Channel Tunnel vision

More than 700 firefighters battled in temperatures topping 1000°C to bring a fire in the Channel Tunnel under control in September. **David Lane** asks what measures should be brought in to avoid a fourth blaze in this vital link between England and France

A FIRE IN A TUNNEL GENERATES A massive amount of destructive power, providing ideal conditions for smoke spread, rapid increases in radiated heat, and – a firefighter's greatest fear – flashover, an almost explosive spread of fire in a confined space, consuming all in its path. Asphyxiation and poisoning by inhaling combustion products, such as CO_2, CO, and HCN, are a serious threat to the lives of tunnel users and responders.

The above are all common enough potential problems. In the 1990s, a tunnel operator hired my company to help it meet the UK's then new *Fire Precautions (Workplace) Regulations 1997*, including, specifically: "To protect responding emergency workers should an incident develop." The company took its duty of care very seriously (this legislation has since been superseded by the *Regulatory Reform (Fire Safety) Order 2005*).

Means of escape

Our first task was to assess and reduce risk by conducting a Fire Risk Assessment (FRA). The FRA has additional benefits – minimising damage, protecting property and processes, safeguarding the market share and protecting the environment. When saving life is the priority, there is clearly a responsibility to design effective means of escape. UK Law bases all safety provisions on perceived risk to occupants should a fire occur; the word 'should' expressing both a duty and an obligation. During our preliminary inspections for the client, certain hazards caused some concern. Not only was there potential for the unhindered spread of fire – as in most long tunnel configurations – but there were large quantities of combustible material and a high-energy source of ignition. We faced a rare combination of problems.

Then came a spate of very serious fires in Europe: Tauern, Mont Blanc, Kaprun, St Gothard and the first Channel Tunnel fire. These all heightened concerns and, through the many different people involved, we sought the practical experience of a variety of experts to contribute to our knowledge and research. It took considerable research, and some real vision to solve the problems.

Areas for immediate attention included: Vulnerability and security of the contents; volume of the tunnel; fire design size; and fire loading. Systems needed to ensure a fire would have minimal impact, and evacuation had to offer safe exits from danger. Fire suppression systems that guaranteed to increase the tenability time limit had to be provided.

Last, but not least, the solution needed to fall within the ALARP region (as low as is reasonably practical), the economically viable zone that falls between negligible risk and intolerable risk. Research indicated a fire-engineered solution was available in the form of fixed and mobile very high-pressure fogging systems (operating at up to 120 bar) that had rapid cooling effects, immediately reducing fire and smoke. Most importantly, these systems scrubbed the soot and gasses, so workers escaping and

The first third of the Truck Shuttle damaged in the incident is removed from the tunnel

Eurotunnel

The incident

***On September 11**, 2008, fire broke out on a train travelling from England to France in the Channel Tunnel. The train was laden with 25 heavy goods vehicles (HGVs) and two vans.*

The Channel Tunnel consists of three tunnels – two 'running' tunnels for rail traffic and a service tunnel for maintenance and evacuation. Although Eurotunnel is a private enterprise, it is controlled by an intergovernmental commission and the Fire and Rescue Services (FRS) from Pas-de-Calais, France (SDIS 62), and Kent FRS from the UK, both sit on the commission's security committee. French territory extends from the central point of the tunnel up to the French exit and terminal and operational command of any incidents within this territory falls to the French services.

At 15:54hrs, following safety protocols, the train stopped next to an entrance to the service tunnel 12km from the French exit, with the aim of facilitating the evacuation of the 32 people in the train's passenger carriage. By 16:00hrs, detection systems warned that the fire was spreading and the first response teams, along with a command unit, had been deployed from the French side. In this instance, SDIS 62 assumed command, with operational support and management from Kent FRS. The First Line of Response (FLOR) crews were deployed.

At 16:05hrs, the bi-national emergency plan was activated and Second Line of Response (SLOR) teams were sent in. A civil security helicopter brought the Préfet of Pas-de-Calais and emergency services directors, as well as the chief medical officer, to the site. On learning of the incident, Mme Michèle Alliot-Marie, French Minister of Interior, set off for the scene immediately.

