David Sugden, Chairman of the Passive Fire Protection Federation, discusses how to protect the Channel Tunnel from the devastating effects of fire.

The Channel Tunnel Trials

In September 2008 the Channel Tunnel was closed by fire for the third time. Yet again catastrophe was narrowly avoided. Clearly the current fire strategy isn't working well enough; it needs to be addressed and modified. A sensible solution does not require new technology; off the shelf materials already exist within the fire protection industry. The ideas are not new - various built-in fire protection options were discussed when the project was designed – but those measures which were initially dismissed must be reconsidered.

In each incident – in 1996, 2006 and the latest in September 2008 - the fire started in or around one of the lorries being transported on an open shuttle. For safety lorry drivers travel separately in a 'club car' or amenities carriage which means that although the fires were serious there have been no fatalities. In each case the detailed plans for life safety worked well and there have been no major casualties, although 14 drivers were injured in the latest fire.

But as well as the safety of individuals it is also important to consider the effect on trade. In 2007 an estimated 18.4 million tonnes of freight were carried through the tunnel on more than 1.4 million trucks. This flow was brought to a halt on September 11th this year; a limited service was in operation within a couple of days but the affected section of tunnel is not expected to reopen until February 2009. After the fire in 1996 services were disrupted for six months and repairs cost £200 million pounds. Eurotunnel predicts that repairs will cost less this time but the final cost is surely unknown until the full extent of the damage is assessed.

The cost to the economy is harder to calculate but delays in transport lead to increased costs and in the current climate more expense is the last thing industry wants.

Can anything be done to minimise the effect of fire in the tunnel?

When the tunnel was first built the cost of using built-in fire protection in the form of a cementitious lining was estimated at between £48m and £70m. At the time it was felt that the risk of fire was minimal. A major fire would be a 'one in a hundred years' event, so the Channel Tunnel management preferred to rely on their sophisticated warning systems and evacuation procedures.

The September 2008 fire was the third in 14 years. The cost of repairs after the 1996 fire was £200m and, although the projected bill this time is estimated to be (only!) £46m it seems that the initial saving has proved to be a false economy. If the repairs simply repeat the same procedure the situation will certainly arise again and might have a worse outcome.

In the 1996 fire the damage to the tunnel lining was severe. In places the 0.4m thick concrete lining was reduced by spalling to a mean depth of 0.17m, with the thinnest area being a mere 0.02m. This could have resulted in partial or even total collapse of the tunnel. Although the policy is to drive the train out of the tunnel to where the fire can be tackled in relative safety, in this case the driver had to stop the train in the tunnel. This in turn led to extensive damage to the fabric of the lining, with explosive spalling injuring the firefighters as they worked.

So, is it possible to repair and renovate the tunnel, at a reasonable cost, at the same time improving the fire safety strategy and minimising the potential damage to the tunnel? Yes.

The 1996 fire caused much damage. The 2006 one didn't. Why?

The first fire in 1996 caused extensive damage, but in the 2006 incident the fire was put out quickly and damage was limited. The tunnel reopened to traffic within a few hours. So what was the difference? The second fire was in a closed vehicle and probably due to a lack of oxygen smouldered rather than burned until the aluminium fractured or the van was opened up, allowing air to feed it. The smoke had permeated the seams of the van and activated the alarms as the train passed and although the

truck was totally destroyed it would seem that the fire was fought under what may be termed "controlled conditions". The fire load was rolls of packaging materials that would be very dense and not burn fiercely until opened up for oxygen and the vehicles either side of the outbreak suffered little damage. In other words, one of the basic elements of built in fire protection was in place – compartmentation. Because the fire was contained to the point of origin it was easier to put out and caused less damage to the fabric of the tunnel.

In the latest case it is said that damage to the tunnel lining is severe and possibly worse than that suffered in the first fire. Although we do not know the exact details yet - the full report on the fire from the Channel Tunnel Safety Authority will be produced by September 2009 - it stands to reason that if any fire is **on** a vehicle rather than **in** a vehicle it will be a much fiercer fire and be fanned by the movement of the train through the narrow tunnel. It will create more heat with the potential to cause more explosive spalling of the lining and if the train stops the fire will be concentrated on the lining at that point. If the train continues the open nature of the carrying vehicles will allow good air circulation and fan the flames thus spreading the fire down the train to other vehicles and so escalating the incident. Neither of these circumstances is acceptable.

