

## Sub-Surface Station Fire Evacuation Research and Best Practice

Trevor Downens<sup>†</sup>

### Abstract

The basis of modern risk-based safety management is to focus on what might happen and ensure it is designed out of the system by robust hazard identification and risk analysis. However, in the real world things go wrong and it is essential to be prepared for the worst so that the response can minimise harm and loss of property and damage to the environment. Whilst some hazard mitigation measures are aimed at preventing incidents, others are aimed at minimising harm and preventing escalation. The results of the tests concluded that the most effective means of evacuation was that carried out by the control room, both with and without, local station staff assistance using directive public address announcements and CCTV surveillance.

**Keywords :** Fire Evacuation, Surveillance System

### 1. Introduction

No one wants fires on a railway system, least of all in an underground location where escape is difficult and access for fire fighting restricted. The basis of modern risk-based safety management is to focus on what might happen and ensure it is designed out of the system by robust hazard identification and risk analysis. However, in the real world things go wrong and it is essential to be prepared for the worst so that the response can minimise harm and loss of property and damage to the environment. Whilst some hazard mitigation measures are aimed at preventing incidents, others are aimed at minimising harm and preventing escalation. Addressing fire hazards can be done effectively through engineering design and compliance to standards and good practice but more can be done. The aims of this paper are to:

- Provide information on a model of sub-surface station fire evacuation which seeks to reconcile the engineering and psychological approaches to evacuation.
- Present the findings of fire evacuation research and tests carried out at Tyne and Wear Metro in the UK.
- To promote awareness of passenger behaviour during fire evacuation.
- Describe the measures taken by Tyne and Wear Metro

in the UK to adopt best practice in sub surface fire evacuation

- Explain the underpinning theory and research into the fire evacuation approach.

The paper is not intended to cover technical fire engineering requirements although the design and functionality of station sub systems including, fire detection, Closed circuit television (CCTV) and public address (PA) etc is important to the effectiveness of the process.

### 2. The Tyne and Wear Model

#### 2.1 Metro a Brief Description

##### 2.1.1 General

At the time of this project, Tyne and Wear Passenger Transport Executive were the owners and operators of the Tyne and Wear Metro system; a 1500VDC electrically powered light rapid transit system using driver only operated trains.

The Metro operates a fleet of 90 metro cars over 78 Km of track of which they own operate and maintain 59 Km.

Subsequently, a 18.5 Km extension, owned, operated and maintained by Network Rail was added, over which the Metro operates as a UK Train Operating Company.

Nowadays there are approximately 43 million passenger journeys requiring 4 million operated train miles. High frequency characterises Metro services with headways of 3 minutes through the central areas of the system.

<sup>†</sup> Principal Consultant, Lloyd's Register Rail Limited.  
E-mail: Trevor.dowens@lrrail.com

### 2.1.2 Operation of Services

The whole of the Metro system including station control on Network Rail infrastructure is controlled and managed from one centralised control centre at South Gosforth.

### 2.1.3 Stations

The Metro serves 58 stations of which 46 are located on the Metro system and 12 on Network Rail controlled infrastructure. In total Metro are the station operators of 57 of the 58 stations.

Twelve of the 58 stations are classified as sub-surface stations in accordance with UK fire regulations, Metro having direct responsibility for 11 of them, 10 on the Metro infrastructure and one on Network Rail infrastructure. A high degree of control and co-ordination is achieved through the concept of central control and more specifically using monitoring and surveillance equipment designed originally for un-staffed stations e.g.:

- Supervisory Control and Data Acquisition System (SCADA) equipment for fault reporting, including fire monitoring at each sub-surface station;
- Public address equipment;
- CCTV monitoring and recording;
- Passenger “help” and “emergency” communications points.

## 2.2 Tyne and Wear Approach to the New Sub-surface Station Fire Regulations

The Fire Precautions (Sub-surface Railway Stations) Regulations 1989 were brought into force in the UK following publication of the Fennel report into the Kings Cross fire accident which occurred in 1987 resulting in 31 fatalities.