The Channel Tunnel's control centre set the tunnel's ventilation towards the UK end of the tunnel with the aim of blowing toxins and smoke away from the train's passenger carriage, before opening the carriage's doors and evacuating passengers into the service tunnel. Unfortunately, several passengers panicked, broke emergency escape windows and began to run down the rail tunnel towards France. This impromptu self-evacuation required firefighters to conduct a rescue in the train tunnel and there are indications that communication with those on the train could have been improved during this ventilation process. One report quoted an eyewitness as saying: "We heard two loud bangs, like explosions, and suddenly thick smoke swept through the carriage. The train came to a grinding halt, we were all thrown forwards, the lights went out and there was total mayhem – people just started to panic.

"We didn't know what had happened. The door of our coach was locked and impossible to open. We saved ourselves by breaking a window with a hammer. We left the train through this window."

At 17:04hrs, all passengers and the train's staff were safely in the service tunnel, had been triaged for medical treatment and were taken out of the tunnel in two groups. Medical services had assessed the evacuees – two people were injured by broken glass and four were suffering from smoke inhalation.

French and British firefighters began to tackle the blaze with two main water jets – one aimed at the middle of the train by French firefighters and the other at the end of the train by British crews. Ventilation was reduced to help ease the visibility and progress of the British firefighters and to slow the fire's progress. At this stage, says a spokesperson from SDIS 62, the kinetics of the fire were known, the Anglo-French attack strategy seemed to be efficient, progress was slow but effective (15 to 20 metres per hour) and the front of the locomotive was unaffected. For these reasons the decision not to reverse the ventilation flow was taken.

Ambient temperatures for firefighting crews were close to intolerable. Tympanic temperatures were recorded as high as 41°C and firefighters suffered significant dehydration. Each crew member spent less than ten minutes at the fire before being relieved by a colleague.

Progress was difficult from both sides and, after a video conference with the British officer in charge, French commanders decided to protect the locomotive with a water curtain and unite the Anglo-British firefighting efforts at the centre of the train. This decision was taken with the aim of concentrating the attack, increasing rotation of personnel, and by using ventilation to reduce CO levels and heat at the fire front. Once these measures were in place, the ventilation was adjusted and helped to cool the attack point, reducing the ambient heat in the tunnel and allowing two jets, supported by a portable monitor, to move forwards.

The fire was brought under control at 07:50hrs on September 12 and was declared to be out at 12:42hrs – 18 hours and 41 minutes after it began. Firefighters then undertook cooling operations for several days, and on September 12 at 12:00hrs, the Préfet of Pas-de-Calais lifted the bi-national plan, effectively handing the infrastructure back over to Eurotunnel.

In total 500 firefighters from the French FRS were involved in fighting this fire, along with 211 firefighters from the UK.

According to SDIS 62, quick reactions during the alert phase and effective scaling up of command structures led to a rapid operational strategy being formulated. Prior liaison and good relationships between the French and British commanding officers paid off, and evacuation was relatively good, owing to the low number of people involved and the proximity of the incident to the French end of the tunnel.

However, radio communication was an issue at times, as were water supplies from the hydrant network, and language barriers did sometimes complicate exchanges.

On September 12, it was decided that the South Tunnel could be reopened for service, a test train was run through the tunnel at 100kph (62.14mph) and some traffic resumed.

By September 29, five out of the six intervals that make up the Channel Tunnel were operational and on October 1, Eurotunnel removed the first third of the truck shuttle that was damaged in the fire from interval 6.

Eurotunnel has approved contracts to renovate the damaged area in interval 6, saying that work will take around four months and the Channel Tunnel is expected to reopen completely in mid-February 2009. The total budget for restoration is expected to be €60m (£50.4m, US$76.5m).

emergency staff alike could breathe safely.

