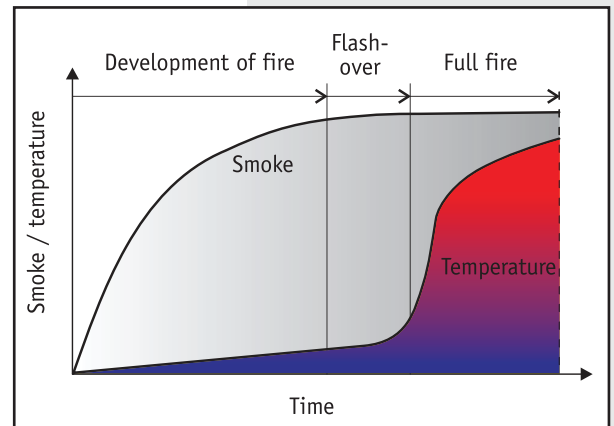
## ► When safety has top priority ►►

**In comparison to open spaces** and buildings, the escape routes from underground transportation systems are very limited. If the safety standards are not met, a fire in a transportation tunnel can have catastrophic consequences.

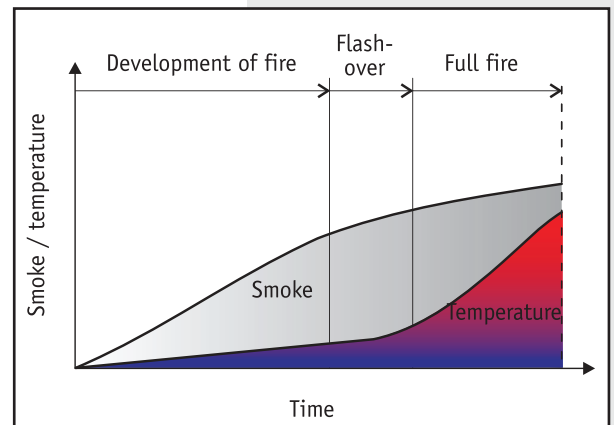
**The development of smoke** from a burning vehicle located in an open space is relatively harmless. In a tunnel however, it can have deadly consequences. The speed at which hot and noxious smoke spread within the tunnel far exceeds the rate in which people can evacuate the tunnel to safety.

**Most people** who have perished in tunnel fires were actually victims of smoke inhalation.

**A burning vehicle or train** generates a fire load anywhere between 5 MW and 100 MW. Such fire loads have destructive effects on the supporting structure of the tunnel and can lead to damage costing millions.



*Tunnel without smoke extract*



*Tunnel with smoke extract*



**In the case of a fire in a tunnel** without a fire isolation and smoke extract system passengers have five minutes at most to save themselves. After that the level of smoke generated will be deadly. The period of time available must therefore be extended by the use of an appropriate fire isolation and smoke extraction system. In addition to helping passengers save their lives, these systems must also aid fire fighting. To enable the fire brigade to extinguish the fire quickly, it is important not to allow smoke from spreading and hinder the fire crews from fighting the fire.



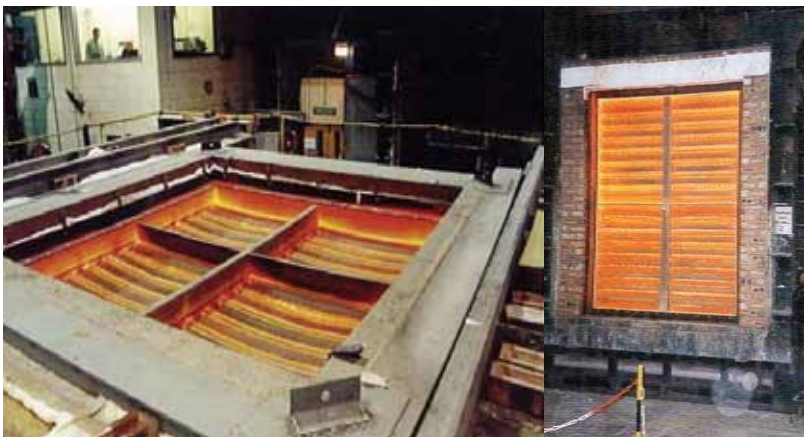
**Extensive testing** of the TROX Type "JFM" tunnel fire and smoke damper ensures proven performance in a fire and reliable operation under extreme operating conditions in a tunnel.

