RAIB
Rail Accident Investigation Branch

Rail Accident Report

Passenger trapped in a closed train door, Tooting Broadway, Northern Line, London Underground 1 November 2007

Department for Transport

Report 17/2008
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This investigation was carried out in accordance with:

- the Railway Safety Directive 2004/49/EC;
- the Railways and Transport Safety Act 2003; and
- the Railways (Accident Investigation and Reporting) Regulations 2005.

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Introduction

1 The sole purpose of a Rail Accident Investigation Branch (RAIB) investigation is to prevent future accidents and incidents and improve railway safety.

2 The RAIB does not establish blame, liability or carry out prosecutions.

3 Access was freely given by London Underground Limited to their staff, data and records in connection with the investigation.

4 Appendices at the rear of this report contain the following glossaries:

- acronyms and abbreviations are explained in Appendix A; and
- technical terms (shown in *italics* the first time they appear in the report) are explained in Appendix B.

Summary of the Report

Key facts about the accident

5 On 1 November 2007, at approximately 14:30 hrs, the hem of a passenger's coat was trapped in the closing doors of a southbound Northern Line train at Tooting Broadway as she left the train.

6 The passenger fell on the platform while extracting the coat from the door, she was conveyed to hospital by ambulance and released pending further treatment.

7 The train was stopped as it left the station following the activation of the *passenger emergency alarm* (PEA) by a passenger on the train.