The Tyne and Wear Metro did not consider that the regulations were appropriate for a modern system with centralised control but were more in keeping with the nature of design, age and operation of London Underground Limited at that time.

Specific issues were with Regulation 10(4) requiring a minimum of two members of staff on duty whilst the station is open to the public. Regulation 6(6) requiring that:

“The station premises shall be provided with a public address system for use by or on behalf of the occupier of the premises to give warning of fire to members of the public in the premises and advise them of the action to be taken by them in case of fire.”

Subsequently they were keen to demonstrate that due to the design of their Metro system and the operational philosophy of running an un-staffed system with the use of effective centralised control, that their approach was appropriate and a successful staffing exemption could be achieved.

A study was commissioned in collaboration with the Fire Authority, “User evacuation safety evaluation”. The study was aimed at establishing whether a control centre system could be as effective, if not more effective, than the conditions demanded by the regulations.

It is interesting to note at this point that the Regulations did not identify the advantages of surveillance equipment in the process of safe station evacuation.

## 2.3 The Tyne and Wear Study

The Tyne and Wear Metro study comprised of two stages:

Stage one involved an appraisal of the information system in the sub-surface stations. This concentrated primarily on visual displays such as signs and the architectural spaces of the sub surface stations in relation to way finding by passengers during normal circumstances of entry and exit i.e. from the concourse level and travel to the platforms and vice versa.

Stage two of the study concentrated more specifically on evacuation communication and procedures in the sub surface stations. Based on the stage one appraisal and discussion with the Fire Authority, a series of monitored evacuation tests were conducted to demonstrate the effectiveness of a human behavioural approach to evacuation communications and procedures in contrast to the traditional engineering based evacuation model.

The evacuation study and tests were carried out in association with Dr Jonathan Sime, an expert in the field of behavioural science and evacuation from complex underground spaces.

## 2.4 The Theory

A paper presented to an international seminar, Communication Systems for Tunnels, June 1993. “Guiding Passengers to Safety: Communication and Way Finding in Rail Tunnels and Underground Stations” by Dr J Sime, reconciles engineering and psychological approaches to evacuation.

In summary, it is argued that an engineering approach to passenger safety tends to assume that people “panic” in a situation of potential entrapment and their movement can therefore be equated with non-thinking objects in motion.

Emergency information is restricted and attention is focused on the physical dimensions of vehicles, tunnels and underground spaces, which will permit movement.

A psychological approach emphasises the interpretation of a threat by passengers and the information they need if they are to act properly, rather than just the physical environment.

In attempting to reconcile these approaches, lessons from the field of environmental psychology have been

considered. This argues that settings such as tunnels underground stations and vehicles should be considered as information and communication systems as well as physical structures. This emphasises the importance of communications with the passengers most at risk.

Research, supported by many accident reports indicate that disasters are characterised by poor communications with the public prior to, during and in the immediate aftermath of an incident. Therefore, passengers would benefit from specific guidance on what to do in the event of an emergency.

This therefore suggests that the important factor in any given evacuation scenario is the ability to communicate effectively with the public throughout the emergency and to get people to move and evacuate quickly and effectively, following the initial warning, by directing them through clear communication and surveillance to a place of safety.

### **3. Sub-surface Station Fire Evacuation Tests**

#### **3.1 Test Methodology**

A series of monitored evacuation tests were carried out in real time, to test the effectiveness of different communications and staffing arrangements in the event of a fire. Further, the tests using actual Metro passengers were designed to satisfy the conditions required for an exemption to regulation 10(4).

Following discussion with the Fire Authority, Monument station in Newcastle was selected as the location for the fire evacuation tests due to the complex nature of the layout and the fact that it most closely replicated the Kings Cross station layout.

Because of the location chosen and the fire evacuation scenario, this was considered the most stringent test of evacuation safety possible on the Metro.

