



Rail Accident Investigation Branch

Rail Accident Report



Derailment at Bordesley Junction, Birmingham 26 August 2011

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 Bordesley junction, Birmingham

26 August 2011

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Summary

At 00:44 hrs on 26 August 2011, a freight train comprising a diesel-electric locomotive, 30 empty aggregate wagons, and an unloading wagon derailed on the approach to Bordesley Junction, Birmingham. The rear four wagons of the train, which was travelling between Banbury and Barrow-on-Soar, derailed and re-railed during the accident. There was extensive track damage at Bordesley Junction and some damage to the vehicles involved. No one was hurt.

The immediate cause was that the fourth wagon from the rear derailed when its leading right-hand wheel flange climbed onto the rail head just before the junction. This was because the dynamic load on this wheel was reduced by a combination of factors related to the wagon's suspension and the track geometry:

- The trailing left-hand wheel's suspension had probably locked-up (ie it had stopped responding to vertical movements) after passing over a track twist. Once locked-up, dynamic load transferred from this wheel and the diagonally opposite leading right-hand wheel to the other wheels, making this wagon more susceptible to derailling on a further track twist. The suspension had locked-up because worn suspension components were not detected during planned maintenance, and no changes had been made to this wagon's suspension, or to its maintenance regime, after testing had shown this type of suspension was prone to locking-up. An underlying cause was that no organisation took overall ownership of this problem of suspension lock-ups.
- There were two track twists that had been present for a long time because Network Rail staff carried out repair work in the wrong place. These track twists had formed due to the deteriorating condition of the formation, and although they were identified as repeat faults, no action was taken to investigate why these faults were recurring. Four days before the accident, planned overnight work that would have corrected these faults ran short of time, so the line where the track twists were was not worked on.

The RAIB has made four recommendations, two directed to Network Rail's Network Certification Body, one to Lafarge Aggregates Ltd, and one to Network Rail. These cover making improvements to the way the risk of operating privately owned wagons is managed once a fleet wide problem is discovered, carrying out a fundamental review of how the suspension components on these wagons are maintained, implementing modifications to these wagons' suspensions which reduce the number and duration of lock-ups, and changing the process for briefing staff controlling on-track machine work so information about the priorities for their work is provided.

There are also two previous RAIB recommendations that were made to Network Rail, which are relevant to this investigation. One calls for measures to improve the accuracy of location information for track geometry faults and the other calls for processes to be put in place for investigating and monitoring the repairs of repetitive track geometry faults. Their implementation is subject to ongoing correspondence between Network Rail and the Office of Rail Regulation.

Introduction

Preface

- 1 The purpose of a Rail Accident Investigation Branch (RAIB) investigation is to improve railway safety by preventing future railway accidents or by mitigating their consequences.
- 2 The RAIB does not establish blame or liability, or carry out prosecutions.

Key definitions

- 3 All measurements in this report are given in metric units, except speeds and locations which are given in imperial units, in accordance with normal railway practice. Where appropriate the equivalent metric value is also given.
- 4 The report contains abbreviations and technical terms (shown in *italics* the first time they appear in the report). These are explained in appendices A and B.
- 5 References made to left and right are as viewed facing forwards in the direction of travel of the train involved in the accident.

The accident

Summary of the accident

- 6 At about 00:44 hrs on 26 August 2011, the fourth wagon from the rear of a freight train derailed just before Bordesley Junction, Birmingham (figure 1), while travelling at 11 mph (18 km/h). The train continued and the following three wagons were pulled into derailment at the junction. The four derailed wagons then ran foul of the adjacent line for 103 metres before they re-railed on a *crossover* (figure 2). The train finally stopped with its rear wagon 33 metres beyond the crossover.



Figure 1: Extract from Ordnance Survey map showing location of accident

- 7 During the derailment, another freight train was approaching on the adjacent line. This train stopped when its driver saw the signal for the junction change from green to red in front of him. He could also see clouds of dust from the rear of the train coming towards him. The two freight trains stopped alongside each other. Neither train driver was injured.
- 8 The rear four wagons which ran derailed suffered damage to their suspension and brake equipment. There was extensive damage to the track and signalling equipment at the junction.
- 9 The railway line through the junction remained closed while the train was repaired so it could be moved to a nearby siding, the track damage was repaired, and the signalling restored. A restricted service in one direction over the junction was implemented in the early hours of 27 August, with a full service running again on 28 August, albeit with an *emergency speed restriction* over the junction.

