



Rail Accident Investigation Branch

Rail Accident Report



**Derailment at Phipps Bridge on Croydon
Tramlink
25 May 2006**

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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Derailment at Phipps Bridge on Croydon Tramlink, 25 May 2006

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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 given by Tramtrack Croydon Ltd and Tram Operations Ltd to their staff, data and records for the purpose of this investigation.
- 4 Appendices at the rear of this report contain Glossaries:
 - acronyms and abbreviations are explained in the glossary at Appendix A; and
 - certain technical terms (shown in *italics* the first time they appear in the report) are explained in the glossary at Appendix B

Summary of the report

Key facts

- 5 Tram number 2532, a 3-section articulated unit, travelling eastbound on the single line between Wimbledon and Croydon with approximately 180 passengers on board, became derailed after passing over *facing points* PBR02G at the single to double line junction on the approach to Phipps Bridge tram stop near Merton, Surrey, at 15:57 hrs on Thursday 25 May 2006. As the tram approached the points they were set, incorrectly, in the *reverse* position. After the leading *bogie* of the tram had passed over, the points sprang back to the *normal* position and the centre and rear bogies of the tram took that route. As the paths taken by the front and rear of the tram diverged, the centre bogie became derailed. The tram came to rest about 43 m beyond the points (Figure 2).



Figure 1: Extract from TfL map showing diagram of Croydon Tramlink system and location of accident

- 6 There were no injuries, and the passengers were evacuated to the adjacent tram stop by the driver and other staff. Recovery of the tram was completed at 21:40 hrs and normal services were reinstated at 22:10 hrs the same day.
- 7 A derailment occurred at the same location in very similar circumstances on 21 October 2005. A report of the RAIB investigation into that incident was published on 29 March 2006.

Conclusions

- 8 The immediate cause of the accident was that the tram driver did not react to the ‘points not correctly set’ indication on the *points position indicator* (PPI) sited 4 m on the approach to points PBR02G at Phipps Bridge, and did not stop the tram before reaching the points.
- 9 Causal factors were:
 - the points did not return to normal after the passage of the previous tram, and the vibration of the tram passing over the points caused them to spring back to the normal position under the tram.
 - the poor conspicuity of the indicator display when the points are not set correctly.
- 10 In addition, the following factors were considered to be contributory:
 - the control room staff were not able to alert the tram driver in time to the malfunction of the points.
 - the unreliability of this set of points, which was the subject of recommendation 2 from the report into the derailment on 21 October 2005, and which had not been remedied.
 - the recommendations from RAIB’s report into the derailment of 21 October 2005 (published on 29 March 2006) relating to:
 - a. the conspicuity of the PPI indication; and
 - b. the reduction of the number of alarm messages received by the control room staff had not been implemented.
 - the absence of a systematic approach to investigating and rectifying faults in the points mechanism at Phipps Bridge.

Recommendations

- 11 Recommendations can be found in paragraph 85. They relate to the following issues:
 - Implementation of the recommendations from the report into the derailment of 21 October 2005 (see paragraph 10 above).
 - Further work to improve the response of the infrastructure controller to recurrent faults.

The Accident

Summary of the events

- 12 At 15:57 hrs on Thursday 25 May 2006, tram 2532 approached Phipps Bridge tram stop on its journey from Wimbledon to Elmers End (Figure 1). The PPI for facing points PBR02G was displaying a single white dot, indicating that the points were not correctly set for the normal route (to the left, in the direction the tram was travelling). The tram driver did not react to this indication, and drove the tram over the points. The points were set, incorrectly, to reverse (for the right-hand route). The leading bogie of the tram followed this route. As the tram passed over the points they sprang back to normal, and the centre bogie of the tram followed the route to the left. The leading wheels of the centre bogie became derailed and the tram stopped abruptly after travelling 43 m past the points, about 50 m before the tram stop platform.
- 13 There were about 180 passengers on board the tram. There were no injuries to staff or passengers.
- 14 The tram was re-railed at 21:40 hrs and normal services resumed at 22:10 hrs.

Previous occurrences of a similar character

- 15 A derailment in very similar circumstances occurred at the same place on 21 October 2005, and was the subject of an RAIB investigation, the report on which (number 04/2006) was published on 29 March 2006. This report concluded that the derailment occurred because the tram driver did not react to the ‘points not correctly set’ indication. Four recommendations were made, which are discussed at paragraphs 60 - 69. There had been a previous derailment on spring facing points at Mitcham in August 2002. This was caused by a wrongly adjusted points mechanism, and subsequently all the points mechanisms on the Tramlink system were checked and adjusted as necessary.

The parties involved

- 16 The Croydon Tramlink system, which opened in 2000, is run under contract by Tramtrack Croydon Ltd (TCL), which has a 99-year concession from Transport for London (TfL) to provide a service. The system is operated under contract to TCL by First Tram Operations Ltd (TOL), which employs the tram drivers and controllers, and the trams are maintained by Bombardier Transportation Ltd. Maintenance of the infrastructure is contracted by TCL to Mowlems (now part of Carillion plc).

Location

- 17 The Wimbledon to Croydon line of the Tramlink system runs in a generally north west – south east direction throughout its 10 km length. It is double track from a short distance outside Wimbledon station for 2.13 km as far as Morden Road, where the line becomes single for 0.72 km. Double line resumes at points PBR02G, which are located some 90 m before reaching Phipps Bridge tram stop (Figure 2).