Solutions are available now

The question then is what options are available to the owners and operators of the tunnel? Standard, off the shelf solutions are available. This is not rocket science.

The first option is to protect the lining of the tunnel to the standard required if the tunnel were built today. This would involve either coating the surface with cementitious or intumescent passive fire protection materials or fitting preformed lining panels that could give up to 2, 3 or more hours before the lining temperature reaches a level at which explosive spalling occurs. These would be materials tested to the Dutch RWS (Rijkwaterstraat) standard, already required in tunnels in Holland and other European states. Use of such a lining would buy time for action to be taken. The experience of the 2006 fire shows that if fire fighters can get in and begin to tackle the blaze their success depends on the nature of the fire and the fire load.

However, if concentrated volumes of highly flammable materials are involved (and at the very least diesel fuel will be present) this time may not be enough.

But the cost of lining the tunnel now that all cabling is in place with all the associated equipment would be vast and take a long time, restricting access and limiting services.

A more realistic alternative is to work on the containment principle that applies to the passenger trains using the tunnel. **Enclose the wagons which carry the lorries.** This would make them into fire 'compartments' so that any outbreak could be contained while the train continues its journey out of the tunnel. Trains would have to be taken out of service for conversion but **there would be no closure of the tunnel itself.**

Existing standards and materials can be used

The project should consider lining the existing skeletal frames of the wagons with a thin membrane that has 30 to 60 minutes fire integrity. Insulation is not required but a low surface spread of flame rating on both surfaces should be included. To complete the compartment it would be necessary to provide curtains with the same characteristics at each ends of the wagon. Any connecting cabling which is not already fire rated should be protected with fire resistant materials. The floor is already fire resistant to ISO 834, to protect the running gear, brakes and train lines so would not involve further modification.

Of course there are some problems with this solution. The first is bogey weight; with fully loaded trucks at the maximum axle weight there may be little scope for added material. Secondly, there may be little room for extra constructions such as doors to seal the ends of each rail vehicle. Thirdly there is the cost of rebuilding all the rolling stock, but this has to be cheaper than lining the tunnel.

But these problems can be solved. The major difficulty, the weight penalty, could be solved either by imposing a weight limit on the lorries or perhaps splitting tractors and trailers that are at the maximum gross weight – a challenge for management rather than engineering.

Existing materials are on the shelf and already in use in many rail networks, notably London Underground. The thin membrane could be Glass Reinforced Phenolic sheeting and if necessary this could be coated with surface spread of flame rated materials. An integrity test for 30 minutes fire-resistance to BS EN 1364 - 1 is a minimum requirement: 60 minutes would be better. Little or no development of special products is likely to be required.

Fire Suppression Systems

If there is another incident in the tunnel where a truck catches fire (and the chances are there will be) then the fact that it is enclosed would allow the use of a fire suppression system. As weight seems to be the main problem a gaseous system may be lighter than a water mist system.

To bring suppression systems into use on an open vehicle or in the tunnel itself is of limited effectiveness – if the train is still moving the flames will be fanned and spread, if not, the heat is concentrated at a single point of the tunnel which could damage pipe-work and interfere with the flow of the suppressant. But if the fire compartment is enclosed suppression systems would be of benefit, even if the train were moving. Once again standard systems are available, off the shelf. Mobile fire suppression systems already exist for rally and race cars.

Action must be taken now

This combination of active and passive fire protection methods should help us avoid the disastrous situation that would follow collapse of the tunnel, which has been narrowly avoided now on two occasions.

All the solutions I have mentioned are available from the Fire Protection Industry and no time should be lost in specifying requirements and making the decision before terminal damage is caused.

There is every likelihood that there will be more fires in the tunnel. The question is when, and at what cost?

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