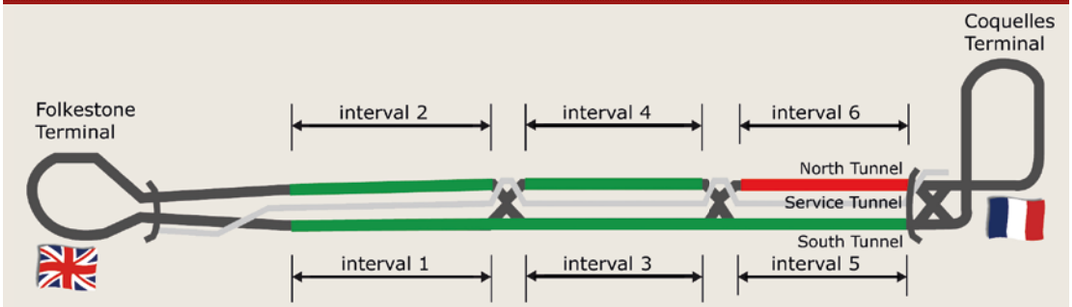
Fast forward to November 1996: the Channel Tunnel was severely damaged by a fire on a freight train and burned for about seven hours. The tunnel's concrete lining was severely damaged, requiring extensive refurbishment, which took approximately six months and cost about £200m (US$1.55m; €1.22m). In August 2006, fire broke out on a lorry on a freight train about 12km from Folkestone, UK, leading to the tunnel's closure for several hours.

On Thursday, September 11, 2008, fire within the running tunnel from the UK to France was reported (see panel).

Immediately after the blaze, the UK and French governments asked the Channel Tunnel Safety Authority (CTSA) to review risk assessment for the tunnel and make recommendations. The CTSA has been instructed to: "Conduct a fundamental review of the extent to which experience has modified the original risk assessment assumptions and to make recommendations." The new British Transport Minister, Lord Andrew Adonis, says he expects this report by September 2009 at the latest.

The cause of fire had yet to be established at the time of writing; an investigation has been started by the Bureau d'Enquêtes sur les Accidents de Transport Terrestre (the French land transport accident investigation bureau), supported by the British Rail Accident Investigation Branch.

Figure 1



The red interval is the section of the North Tunnel that was damaged by the fire

Eurotunnel

500 French and 211 UK firefighters were involved in the September incident, where temperatures where close to intolerable

Bertrand Théry:Sdis 62

Clear questions

While we should not speculate on the reasons for the fire outbreak and the actions likely to be recommended by the investigations, some questions are clear: How and why the fire started; how the fire evacuation was managed; whether the smoke control/ventilation system contributed to the life safety during evacuation by sustaining 'tenability limits'; why were injuries sustained; and what was the real time-line for the event?

Presumably these inquiries will consider the Fire and Rescue Services' (FRS) response and should provide recommendations for any improvements in design, operation or fire safety management of the Channel Tunnel.

Given the strategic importance of this link between the UK and France, this third major fire event raises serious questions about the safety of those using the facility, and its business continuity for trade operations. Aside from any inquiries, it seems the owners and operators of the Channel Tunnel should undertake a thorough review of the tunnels' design and construction, their fire protection, operational procedures and the use of the tunnels by passenger and freight/vehicle trains from an FRA perspective. After all, after three major fire incidents, no-one can argue that "fires don't happen".

After the FRA there are some key steps to be taken and questions that should be asked, including:

- Life safety first. Should improved means of automatic fire detection be provided on the trains prior to entry into the tunnels and within the tunnels themselves?
- Removal of risk is a first step, but not always practical for operations; we need to apply the ALARP principles. Several years ago, a water mist fire suppression system was designed and passed a series of fire tests for Eurotunnel, but was never installed. Had this system been fitted, would one of the tunnels have been closed? Might there be a case for providing the freight wagons carrying heavy goods vehicles with automatic fire suppression systems?
- Should all high risk areas and shuttle cars carrying vehicles be provided with high pressure, water fogging fire suppression systems to control outbreaks to help maintain tenability conditions for safety during evacuation?
- Should the running tunnels be fitted with high pressure water mist or other viable fire suppression systems to reduce the impact of any future fires on the tunnel linings and operational systems, enable tunnel operations to be restored as quickly as possible, minimising loses of revenue and the threat to safety of all occupants, including the first responders? This is a duty upon everybody else operating businesses.

Clearly the answers to these and other questions should be sought and form the basis for future operations of the Channel Tunnel if such incidents and their impacts are to be minimised in the future. CRJ

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