RAIB
Rail Accident Investigation Branch

Rail Accident Report

Runaway permanent way trolley at Notting Hill Gate
24 May 2006

Department for Transport

Report 12/2007
May 2007

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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Report on a runaway permanent way trolley at Notting Hill Gate, 24 May 2006

Contents

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 Metronet, Waterflow and Sportech to their staff, data and records in connection with the investigation.

4 Appendices at the rear of this report contain 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.

5 References to the Inner and Outer tracks of the Circle Line refer to the tracks used by trains travelling in an anti-clockwise and a clockwise direction respectively.

Summary of the report

Key facts about the incident

6 At 01:40 hrs on 24 May 2006, a manually propelled *track trolley* being used in connection with engineering works on the Circle Line of London Underground ran away down a gradient of 1 in 70 and collided with a stationary trolley of a similar type. A warning had been given and all staff were clear of the line. There were no injuries.

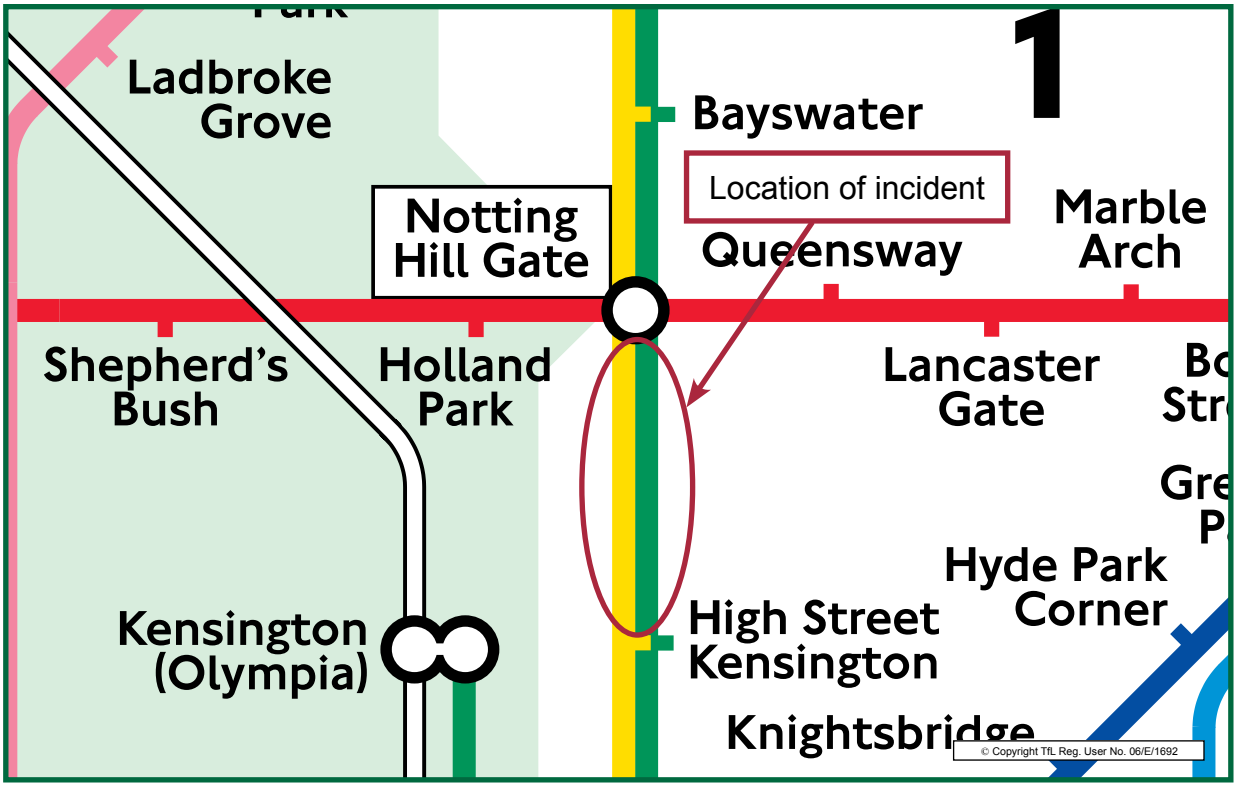

Figure 1: Extract from Transport for London map showing location of incident.

7 There has been detailed technical investigation by the RAIB into generic track trolley brake systems and their performance as a result of this incident. This issue has been considered in detail in a previous RAIB investigation into a trolley incident at Larkhall[1].

[1] RAIB report 20/2006 - Report on the runaway manually propelled trolley between Larkhall and Barncluith Tunnel: 2 November 2005

Immediate cause, causal and contributory factors, underlying causes

8 The immediate cause of the incident was that, once applied, the trolley brakes failed to stop it.

9 Causal factors were that:

- the prescribed pre-use check to detect brake faults and discard the defective trolley was not carried out;
- the brake system had been modified in a way that reduced its effectiveness.

10 In addition, the following factors were considered to be contributory:

- the construction of the brake mechanism made it easy to modify;
- the failure of a *roll-pin* provided an immediate incentive to modify the mechanism;
- the failure to adequately appreciate the risks arising from not carrying out the pre-use brake tests when operating trolleys on gradients; and
- *Track Trolley Operators* (TTOs) were not provided with appropriate gradient information.

11 The underlying cause was identified as:

- the widespread unauthorised modification of brakes allowed and encouraged by this design of trolley.

Recommendations

12 Recommendations can be found in paragraph 130. They relate to the following areas:

- the design, acceptance and maintenance of track trolleys;
- training of Track Trolley Operators (TTOs);
- management of sites where track trolleys are used;
- the reporting of incidents on the London Underground network.

The Incident

Summary of the incident

13 At 01:40 hrs on 24 May 2006, a manually propelled track trolley being used in connection with engineering works on the Circle Line of London Underground ran away. The trolley travelled 450 metres down a gradient of 1 in 70, reaching a speed between 5 mph (8 km/h) and 12 mph (20 km/h) and collided with a stationary trolley of a similar type at the site of planned work. The two trolleys travelled together a further distance of between 15 metres and 20 metres and came to a stand. A warning had been shouted and all staff were clear of the line. There were no injuries.