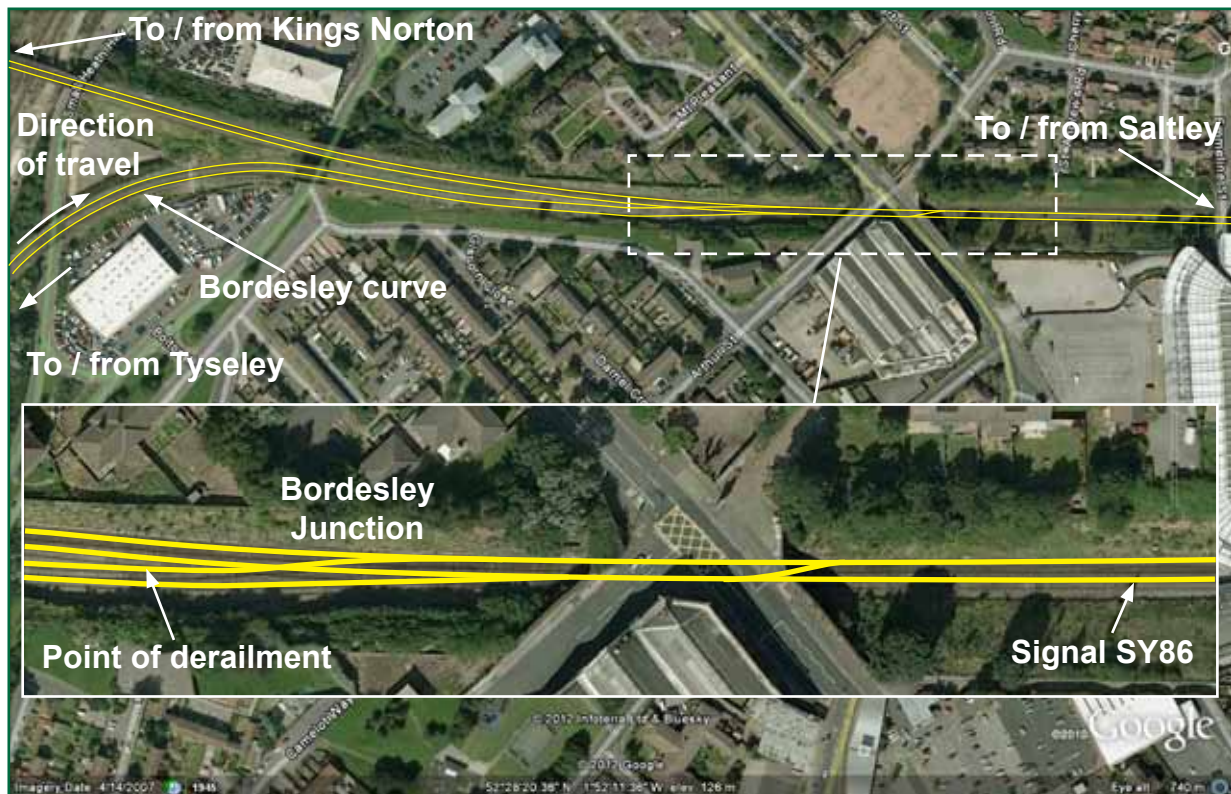


Figure 2: Google Earth view of accident site

Context

Location

- 10 Bordesley Junction is located near both Small Heath and Bordesley in Birmingham. The junction connects a long double track spur, referred to as the Up and Down Main (Bordesley) lines, which runs off the railway line between Leamington Spa and Birmingham Moor Street, to the double track railway line running between Saltley and Kings Norton, which is referred to as the Up and Down Camp Hill lines (figures 3 and 4). The junction is located at 128 miles 11 *chains* on the Main (Bordesley) lines, from a zero reference at Paddington station, and at 41 miles 44 chains on the Camp Hill lines, from a zero reference at London Road Junction, Derby.
- 11 The train was travelling on the Down Main (Bordesley) line and crossing onto the Up Camp Hill line (figure 4). This route over the junction has a *permitted speed* of 20 mph (32 km/h). The train travelled round a long right-hand curve, known as Bordesley curve, on a rising gradient to reach the junction but there are no steep gradients over the junction itself.
- 12 The track on the approach to the junction on the Down Main (Bordesley) line consists of *continuous welded rail* on concrete *sleepers*, changing to a jointed 20 metre section of rail on wooden sleepers. The other end of this rail section is connected to the junction itself. The *switches* and *crossings* at the junction are fastened to long wooden *bearers*. Signalling in the area is by the *track circuit block* system with *four aspect colour light signals*, and is controlled from Saltley power signal box.