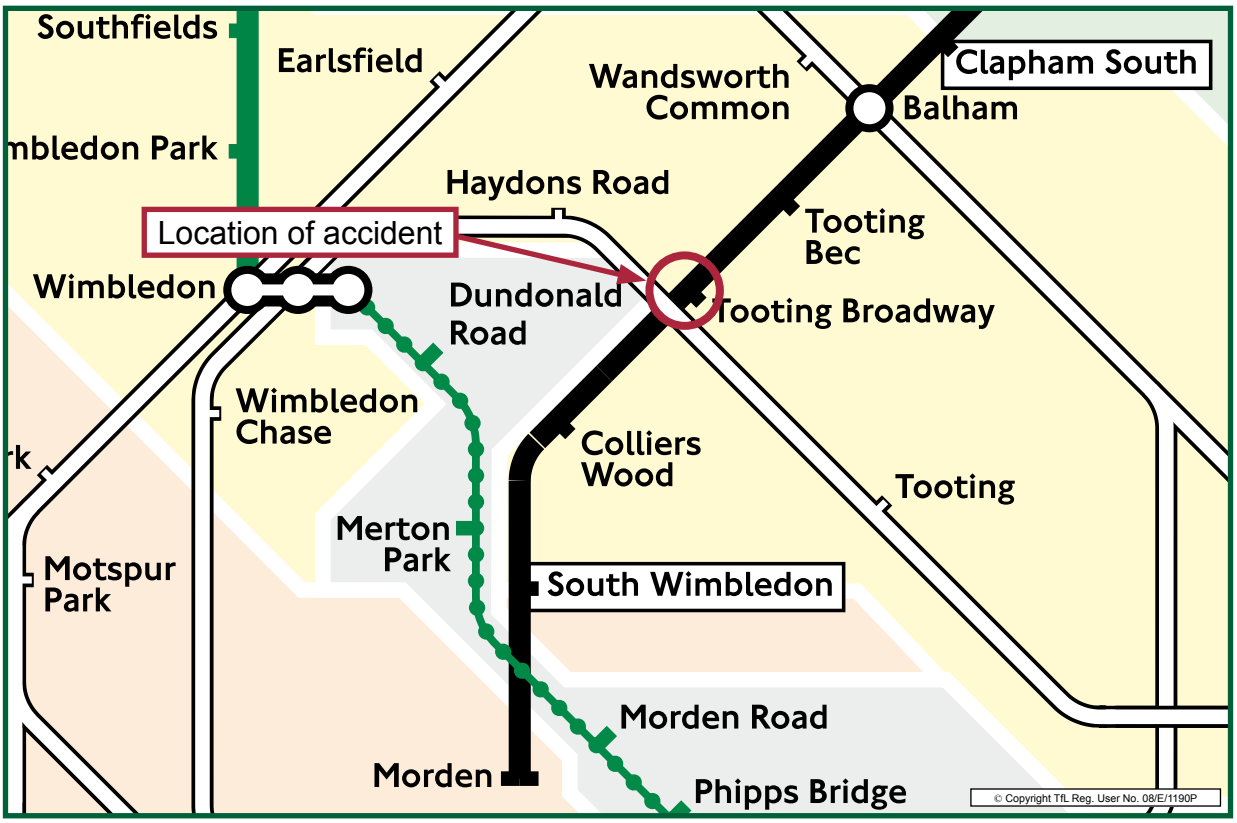

Figure 1: Extract from London Underground map showing location of accident

Immediate cause, causal and contributory factors

8 The immediate cause of the accident was the train operator starting the train while an item of passenger's clothing was trapped in a bodyside door.

9 The causal factors were:

a. the train operator did not observe that all passengers were clear of the train doors before starting the train at Tooting Broadway;

b. the train operator exclusively observed the line ahead while the train departed from Tooting Broadway instead of also monitoring the station platform; and

c. the passenger leaving the train very shortly before departure.

10 A contributory factor may have been that the train operator concentrated on avoiding passing a signal at danger to the exclusion of monitoring the conditions on the platform.

Severity of consequences

11 The injured passenger was conveyed to hospital by ambulance and returned home later that day pending further investigation and treatment.

Additional observation

12 The risk of a regular user being killed in a trapping incident is one in every 21 million years. This level of individual risk is well within the bounds defined in the HSE guidance on the tolerability of risk as '*broadly acceptable*'. However, the Northern Line has experienced a proportionately greater number of persons trapped and dragged by closed doors than other LUL lines.

Recommendations

13 A single recommendation can be found in paragraph 71. This relates to the need for London Underground to investigate the reasons for the apparently greater proportion of instances of persons being trapped and dragged by closed doors on the Northern Line when compared with the average for other LUL lines.

The Accident

Summary of the accident

14 On 1 November 2007, at approximately 14:30 hrs, the hem of a passenger's coat was trapped in the closing doors of a southbound Northern Line train at Tooting Broadway as she left the train.

15 The passenger was not able to release herself from the coat until after the train began to move away. Although she fell to the platform while extracting the coat from the door, the injuries she sustained did not cause her to be detained in hospital.

16 The train was stopped as it left the station following the activation of the PEA by a passenger on the train. On completion of its journey to Morden it was taken out of service for examination.

Figure 2: Southbound platform at Tooting Broadway, Northern Line

The parties involved

17 London Underground Limited (LUL) operated the train and employed the staff involved.

18 Alstom Transport built and maintain the train concerned.

Train

19 The train was formed of *'95 tube stock*.

Events constituting the accident

20 The train was running from High Barnet to Morden via Bank, and was timetabled to leave High Barnet at 13:24 hrs and arrive at Morden at 14:35 hrs. The journey had been uneventful, though the train was running approximately 6 minutes late as it approached Tooting Broadway.

21 At Tooting Broadway, the train operator opened the doors to allow passengers to leave and enter the train. After observing in the Closed Circuit Television (CCTV) monitor on his control desk that the process was complete and passengers were clear of the train, he closed the doors. When he received an indication that the doors were closed through the *doors closed visual indicator* light being illuminated, and having ensured that the *platform starting signal*, located short distance ahead in the tunnel, was showing a 'proceed' aspect, he restarted the train.

22 A passenger was leaving the train from the fourth vehicle from the front very shortly before the doors closed. As she passed through the doorway, the door closed trapping the tail of her coat.

23 The passenger was unable to extract the coat from the closed door. As the train began to move, she struck the side of the train with her hand to attract attention and was dragged for a short distance before she then managed to remove the coat, falling onto the platform in the process.

24 Another passenger in the fifth vehicle noticed the incident and operated the PEA.

25 This alerted the train operator who stopped the train immediately. He attempted to speak to the passenger who had operated the PEA, but received no response. He looked at the CCTV monitor and saw a passenger on the platform with another passenger standing over her.