**4 hour fire** integrity rated in accordance with BS 476 Part 20 and AS 1530.4 at a temperature in excess of 1150°C. Fire tested at Warrington Fire Research Centre in the UK for both vertical and horizontal installation with a variety of different pneumatic and electric actuators. Both double acting and spring return actuators are certified.

**High temperature operation** for smoke control. Tested at Warrington Fire Research Centre in the UK at temperatures up to 400°C for 2 hours with a variety of different pneumatic and electric actuators. Both double acting and spring return actuators are certified.

**Low leakage for isolation of smoke.** Smoke leakage rate at 250°C equivalent to UL555S Class 1 rating at pressures in excess of 3kPa.

**Robust design** tested to withstand a cyclic pressure of +/- 6kPa for 8 million cycles at BSRIA in the UK.



*Fire Integrity tested for 4 hours*

## Extreme operational conditions

### In normal operation

- Large temperature and moisture fluctuations
- Pressure waves and vibrations created by vehicles
- High degree of dust and soiling

### In case of fire

- Hot fire gases
- High temperatures
- Extinguishing water and steam

## ► Tailored solutions ►►

**Underground transportation systems** are generally unique. Standard solutions in this area hardly exist; not even for tunnel dampers. TROX engineers and product managers are available to provide support during the design stage and to assist in finding optimised engineering solutions tailored to meet technical and economic requirements.



**Individual project planning** includes generally, project specific service that not only guarantees a permanently high safety standard, but also lowers operating costs and minimises downtime.

**The benefit of selecting TROX** tunnel dampers is demonstrated both during installation and operation. Materials of construction are selected for the specified design life and operating environment. Corrosion protective finishes can also be applied. TROX will undertake a full durability assessment to ensure that the appropriate materials and finishes are selected for the project.

**TROX engineers can optimise the design** with a special focus on fast, safe installation. Mounting the dampers directly onto the structural opening with clamp plates substantially reduces the cost of installation as a special subframe is not required.

**The large manufacturing capacity of TROX** and sophisticated logistics guarantee the timely delivery to tunnel projects throughout the world.

## ► Uncompromising safety ►►

### **TROX tunnel dampers are available as a complete solution**

including either pneumatic or electric actuators, damper status indication switches, mesh screens, joining angles and fixings for multi-module assembly together with fixings and gaskets for installation. This ensures performance, reliability and safety are not compromised.

### **Greater efficiency**

Damper blade incorporate a “V” groove on both edges that interlock and expand into each other in the event of a fire thus providing an impenetrable fire barrier.

The blade edge “V” groove can be provided with compressible ceramic seal that ensures a tight seal against smoke. The blade landing angle position is adjustable enabling any distortion in the damper case created during installation to be easily compensated to ensure that the tight seal is maintained after damper installation.