Monument station is on two levels with escalators to each. For the purpose of the tests, the normal route out of the deepest level of the station via the main escalators was blocked to prevent escape. The means of evacuation therefore for passengers on platform level would be by either evacuation train, or an alternative route out via the stairs at the far end of the platforms.

The aim of the tests was to establish whether a centralised control centre system could be as effective, if not more effective, than the conditions demanded by the above regulations.

The tests were conducted as trains were disembarking passengers to include as many passengers as possible in real time. Five tests were conducted in total which sought to assess the effectiveness of evacuation adopting direc-

tive or non-directive public address announcements and a combination of control room only, staff only and control room with staff assistance evacuations.

In particular, the tests incorporated a scenario that replicated the requirements of Regulations 10(4) and 6(6) i.e. two members of staff on the station with non-directive public address (i.e. automatic public fire evacuation announcements).

#### **3.2 Test Findings**

The most significant findings of the tests related to the scenario, which most closely replicated the requirements of Regulations 10(4) and 6(6). This involved two members of staff on the station with access to public address, as demanded by the above regulations. However, a number of weaknesses were observed during the test.

The most serious of which was that during the evacuation a large number of passengers were directed in person by one of the staff members directly into the source of the station fire.

In the Kings Cross fire passengers were also mistakenly directed by the local station staff in a similar way via the Victoria line escalator up to the concourse, which was engulfed by flames from the Piccadilly escalator.

These results demonstrated that local station staff on a complicated sub-surface station cannot be expected to have an effective geographical overview of the station and fire spread nor understand what passengers are doing and therefore give effective timely instructions for their safety in the prevailing circumstances.

Thus the expectation that local station staff working independently to evacuate the station in a procedural and routine fashion could take account of the location of passengers, fire evacuation strategy and the location and development of the fire on a complex underground station, is unrealistic.

This inability of local station staff to logistically initiate and co-ordinate an evacuation was further compounded by the absence of surveillance and communications technology.

In contrast, the most effective means of evacuation in terms of speed in clearing the station by the most effective route were those carried out by the control centre both with, and without, local station staff assistance using manual directive public address announcements and central CCTV surveillance.

This helped to confirm the importance of direct, timely and accurate emergency warning to the public. The importance of which is not always recognised in the provision of automated detection and fire warning systems which are used on many systems today.

### **3.3 Conclusions**

The test results highlighted the inability of local station staff to logistically initiate and co-ordinate an evacuation compounded by the absence of surveillance (CCTV) and communications (directive public address) technology.

The results of the tests concluded that the most effective means of evacuation was that carried out by the control room, both with and without, local station staff assistance using directive public address announcements and CCTV surveillance.

The tests demonstrated the advantage of centralised control and the use of surveillance systems and directive public address announcements, whilst the weaknesses of staff only fire evacuation related to the lack of station overview, misunderstanding the prevailing fire conditions and problems relaying timely and accurate information to passengers.

The findings of the study were supported by research in the field of behavioural psychology, which expressed the view that underground stations and other structures and vehicles should be viewed as communications systems.

The fire evacuation tests carried out at Tyne and Wear helped demonstrate the effectiveness of centralised control for the safe and effective fire evacuation of sub surface stations.

The use of a centralised surveillance system, direct public address announcements, clear fire detection information and other passenger information systems were found to be more effective in the evacuation of a station than the measures prescribed in the UK Regulations implemented as a result of the Kings Cross fire or in the provision of

automated fire alarm systems provided on many systems today.

Station systems and architecture required to support the application of best practise in fire evacuation strategies and the integration of such facilities to achieve safe station operation during fire conditions are also important to the successful implementation of best practice in fire evacuation. The review of such systems and associated functionality is beyond the scope of this paper.

Finally, the concept of centralised control can also apply to the provision of local station control rooms located within sub surface stations (usually the Station Managers Office) from where this model of station evacuation can also be effectively applied providing the installation of appropriate local sub systems including public address and CCTV.

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