



# Traffic & Transportation

## Jubilee Line Extension Tunnel

### The Challenge

The £2.6 bn extension to the London Jubilee Line was during its time, one of the largest construction projects undertaken in Europe, and incorporated the largest active fire protection contracts.

When it was completed in 1999, the Jubilee Line extended by nearly 26 km into south and east London. This created a valuable link to the Docklands and brought many benefits to an area of London that is continuing to undergo regeneration.

The six year construction programme included 18 operating sites, of which 11 were stations. Six of these were designed and built for the JLE, while five existing London Underground Limited (LUL) stations were improved, re-designed, extended and modernised to the new Jubilee Line standards.

The extension brought Underground services to an entire area south of the River Thames for the first time, with stations provided in Southwark and Bermondsey. The North Greenwich peninsula has also been transformed with the creation of a new station which feeds the Millennium Dome, while south east London and Kent have been opened up to Underground commuters.

### Mammoth Task

This massive project involved scores of contractors and specialist sub-contractors requiring co-ordinated project management on an immense scale. Tyco Fire & Integrated Solutions, working in partnership with Drake & Scull, was awarded the contract to install active fire protection, fire detection and alarms, and employed a dedicated team on the Jubilee Line project from its inception in 1994.

Tyco's task was to provide a fire protection infrastructure that would ensure the safety of the tunnel, its services and staff during construction, as well as protecting passengers once the line became operational.

To co-ordinate the project Tyco Fire & Integrated Solutions brought together a team of 12 engineers, who managed the highly complex logistics system from the project management headquarters based at Canary Wharf. Their job included design, specification, ordering, deliveries, storage, staff transport, work scheduling and installation.

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The decision to develop the system design on site, alongside other contractors and sub-contractors, brought many benefits in managing some 5,000 mechanical and electrical designs that were involved in each design at submission stage. The design programme was co-ordinated by JLE itself, which operated a 1,000 strong team of monitors and supervisors above and below ground.

Tyco's team included design managers and design project engineers, installation teams, surveyors, and a quality assurance and health and safety adviser. Due to the size of the project, the team was divided into four project groups covering specific geographical areas, working with site specific teams of foremen and operators who were spread the length of the Jubilee Line Extension, over 18 operational sites.



This project team was responsible for what was, in effect, a design and build contract to deliver a complex fire protection system involving stations, escalators and tunnels. The sheer size of the project (26 km) with access stations based in some of the country's most traffic-congested areas meant that it was highly complex.

### Project Scope

Following the award of the contract to provide mechanical active fire protection, including water supply measures, Tyco Fire & Integrated Solutions was also given responsibility for installing the compressed air systems. These control the track points, track signalling, public and non-public ventilation systems, and sewage ejection systems, which force waste from underground station toilets up into the City's main drains above.

The scope of the contract therefore involved London Underground Stations, escape and ventilation shafts, as well as the underground tunnel itself. It included:

- Sprinkler systems (active)
- Hydrant systems (fire fighting)
- Hosereels systems (fire fighting)
- Portable extinguishers (fire fighting)
- Compressed air systems (non-fire)
- Detection, alarms and remote signalling (electrical)

Tyco's part in the Jubilee Line project was valued at more than £20m, over more than 5 years. In terms of equipment alone it involved 85 km. of pipework, 1,200 portable extinguishers, 150 hosereels, 500 hydrant outlets, 2,000 fire sprinklers and 450 control valves.

The electrical element of the contract involved 500 km. of mineral insulated cabling, 29 main fire alarm panels, 70 linear heat detection and sprinkler actuation panels, 200 ancillary/interface panels, 5,000 analogue addressable fire detectors, 2,000 manual callpoints and 55 km. of linear heat detection cabling.

**For further information contact your local Tyco Fire & Integrated Solutions office on:**

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### High Speed 1 - St. Pancras CTRL Rail Link

#### The Challenge

The Channel Tunnel Rail Link is an extension to the existing Channel Tunnel railway, which runs from London to Paris. The part of the fast link that is now under construction runs from Ashford in Kent to St Pancras Station in London. This link is of both national and international importance.