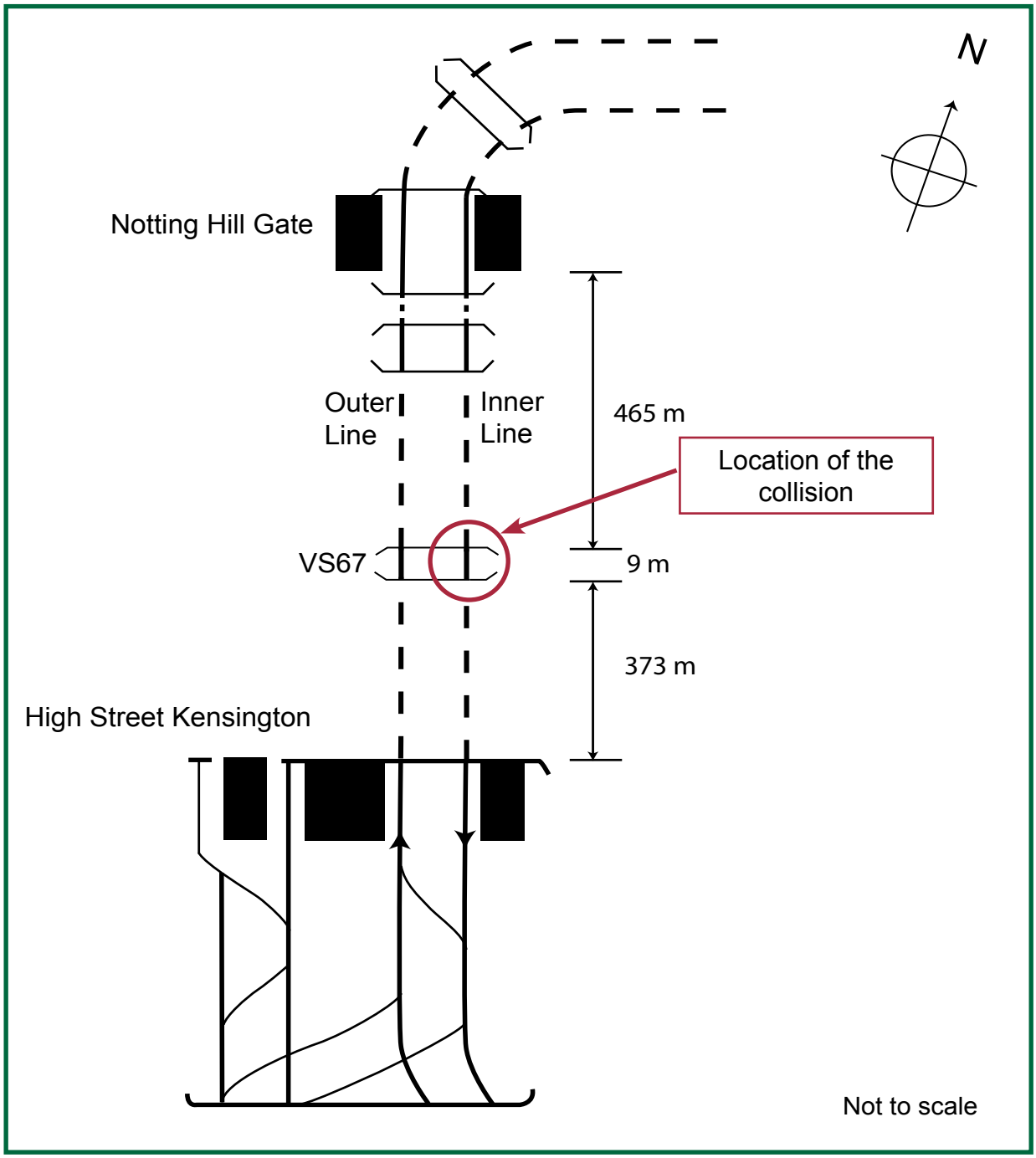

Figure 2: Diagram of the location.

The parties involved

14 London Underground Ltd (LUL) is the Infrastructure owner. The Underground network is operated by LUL. The infrastructure and rolling stock are managed and maintained under the Public Private Partnership (PPP) by two contractors (Infracos). The Infraco responsible for the Circle Line is Metronet. For drainage and permanent way works Metronet use a number of *term-contractors*; one of these is Waterflow. This contract operates within a section of Metronet called the Metronet Alliance.

15 To operate their contract with Metronet, Waterflow directly employs technical, supervisory and safety staff. Site operatives are provided to Waterflow by other labour suppliers; in this instance Sportech were the supplier.

16 Rotamag are a permanent way equipment manufacturer. They had manufactured the trolley involved in this incident.

17 The other Infraco, Tube Lines, has a division, Transplant, based at Lillie Bridge Depot, west London, which maintains a register of power tools and lifting equipment used on the London Underground network. In this instance Transplant was also the maintainer contracted by Waterflow to maintain its trolleys.

Location

18 The incident took place on the inner track of the Circle Line between Notting Hill Gate and High Street Kensington. Figure 2 shows the location.

19 The Circle Line is a *sub-surface route* of the London Underground network. Traction power is supplied via a *conductor rail* system. The line is double track and at this location it consists of *bullhead* rail carried in *chairs* on timber *sleepers* with limestone *ballast*. The underground sections of the line include *ventilation shafts* (VS) open to the surface. The location where the work was to be carried out was adjacent to VS67.

20 The opening at VS 67 is 9 metres long. It begins 465 metres from the platform at Notting Hill Gate and ends 373 metres before the platform at High Street Kensington.

21 The gradient, in the normal direction of trains on the inner track, falls at 1 in 70 from a point 11.9 metres after the platform end at Notting Hill Gate to a point 4.2 metres before the platform at High Street Kensington. The platform at Notting Hill Gate is level. The platform at High Street Kensington is on a falling gradient of 1 in 250.

Background

22 The dynamic loading of sleepers generated by the passage of trains degrades the track ballast and reduces the effectiveness of the drainage system. *Wet beds* can then develop leading to loss of track support and variations in track geometry, which is undesirable and causes a rough ride for passengers. When this becomes unacceptable it is necessary to excavate under the sleepers, remove the old ballast and replace it with new clean ballast. In the sub-surface sections this activity is carried out manually over a small number of sleepers, usually with the aid of small power tools. This is a repetitive activity, takes place frequently, and was the task that the work gang involved in this incident were preparing to undertake.

23 Following any work which affects the support and stability of the track a nominated responsible person, a Handback Engineer, licensed to *T002* level, is required by LUL operational procedures to assess and confirm that the track is fit for the resumption of service traffic. This role is assessed and certificated under LUL procedures. Although not part of the certificated role, this person will often also supervise the work to ensure the requisite quality is achieved.

24 The activities included in the Waterflow contract are carried out in accordance with the contract Health, Safety & Environmental Plan, dated January 2005. This plan includes a statement on the scope of works covered, in this case a range of drainage works and 'Wet Bed Regeneration'. A site-specific method statement, reference MS/LUL 1241, compiled by Waterflow, further detailed the wet bed rectification works planned to take place between Notting Hill Gate and High Street Kensington in May 2006.

External circumstances

25 The weather on the night of the 23 May was dry and clear. The railhead was dry, but as with much of the underground network there was some grease on and around the railhead.