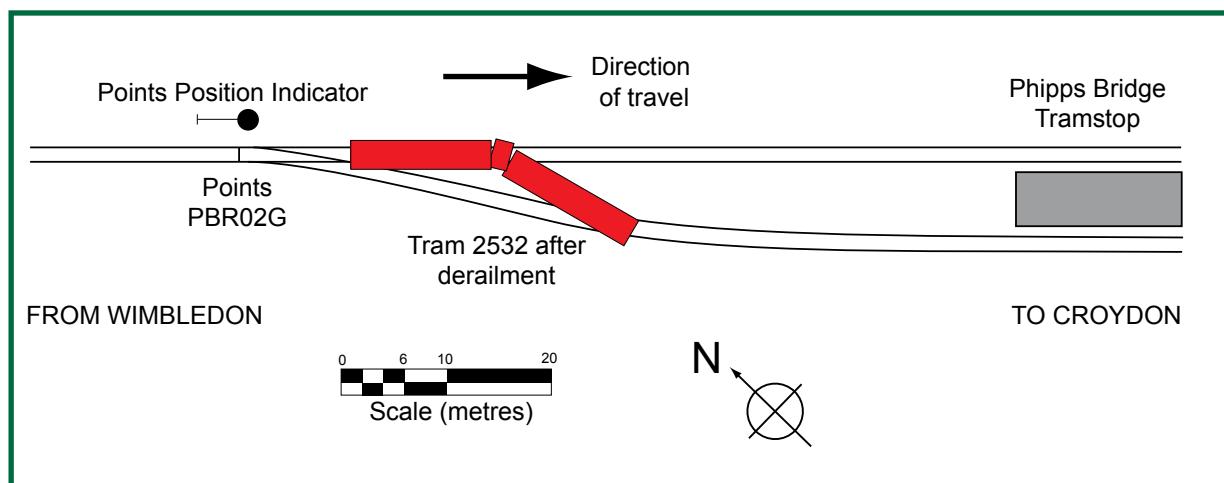


Figure 2: Site plan

Infrastructure

- 18 In common with all of the single/double line junctions on the Tramlink system, PBR02G points at Phipps Bridge are equipped with a Hanning & Kahl HW160 type mechanism, arranged to operate as spring points. An outline description of the points mechanism was given in the previous report. In view of the connection between the problems with the points mechanism and the derailments at Phipps Bridge, a more detailed account is given below.
- 19 The Hanning & Kahl mechanism in use at Phipps Bridge is deemed by the manufacturer to be suitable for use with *flatbottom* section switch rails. The off-street turnouts on the Croydon Tramlink system use rail of this type, with *shallow-depth switch rails* and S49 section running rails. S49 rail is a German standard flat bottom rail weighing 49 kg/m and normally used in main-line railway applications, and comparable in size to British BS 98 rail. The switches are of standard shallow depth pattern, on timber bearers, and are additionally fitted with support rollers.
- 20 The basis of the HW 160 mechanism is explained in Figure 3. It drives the switches via a lever running between rollers in the centre part of the *stretcher bar*. The compression spring, contained in the spring packet (A) acts through the linkage and the switch lever (B) to push the stretcher bar (C), and thus the switches, over to the right hand stock rail (as shown), setting the switches for the normal route.