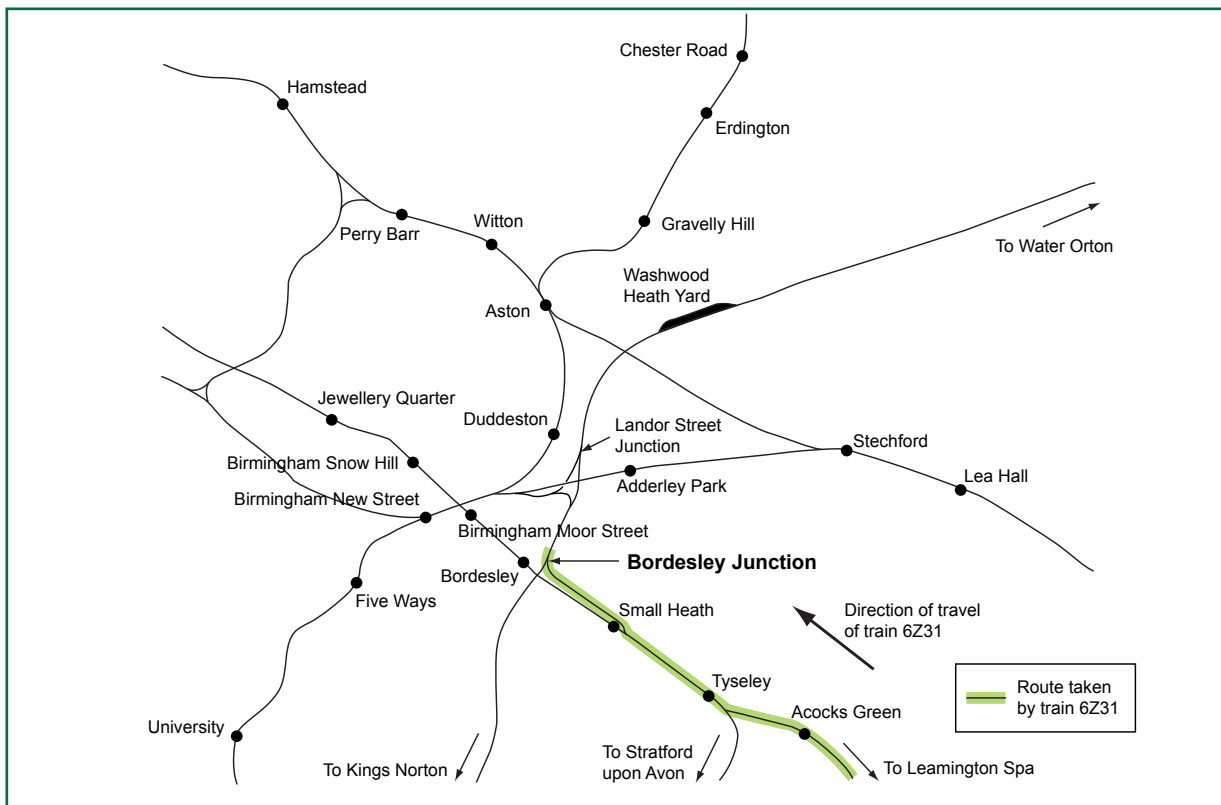


Figure 3: Railway lines and stations in the vicinity of Bordesley Junction

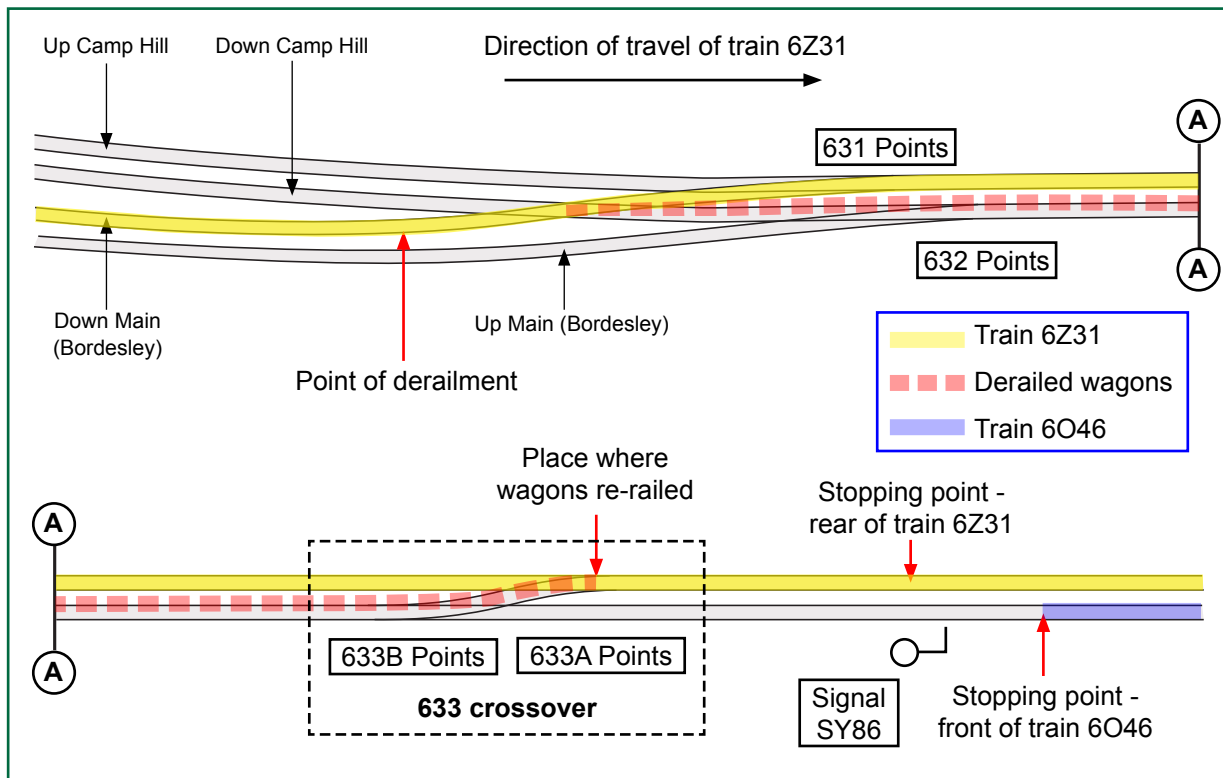


Figure 4: Track layout at Bordesley Junction and paths followed by trains

Organisations involved

- 13 Network Rail owns, operates and maintains the infrastructure. Both freight trains were operated by DB Schenker, who also employed the drivers.
- 14 Lafarge Aggregates Ltd owns the wagons that derailed and Wabtec Rail Limited is contracted to maintain them. Network Rail's Private Wagon Registration Agreement Management Group (PWRAMG)¹ gives approval for these wagons to operate over Network Rail's infrastructure.
- 15 Network Rail, DB Schenker, Lafarge and Wabtec freely co-operated with the investigation.

Train involved

- 16 The freight train that derailed was 6Z31, the 23:45 hrs service from Banbury Redland Stone sidings to Barrow-on-Soar. It consisted of a class 66 diesel electric locomotive hauling 30 two axle *hopper wagons*, type PHA, and an unloading wagon, type KJA (figure 5). The train was 290 metres long. All of the wagons were empty giving a trailing weight of 472 tonnes.



Figure 5: Train 6Z31 showing a PHA wagon (right), a KJA wagon (top left) and the locomotive (bottom left)

- 17 The freight train approaching on the adjacent line was 6O46, the 21:31 hrs service from Halewood to Southampton Docks.

Staff involved

- 18 The driver of train 6Z31 had signed on for duty at Saltley depot at 14:59 hrs on 25 August and had driven this train from Landor Street Junction (figure 3) to Banbury that afternoon. The driver had then brought it back that evening as train 6Z31 and was due to hand it over to another driver at Landor Street Junction. The driver of train 6O46 was based at Eastleigh and had taken this train forward from Walsall. The RAIB has found no evidence that the driving of either train contributed to the accident.