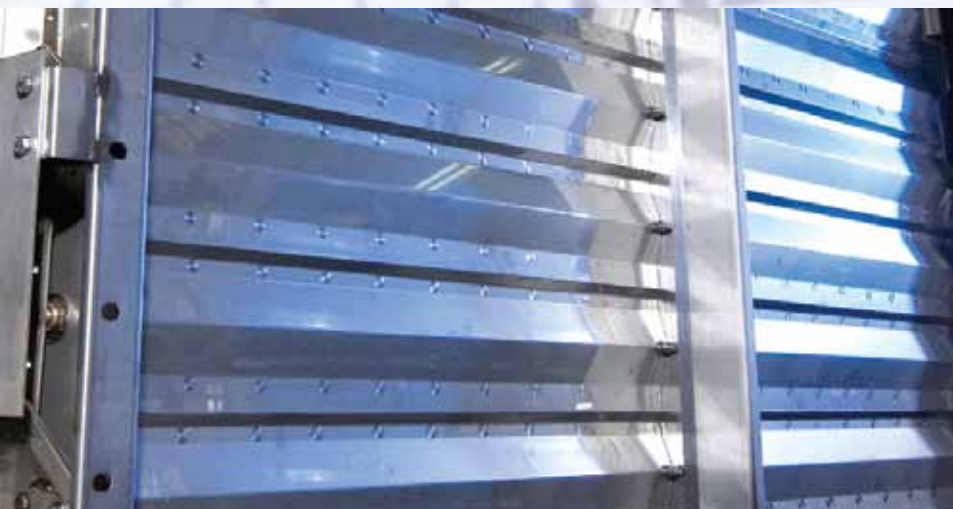
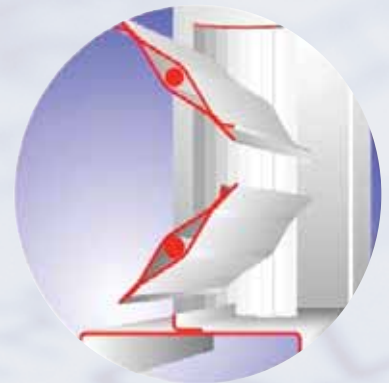
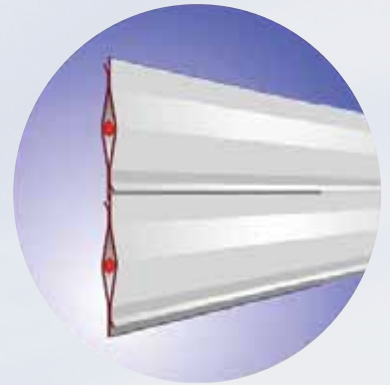
Damper blades have opposed action so that the dampers can also be used for modulating or volume control. Dampers can be provided with either modulating or 3 position actuators to enable the damper to be operated to an adjustable mid position.

### **Extreme temperature resistance**

Pneumatic actuators and damper position limit switches are suitable for operation at temperatures up to 400°C. Electric actuators are provided with thermal insulation enclosures rated at 400°C for 2 hours.

### **Safe function tests**

Damper position limit switches directly mounted on the damper and independent from the actuator can be provided to enable constant monitoring of the damper position from a remote control room.



### **Variable design**

- Stainless steel or galvanised steel
- construction
- Pneumatic or electric actuators
- Spring return, double acting, modulating or
- 3 position actuators
- Actuators side or face mounted
- Damper position switches actuator or
- damper mounted
- Damper modules individually driven or
- coupled to a single actuator

## ► Tested quality ►►

**TROX leaves nothing to chance.** To prove the functional reliability of TROX tunnel dampers under realistic conditions, they are subjected to extensive internal and external tests. Tests reports from international testing institutes document the high level of safety attained. TROX thus fulfils the highest standards worldwide.

**With a certified production process,** TROX guarantees production quality without compromise all over the world. TROX tunnel dampers are manufactured in Malaysia, China and Germany. From goods inwards inspection to delivery of the final product, all processes are subject to thorough quality control. The results of the relevant test are documented and provided to the customer upon request.

**The TROX quality management system** is certified in accordance with ISO 9001. The manufacturing process is quality controlled at all levels. Material certificates are maintained for all steel used.

**TROX employees are fully qualified** and have considerable experience. External service providers to the manufacturing process are certified according to all aspects of ISO 9001. Customers are encouraged and welcome to attend factory acceptance tests. These tests can include full damper operation testing, pressure drop testing in accordance with AMCA 500, static pressure testing at 6 kPa and leakage testing at elevated temperature in accordance with UL 555S. All test facilities are available in the TROX factory in Malaysia.