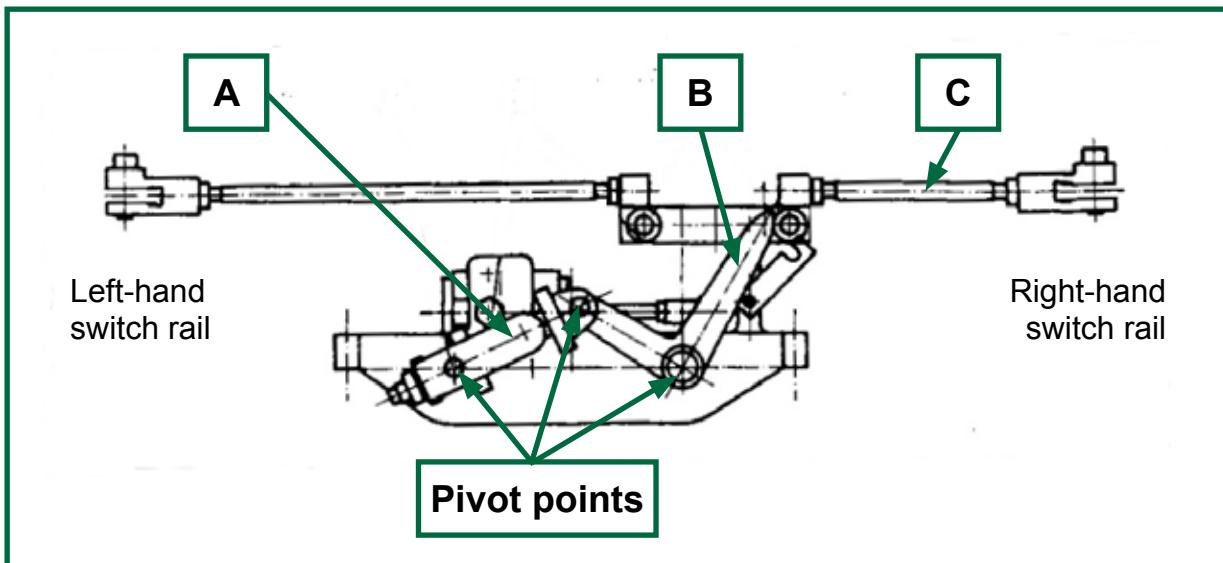


Figure 3: Hanning & Kahl spring point mechanism

- 21 This type of mechanism is not locked, and is deliberately designed so that the switches can be *trailed through*, after which they will return to their previously set position. In the case of the points at Phipps Bridge, eastbound trams are directed to the left-hand route; westbound trams approach from the right-hand route in the *trailing direction* and push through the switches, which should then return to the normal position (for the left-hand route).
- 22 When this type of mechanism is trailed through, the action of pushing the right hand switch open pushes the stretcher bar C to the left. This in turn rotates the operating lever B anti-clockwise and compresses the spring in its carrier A, which also rotates clockwise.
- 23 A characteristic of this type of mechanism is that if the spring carrier is rotated sufficiently to line up all three pivot points in the linkage, it will reach a *dead-centre* position in which there is no turning moment to restore the mechanism to normal, and it will remain in that position until disturbed. In this position, although the spring is compressed to its greatest extent, the force required to disturb the mechanism is very low, and only a small impulse is required to cause the mechanism to spring back to the set position. As with all such mechanisms, whilst the theoretical dead-centre state only exists when all the pivots are exactly aligned, in practice the effect of friction in the pivot pins is such as to widen the range in which the mechanism can become stuck.
- 24 In normal operation, the movement of the stretcher bar (which is limited by the throw of the switches) should never push the operating lever into the dead-centre position. The dead-centre band is approximately 15° either side of the centre line (when the three pivot points line up as described in paragraph 23). To avoid this, the normal movement of the lever should be in the range 30° to 75° from the centre line, with the area from 15° to 30° allowing for wear or errors in setting. The manufacturer's instructions specify a maximum switch movement of 80 mm to achieve this. However, the length of the stretcher bar is adjustable using the threads at both ends of both portions, so it is possible for a wider range of movement to exist if the stretcher bar is not set up correctly. It is also possible to set the stretcher bar so that the throw is correct, but the range of movement of the operating lever (B) is asymmetrical.

- 25 Movement of trams through the turnout in the *facing direction* is controlled by a PPI, situated on a post 4 m on the approach to the turnout. This has three aspects, 'left', 'right' and 'no detection', although as is standard at spring points, only the 'left' and 'no detection' aspects are used at Phipps Bridge. 'Left' corresponds to the normal route; 'no detection' indicates that the switches have not been correctly detected as being in the normal (or reverse) positions and is treated as equivalent to a stop aspect. In common with other indicators and signals on the system, the PPI was originally fitted with incandescent lamps, but these were changed to LED type in June 2005, to reduce maintenance costs.
- 26 When the points are set and detected normal, the PPI indicates the left-hand route (see Figure 4). If the points are not correctly set, only the central white light of the PPI is lit (see Figure 5).



Figure 4: Points position indicator - Points correctly set



Figure 5: Points position indicator - Points not correctly set

The tram

- 27 The vehicle involved was tram 2532, one of the 24 units that make up the Tramlink fleet. It was built by Bombardier Transportation in Austria in 1998. Following the derailment, it was examined on site by Bombardier staff and driven back to the depot the same evening. On examination, no faults were found. There were marks on the underside of the centre section bogie consistent with the derailment, but no other damage.

Events preceding the accident

- 28 Following the derailment on 21 October 2005, the points at Phipps Bridge were examined by TCL and their maintenance contractor, Mowlems, and no faults were found. However, reliability problems with this set of points persisted, and through November and December 2005 the points were reported as failing to return to the normal position on six occasions (there is evidence that this is significantly higher than the failure rate of other sets of points on the system during this period, but exact figures are not available). The frequency of these failures increased suddenly, for no apparent reason, in January 2006. On 16 January the points were reported as sticking persistently, after the passage of almost every westbound tram. TOL posted an attendant to the site, with the duty of ensuring that the points were in the correct position for eastbound trams. On 17 January maintenance staff attended and cleaned and oiled the points, which appeared to solve the problem, and the points attendant was withdrawn. No further problems were reported until 5 March. On this day the points again began to fail intermittently, and the points attendant was reinstated. Maintenance staff attended four times over the next two weeks, but failures continued to occur (more than 182 failures were reported between 5 and 31 March).
- 29 Tram drivers were advised about the problems, through special notices issued on 5, 6 and 20 March. These notices stated that the points were failing intermittently, with loss of detection, and drivers should approach the points at extreme caution. If there was no detection displayed, drivers were instructed to ‘stop and *manually adjust* the points to obtain detection’ before proceeding.
- 30 On 21 March, an incident occurred at the points when an eastbound tram passed the PPI when it was displaying a single white dot. The tram stopped with the leading bogie on the points, and did not derail. The incident was not reported to RAIB because such reporting was not necessary in this case, and the subsequent investigation by TOL found that the driver had been aware of the indication displayed by the PPI, but had misjudged his braking while looking at the points to see which way they were lying.
- 31 Following this incident a temporary speed restriction of 20 km/h was imposed in both directions over the points, and the attendant was reinstated as and when staff were available.
- 32 Reports obtained from tram drivers during this period confirmed that, in general, the points were failing with the mechanism stuck in the dead-centre position, as shown by the observed position of the socket for the manual operating lever (which is on the same shaft as the switch lever (B in Figure 3)). TCL staff observed the operation of the mechanism with the cover removed. With the mechanism stuck in the mid-position, the switch rails were not forcibly held to one side or the other, and after being trailed through they could take up a position anywhere in their travel.
- 33 At the time, the TCL chief engineer concluded from this that the operating lever was being pushed close to the vertical position as the trams trailed through the points, and was remaining in this position because of the over-centre action of the mechanism. The throw of the switch rails was measured and was found to be approximately 85 mm. The maximum throw specified by the manufacturers for this type of mechanism (see paragraph 24) is 80 mm.