Rail equipment

Trolleys

26 The trolley involved was a Rotamag split trolley (manufacturers number UD524-13). This type of trolley has been in service with LUL and the main line network for many years. A Rotamag split trolley is shown in Figure 3.

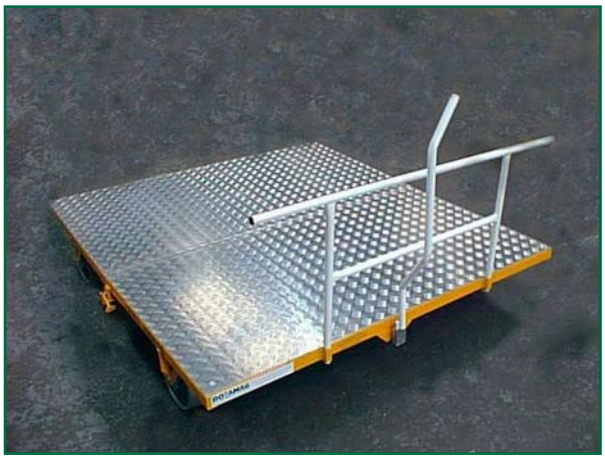

Figure 3: A Rotamag split trolley.

27 This trolley was manufactured in 2000 and delivered to Transplant on 18 January 2001, becoming asset number TTXC01305. On the 19 January 2001, ownership passed from Transplant to Waterflow.

28 Trolleys of this type consist of two half-trolleys, which are joined together to form a four-wheeled, flat-decked load platform. The trolley has a Safe Working Load of 2000 kg and this is stipulated on a plate fixed to each half of the trolley.

29 One wheel on each half of the trolley is directly braked via a spring-applied shoe. The brake is released when the TTO depresses a handle at the end of the trolley, rotating a longitudinal shaft and pulling the brake release cables via a brake release arm describing an arc around the longitudinal shaft. An underside view of the incident trolley is shown in Figure 4.

Figure 4: An underside view of the incident trolley.

30 The release cables are adjusted during maintenance to ensure that the handle movement required to release the brakes is not excessive. The adjustment is made via a slack adjuster within each release cable.

31 Each slack adjuster consists of a turnbuckle, the rotation of which will loosen or tighten the cable dependent upon the direction of rotation. When the correct degree of slack is achieved in the cable, the turnbuckle is locked in position using a 6 mm threaded nut. A slack adjuster is shown at Figure 5.

Figure 5: A Rotamag slack adjuster.

32 The two half-trolley brake shafts are automatically linked when the halves are joined, such that the handle releases the brakes on both halves simultaneously. This allows the handle to be used at, and the brake to be released from, either end of the assembled trolley.

33 A separate tubular push-bar frame is inserted into sockets at the trailing end of the trolley for operators to manually propel the trolley.

34 In order to propel the trolley, the operator is required to depress the brake release handle laterally, against the combined force of the two brake application springs, while pushing the trolley along the track using the push-bar frame.

35 The London Underground Ltd Reference Manual, section Qb004 'Track Trolleys', is the governing standard for track trolleys used on the Underground network. Trolleys must be registered on the *Plant Maintenance Management System* (PMMS) database managed by Transplant and are subject to a requirement for cyclic inspection and maintenance. Currently this cycle is six-monthly.

36 Waterflow contracted Transplant to carry out the inspection and maintenance work on their trolleys.

37 The inspection and maintenance of the type of trolley involved in this incident is carried out to *Plant Standard Work Instruction* (PSWI) 433 'STATUTORY EXAMINATION OF TRACK TROLLEY (PERMAQUIP TYPE A & B) + (ROTAMAG SPLIT TROLLEYS)'; revision 4 is dated 25/09/99. This stipulates the wear limits on brake shoe friction materials and the minimum rotational resistance of braked wheels, which is measured before trolleys are recertified for service use.

38 Whilst records are made of work done, components replaced, dimensions taken and test results achieved, no record is made of the condition of trolleys arriving for planned maintenance.

39 Service records for trolley TTXC01305 at Lillie Bridge Depot are given in Figure 6.

Date	Action	Repairs done	Defects remaining	Further attention needed	Interval months
19/01/2001	Transfer to Waterflow				
22/01/2001	6 Monthly Statutory Examination	None	None	None	
11/02/2002	6 Monthly Statutory Examination	2 Brake Blocks + 1 Wheel replaced	None	None	13
07/10/2002	6 Monthly Statutory Examination	2 Brake Blocks replaced	None	None	8
22/09/2003	6 Monthly Statutory Examination	None	None	None	11
11/12/2003	6 Monthly Statutory Examination	None	None	None	3
12/01/2005	6 Monthly Statutory Examination	None	None	None	13
26/09/2005	6 Monthly Statutory Examination	None	None	None	8
02/05/2006	6 Monthly Statutory Examination	None	None	None	8

Figure 6: Service records for trolley TTCX01305.

Track trolley operators

40 On the London Underground network, TTOs are required to be certificated. Certification involves training and assessment and is valid for 2 years. The training requirements are described in LUL HR Training Standard G9333 v A7 (02 June 2004).

41 The training includes pre-use checking of track trolleys, including physical tests to demonstrate a minimum level of brake effectiveness, positioning, loading and use of trolleys, and their safe storage. Candidate understanding is assessed by written and practical assessments.

42 Following a previous trolley runaway incident investigated by the RAIB the *M&E Engineers Networking Group* conducted further tests and produced a Code of Practice (COP 18). In this COP the risks associated with the operation of trolleys on gradients were recognised and, as an initial response, a reduction in the working load capacity of trolleys of 50 per cent was mandated. LUL and the Infracos operating on the LUL network are not officially represented on this group. However, they were in receipt of the COP and, in response, had reduced the working capacity of manual track trolleys to 50 per cent of their original rated capacity. This was achieved initially by the issue of a 'HEALTH, SAFETY & ENVIRONMENTAL ALERT' on the 20 January 2006, which restricted the load to half of that designated on the trolley. Subsequently trolleys used on the LUL network were re-plated, with a load rating of half of the original value.

43 The Waterflow staff on site on 24 May had received a briefing regarding the reduction in load capacity. They were aware that the reasons for this action were connected with trolley braking performance and gradients.

Events preceding the incident

44 The Handback Engineer (T002) received confirmation and details of the work to be carried out on the night of 23/24 May during the afternoon of 23 May. This contained the site and work specific information and constituted page 4 of the site-specific method statement MS/LUL 1241. Neither the work specific information nor the site-specific method statement contained reference to trolley working arrangements or gradients existing at or around the worksite.