Tyco Fire have been contracted to install the fire hydrant systems into the three railway tunnels known as Thames Tunnel and London Tunnels 1 and 2. Each section consists of two separate tunnel bores running parallel to each other. This gives a total length of the north and south bound tunnels of 46km. The tunnel length is interspersed with a number of ventilation and access shafts.

Each tunnel has its own stand-alone fire hydrant installation, which is a looped pipe work system running both north and south bound. The pipe work to be installed will be a mixture of both 150mm and 200mm diameters depending upon the hydraulic requirements of the systems.

The fire hydrants are spaced at a distance not exceeding 60 metres with system isolating valves installed at every third hydrant. Because of the client's particular requirements, each hydrant point has two independent pressure reducing hydrant valves. This gives a total number in the region of 1600 fire hydrants, with approximately 275 number 200mm or 150mm diameter isolating valves.

The installation works were due for completion by March 2006, with the railway opening for passenger revenue in January 2007.

One of the major challenges we faced was to install 43km of brackets, 200mm hydrant main and all components within tunnels to a tight co-ordinated installation programme and designed to withstand the specified surge pressures of 24 Barg and 56 KN of end cap loads (subject to the contractors design verification): -



### Why is this fire protection project different to any other?

#### Size

- Largest Fire Protection contract carried out in the UK.
- 25 Miles of pipe work installed within tunnels.
- Circa 850 PRV Hydrant valves installed.
- Geographical, Ebbsfleet in Kent to St Pancras in London.

#### Safety

- Primary function was the safety of passengers and tunnel staff.
- Reliability of systems required a minimum 25 year design life.
- High speed trains.
- System integrity and capability – System must pass highest level of safety standards set for project (SIL 3) requires passing full fault tree analysis test.

#### Design

- Bespoke design of bracketry to withstand substantial surge pressures and Axial forces.
- Transient calculations, not normally carried out on fire systems.
- Supplying 4 Hydrants simultaneously at 35.3 L/s, BS 5306 Pt 1 requires 3 Hydrants at 25 L/s.
- Non-destructive and destructive test and load test at University specialist department.

#### Logistics

To install 25 miles of Hydrant main and all its component parts working off trains.

Managing material deliveries and labour over a site from Ebbsfleet, Kent to St Pancras, London. Pressure testing all pipe work to 24 Barg. The normal test pressure is 15 Barg Max.

Full Dynamic flow and pressure test of hydrants from trains.

#### Scope / Overview

To supply design, install, test and commission Fire Hydrant Systems to three twin bore tunnels (known as Thames Tunnel, London Tunnel 2 and London Tunnel 1).

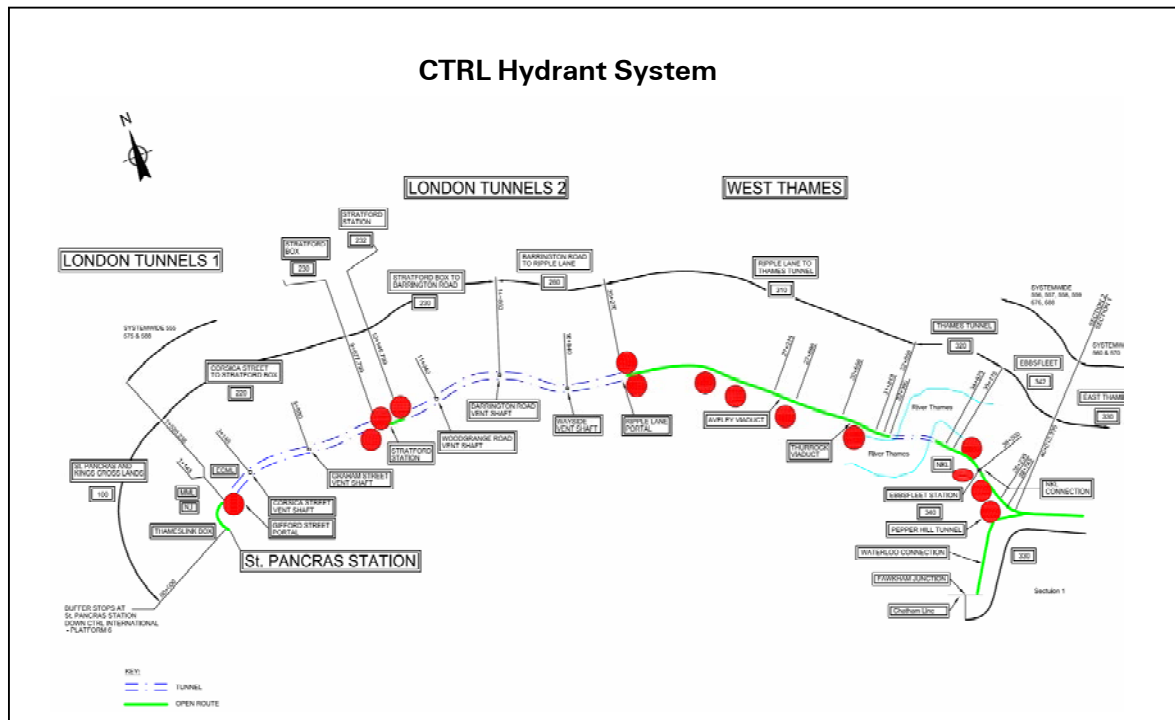
- Thames Tunnel is circa 3.5km each bore.
- London Tunnel 2 is circa 10.5km each bore.
- London Tunnel 1 is circa 7.5km each bore.