26 He then walked back through the train to investigate the matter. On reaching the fifth vehicle from the front, an LUL employee travelling off duty identified the passenger who confirmed that she had operated the PEA. She explained that she thought she had seen somebody being dragged by the train. The train operator, after resetting the PEA, returned to his cab to summon assistance.

27 The *service controller* now called the train operator to establish what had happened and instructed the train operator that the train was to be taken out of service for examination on arrival at Morden.

28 The train operator sounded the train whistle to attract the attention of LUL station staff on the platform in order to obtain authority from them to restart the train since part of it was still at the platform. A staff member on the platform raised his hand above his head to indicate that the train could continue its journey.

Consequences of the accident

29 The injured passenger was conveyed to hospital by ambulance and returned home later that day pending further investigation and treatment.

The Investigation

Sources of evidence

30 These comprise:

- Witness evidence.
- CCTV images recorded at Tooting Broadway.
- *Train Data Recorder* (TDR) evidence taken from the train.
- Examination of and tests carried out on the train doors

Evidence

Condition of the train

31 Examination of the train, its associated door control systems and doors by Alstom Transport, under RAIB supervision, showed them to be working correctly.

Condition of the station platform

32 The platform edge and surface were in good condition with no damage or surface contamination which might have caused a person to fall.

33 The station lighting was in good order.

Situation of the train operator

34 The train operator was in good health. He had been on duty since 06:24 hrs. Since then he had had a meal break of about an hour starting at about 10:45 hrs. He had been working slightly more than 7 hours at the time the accident occurred and was due to leave duty about 6 minutes after leaving Tooting Broadway on arrival at Morden.

35 Some 26 months previously the train operator had been involved in a 'signal passed at danger' incident. There is some evidence that this event had caused the train operator to become concerned to observe signals closely in order to avoid a recurrence.

Previous occurrences of a similar character

36 Between 1997 and 2006 inclusive, there have been 64 instances of persons being trapped and dragged along the platform by closing doors on LU. See Table 1. These are discussed in paragraphs 58 –65.

Year	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Incidents	7	7	8	6	5	6	7	5	6	7

Table 1: Yearly instances of persons being trapped and dragged by London Underground trains

37 During the period shown in Table 1 the number of journeys made increased from 774 million in 1996/7 to 1014 million in 2007/8.

Tests carried out on the doors of a similar train extracting samples of the coat

38 The RAIB carried out tests to establish the force required to withdraw the passenger's coat from the closed door. The results are shown in Table 2 together with comparative data found in earlier investigations for trains operating on the national network and trams[1].

[1] Report 11/2007 'Huntingdon train door incident 15 February 2007 and Report 40/2007 'Incident at Wellesley Road on Croydon Tramlink 15 June 2007'

39 The RAIB carried out three sets of tests with the coat. Initially the coat was inserted as the hem only, then it was folded over to a double thickness and finally it was inserted with a seam so that it might trap the coat. In each case the coat was pulled sharply as though being snatched out of the door and then with a slower steady pull horizontally and perpendicular to the coach body. With the coat folded it was also withdrawn horizontally but at an acute angle of about 30º to the coach as might have occurred had someone being dragged been unable to keep up with the moving train.

40 The values given in Table 2 are the arithmetical mean of each value found and in each case there were significant spreads in the forces required. The mean values are generally less than those found for the tram or the classes 317 and 365 previously tested by the RAIB. While the vehicles and test conditions were different, and a direct comparison cannot be made, they are representative of situations which could be encountered by persons with trapped clothing.

41 The LUL standard E6721 specifies an extraction force no more than 90N using specified canvas. There is no indication whether the material is to be pulled with a steadily increasing force or snatched sharply. The value of 90N was accepted as that arising when the door closing force was increased sufficiently to prevent *door judder*.

42 The results obtained generally comply with the specification, with the exception of the 'Hem only, sharp pull' and 'Gentle pull at an angle' sets. Given the difference in the interaction between the rubber door edges and different materials, more detailed testing would be required to understand whether the exceptions are significant.