45 In accordance with the plan of work, the staff allocated for this shift met at Notting Hill Gate station at approximately 00:45 hrs on 24 May 2006. The T002, the Protection Master Engineering Hours (PMEH) and the Site Person In Charge (SPIC) for this worksite plus another PMEH and SPIC were Waterflow employees. The two TTOs (TTO1 and TTO2) and 19 operatives were provided by Sportech. A Waterflow operated road vehicle delivered the tools and lights, manual track trolleys and 25 kg bags of new track ballast. This was a repeat of the previous night's work activities.

46 After the last service train had left, the SPIC allocated to the work site and the T002 conferred on the format and content of the work and then briefed the staff, while on the platform at Notting Hill Gate. The SPIC covered issues of health and safety including general Personal Protective Equipment (PPE) and the T002 briefed on the work activities and specific arrangements. No reference was made to trolley working or gradients. The men on site signed for the briefing. Neither the T002 nor the SPIC checked the TTO's certification, accepting that their knowledge of the individuals concerned and previous certificate checks were adequate. There was no explanation of actions to be taken in the event of an incident.

47 The tools and lights, two of the track trolleys and 1000 kg of the ballast (40 of the 25 kg bags) were carried down to the inner line platform. The PMEH carried out a briefing in which he defined the railway protection limits and the emergency evacuation procedures. Shortly afterwards the PMEH confirmed that the traction power was switched off.

48 At 01:25 hrs the first trolley was placed on the inner line adjacent to the platform. In accordance with his responsibilities specified in the *Shared Working Manual* section Qb004, TTO1 carried out a pre-use trolley check. The trolley was then loaded with the tools, generator and lights.

49 The T002, PMEH, SPIC and a Sportech ganger walked to the site of work, 490 metres down the gradient towards High Street Kensington, before the rest of the staff, to assess and mark out the work for the shift. They were accompanied by a Metronet Alliance Manager and a Waterflow Project Manager who were planning to inspect a cable route on the outer line, but whose PMEH had not yet arrived at the station.

50 A few minutes after their arrival at the site, the first track trolley, under the control of TTO1, arrived loaded with its tools and lights. Approximately twelve of the operatives also walked to site with the trolley. The T002 took the worksite sign and prepared to walk back towards Notting Hill Gate to position the sign 30 metres on the approach to the site. This sign indicates the location of the worksite to anyone approaching along the track.

Events during the incident

51 After the first trolley had left for the worksite, the second track trolley was placed on the inner line at Notting Hill Gate platform. No pre-use checks were carried out. It was claimed that the TTO2 had asked, and had been told, that it was one of the two trolleys used at this site on the previous night. He was informed that there had been no problems with the trolley then and it had remained stored on the road vehicle since. No push-bar was fitted to the trolley.

52 This trolley was loaded with 40 bags of ballast, weighing in total 1000 kg.

53 TTO2 and two operatives began to move the trolley towards the site of work. TTO2 did not push the trolley but started walking with the operative who was pushing. The trolley and the operative moved faster than TTO2 and soon were some distance ahead. TTO2 called to the operative to stop. The operative replied that he had released the brake handle, but that the trolley was not slowing down.

54 The operative attempted to retard the trolley by pulling back on the brake handle, but was unable to slow it down. After some distance, the operative was no longer able to keep up with the trolley so he released his hold and let the trolley run away. Estimates from witnesses suggest that this point was between 50 metres and 100 metres from the site of work.

55 As he approached the site of work and before releasing his grip on the brake handle he began to shout a warning to those ahead. The shouting was heard by the T002 and others. The T002 rapidly understood the situation and instructed all to stand clear. He also shouted a warning to another gang who were working on the same track further along, and who had accessed the track from High Street Kensington station.

56 The second trolley arrived at the site of work and crashed into the first stationary trolley. The two units together then travelled a further distance, variously estimated at between 5 metres and 50 metres, before being stopped by the action of the brakes on the first trolley.

57 The Metronet Alliance Manager and Waterflow Project Manager had commenced their inspection and were standing by the cess rail of the outer track. They heard the warning and observed the trolley approach and collide with the stationary trolley.

Consequences of the incident

58 No one was injured. Neither trolley derailed or suffered damage.

Events following the incident

59 As a simple test of the effectiveness of the brake, the T002 attempted to push the ballast carrying trolley and discovered that it could be moved with the brake handle in the released position, ie with the brakes applied. The trolleys were then pushed back to the site of work and a brief discussion took place, which involved T002, the Metronet Alliance Manager and the Waterflow Project Manager, who had arrived on site in connection with the adjacent inspection works. They decided that the first action was to unload the bagged ballast from the second trolley and remove the trolley from site. This was done and the apparently defective trolley was placed on the road vehicle. A replacement trolley was taken from the road vehicle and placed on the inner line at Notting Hill Gate. A pre-use brake check was successfully carried out and the trolley was pushed to the site of work.

60 At approximately 01:50 hrs, while at Notting Hill Gate station platform, T002 called the Waterflow Night Rail Manager by telephone and informed him of the incident. The Night Rail Manager was in the locality and went to Notting Hill Gate station. Together the Night Rail Manager and T002 walked to the site of work. By the time they arrived, the gang had started to excavate ballast and clear some wet beds. T002 and Waterflow Night Rail Manager decided that as the work had reached an advanced stage it would be appropriate to continue for the remainder of the shift. They also agreed to submit an incident report upon completion of the shift.

61 At 04.10 hrs, T002 called the Metronet Ballasted Track Division Works Controller as mandated, to report the satisfactory completion of the night's work. In this call he also related the details of the incident. The Metronet works controller was satisfied that based upon the information he had received, the proposal by the T002 to submit a Contractors Incident Report Form (CIRF) and carry out an investigation in accordance with Waterflow safety procedures was an acceptable course of action.

62 At the completion of work all material and equipment was removed from site, transported to Notting Hill Gate station and placed on the road vehicle. The road vehicle left for its normal daytime stabling point at Ockendon.

63 At 05:55 hrs, the Waterflow Night Rail Manager called the Waterflow Contract Manager Rail to inform him of the incident. The Contract Manager Rail subsequently informed the General Manager (Rail) at 06:30 hrs.

64 The T002 left and site and travelled home. He completed a Waterflow incident report form electronically and at 07:00 hrs, he called the Waterflow General Manager (Rail) to explain the events of the night.

65 At 09:00 hrs, the Metronet Delivery Manager was informed of the incident by the Waterflow General Manager (Rail) and a CIRF e-mailed by the Waterflow Safety Manager.

66 Arrangements were made by the Waterflow General Manager (Rail) to collect the trolley from the road vehicle, which was now at Ockendon, and return it to the main Waterflow depot at Colnbrook.