Total length of tunnels to be protected amounts to 43km (put into perspective this equates to 27 miles). There are eleven shafts/Portals serving the tunnels and thirty-four cross passages (the cross passages are passages interlinking two bores of a tunnel for the purpose of access between each bore).

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There are circa 850 PRV (pressure regulating valves) hydrant valves located within the shafts and tunnels (tunnels at not more than 60 metres apart and shafts at each level).

The hydrant system to each twin bore tunnel is interlinked at each shaft and tunnel eye. The system is able to be used as a ring main and provides the emergency services with the facility to isolate sections of the hydrant system in order to maintain a fire fighting system in the event of damage to any section of the hydrant system.

The water supply is from a pair of four way Breaching outlets/inlets located at the top of each shaft (ground level). In order to activate the system the Fire Brigade connect their Fire Appliance to the breaching outlet (connected to Town's main water supply) and the breaching inlet (hydrant system water supply inlet). The Fire Brigade Appliance acts as the pump to provide the required flow and pressure to each hydrant valve.



West Box Portal Breaching Point

The schematic of the hydrant system for London Tunnel 2 shows the typical configuration of water supplies and pipework/valve arrangement to shaft and tunnels.

The hydrant main within the Tunnels (between shafts) can be fed from either shaft or both simultaneously providing the Fire Brigade with total flexibility.

**SPECIFICATION REQUIREMENTS**

Tyco Fire designed, supplied, installed, tested and commissioned the hydrant systems to BS 5306 PT1 and was able to supply four 20mm nozzles (Fire Brigade Branch) at any location of the tunnels or cross passages, at a total rate of 35.3 litres per second and at a pressure of 4.5 plus or minus 0.5 Barg at the hydrants.

The design flow and pressure was achieved from the supply point up to the adjacent possible supply point i.e. portal or shaft. To achieve the design flow rate the wet mains are charged by the Fire Brigade Appliance providing a minimum of 7 Barg outlet pressure at the pumps.

The system included pressure release valves on the downstream side of each inlet breaching connection, which should be set to open if the Fire Brigade Appliance pressure exceeds 10 Barg.

The systems are for fighting uncontrolled Class 'A' fires (defined as fire involving solid materials) on trains stopped in tunnels. They are wet systems kept under a low positive pressure and pressurised to the duty pressure by the Fire Brigade Appliances.





The systems were designed to form an effective means of rapidly bringing under control, fires in tunnels (running tunnels and cross passages). Their primary function is to ensure the safety of passengers and tunnel staff. The systems form part of the comprehensive safety provisions in Tunnels. The reliability of the systems is therefore paramount.