The procedures for starting from a station stop

43 The procedures for starting a train from a station require the train operator to observe that the platform starting signal shows a 'proceed' aspect and to observe through the CCTV monitor on his desk that all passengers are clear of the train doors before he initiates the door closing sequence.

44 Once the doors closed visual indicator is illuminated, he is also required to check that no passengers have been caught in the train doors by their clothing or any bags they may be carrying.

45 The train operator is then required to ensure that the platform starting signal continues to exhibit a 'proceed' aspect before starting the train.

46 As the train leaves the platform, the train operator must continue to observe the CCTV monitor until it is extinguished when the rear of the train has left the platform.

Assessment of the train operator's competence and performance

47 The train operator had achieved full marks in his latest oral assessments in April 2005, March 2006 and March 2007. He satisfied all requirements in competence assessments in June 2005, July 2006 and June 2007. Similarly, in practical assessments he satisfied all requirements in December 2005 and November 2006.

48 No issues were raised in connection with his observation of the CCTV monitors and signals during the above assessments.

Management of the 'platform train interface' risk by LUL

49 Passengers becoming trapped in train doors and being dragged along the platform is an example of a '*platform train interface*' (PTI) risk. LUL have assessed the risk associated with the PTI by means of Quantified Risk Assessment (QRA). This assessment has concluded that the PTI generates 45.9 % of the total risk to passengers generated by the activities of LUL. However, only a small part of this overall PTI risk is associated with passengers becoming trapped in train doors

50 Given the significance of the overall PTI risk LUL have systems in place to review all incidents involving such incidents and have introduced a range of measures to mitigate the risk. Those relevant to trapping in doors on the Northern Line include;

- door chimes to warn of closure;
- 'keep clear of the doors' signage;
- in-cab CCTV;
- passenger emergency alarm (and brake activation); and
- operator training and associated materials.

Type of Train	Standard	Object specified in standard for removal	Specified force to extract	Results obtained in tests carried out as part of RAIB investigations	Notes
Tram	BS EN 14752:2005	Smooth bar 10mm x 50mm with longest edge vertical.	Not more than 150 N.	Withdrawal force in the range 58 –116 N with a mean of ~ 90 N.	
National network	Railway Group Standard GM/RT2473	Object less than 25 mm thick should be capable of being easily extract.	Not more than 150 N in accordance with EN14752	Group standard test on class 365 in the range 80 – 220 N with a mean of 164 N over 36 tests.	The RAIB recommended a review of the design Class 365 doors to reduce the force required to extract trapped objects. Ref: Huntingdon train door incident 15 February 2006, Report 11/2007, Recommendation 3
Tube	London Underground Standard LUL E6721.	Double thickness canvas to drawing 76340, to be pulled through the door edge seals at right angles to the door leaf.	90 N.	SP GP SA GA Hem only 128 87.6 Folded once 38.8 67.6 87 121 Seam snagged 62.6 78 All forces in Newtons. SP Sharp pull, perpendicular to the coach. GP Gentle pull perpendicular to the coach. SA Sharp pull at an angle towards being parallel with the coach. GA Gentle pull at an angle towards being parallel with the coach	RAIB tests on the tube train used samples of the coat involved in the accident. .

Table 2: Comparative specified and test data for the extraction of material trapped in power operated train doors

Analysis

Identification of the immediate cause

51 The immediate cause of the accident was the train operator moving the train away from Tooting Broadway station while a passenger's coat was trapped in a closed door.

Identification of causal and contributory factors

52 The on-train CCTV at Tooting Broadway was working satisfactorily. The incident was clearly recorded on the station monitoring CCTV.

53 Evidence indicates that the train operator was using the doors closed visual indicator to gain confirmation that the train doors were closed and that, in terms of door closure detection, it was safe to start the train.

54 Evidence also indicates that the train operator may have been concerned not to pass a signal at danger, as he had done rather over two years previously, and concentrated on ensuring that the signals ahead were displaying a proceed aspect. Trains leaving Tooting Broadway in a southbound direction encounter a curve so that the sighting of signals is less than that which can be achieved on a straight section of line. This may have influenced the train operator's behaviour.