67 Metronet and Waterflow each submitted CIRFs to Metronet Safety and Assurance in accordance with their understanding of the LUL contractors safety requirements. These reports did not arrive at Safety and Assurance until the morning of 25 May. At that point the significance of the event was recognised by Safety and Assurance and both London Underground Ltd and the RAIB were informed.

68 Waterflow initiated an internal investigation in accordance with their safety management procedures. An initial fact finding meeting was convened by the Waterflow General Manager (Rail) on 26 May 2006 and during this there was a visual inspection of the trolley.

69 As a result of the significance of the incident being identified; Metronet initiated an internal investigation.

The Investigation

Investigation process

70 The incident was not reported to the RAIB until more than 24 hours after it occurred.

71 There has been no detailed technical investigation by the RAIB as a result of this incident into generic track trolley brake systems and their performance. This issue has been considered in detail in a previous RAIB investigation into a trolley incident at Larkhall and is not considered causal or contributory to this incident. The brakes on the trolley involved in the Larkhall incident were heavily contaminated with grease and water and the trolley was heavily laden. In this incident at Notting Hill Gate there was little surface contamination and no water and therefore the issues relating to brake friction material performance are considered to be of little relevance (paragraph 93 refers). The major issue at Notting Hill Gate was the incorrect adjustment of the braking mechanism.

Sources of evidence

72 Evidence gathered included:

- Examination and tests of trolley TTXC01305.
- The history of the trolley and the maintenance records.
- Witness statements.
- LUL documentation including:
  - the LUL Reference Manual;
  - TSW 009 – 'Taking responsibility about the track' a LUL 'Safety on the track handbook';
  - HR Training Standard G9333 v A7 – 'Track Trolley Operator';
  - HR Training Standard G9272 v A3 – 'Site Person in Charge – Safety on the Track (Engineering Hours)';
  - TTO trainers notes and presentation material.
- Tubelines trolley maintenance procedure PSWI 133.
- Rotamag (trolley manufacturers) post incident discussions.
- The Waterflow H&S Plan for package SMN 01005 and Waterflow Method Statement MS/LUL 1241.
- Metronet internal investigation report.
- Network Rail M&EE Networking Group COP 18.

Key evidence

73 The inspection and testing of the trolley identified significant deficiencies in braking performance. With the brake handle removed and the brake in the fully 'on' position, the resistance of the braked wheels to rotation was negligible. It was possible to rotate each wheel easily by hand.

74 This was a result of two factors: there was a light coating of grease on both of the brake shoes' friction material, and the brake mechanism slack adjusters were tight and pulling the brake release cable, to the point of lifting the shoes away from the wheel tread against the force of the applying spring. The locknuts at each end of both slack adjusters were not tight and three of the four were standing off from their locking contact face by 1 mm or more.

75 One brake release arm had become disconnected from the longitudinal shaft, because of the loss of the roll-pin, which passes through the boss of the arm the shaft. There was a distinct bruise and fresh yellow paint residue on the arm boss, which matched that on the frames of the trolleys. Figure 7 shows the detail of the release arm boss. There was light corrosion to the bore of the drilled hole in both the arm boss and longitudinal shaft.

76 Because of the loss of connection between the longitudinal shaft and the arm boss, the operation of the brake handle no longer rotated the arm to pull the cable and release the brake on the associated wheel.

Figure 7: Detail of the release arm boss.

77 The lock nuts on the brake application springs were both undone. However, there was no reduction in the application spring pressure as a result. Details of the spring seat and its mounting bracket are shown in Figure 8.

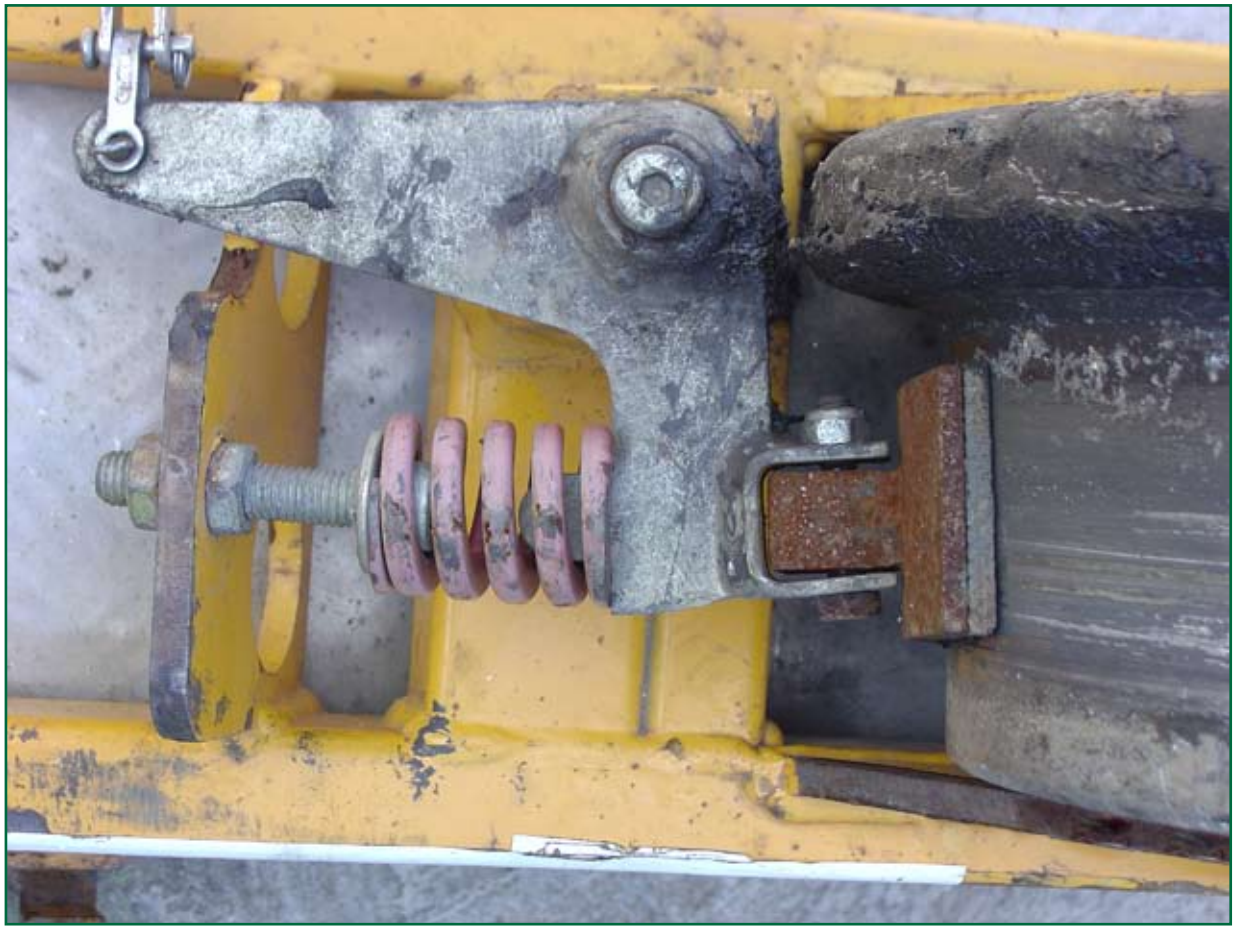

Figure 8: Detail of the application spring seat and mounting.