With these factors in mind, the system was designed to have a minimum life of at least 25 years. The system design also met the environmental corrosivity conditions of C4 (BS EN ISO 12944-2: 1998) and local IM2 regulations.

#### LOGISTICS

To install test and commission 43km of hydrant main and all its component parts within tunnels takes considerable planning and must be executed systematically to ensure revisits do not occur and delays are not caused to others.

To ensure this was achieved the brackets were installed prior to track laying, the brackets were off loaded along the tunnel for installation teams to install, all fixings being torqued to the correct NM (Newton Meters). This work was planned along with other contractors to ensure sequential completion of areas and use of shared welfare facilities within the tunnels.

The plan was to install 180 metres of pipe per day to meet the programme, although it soon became apparent that this did not leave sufficient programme float and being a partnering contract with incentives it was vital to consider ways of improving the output.

To this end a "brainstorming session" was held between Tyco Fire & Integrated Solutions and all parties involved, from the train loader, teams on the trains and engineers to review the installation methodology and investigate how to improve the productivity levels. This included the use of SIX SIGMA and the results enabled us to significantly increase our productivity to circa 230 metres a day including all components.

The hydrant main and all its components were installed after track laying from a diesel train equipped with welfare facilities, further trailers (flat beds) for the purpose of storage of materials (36 lengths of 6.5 metre pipework and all valves, fittings, jointing couplings etc. and finally two Hiabs for off loading pipework onto brackets and moving materials to the pre-fabrication workshop on one of the trailers.

This ensured the installation trains were fully self sufficient to off load and install circa 230 metres of pipework and all components per day.



### Why Emcor Rail chose Tyco Fire

Emcor Rail was looking for partner contractors, but significantly, parties who had worked with them in the past. At Emcor's request, the Tyco Fire project team that worked very successfully for them on the Jubilee Line Extension was re-assembled. Tyco Fire, Slough completed the Jubilee Line Extension in 1999. It had a project value £23 million.

The success of this project was overwhelmingly down to unrivalled engineering expertise of this team. Emcor needed such a team, a team that could rise to unparalleled feats of engineering ingenuity, skill and expertise.

This requirement was particularly evident when calculating the system Design Pressure and Axial Forces.

The Tyco Fire design team ensured that the system could withstand significant surge pressure and axial forces at changes in direction and closed valve positions. They also had to account for specified expected maximum surge pressure of 23.6 Barg and expected maximum axial forces at bends being 55.7kn.

### Material Selection and Bracket Design

Having carried out the hydraulic and transient pressure calculations materials had to be selected that would withstand the peak loads calculated along with designing bespoke brackets and associated fixings that would likewise withstand the expected loads and specified corrosion levels.

### Fixings and brackets

The fixings and brackets had to withstand maximum transient pressure loads 24 Barg, end cap loads of 70kn (7 Tonne load plus safety margin) together with weight loadings, 20kn vertical reaction forces, curvature of tunnel wall, vibration and pressure variances caused by passing high speed trains,

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Tunnel Ring Roll (Final positioning of each concrete ring, making up tunnel wall, in relation to a fixed datum i.e. tunnel ring roll tolerance of plus or minus 40mm).

Detailed bracket and fixings design substantiation calculations and drawings were produced taking all the above into account. Various types of fixings were subjected to pull out tests (the tunnel curved wall was replicated for this purpose) to ensure the design calculations were physically achieved.

A sample batch of brackets were manufactured for testing purposes and the brackets were then subjected to non destructive (which also verified the galvanising thickness) and destructive tests at a specialist testing laboratory, a proportion of the brackets were taken to Reading University where they were subjected to rigorous loading tests (up to 8 Tonne) to prove their integrity.

### Proving System Integrity and Performance

The hydrant systems successfully completed rigorous hydraulic pressure and performance testing to demonstrate their integrity and that they met the specified performance criteria.

All the systems had to be subjected to 24 Barg hydraulic pressure tests. Full dynamic flow and pressure tests had to be carried out to prove that any 4 PRV hydrant valves performed to the specified flow of 35.3 litre per second (2100 litres per minute) 4.5 plus or minus 0.5 Barg is achieved.