55 Two causal factors in the accident were that the train operator was not observing the CCTV after he initiated the door closure and that he did not continue to monitor the CCTV as the train left the platform.

56 For a passenger to catch a coat tail in a closing tube train door, he or she has to leave the train when it is about to leave the station. The passenger left the train while the doors were closing and this is a causal factor in the accident.

57 The train operator's concern to observe the signals may have contributed to his not observing the CCTV monitor and therefore constitutes a possible contributory factor in relation to the accident.

Analysis of data

58 Her Majesty's Railway Inspectorate Annual Reports show that since 1990 there have been three deaths resulting from trapping on the entire LUL network. This gives an annual rate of fatalities of 0.167 for the years 1990 – 2007.

59 The RAIB has analysed incidents reported for the whole of LUL in the period 1997 – 2007 and categorised them by severity of the consequences and the nature of the item actually trapped as shown in Table 3.

Severity/ Item	Fatal	Major	Minor	None	Total
Body			9	9	18
Bag			4	7	11
Clothing	1		7	11	19
Other item			3		3
Insufficient data		1	9	5	15
Total	1	1	32	32	66

Table 3: Severity of consequences and item involved in reported incidents 1997 to 2007

60 The fatal incident occurred on 21 October 1997 at Holborn station on the Piccadilly Line when a child was dragged by the drawstring of his anorak trapped in the closed door by its toggle.

61 Using the data for the years 1997 – 2007, the risk to an individual of being trapped when joining or leaving an LUL train is equivalent to one incident in more than 158 million journeys. For a regular user[2] this equates to one incident in 317,321 years. The risk of an individual regular user being killed in a trapping incident is one in every 21 million years.

62 The risk of death or injury to an individual regular passenger through being trapped in the doors of an LUL train is well within the bounds defined in the HSE guidance on the tolerability of risk as 'broadly acceptable'[3]. However, in terms of the collective risk[4], and given the large number of persons exposed to the risk of being trapped, this is an issue that deserves attention given the current annual rate of *fatalities and weighted injuries* of 0.115.

63 An examination of data provided by LUL on instances of persons being trapped by closed doors shows that 21 instances were on the Northern Line and when normalised against the number of stations on each line over the period, the Northern Line experienced 0.038 per station per year against a mean of 0.022 for the entire network or 0.018 if the Northern Line is excluded. This data suggests that Northern Line has experienced a proportionately greater number of persons trapped by closed doors than is typical for other LUL lines. The same conclusion can also be drawn if the data is normalised against the number of passengers boarding and alighting on each line.

64 Of the total number of incidents on the LUL network, 62 % occurred either at stations which are particularly busy or which are in central London. The equivalent figure for the Northern Line is 55 %. The proportion of busy or central stations on the whole LUL network (30 % of the total) is less than that on the Northern Line which is 38.5 %. It is not possible to state whether the greater likelihood of a trapping incident at a busy/central station is due to the greater number of persons exposed or if crowding on platforms is an exacerbating factor.

65 The statistical significance of the data obtained has been assessed by the RAIB using an established technique, the *chi-square test*. This has been applied to the data on trapping incidents against the number of reported passenger journeys for each line. This has confirmed that the proportion of incidents on the Northern Line is unexpectedly high.

[2] For the purpose of this analysis, a regular user is defined as a person making 500 journeys per year.

[3] HSE's decision-making process is described in the publication 'Reducing Risks, Protecting People'.

[4] The average number of fatalities and weighted injuries per year that would be expected to occur from a hazardous event, measured as a frequency of a particular outcome (e.g. fatalities and weighted injuries per annum)

Conclusions

Immediate cause

66 The immediate cause of the accident was the train operator starting the train while an item of passenger's clothing was trapped in a bodyside door (paragraph 51).

Causal factors

67 The causal factors were:

a. the train operator did not observe that all passengers were clear of the train doors before starting the train at Tooting Broadway (paragraph 55);

b. the train operator exclusively observed the line ahead while the train departed from Tooting Broadway instead of also monitoring the station platform (paragraph 55); and

c. the passenger leaving the train very shortly before departure (paragraph 56).