- 34 To make the mechanism work correctly, TCL decided to significantly reduce the throw of the points by extending the stretcher bars, thus bringing the throw within the manufacturer's specification. To do this it was necessary to manufacture new stretcher bars because the required dimension was outside the range of possible stretcher bar adjustment. The new bars were fitted on 31 March, and the speed restrictions were withdrawn. The reliability of the points improved dramatically, although there were some failures in the following days, which led to the imposition of temporary speed restrictions on 3 and 10 April while the points were given attention. The attendant was withdrawn from 10 April.
- 35 In the seven weeks between the fitting of the new stretcher bars and the derailment on 25 May, whilst the failure rate was reduced (from an average of 12 per week over the previous five months to 2 per week), there were 14 reports of the points sticking. This rate was higher than that observed between November and December 2005 (see paragraph 28). During the same period there were no other reports of this problem with points on the Wimbledon line, and very few on the rest of the system.
- 36 After 31 March, TOL issued further special notices to tram drivers on 1, 3 and 10 April, advising them of the work that had been done at Phipps Bridge, the problems that were still occurring, and the need for extreme caution when approaching the points.

Events during the accident

- 37 On 25 May, tram 2532 was in service on route 1 between Wimbledon and Elmers End. The driver took it over at 12:50 hrs at the Therapia Lane tram stop (near Coomber Way depot), and then made two complete journeys over the route. On his third run he left Wimbledon at about 15:48 hrs. The tram was heavily loaded, with standing passengers including many schoolchildren. The journey was uneventful and the tram left Morden Road on time. The driver accelerated to 75 km/h (the line speed on this section is 80 km/h), and braked normally on the approach to Phipps Bridge. The sun was behind the tram, shining over the driver's right shoulder. The PPI for the points at Phipps Bridge was displaying a single white dot (meaning that the points were not detected in the normal position, and the tram should stop) as 2532 approached.
- 38 The previous west bound tram had passed the points at Phipps Bridge at 15:52 hrs, and at 15:52:22 hrs the control room received a 'red' alarm message that the points had become stuck in an 'undetected' position. The controller intended to contact tram 2532 to warn the driver of this (see paragraph 51). At 15:55:20 hrs a 'green' message indicated that the points had reset themselves (as tram 2532 passed over). The controller made a call to tram 2532 at 15:55:25 hrs, five seconds later, to ask what position the points had been in when the tram passed over them. The driver reported that the tram had taken the wrong route and had become derailed.
- 39 The points were lying reverse as tram 2532 approached. The leading bogie of the tram passed over the points, which then sprang back into their normal position, for the left hand route. The second and third bogies of the tram went to the left, and as the paths taken by the front and rear sections of the tram diverged, the leading wheels of the centre bogie became derailed. The driver, realising that the tram was taking the wrong route, applied the service brake and the tram stopped. The front of the tram was 43 m beyond the toe of the points.

Events immediately following the accident

- 40 The passengers on the tram were evacuated by the driver, with the assistance of revenue protection staff who were on duty at Phipps Bridge. There were no injuries and the emergency services did not attend. A replacement bus service operated between Mitcham and Morden Road tram stops. Trams from Croydon were reversed at Phipps Bridge, and a tram shuttle service was operated between Morden Road and Wimbledon.
- 41 The Emergency Response Unit from London Underground was called to re-rail the tram, and this was completed at 21:40 hrs the same day. There was minor damage to the tram, and no damage to the track. Normal services were reinstated at 22:10 hrs.
- 42 In accordance with the requirements of TOL's operating procedures, the tram driver was screened for alcohol and drugs immediately after the derailment. The results of these tests were satisfactory.

The Investigation

Investigation process

43 RAIB obtained evidence from:

- a member of TOL staff appointed as an RAIB *Accredited Agent* to record evidence from the site;
- interviews with staff carried out by RAIB inspectors;
- information from the CCTV equipment and data recorder on the tram on 26 May; and
- reports prepared, and documents supplied, by TOL, TCL and TfL.

Analysis

Identification of the immediate cause

- 44 The CCTV evidence from the forward-facing camera on the tram shows that the PPI was displaying a single white dot as tram 2532 approached the points at Phipps Bridge. The image recorded by the CCTV may not be what could be seen by the driver, especially in strong sunlight. The sun was shining on the indicator, which further reduced the clarity of the indication (see report¹ on the previous derailment, paragraph 29). The points can be seen to be lying reverse. Following the derailment the points were found to be set normal. The points had moved as the tram passed over them, and they were not correctly set (and indicated as such) as the tram approached.
- 45 The immediate cause was the same as for the previous derailment on 21 October 2005. The driver did not react to the display of the ‘points not correctly set’ indication, and did not stop the tram before reaching the points.

Identification of causal and contributory factors

Points Position Indicator

- 46 The driver was presented with the ‘no detection’ indication of the PPI, a single white dot, the conspicuity of which was degraded (both because of its general appearance, and the sun shining on it), at the time that he was concentrating on bringing the speed of the tram down to 40 km/h to pass over the points (which he did, 26 m before reaching the points). The driver gained the impression that the indicator was showing that the points were correctly set, and continued to concentrate on controlling the speed of the tram. The sun was shining over the driver’s right shoulder onto the face of the PPI. This reduced the conspicuousness of the single dot indication, and may also have created a false impression that the route lights were lit. In the past the driver had encountered ‘two-way’ points indicators with the sun shining on them and giving the impression that both sets of route lights were lit (see picture below, Figure 6, in which only the centre dot is actually lit). Drivers’ representatives have also expressed concern about the visibility in sunlight of another signal on the system, and this signal has since been re-angled as a mitigation measure. It is TOL’s intention to carry out a system-wide review to try to identify any other signals or PPIs where similar problems may be experienced.