78 A review was conducted into the procedures, practice and competence of those involved in the maintenance of this type of plant. The training, assessment, monitoring and supervision process was found to be robust and appropriate for the equipment involved.

79 The records (Figure 6) show that the trolley had replacement brake shoes fitted in February 2002 and again in October 2002. Records show that it is not unusual for trolleys to have an irregular maintenance history. The frequency of use, loading and storage conditions can vary significantly. Trolleys may see little or extensive use in each six month inter-maintenance period. However,

- the trolley had only been returned to service following its normal cyclic maintenance 3 weeks prior to the incident;
- the interval between inspections had exceeded the 6 month specified interval in all but one instance.

80 Witness evidence suggests that approximately 10 per cent of this make and type of trolley are returned for inspection and maintenance with brake mechanisms that have been the subject of unauthorised modifications. These modifications include the adjustment of turnbuckles to reduce brake shoe application force and reduce brake release movement. Other modifications have included ad-hoc methods of retaining the brake handle in the released position using wire or rope.

Previous occurrences of a similar character

Larkhall

81 On 2 November 2005, a trolley ran away down a gradient on the Network Rail Larkhall branch in southwest Scotland. Deficiencies were identified in the performance of the braking system on the trolley and also the operational arrangements at the site. Dynamic tests were carried out on similar trolleys and an Urgent Safety Advice was issued by the RAIB. The railway industry also carried out tests, and as a direct result the Network Rail M&EE Networking Group issued a Code of Practice (COP 18) to address a number of the failings that had been identified. A key change was the reduction in Safe Working Load on these trolleys to 50 per cent of the previously rated load. This provides a greater factor of safety against loss of brake performance.z

82 The brake friction material used on trolley brakes was found to be inappropriate and easily contaminated by lubricants carried over from the rail surface. When water was also present, the performance of the material as a dynamic brake was found to deteriorate significantly. The report recommended investigation of improved brake friction material and changes to the Group Standard specification for brake performance testing.

83 These details of these issues are not repeated in this report. Reference should be made to the Larkhall report RAIB 20/2006 published on 2 November 2006 for further information.

84 Most of the issues found during the investigation into the incident at Larkhall are not relevant to this incident. Those factors which have relevance are:

- the absence of gradient information in the method statement;
- no consideration of the risks associated with the use of trolleys on gradients in the method statement;
- briefings to staff did not include reference to the risks of operating trolleys on gradients;
- the fitness for purpose of site pre-use checks;
- the brake friction material;
- contamination of brake friction material.

Whiteball

85 In 2003 at Network Rail's Whiteball Tunnel, near Taunton, a loaded Permaquip Type B trolley was being used within a worksite under a *T3 possession*. The trolley ran away for approximately 770 yards on a 1 in 127 falling gradient. This incident predated the RAIB's existence and was investigated by Network Rail. The cause of this incident was identified as wear to the brake linings, which resulted in the brake failing to secure the loaded trolley. The trolley had been passed fit for operational use only two days prior to the incident. The trolley's brake material was likely to have been cotton weave as this material was widely used at that time. Whilst there was an absence of any form of competency training or assessment for the safe operation of Permaquip trolleys or training to operate the trolleys, there was no operator error evident to the Network Rail investigators.

86 The conclusions of the Network Rail investigation into the Whiteball Tunnel incident were:

- The absence of competency training or assessment for the safe operation of trolleys.
- The method statement did not make reference to risks of falling gradients.
- The subcontractor was not supplied with any information about gradients within possession limits.
- A lack of knowledge about effects of water and contamination on the brake lining material.
- A lack of information within the manufacturer's manual on:
  - how to test brakes;
  - reduced efficiency of brakes in wet conditions;
  - limits of wear.
- The absence of reference to use of trolleys within section T3 of the Rule Book.

87 Relevant recommendations and actions from the Whiteball investigation are:

- 'Network Rail to ensure that all site method statements address the risks imposed by gradients within the vicinity of the worksite and if plant was to be used or intended for use';
- 'Network Rail to review competency, assessment and training of staff operating rail mounted equipment'.

88 Network Rail's investigation was focussed on the particular incident, and the recommendations were addressed to the parties involved. There was no consideration of application to the rest of their system, nor to other systems such as LUL.

Analysis

Identification of the immediate cause

89 Witness evidence at the time the trolley was released confirms that the brake handle was in the upright, fully released, position and that the trolley did not slow down. The brake was therefore ineffective and failed to control the speed of the trolley. The ineffective brake was the immediate cause of the incident.

Identification of causal and contributory factors

90 The pre-use checks prescribed for TTOs were not carried out on the second, runaway trolley.

91 After the incident T002, who had been previously certificated as a TTO, was able to identify, by using the push-test as prescribed in the TTO training, that the brakes on the trolleys were ineffective.

92 Had the pre-use checks been carried out as specified and the relevant procedure been followed for defective equipment, the trolley would not have been used during that shift and the incident would not have occurred. The fact that the pre-use check was not carried out and the track trolley not discarded as a result was therefore a causal factor.

93 During the distance that the trolley ran with the brake handle released (between 200 and 300 metres), there may have been some reduction in the braking effort applied to the wheels by the brake shoes as a result of loss of friction surface and contamination and polishing of the friction material.

94 This is unlikely to have been significant, as upon subsequent inspection the friction material was not found to be heavily contaminated with grease or significantly polished. The trolley had only been in service for three weeks following its previous maintenance and is designed to operate satisfactorily under normal service conditions for at least six months, until the next maintenance. Friction material surface contamination has therefore been discounted as a factor in this incident.

95 The post incident inspection revealed a number of mechanical issues on the trolley.

96 There was visible corrosion to the roll-pin hole. This suggests that the pin had been missing for some time. If the pin had been missing at the time of maintenance three weeks earlier, it would not have been possible to adjust the brake mechanism correctly. The bruise mark to the arm, and fresh yellow paint residue, indicates that there had been an impact of some magnitude with another trolley section, probably during stowage on or unloading of the trolley from the road vehicle.