Possible contributory factors

68 The following factor may have been contributory:

a. the train operator concentrated on avoiding passing a signal at danger to the exclusion of monitoring the conditions on the platform (paragraph 54).

Additional observation

69 The risk of a regular user being killed in a trapping incident is one in every 21 million years. This level of individual risk is well within the bounds defined in the HSE guidance on the tolerability of risk as 'broadly acceptable'. However, the Northern Line has experienced a proportionately greater number of persons trapped and dragged by closed doors than other LUL lines (paragraphs 63 to 65, Recommendation 1).

Actions reported as already taken or in progress relevant to this report

70 London Underground has issued a notice to train operators reminding them of the need to observe that persons are fully clear of trains before they start from station platforms and that they must continue to monitor the situation on the platform during departure until the train has fully left the platform.

Recommendations

71 The following safety recommendation is made[5]:

Recommendation to address an observation arising from the investigation

1. London Underground should investigate the reasons for the apparently greater proportion of instances of persons being trapped and dragged by closed doors on the Northern Line when compared with the average for other LUL lines and take any reasonably practicable steps that are identified to reduce the number of incidents. This investigation should include an analysis of the impact of the following factors:

   - passenger flow patterns/densities;
   - visibility of trains during dispatch;
   - the interface between train operators, in-cab CCTV and other in-cab equipment during train dispatch;
   - operating procedures; and
   - the performance characteristics of train doors.

   (paragraph 69)

The RAIB has made no recommendation about briefing train operators to observe that persons are clear of doors as trains start from platforms. This is because the LUL actions in paragraph 70 deal with all the areas that the RAIB would have covered in such a recommendation.

[5] Duty holders, identified in the recommendations, have a general and ongoing obligation to comply with health and safety legislation and need to take these recommendations into account in ensuring the safety of their employees and others.

Additionally, for the purposes of regulation 12(1) of the Railways (Accident Investigation and Reporting) Regulations 2005, these recommendations are addressed to HMRI to enable them to carry out their duties under regulation 12(2) to:

(a) ensure that recommendations are duly considered and where appropriate acted upon; and

(b) report back to RAIB details of any implementation measures, or the reasons why no implementation measures are being taken.

Copies of both the regulations and the accompanying guidance notes (paragraphs 167 to 171) can be found on RAIB's web site at www.raib.gov.uk

Appendices

Appendix A - Glossary of abbreviations and acronyms

CCTV	Closed Circuit Television
LUL	London Underground Limited
PEA	Passenger Emergency Alarm
PTI	Platform Train Interface
TDR	Train Data Recorder

Appendix B - Glossary of terms

’95 tube stock	The type of train used on the Northern Line of LUL built by the then GEC Alsthom Metro-Cammell and which entered service from June 1998.
Broadly acceptable	A level of individual risk generally regarded as insignificant and adequately controlled. It is the view of the HSE that risks that are *‘broadly acceptable’* do not usually require further action to reduce risk unless reasonably practicable measures are available.
Chi-square test	A test used to compare three or more proportions against each other to decide if they are statistically different developed by Karl Pearson (1857- 1936).
Door judder	Slight movement of power operated doors when a train is moving sufficient to cause the train’s monitoring equipment to detect them as being open.
Doors closed visual indicator	A light on the train operator’s desk which when illuminated indicates that the doors are detected as closed, also commonly known as the pilot light.
Fatalities and weighted injuries	The sum of fatalities and injuries valued in proportion to their severity such that a number injuries will be valued as the equivalent to one fatality.
Passenger emergency alarm	A handle in each vehicle to enable passengers to gain the attention of the train operator in an emergency.
Platform starting signal	A signal at the end of each platform controlled, usually automatically, by the signalling system.
Platform train interface	A term used by LUL to describe the risk associated with the interface between trains and passengers on platforms.
Service controller	The member of staff in charge of the operation of a line on LUL located in a central control office.
Train data recorder	The equipment on a train which records parameters such as speed, distance run and the positions of controls.

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