¹ Rail Accident Report: Derailment at Phipps Bridge, Croydon Tramlink, 21 October 2005. Published on the RAIB web site www.raib.gov.uk on 29 March 2006.



Figure 6: Phipps Bridge soon after the derailment. This picture is not taken from the viewpoint of the driver, and may not represent what he saw on this occasion. The points have been manually changed since the derailment, and are set for the right hand route

Distractions

- 47 The passengers on the tram were mainly schoolchildren. The CCTV footage from the internal camera shows that a number of them were standing close to the partition behind the driver. The driver could hear a certain amount of noise coming from the passengers, which was not unusual at that time of day, but the driver was not aware of any specific attempt by passengers to attract his attention. The trams are equipped with blinds at the back of the cab which the driver can use to reduce glare from the saloon lighting after dark, and these can also help to reduce the potential distraction from passengers. The driver had these blinds in use. It is concluded that distraction of the driver was not a factor in the derailment.

Points reliability

- 48 If the points had returned to the normal position after the previous westbound tram had run through them, the derailments on 21 October 2005 and 25 May 2006 would not have occurred. The history of points failing to return to the normal position is described in paragraphs 28 – 36 above. The steps taken by TCL to deal with it had not solved the problem.
- 49 Following the derailment, TCL removed the points mechanism from the track and replaced it with another mechanism taken from the siding at Wimbledon, which had had very little use because that siding is only used for stabling defective trams. There were no further reports of points failures at Phipps Bridge in the first two months following this action.

Control room

- 50 When points fail to return to the normal position, a non-detection ‘red’ alarm is received in the control room. The controller should acknowledge it and make a group or individual call to warn drivers of the hazard. ‘Red’ alarms refer to operational matters, such as stuck points, but are also received for intermittent low levels of radio signals, which are not safety-related. ‘Yellow’ alarms relate to low-risk or commercial matters, such as ticket vending machines requiring replenishment.
- 51 The ‘red’ alarm indicating that the points had stuck was received by the controller about three minutes before the derailment occurred. This alarm would have remained visible to the controller for only a short time, since only the last two alarms received are displayed at the base of the controller’s screen, and in the next three minutes 31 ‘yellow’ alarms were received (mostly related to a duty number and driver identity that were not recognised at successive *induction loops* on the system). On receiving the ‘red’ alarm, the controller was aware that it was linked to points not returning to ‘normal’ after the passage of a westbound tram over the points, and that it would be a few minutes before an eastbound tram would be approaching them. He was dealing with another matter at the time, and once he had finished with this he identified the next eastbound tram and attempted to contact it, but only managed to do so five seconds after it reached the points, after the derailment took place, and after a ‘green’ alarm had confirmed that the points had reverted to normal.
- 52 The large number of low-level alarms displayed to the controller was identified as a factor which may have contributed to the derailment on 21 October 2005, when the controller did not attempt to contact tram drivers following receipt of the non-detection alarm. In the 25 May 2006 derailment, there would have been sufficient time (three minutes) for the controller to have called and warned the tram driver, but in fact the controller was trying to contact the driver of tram 2532 as the derailment occurred. There is insufficient evidence to conclude whether the number of other alarms was a factor on the second occasion.

Driver training, experience and fitness

- 53 The tram driver, who is 43 years old, joined TOL as a trainee tram driver on 3 January 2006. He completed his training and qualified as a driver on 2 April 2006. RAIB examined TOL’s training course and assessment and monitoring arrangements as part of the investigation. The training course typically lasts for about 11 to 12 weeks, and includes a minimum of 171 hours in-cab driving experience. The course has been developed on the basis both of good industry practice and the experience gained over some 8 years of operation in Croydon. No factors related to training were identified that contributed to the derailment.
- 54 Assessment following completion of training takes place when feedback from trainers indicates that a candidate is consistently demonstrating that they are able to meet the required standards. The assessments follow a predefined format and require candidates to provide evidence of their ability to meet system-specific standards linked to the National Occupational Standards for Tram/Light Rail Driving². Once a trainee has been assessed as competent in driving, they will undergo a period of solo driving practice during non-service hours (at night), to build confidence in their ability to handle the tram and deal with infrastructure interfaces before commencing training in service and having to cope with the additional demands of carrying passengers.

² National Occupational Standards (NOS) for Light Rail/Tram Driving are maintained and revised by the Sector Skills Council for Passenger Transport (GoSkills) on behalf of the light rail industry. There are twelve units, including among other topics preparation, communications, driving, dealing with passengers, responding to abnormal events, and handover and stabling.

- 55 All newly qualified drivers are given monitoring and assistance after their final assessment, because experience in Croydon has shown that drivers are approximately twice as likely to be involved in a safety-related incident in their first six months of driving as in their second six months. This performance trend is generally found in newly qualified car, bus and train drivers, as well as drivers on other tramways.
- 56 On 13 April 2006 the driver was involved in an incident at King Henry's Drive, when he passed signal KHD02S when it was displaying a 'stop' indication (horizontal bar), and proceeded onto the single line section towards New Addington. He stopped on seeing a tram coming towards him on the single line. The incident was investigated by TOL, and the driver was found to have lost concentration. TOL's investigation concluded that the number of journeys (seven in a shift) that he had made on this route may have been a factor in creating a tendency to anticipate the clearance of the signal. The driver's performance in this incident was reviewed by TOL and did not cause TOL to decide that he was unsuitable for tram driving. Following this incident disciplinary action was taken, and the driver was specially monitored.
- 57 The driver was relatively inexperienced, and although he was aware that there had been problems with the points at Phipps Bridge, he had not been driving on that route at the time that the points were failing most frequently. However, he had seen the special notices relating to the problem that had been issued during April. By the middle of May, these had been withdrawn and the frequency of failures had reduced to the point where he was under the impression that the problem had been solved.
- 58 The derailment on 25 May occurred early in the driver's first shift following a rest day. He had slept well the previous night and it is unlikely that fatigue was a factor in what happened. The driver has no known medical problems that would affect his ability to drive, and the results of the drugs and alcohol screening following the accident were satisfactory.
- 59 The driver had already been over the Wimbledon route twice on 25 May, and had not experienced any failures of the Phipps Bridge points on that day, or indeed for almost two months. He was not expecting the indicator to be showing a single dot, and was concentrating on controlling the speed of the tram over the points.