97 The slack adjusters are of simple but robust construction. It is highly improbable that four lock nuts, two on each slack adjuster, could all have become loose in the three weeks since the previous maintenance and in the case of three of the four move away from the adjuster fitting. It cannot be conclusively established if the condition of the trolley resulted from deficiencies in the preceding maintenance or as a result of some subsequent occurrence. However, the balance of evidence suggests that the adjusters had been modified after the return from maintenance and before the night of the incident. It is therefore concluded that the unauthorised modification of the brakes is a causal factor. The missing roll-pin was the likely motive for this modification and is therefore a contributory factor.

98 The slack adjusters are easily accessible. Only basic tools would be required to release the lock nuts and tighten the adjuster. The fact that it is relatively easy to modify the brakes so easily is a contributory factor.

99 There was no consideration of the risks associated with trolley working on gradients. This is a contributory factor.

100 TTOs are not provided with information on gradients at sites of work. This is a contributory factor.

Identification of underlying causes

101 There are two possible explanations for the unauthorised modification:

- In the case of this particular trolley, if the damage and subsequent loss of the roll pin had gone undetected on a previous occasion until after the trolley was placed on the line and loaded, then the brakes, because of their fail-safe design, would not have been released by normal use of the release handle. A person with a basic understanding of the mechanism might realise that tightening the slack adjusters to the point of releasing the brakes would allow the trolley to be used, albeit with little or no braking available, as an alternative to unloading it and obtaining a replacement;
- The RAIB obtained evidence from the maintainers that this type of trolley is often found with modified brakes. The design of the trolley requires the TTO to move the brake release handle sideways and downwards, against the brake application spring force, whilst pushing the trolley forward using the push-bar. This two directional operation is neither ergonomically logical or physically convenient. There is evidence that on many occasions, as in this incident, the push-bar was not fitted thus exacerbating the ergonomic difficulties. By tightening the slack adjusters to the point of brake release, the physical force and degree of movement required to move the brake handle is reduced, thus providing a motive to modify the brakes.

102 The relatively widespread unauthorised modification of brakes allowed and encouraged by this design of trolley is concluded to be the underlying cause of the runaway trolley.

Severity of consequences

103 Calculations based on witness evidence suggest that the trolley was travelling at a maximum speed of 12 mph (20 km/h) at the point of collision with the stationary trolley. The two trolleys then travelled a distance of between 15 metres and 20 metres.

104 It is fortunate that those at the site of work heard the warning and the approaching trolley. As a result all staff were able to stand clear before the instant of impact.

105 The first (stationary) trolley brakes quickly arrested the motion of the two trolleys' combined masses. It can be concluded that the brakes on this trolley were working effectively and had not been modified.

Other factors for consideration

Incident reporting

106 There were two independent site activities taking place at VS67 at the time of the incident. Each was under the technical control of a separate supervisor, although protection systems were being shared. The Metronet Alliance Manager and Waterflow Project Manager were not part of the wet bed team.

107 After the incident occurred there was a lack of clarity amongst those on site as to whether the incident was reportable and if it was, then who was responsible for reporting it and the timescales for this to be carried out.

108 As there had been no significant consequences as a result of the event, there was some reluctance amongst the staff on site to report the event at all.

109 The Metronet Alliance Manager was considered, by the rest of the staff on site, to be the most senior person. He was the client's representative. The remaining site personnel considered that he would take the lead in any post-incident action. Although he was party to the immediate discussion and observed the actions taken he had no official role in the management or safety management of the wet bed works. Although no discussion took place between him and the others on site regarding any subsequent actions or reporting he did subsequently submit a CIRF regarding the event.

110 Only the T002 seemed to appreciate the seriousness of the event and through his Night Rail Manager considered that he had complied with the Waterflow incident escalation procedure. He was advised to report it to the Metronet Ballasted Track Division Works Controller at conclusion of the shift and submit a CIRF at the earliest opportunity. He did this when he arrived home at 07:00 hrs on the morning of the 24 May. As there were no physical injuries or significant damage, he believed that Waterflow had 24 hours to report the incident to Metronet.

111 Although a role defined and managed within LUL, the SPIC did not consider that he had any responsibilities in regard to the reporting of incidents to LUL. He believed that the appropriate course of action was through the Waterflow incident reporting and escalation procedure and as he had understood that the T002 would manage this he took no further action.

112 The contract safety conditions applicable to the Waterflow works only required a written report to the Metronet employer's representative within 24 hours. No requirements had been placed on Waterflow in respect of real-time incident reporting arrangements or any guidance given in respect of the severity of incidents which were to be reported. The Metronet Ballasted Track Division Works Controller failed to grasp the seriousness of the event and did not progress an incident report. In his works report he indicated that there had been no accidents.

113 It was the morning of the 25 May before the completed CIRFs from the Metronet Alliance manager and Waterflow reached the Metronet Health Safety and Environment Advisor. The implications were immediately appreciated by them and the relevant reports made to LUL control and the RAIB.

114 The key conclusions related to the reporting of the incident are:

- Although he was the person on site with responsibility for safety, the SPIC was not aware of his responsibilities for reporting to Metronet Engineering Control Centre (ECC) or LUL Network Operations Control (NOC) in the event of an incident.

- The training he had received did not adequately cover the actions to be taken or any guidance as to the severity of event to be reported; Metronet procedure MR-Pr-10015 (Incident and RIDDOR reporting) had not been communicated to Metronet's contractors and their employees.
- Waterflow have an incident reporting and escalation procedure. This was not followed correctly. The 'lead' SPIC named in their procedure, in this incident the T002, should have reported to the Waterflow Health & Safety Manager and the station supervisor. This omission is not considered to have had any detrimental effect on the reporting of the incident or the timescales, because the Health & Safety Manager would have referred the incident to the Waterflow Night Rail Manager who was on site and was instrumental in the course of action followed.
- The contracted arrangements between Metronet and Waterflow specified procedural arrangements and mandatory reporting of incidents, which did not allow Metronet and LUL to comply with their legal reporting obligations including those required under RIDDOR and RAIR regulations;
- Insufficient guidance and instruction had been provided by Metronet to their Ballasted Track Division Works Controller to allow him to assess the significance of any incident reports and take the appropriate action.

Conclusions

Immediate cause

115 The immediate cause of the incident was that, once applied, the trolley brakes failed to stop it.

Causal and contributory factors

116 Causal factors were:

- the prescribed pre-use check to detect brake faults and discard the defective trolley was not carried out (Recommendation 1);
- the brake system had been modified in a way that reduced its effectiveness (Recommendation 1).

117 In addition, the following factors were considered to be contributory:

- the design of the brake mechanism made it easy to modify (Recommendations 2 and 3);
- the failure of the roll-pin provided an immediate incentive to modify the mechanism (Recommendation 2);
- the failure to adequately appreciate the risks arising from not carrying out the pre-use brake tests when operating trolleys on gradients (Recommendations 2 and 3);
- TTOs were not provided with appropriate gradient information (Recommendation 5);

Underlying causes

118 The underlying cause was identified as:

- the widespread unauthorised modification of brakes allowed and encouraged by this design of trolley (Recommendation 4).