TROX welding is certified to BSEN288



*The total length of tunnels around the world amounts to 38,900 km. This is about 93% of the circumference of the earth and rapidly increasing in areas where overland travel is congested or the geography is difficult. Travel through tunnels is increasingly becoming a part of everyday life for many people.*

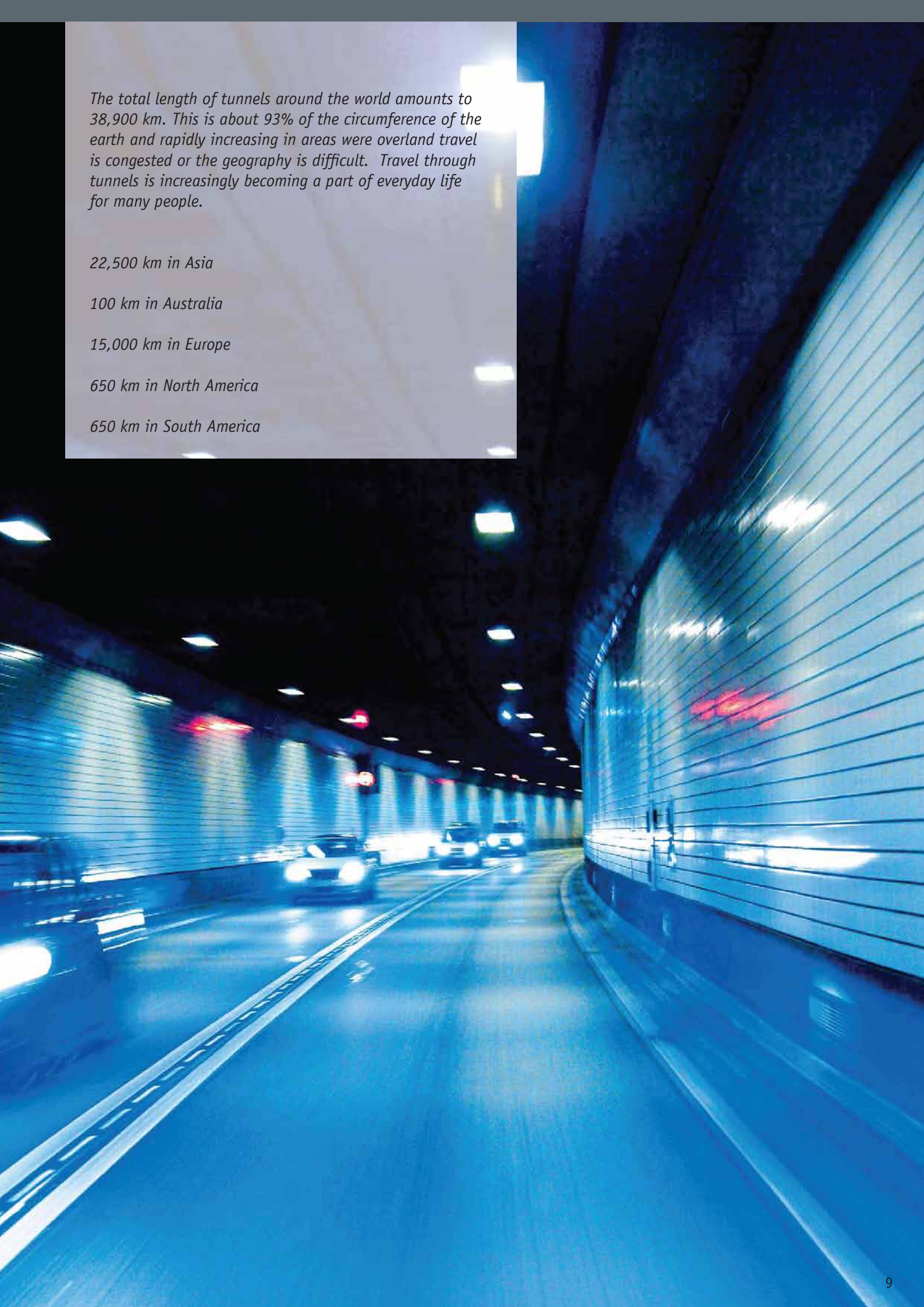
*22,500 km in Asia*

*100 km in Australia*

*15,000 km in Europe*

*650 km in North America*

*650 km in South America*





## ► Challenges mastered ►►

### Fire and smoke protection for Delhi Metro, India

Delhi Metro is a world-class transport system. To ensure reliability and safety, it is equipped with the most modern communication and control systems. The Delhi Metro Rail Corporation (DMRC) demanded the highest standards for fire safety and smoke control. In addition to the need for the TROX fire and smoke dampers to comply with these requirements, the DMRC specified that the dampers should be subjected to exhaustive factory tests prior to acceptance. These tests included smoke leakage at 250°C at a pressure of 2.5 kPa, pressure loss test in accordance with AMCA 500, and