Response to recommendations arising from RAIB's investigation into the derailment on 21 October 2005, published on 29 March 2006.

Conspicuity of the PPI

- 60 Recommendation 1 of the report into the above derailment was that 'the conspicuity of the PPI 'abnormal' indication should be assessed and improved by an appropriate means, such as display of a horizontal white bar when the points are not correctly set.'
- 61 At the time of the second derailment this recommendation had not been implemented. On 27 April 2006 TCL responded to the recommendation, saying:
'TCL believe the issue should be subject to Human Factors Review, which would include factors such as points sticking being 'an extremely infrequent event', prior to determining whether any action is required to 'improve by an appropriate means' the conspicuity. This we believe should be conducted by the Operator TOL with TCL making a contribution.'
- 62 The points had been reported as stuck or had lost detection on at least 266 occasions on 28 days in the seven month period between the first and second derailments, and on some of those days the failure had occurred more than 25 times. Points failures, which TCL was aware of, were therefore a frequent event.

- 63 TOL commissioned Human Engineering Ltd to carry out a human factors assessment of PPIs. This study was completed on 16 May 2006, and concluded that the greatest impact would be achieved by changing the existing ‘no detection’ aspect from a single white dot to a white horizontal bar. This is consistent with recommendation 1 of the RAIB report into the previous derailment. TCL were provided with a copy of the Human Engineering Ltd report, but decided to commission their own analysis of the human factors issues surrounding tram driver errors at signals, PPIs and elsewhere on the system. The results of this are not yet available.

Reliability of the points

- 64 The history of problems at the Phipps Bridge points is described at paragraphs 28 – 36. At the time the accident occurred, TCL had chosen to address the problem by reactive maintenance, by cleaning and adjusting the points and by modifying the throw. While close attention was given to the points after the first derailment, this did not improve the performance of them to the level achieved by other similar pairs of points on the Tramlink system, where failures are almost unknown. In the seven weeks before the second derailment there were 14 reports of the points sticking, from which TCL concluded that the excess switch throw was not the only cause of the ongoing problems.
- 65 Recommendation 2 of the previous report was that TCL and Mowlem should ‘review the inspection and maintenance regime for the points at Phipps Bridge to ensure that the risks associated with the use of facing spring points at speeds up to 40 km/h are being adequately controlled’. TCL responded to ORR in respect of this recommendation, saying that ‘Review of the failure rates, inspection and maintenance regime for points has been completed by TCL and Mowlem and it is not considered to warrant additional change in respect of either frequency or content.’
- 66 The second derailment then occurred. While the points had been the subject of close attention and modification, this had failed to improve their reliability to a level comparable with the other sprung facing points on the system, where there can be periods of months without failures (paragraph 35). After the second derailment TCL replaced the mechanism. If this had been done at an earlier stage, it is likely the derailment would not have happened.
- 67 The Hanning and Kahl point mechanism is used throughout the Croydon system without problems similar to those encountered at Phipps Bridge, and the satisfactory operation of such a mechanism at Phipps Bridge since the change-over after the second derailment underlines that there does not appear to be a systematic problem with the mechanism. TCL’s approach to fault finding at the points at Phipps Bridge may be a contributory factor to the derailment.

Control room information systems

- 68 One of the factors in the derailment on 21 October 2005 was that the control room staff had not alerted drivers on the Wimbledon line to the failure of the points, despite an alarm appearing on the controller’s screen. This may have been related to the large number of low-level alarms generated by the system.
- 69 Recommendation 3 of the previous report was that TOL and TCL should ‘jointly complete their review of the number and nature of the alarms received in the control room with a view to sorting them by risk and eliminating unnecessary information being presented to the controllers’.
- 70 The review was completed and a technical proposal was produced by the system supplier. The changes were implemented in February 2007.

Ensuring RAIB recommendations are acted upon where appropriate

- 71 In discharging its responsibilities under EU Directive 2004/49 and the Railways (Accident Investigation and Reporting) Regulations 2005, to ensure that the RAIB's recommendations are duly taken into consideration and where appropriate acted upon, Her Majesty's Railway Inspectorate (HMRI) has been monitoring the implementation of the recommendations made by the RAIB in the report into the derailment on 21 October 2005.
- 72 After TCL failed to take sufficient steps to remedy apparent breaches of health and safety legislation, originally highlighted by recommendations 1 and 3 of the above report, HMRI served two Improvement Notices (IN) on TCL on 11 October 2006. These required TCL to implement suitable measures to improve safety in respect of the risk of derailment at spring points (changes to the PPIS), and the control room alarms by 7 January 2007. Following representations from TCL, in December 2006 the date for compliance with the notices was extended by HMRI to 30 April 2007. The works were completed and the notices were complied with by the revised due date.

Conclusions

Immediate cause

- 73 The immediate cause of the accident was that the tram driver did not react to the display of the 'points not correctly set' indication on the indicator close to points PBR02G at Phipps Bridge, and did not stop the tram before reaching the points (paragraph 45).

