Underground fires in metro systems – failures, accidents and terrorism

Dr Fathi Tarada
Mosen Ltd

RIFA Seminar 22-03-2018
Issues

• Higher threat of fire & explosions in congested underground metro stations?
• What do recent incidents tell us about the way forward?

TST Station Fire, Hong Kong
Agenda

• Historical underground metro fires
• Firebomb attack on TST Station, Hong Kong
• Reaction-to-fire properties of rolling stock
• Cross-passage spacing
• Future fire safety measures
Historical underground metro fires
Jungangno Station, Daegu Subway, South Korea

- 18 Feb 2003
- Arson attack
- 192 deaths, 151 injuries
- Two subway trains destroyed
- Doors locked on second train
King’s Cross Fire, London, UK

- 18 November 1987
- 31 deaths, 100 injuries
- Match ignited rubbish underneath escalator?
Baku Metro Fire

- 28th October 1995
- Electrical fault
- Train stopped between stations
- Ventilation drew smoke over evacuees
- 289 fatalities, 270 injuries
London Underground Bombings

- 7\textsuperscript{th} July 2005
- Three trains underground trains bombed
- Homemade organic peroxide-based devices in backpacks
- 37 fatalities
- Incident trains smouldered, but did not burn
Firebomb attack on TST Station, Hong Kong
Background to TST Station Firebomb Attack

• 10th February 2017
• 19 injured, including 3 critically hurt
• Arson attack with liquid accelerant
• Similar attack occurred in 2004
Lessons learnt from TST Station Incident

• Human factors – reaction of passengers (standing around, taking pictures)
• Lack of CCTV cameras on the platforms
• Good reaction-to-fire properties of train materials
• Smoke escape to platform: close doors after evacuation?
• Delay in station operator response
• Conditions would be far worse in tunnel
Reaction-to-fire properties of rolling stock
Superseded Standard

- BS 6853:1999 “Code of practice for fire precautions in the design and construction of passenger carrying trains”

- 3 vehicle categories:
  - Category I: underground
    - Category Ia - single track tunnel with no side exits to a walkway
    - Category Ib - multi-track tunnel or a tunnel with side exits to a walkway
  - Category II: surface
- A lot of rolling stock to this or to older standards still in operation
Current Standards

• BS EN 45545:2013 “Railway applications - Fire protection on railway vehicles” (in seven parts)
• BS EN 50553:2012 “Railway applications - Requirements for running capability in case of fire on board of rolling stock”
• New rolling stock normally specified to these standards in Europe
BS EN 45545:2013

- Minimise the probability of a fire starting
- Control the rate and extent of fire development
- Minimise the impact of the products of fire on passengers and staff
- 4-minute running capability at an average speed of 80km/h
BS EN 50553:2012

• Considers luggage fires, vandalised seat fires, some diesel fires and significant arson events

• Minimum running capability of 15 minutes for individual on-board systems including cables, technical cabinets, pneumatic and hydraulic equipment
METRO project

- Mälardalen University, Sweden
- Maximum fire heat release rate of 77 MW for carriage fire including luggage
- Difficult to start the fires!
- 10 litres of diesel fuel required for ignition
- Minimum heat release rate for ignition was 2 to 3 MW
- Combustible linings carriage did not comply with current European rolling stock standards
CFD Simulation of Fire Growth in Train

- Ignition heat release rises to 150 kW after two minutes
- Conditions within carriage untenable after 3 minutes (heat release rate 540 kW), even with in-car ventilation switched on to dilute smoke
Cross-passage spacing
## Cross-Passage Spacing Standards

<table>
<thead>
<tr>
<th>Standard</th>
<th>Cross-Passage Spacing</th>
</tr>
</thead>
<tbody>
<tr>
<td>NFPA-130</td>
<td>244m</td>
</tr>
<tr>
<td>Australian AS 4825</td>
<td>240m</td>
</tr>
<tr>
<td>European TSI</td>
<td>500m</td>
</tr>
<tr>
<td>Singapore SFSRTS</td>
<td>250m</td>
</tr>
</tbody>
</table>

Significant difference between European TSI and other standards
Cross-Passages in Practice

• London Crossrail scheme: has cross-passages at approximately 500m spacings, with a maximum spacing of up to 693m
• Risk assessment undertaken
• Negotiation with the London Fire Brigade
Quantitative Risk Assessment

- Estimate societal risk for compliant and non-compliant cross-passage spacings
- Investigate additional mitigation measures such as dynamic signage to aid evacuation
- Significant cost-savings can be obtained whilst maintaining acceptable risk levels (performance-based design)
Future fire safety measures
Future Fire Safety Measures

• Tracking and communication with passengers via mobiles, including underground areas
• Dynamic evacuation signage
• Further improvements in reducing combustibility of rolling stock materials
• Innovative ventilation systems for confined spaces (e.g. MoJet®)
Overview
Overview

• Historical underground metro fires
• Firebomb attack on TST Station, Hong Kong
• Reaction-to-fire properties of rolling stock
• Cross-passage spacing
• Future fire safety measures