a cyclic pressure reversal test at 2.5 kPa. All tests were conducted at TROX Malaysia, on dampers selected from the production line by the DMRC. TROX has supplied tunnel fire and smoke dampers for both Delhi Metro Phase 1 and Phase 2 as well as the Delhi Airport Express Line (DAMEL).



Testing Delhi Metro Dampers at TROX Malaysia

*Project: Delhi Metro*  
*Location: India*  
*Owner: DMRC*  
*Contractor: Samsung Corporation*  
*TROX: JFM Tunnel Fire and Smoke Dampers*

## ► Proven Performance ►►

### Burnley Tunnel fire, Melbourne Australia

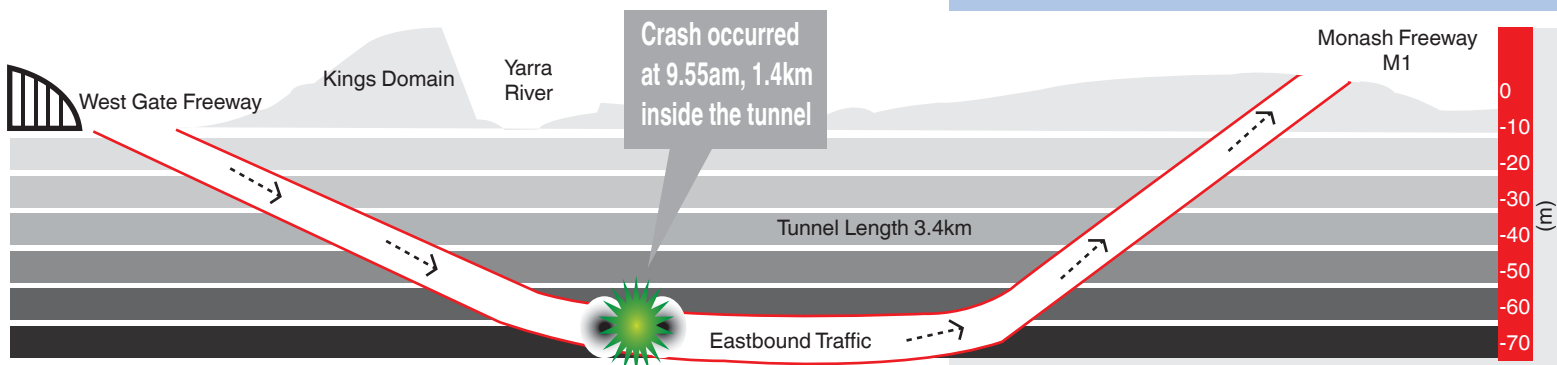
The Burnley Tunnel forms part of the Melbourne City Link which has TROX fire and smoke dampers installed in the smoke extract system. On the 23rd March, 2007 four cars and three lorries were involved in an accident within the tunnel resulting in 3 fatalities. The ensuing fire was so hot that one of the vehicles was melted beyond recognition. Motorists were however quickly and safely evacuated leaving more than 200 vehicles stranded. Acting Metropolitan Fire Brigade Chief Officer said both the drenching and smoke extraction system made it much easier to find the source of the fire.