Additional observations

119 The LUL network actively uses rail lubrication as a preventative measure for *sidewear* and a proportion of this grease finds its way onto the railhead from where it can transfer to trolley wheel tread surfaces and brake shoes.

120 While not identified as causal or contributory to this incident there was some grease contamination on the friction material surface of the brake shoes. Grease contamination on wheels and friction material surfaces reduces the effectiveness of brakes as detailed in the RAIB report on the Larkhall runaway.

121 Additionally, as detailed in the RAIB Larkhall report, the friction material used on these trolleys is not recognised as being suitable for this application.

122 SPICs are not clearly briefed or aware of their responsibilities, criteria and the correct mechanism for reporting incidents through to the Infraco and LUL. Metronet and LUL systems for incident reporting are not aligned (Recommendation 7 and 8).

123 The content of the TTO training standard is clear and the training material used during the training and assessment of TTOs is sufficient to meet the needs of the standard. However, TTOs are not given reference material in a format which is appropriate for retention and use as a reference on site (Recommendation 6).

124 The pre-use checks currently prescribed for TTOs are not a quantifiable measure of brake effectiveness. They are a pass/fail measure, which relies upon a subjective assessment of likely brake performance as the result of a test of pushing against the braked trolley.

125 The significance and seriousness of the incident appears to not have been appreciated by those on site or those to whom it was initially reported. Their considerations seem to have been based upon the actual consequences, which were fortunately minor, rather than the potential consequences, which were very significant.

126 LUL are not part of the Network Rail M&EE Networking Group. This forum has considered issues relating to the use of trolleys on the main line network. LUL received a copy of the M&EE Networking Group COP18 informally and acted independently upon the information contained in it (Recommendation 9).

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

127 Waterflow have instigated a site management procedure, which requires the TTO to confirm by signature to the SPIC that the relevant pre-use checks have been satisfactorily completed.

128 Rotamag have initiated a design review of these trolleys, with an objective of reducing the physical force necessary to release the brakes, while maintaining the existing brake application force.

129 Rotamag are considering a number of options for improving the 'anti-modification' measures on this design of trolley.

Recommendations

130 The following safety recommendations are made[2]:

Recommendations to address causal and contributory factors

1 London Underground Ltd should amend site management procedures to record the satisfactory completion of pre-use brake checks. This should consider pre-delivery and on-site physical inspections recognising that the current tests are only partially effective (paragraphs 116 and 124).

2 London Underground Ltd should ensure that standards which relate to trolley design and acceptance require assessment and mitigation of risks associated with unauthorised modification of brake systems (paragraph 117).

3 London Underground Ltd should ensure that existing trolleys are assessed against the requirements of Recommendation 2 (paragraph 117).

4 London Underground Ltd and Network Rail should conduct studies into trolley design with an objective of improving the ergonomic issues connected with propelling and braking hand trolleys (paragraph 118).

5 London Underground Ltd together with Metronet and Tube Lines, should review and determine how to ensure Track Trolley Operators are aware of and know how to apply the controls to mitigate the risks relating to gradients when operating track trolleys (paragraph 117).

6 London Underground Ltd should ensure that the training of Track Trolley Operators includes the provision of appropriate reference material to carry on site (paragraph 123).

Recommendations to address other matters observed during the investigation

7 London Underground Ltd should revise the Site Person in Charge training and reference material to ensure that the SPIC's responsibilities for accident and incident reporting to London Underground Ltd are defined (paragraph 122).

8 London Underground Ltd, Metronet and Tubelines, if applicable, should ensure that all contracts and subcontracts for work on the network are aligned in respect of legal accident and incident reporting requirements (paragraph 122).

9 The Network Rail M&EE Networking Group should consider the participation of LUL and the Infracos in its activities (paragraph 126).

[2] Responsibilities in respect of these recommendations are set out in the Railways (Accident Investigation and Reporting) Regulations 2005 and the accompanying guidance notes, which can be found on RAIB's web site at www.raib.gov.uk

Appendices

Glossary of abbreviations and acronyms — Appendix A

CIRF	Contractors Incident Report Form
ECC	Engineering Control Centre
LUL	London Underground Limited
NOC	Network Operations Control
PMEH	Protection Master engineering Hours
PMMS	Plant Maintenance Management System
PPE	Personal Protective Equipment
PPP	Public Private Partnership
PSWI	Plant Standard Work Instruction
RAIR	Railways (Accident Investigation and Reporting) Regulations 2005
RIDDOR	Reporting of Injuries Diseases and Dangerous Occurrences - Regulations 1995
SPIC	Site Person In Charge
TTO	Track Trolley Operator
VS	Ventilation Shaft

Glossary of terms — Appendix B

Ballast	Graded stone sub-base used for drainage and support of the track.
Bullhead	A type of rail characterised by a narrow and deep base.
Chairs	Cast-Iron components used to fasten rails to sleepers.
Conductor rail	A separate rail mounted on insulators thorough which DC electricity is supplied to electric trains on the third or fourth rail systems.
Contractors Incident Report Form	A proforma used by contractors working on the London Underground network for the reporting of accidents or incidents.
Handback Engineer T002	A person, specified and licensed by LUL, who has responsibility, after track works are complete, for assessing and confirming that track is in a suitable condition to allow the passage of service traffic.
Roll-pin	A pin created by rolling thin steel into a cylindrical form and used in linking components.
Shared Working Manual	LUL corporate safety and operations document. This includes standards, procedures and safety arrangements for working on the underground network.
Sidewear	the reduction in railhead width due to wear caused by flange contact with the rails as trains run round a curved track.
Sleeper	Wood, concrete or steel object which holds the rails apart and supports the track on the ballast.
Sub-surface routes	Lines within the London Underground network which, when below ground, are constructed close to the surface (Metropolitan, District, Circle, Hammersmith & City and East London).
T3 possession	A procedure by which a section of the line is under exclusive occupation of an engineer for maintenance or repairs.
Term-contractor	An organisation contracted to perform specified tasks over a period of time.
Track trolley	A small platform with a rail wheel at each corner used to transport materials and tools along the railway for maintenance work.
Track Trolley Operator	A person trained and certificated, on London Underground, to take charge of and use Track Trolleys.
Turnbuckle	A tensioning or adjustment device, which utilises the rotation of a central sleeve incorporating threads of opposite hands to pull together connections to other equipment at the remote ends.
Ventilation shaft	A vertical opening between a tunnel and ground level.
Wet bed	An area of ballast under sleepers which is contaminated by slurry.

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