### On time, on budget, every time

Once again, the great care and attention given by the Tyco fire Project Management team ensured that they were able to meet all the stringent requirements of Emcor Rail.



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### Palm Island Jumeirah, Vehicular Tunnel

#### The Challenge

The Jumeirah Palm Island, currently under construction off the coast of Dubai, is rapidly becoming one of the iconic structures in the region. Formed in the shape of a Desert Palm Tree, the "fronds" will be home to over 2,000 executive beach front villas, whilst the "trunk" and protective crescent shaped breakwater will be home to numerous 5-star developments and hotels.

Linking the Palm and the Crescent is a 1.4 Km long, underwater vehicular tunnel.

The tunnel has a three lane carriageway in each direction, separated by a service/emergency escape tunnel.

Tyco Fire & Security UAE LLC have been awarded the contract to Design, Supply & Install all of the Extra Low Voltage systems as an integrated solution, as well as the fire fighting systems for the tunnel and the two control buildings.

Tyco UAE's scope includes the provision of video smoke/fire detection, video analysis of traffic, voice evacuation systems, tunnel communications systems, traffic management and a Radio FM Re-Broadcasting/TETRA system.

All of the systems are monitored and controlled by a PLC based SCADA system, control of lighting levels, ventilation fans, sump and drainage pumps is also provided by the SCADA system.

Tyco's ability to undertake all of the works as well as provide additional solutions for the client has been a major influencing factor in securing the award of this project.

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### Lötschberg Transalpine Tunnel

#### The Challenge

Switzerland, the tunnel building nation, is involved in the construction of a fast train link between northern and southern Europe.

The so called NEAT ("New Transalpine Tunnels"), is a very ambitious project: through the Lötschberg and Gotthard mountains.

The Lötschberg main tunnel runs through the Alps from Frutigen to Raron as part of the main line from Bern to Milano.

Most of the 34.6 km long tunnel is covered by two bores, each with a single directional track. The opening of this gigantic construction, the first high speed rail link through the Alps, is expected to be in December 2007.

The Government awarded BLS AlpTransit AG the contract to design and supply the new Lötschberg main link. For the tunnel safety solutions BLS AlpTransit AG has chosen the TSA Telecom/Tyco Fire & Integrated Solutions consortium as a partner.

The tender process took place during autumn 2001 and in the summer of 2002, Tyco received the order for the fire detection and suppression systems.

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#### Mammoth Task

Over 1500 fire sensors will be installed in the tunnel control and equipment rooms.

In addition, gas and water sensors as well as nearly 35 km of aspirating pipes for the Vesda air sampling smoke detectors, provide extra safety. Approx. 270 off EXPERT MX 1000 fire detection centers are controlling these sensors.

Supplementing the early fire detection system will be 93 INREGEN gas fire extinguishing systems housed in the equipment rooms. A fire can be extinguished at its initial phase as these systems are triggered by the early fire detection systems.

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## London Main Line Stations CCTV Systems

### The Challenge

Tyco Traffic & Transportation has supplied, designed and installed the largest CCTV system in the rail industry within the UK. The networked CCTV Control system covers 16 main line London stations and over 2,300 high performance colour cameras.

It also boasts Remote and Local Monitoring and Archiving, which is complimented by a comprehensive Tyco Maintenance Package.

All of the cameras are networked back to one "nerve centre" Control Room operated by Tyco Traffic & Transportation and British Transport Police. The images are recorded 24 hours a day, 365 days a year.

Tyco Traffic & Transportation CCTV and Maintenance have contributed to the Secure Stations Programme by aiding many of the London stations with their quest for the Secure Stations Award. Recently, awards were presented to the Kings Cross, City Thames Link and Fenchurch Street Stations.

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### Tyco Traffic & Transportation protected the following 16 London Main Line Stations:

- Blackfriars
- Cannon Street
- Charing Cross
- City Thames Link
- Euston
- Fenchurch Street
- Kings Cross
- Liverpool Street
- London Bridge
- Maryleborne
- Paddington
- St. Pancras
- Victoria
- Waterloo Main
- Waterloo East

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