- Fire extinguished by Fire Brigade after approximately 1 hour
- All motorists not directly involved in the initial vehicle accident were safely evacuated
- Non-incident tunnel re-opened the same day
- All vehicles removed in less than 1 day
- Burnley Tunnel re-opened approximately 4 days after incident
- Relatively minor damage to tunnel systems only



*The burnt out lorry in the tunnel.  
Photo: David Caird*

Project: Melbourne City Link  
 Location: Australia  
 Owner: Transurban  
 Contractor: Transfield-Obayashi  
 TROX: JFO Tunnel Fire and Smoke Dampers



## ► Cooling the Tube in London ►►

### London Underground in London, England

The temperature in parts of the London Underground (better known as the 'Tube') had become unbearable in the summer. During the heat wave in 2006, temperatures underground were recorded to be as high as 47°C.

It was estimated that 80% of the heat generated in the Tube was largely contributed by the trains. The passengers only contributed about 5% of the heat, which was calculated to be around 56 Giga Watt-hours on an average year. As a result, the ground temperature surrounding the Tube had risen between 10 to 15°C over a period of 30 years. This is because the tube is built very deep below the ground and is poorly ventilated. The high temperature was not only causing passenger discomfort but also threatened to damage the structure as the surrounding clay dried. To provide a solution London Transport decided to invest in a combination of technologies which included improving the ventilation in the tunnels.

The design concept is to cool down the Tube by introducing increased outdoor air during the winter at the midpoint between underground stations. This will significantly reduce the ground temperature surrounding the Tube. This system can also be used for smoke extraction in the event of a fire. TROX dampers enable the cool air to be supplied into the Tube. The piston effect of the trains then purges the warm air which is vented out through the pedestrian routes at each station.



*Project:* London Underground, Cooling the Tube  
*Location:* United Kingdom  
*Owner:* London Transport  
*Contractor:* Flakt Woods  
*TROX:* JFM Tunnel Fire and Smoke Dampers

## ► Safe in Eagle's Nest ►►



© Leighton

### Eagle's Nest Tunnel, Hong Kong

The Eagle's Nest Tunnel was officially opened on the 21st March 2008. It consists of two 2.1 km three-lane tunnels going through a granite mountain known as the Eagle's Nest which connects Butterfly Valley and Sha Tin Valley. This tunnel is part of the Route 8 highway between Cheung Sha Wan and Sha Tin.

Each vehicle tunnel incorporates an overhead duct for the supply of fresh air and venting of smoke in the event of a fire. TROX dampers are fitted along the length of the duct to ensure the even distribution of fresh air and localised extraction of smoke in the event of a fire. All the dampers are pneumatically operated and rated for operation at a temperature of 250 °C for 2 hours. In addition the dampers are fire integrity rated for 4 hours in accordance with BS 476 Part 20.

*Project: Eagle Nest Tunnel*  
*Location: Hong Kong*  
*Owner: Hong Kong Highways Dept.*  
*Contractor: Leighton – Kumagai*  
*TROX: JFM Tunnel Fire and Smoke Dampers*



## ▶ SMART Tunnel ▶▶

The SMART Project is an innovative solution designed to drain storm water from and to relief traffic congestion into the heart of Kuala Lumpur city centre by utilising a dual purpose tunnel. SMART is the acronym for “Storm Management And Road Tunnel” and is unique since it is the first of its kind in the world.

The tunnel is 9.7 km long with an internal diameter of 11.83 metres. The tunnel is divided into three separate levels or tiers. The top two levels are meant for traffic flow and the lowest level serves as a storm drain.