Causal and contributory factors

- 74 Causal factors were:
- the points did not return to normal after the passage of the previous tram, and the vibration of the tram passing over the points caused them to spring back to the normal position under the tram (paragraph 44).
 - the poor conspicuity of the indicator display when the points are not set correctly (paragraph 46).
- 75 In addition, the following factors were considered to be contributory:
- the unreliability of this set of points, which was the subject of a recommendation from the report into the derailment on 21 October 2005, and which had not been remedied (paragraph 66, **Recommendation 1**).
 - the recommendations from RAIB's report into the derailment of 21 October 2005 relating to:
 - a. the conspicuity of the PPI indication; and
 - b. the reduction of the number of alarm messages received by the control room staff had not been implemented (paragraphs 61, 66, 69).
 - the control room staff were not able to alert the tram driver in time to the malfunction of the points (paragraph 50).
 - the absence of a systematic approach to investigating and rectifying faults in the points mechanism at Phipps Bridge (**Recommendation 1**).

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

- 76 Following the derailment, TOL and TCL modified the 40 km/h speed restriction through the points at Phipps Bridge to commence two OLE stanchions (approximately 80 m) before the points, rather than at the PPI. This will make it easier for the driver to bring the speed of the tram down to 40 km/h and then transfer attention from the speedometer to the PPI as the tram approaches the points (Figure 7).

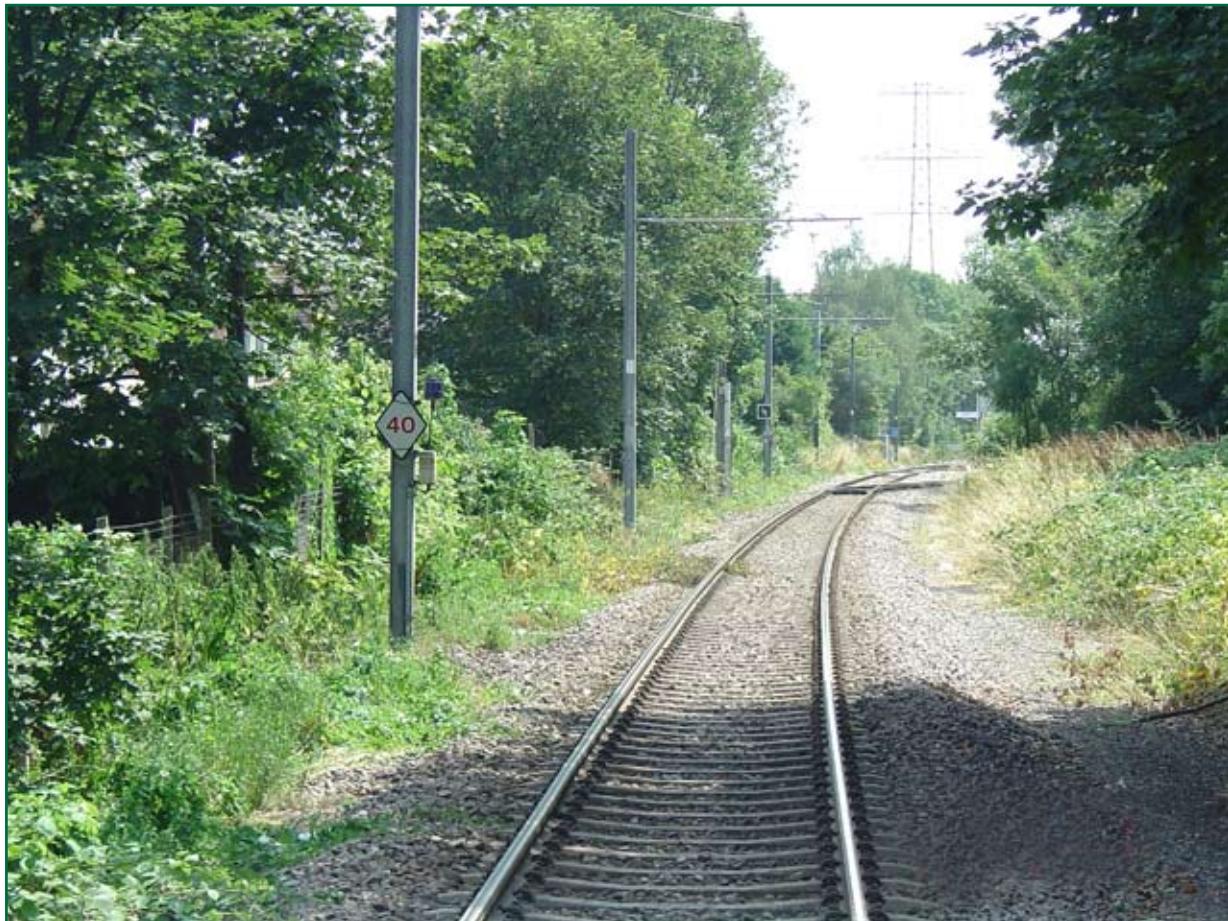


Figure 7: The approach to Phipps Bridge, showing the re-sited speed restriction and the PPI

- 77 TCL removed the mechanism from the Phipps Bridge points and returned it to the manufacturers in Germany for examination. Nothing was found wrong with the mechanism other than normal and expected levels of wear. No problems have been experienced with the replacement mechanism. This mechanism is widely used on tramways both in the UK and the rest of the world, with levels of reliability which are accepted by the operators of those tramways.
- 78 TCL have sent relevant members of their staff to Germany to receive further training from the manufacturers on the maintenance of Hanning and Kahl point mechanisms.
- 79 Following the derailment, the driver's competence was reassessed by TOL and his driving has been monitored over the following 3 months, with no problems identified.
- 80 On 24 July 2006 HMRI conducted an inspection of the safety management of the Tramlink system, and were generally satisfied with the way in which risks were being controlled.