The tunnel can operate in three different modes;

- During the dry season, the tunnel is used only as a road tunnel. The storm drain at the lowest level is usually dry.
- When it rains, the storm drain will help to discharge rain water quickly away from the city centre to prevent. This is expected to occur several times in a year.
- In the event of heavy rain fall, which is expected to happen less than once a year, the second and top level of the tunnel will be closed to traffic and to be used as a storm drain.



Project : SMART Tunnel

Location : Kuala Lumpur, Malaysia

Owner : RTD of Malaysia

Contractor : MMC Corp Berhad-Gamuda Berhad Joint Venture

TROX: JFM Tunnel Fire and Smoke Dampers

► TROX references worldwide ►►



**Road Tunnels**

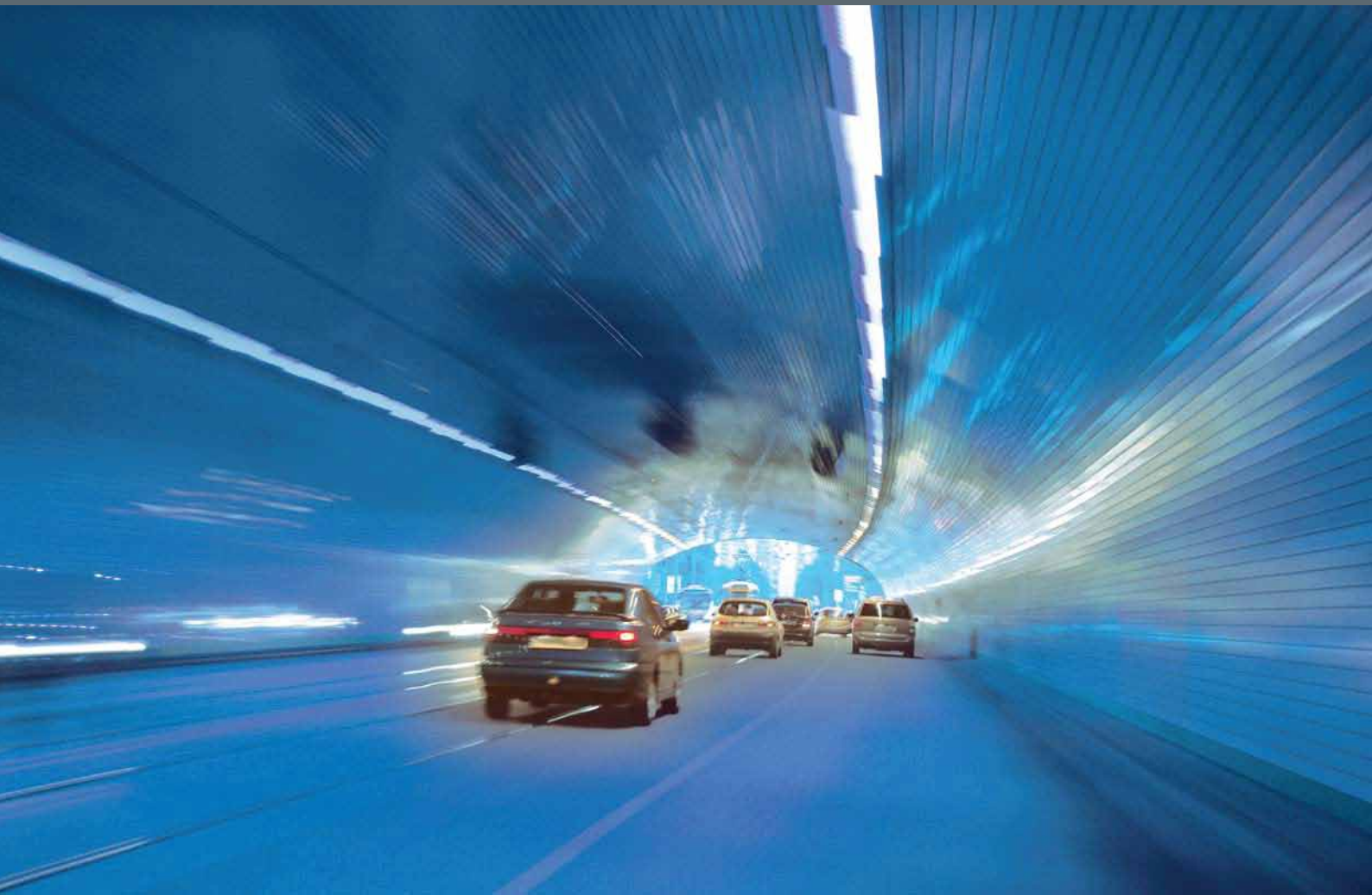
- Aberdeen Tunnel, Hong Kong
- Chongqing Road Tunnel, China
- Cross City Tunnel, Sydney, Australia
- Eastern Harbour Crossing, Hong Kong
- Grand San Bernard Tunnel, Italy
- Lane Cove Tunnel, Sydney, Australia
- Lion Rock Tunnel, Hong Kong
- M5 Road Tunnel, Australia
- Melbourne City Link, Australia
- Route 8 Nam Wan Tunnel, Hong Kong
- Route 8 Eagles Nest Tunnel, Hong Kong
- 'SMART' Tunnel, Kuala Lumpur, Malaysia
- Tate's Cairn Tunnel Hong Kong