Additional Observations

Use of the hazard brake

- 81 After the derailment the driver stopped the tram using the service brake. Although he had the opportunity of using the *hazard brake*, the decision not use it on this occasion was correct, as there was no risk of collision, and the extra braking forces could have injured passengers, or caused the derailment to develop in a less controlled manner. The use (or non-use) of the hazard brake in different types of emergency has been considered in the RAIB's investigations into incidents at Staniforth Road, Sheffield on 27 October 2005 (RAIB report number 01/2006), Radcliffe, Manchester on 8 November 2005 (09/2006), and New Addington, Croydon on 23 November 2005 (11/2006), as well as in the investigation into the previous derailment at Phipps Bridge. Tram drivers must be trained to be ready to use the emergency brake without hesitation when it is necessary to do so, and this is included in the training given to drivers on the Croydon system.

Management of safety

- 82 A poor relationship exists between TCL and TOL, and this has the potential to affect the safe operation of the tramway. Examples of this during 2006 have included the purchase of a new rail-mounted maintenance vehicle by TCL without consultation with TOL, and proposals by TCL for modifications to the control room software (in response to an RAIB recommendation) without reference to TOL (whose staff operate the control room), as well as other evidence from witnesses during the investigation. Although systems and procedures exist for the co-ordinated management of safety and the exchange of safety-related information between the companies, these systems are not being correctly operated. It is important that these problems are addressed before more serious consequences occur. HMRI are aware of these issues and are in discussion with both TCL and TOL, as well as Transport for London, the transport authority from whom TCL hold the concession to operate the system, to develop ways to improve the situation.

Driver training

- 83 Newly qualified tram drivers with less than six months experience are more likely to be involved in a safety-related incident than those who have been driving for a longer period (paragraph 55). Statistics show that the extent of this phenomenon in Croydon is not dissimilar to that experienced on other tramway systems (and by car, bus and train drivers). However, in Croydon (and on new generation tramways in the UK in general), there have not been any incidents associated with the lack of experience of newly qualified drivers which have led to injury or death. Selection and training of transport operators is an area in which much research is being done (First Group/TOL are working with Cranfield University to refine the way in which the selection and training process is undertaken) (**Recommendation 2**).

Recommendations

- 84 In the light of the action taken by HMRI in issuing Improvement Notices, the RAIB is not making any recommendations in respect of the implementation of recommendations from the report into the derailment of 21 October 2005.
- 85 The following safety recommendations are made:³

- 1 TCL should demonstrate to HMRI that they have overhauled the arrangements for investigating and rectifying faults in Hanning and Kahl point mechanisms so as to ensure systematic control of the risk from derailment (paragraph 75).
- 2 TOL should review its driver training programme, to ensure that the training given to new drivers is keeping risks as low as is reasonably practicable (paragraph 83).

³ 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 the RAIB's web site at www.raib.gov.uk.

Appendices

Glossary of abbreviations and acronyms

	Appendix A
CCTV	Closed circuit television
HMRI	Her Majesty's Railway Inspectorate
LED	Light Emitting Diode
OLE	Overhead Line Equipment
ORR	Office of Rail Regulation
PPI	Points Position Indicator
TCL	Tramtrack Croydon Ltd
TfL	Transport for London
TOL	Tram Operations Ltd

Glossary of terms

Appendix B

All definitions marked with an asterisk, thus (*), have been taken from Ellis' British Railway Engineering Encyclopaedia © Iain Ellis. www.iainellis.com

Accredited Agent	A member of rail industry staff who has been trained and certificated by RAIB and who acts on behalf of RAIB at an incident site until an inspector arrives.
Bogie	A metal frame equipped with two or three wheelsets and able to rotate in plan, used in pairs under rail vehicles to improve ride quality and better distribute forces to the track.*
Dead-centre	Position of a mechanism in which the internal components exert no leverage on the mechanism as a whole.
Facing direction	Direction of travel over points in which a vehicle can be directed to one of two diverging routes.
Facing points	Points where two routes diverge in the direction of travel.
Flat bottom	A type of rail characterised by a broad and shallow base or 'bottom' used worldwide.
Hazard brake	On trams, a braking system for use in emergencies which applies an electro-magnet to the rails to slow down the vehicle.
Induction loop	A device fixed between the rails which detects and identifies a tram.
Manually adjust (points)	Ensure, if necessary by levering the switches across, that the points are correctly set for the direction in which the tram is to proceed.
Normal (points)	The normal position of points is determined by the signalling plan. In the case of spring points, the position which they are sprung to lie for.
Points	Items of track which may be aligned to one of two positions, normal or reverse, according to the direction of train movement required.
Points position indicator	An illuminated lineside sign which indicates to a tram driver the position that points are in.
Reverse (points)	The reverse position of points is determined by the signalling plan. In the case of spring points, the position which they are sprung to lie away from.
Shallow depth	A switch assembly in which the switch rail is made from a rail section of shallower depth than the stock rail, obviating the need to machine the foot of the stock rail.
Stretcher bar	Bar which connects switch rails together.
Switch rail	The moving portion of rail on each side of a set of points.
Trailing direction	Direction of travel over points in which a vehicle is moving towards the convergence of the two routes.
Trailing (points)	Points where lines converge in the direction of travel.
Trail(ed) through	To pass through points in the converging direction, pushing the switch rails across in the process.

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