**Metro and Railway Tunnels**

- Athens Metro – Elliniko Extension, Greece
- Athens Metro – Haidari Extension, Greece
- Athens Metro – Peristeri & Anthoupoli Extension, Greece
- Budapest Metro, Hungary
- Copenhagen Metro, Denmark
- DAMEL Airport Link, New Delhi, India
- Delhi Metro Phase 1, India
- Delhi Metro Phase 2, India
- Delhi Metro Airport Link, India
- Gautrain Rapid Rail Link, South Africa
- Istanbul Metro Taksim – Yenikapi, Turkey
- Istanbul Metro Levent – Haciosman, Turkey
- Istanbul Metro Esenler – Kirazli, Turkey
- KCRC West Rail SI 1200, Hong Kong
- KCRC SIL 1250, Hong Kong
- KCRC Beacon Hill Tunnel, Hong Kong
- London Underground Bank Station, England
- London Underground Cooling the Tube, England
- Milan Metro, Phase 2, Italy

**Other Projects**

- MTRC Airport Express Line Kowloon Station, Hong Kong
- MTRC Airport Express Line Lai King Station, Hong Kong
- MTRC C 2619, Hong Kong
- MTRC PSD Ph1, Ph2 and Ph3, Hong Kong
- MTRC Tsuen Line, Hong Kong
- Parrametta Rail Link Sydney, Australia
- Perth Metro, Australia
- Putra LRT, Kuala Lumpur, Malaysia
- Shenzhen Metro Line No.3, China
- Shenzhen Metro Line No. 3 Western Extension Line, China
- Singapore MRT Bishan Station, Singapore
- Taipei Metro Tu Cheng Line, Taiwan
- Taipei Metro MRT 308 Phase 1 & 2, Taiwan
- Taipei Metro MRT C378 C, E & G, Taiwan
- Taipei Metro MRT CB430-358/A, Taiwan
- Taipei Metro MRT CE730A, Taiwan
- Taipei Metro MRT CL700A & B, Taiwan
- Vienna Metro, Austria
- Xian Metro Line No.2, China



# TROX<sup>®</sup> TECHNIK

The art of handling air

**TROX Malaysia Sdn Bhd (278360-V)**  
20 Persiaran Bunga Tanjung 1  
Senawang Land Industrial Park  
70400 Seremban, Malaysia  
Tel. (+6) 06-678 8188  
Fax. (+6) 06-678 8288  
Email [enquiry@troxmal.com.my](mailto:enquiry@troxmal.com.my)  
[www.troxapo.com](http://www.troxapo.com)