¹ Since this accident the Network Rail Private Wagon Registration Agreement Management Group has become a subsidiary company of Network Rail Infrastructure Limited, and is called the Network Certification Body.

- 19 The signaller was based at Sattley power signal box. The RAIB has found no evidence that the actions of the signaller contributed to the accident.

External circumstances

- 20 It was dark at the time of the accident. The local weather conditions that night was dry with cloudy spells. There had been no rain since a light shower during the mid-afternoon so the rails were dry.

Events preceding the accident

- 21 On 25 August, the Up and Down Main (Bordesley) lines and the track over the junction were inspected by Network Rail maintenance staff on foot. This was a planned *basic visual track inspection* that was due to take place that day. No problems were found by the staff that carried out this inspection.
- 22 During the previous week, the wagons that derailed had operated out of Lafarge's site at Barrow-on-Soar four times: to Peterborough and back on 18 August, to Broxbourne and back on 20 August, and to Chesterton (Cambridge) and back on both 23 and 24 August. Each time they had left Barrow-on-Soar loaded with aggregate and returned empty.
- 23 On 25 August, these wagons were again loaded with aggregate and were included in a 31 wagon train that departed from Barrow-on-Soar at 13:46 hrs as the late running train 6Z32, the 12:53 hrs service from Barrow-on-Soar to Banbury Redland Stone sidings. After an uneventful journey, this train arrived at Banbury at 17:04 hrs and was shunted into the sidings. During the evening the aggregate was discharged from the wagons and the train was prepared for its return journey. After the *train preparation* checks were completed, the train was ready to depart as train 6Z31 to Barrow-on-Soar. It left Banbury at 23:04 hrs.
- 24 Just over an hour into its journey, train 6Z31 arrived at Small Heath at 00:11 hrs on 26 August in the Down Goods loop where it was held for about 30 minutes to allow other trains to pass it. At 00:42 hrs, the train was signalled out of the loop and it moved onto the Down Main (Bordesley) line as far as the signal before Bordesley Junction. This signal was showing a red aspect so the driver applied the train's brakes and brought the train to a stand.
- 25 Just as train 6Z31 stopped at 00:43 hrs, the signal changed to show a proceed aspect for it to pass over the junction. The train was stationary for 15 seconds while the driver released the brakes and then applied traction. The train accelerated away from the signal and reached a maximum speed of 16 mph (26 km/h) as the front of the train approached the junction.
- 26 Once at the junction, the driver coasted to maintain the train's speed below 20 mph (32 km/h), as the train was now moving onto a falling gradient on the Up Camp Hill line. The train began to slow down as it passed over the junction and by the time the 28th wagon in the train, REDA 16066, was about 5 metres from the junction, the train's speed was down to 11 mph (18 km/h).

Events during the accident

- 27 As PHA wagon REDA 16066 approached the junction, the *flange* of its front right-hand wheel climbed onto the *rail head*, travelled along the top of the rail head for 3.6 metres, and then derailed to the right. The derailment occurred on *plain line*.
- 28 The rear *wheelset* of this wagon and all of the wheelsets of the next three PHA wagons at the rear of the train were then pulled into derailment as they reached the fixed crossing where the Down Main (Bordesley) line intersects the Down Camp Hill line. The driver felt a jolt from the train as it was passing through the junction, but this was not unusual when coasting over this junction.
- 29 All of the derailed wheels were guided by the rails after the crossing towards the path of the adjacent Down Camp Hill line. The rear right-hand wheel of REDA 16066 and all of the right-hand wheels of the rear three wagons then ran derailed in the *fourfoot* of this line. During this time, the wheels also struck 631 *points* and 632 points (figure 4), causing damage to them.
- 30 After about 100 metres, the derailed wheels were guided back towards the Up Camp Hill line by the rails that form crossover number 633 (figure 4). All of the derailed wheels then re-railed on the Up Camp Hill line at the *toes* of 633A points (figure 6). While these wheels ran derailed, ten sets of coil springs were dislodged from suspensions and found between the fixed crossing and 633A points. The springs were found at places where the derailed wheels were subjected to large vertical movements, such as where they had struck rails and been dragged over them.

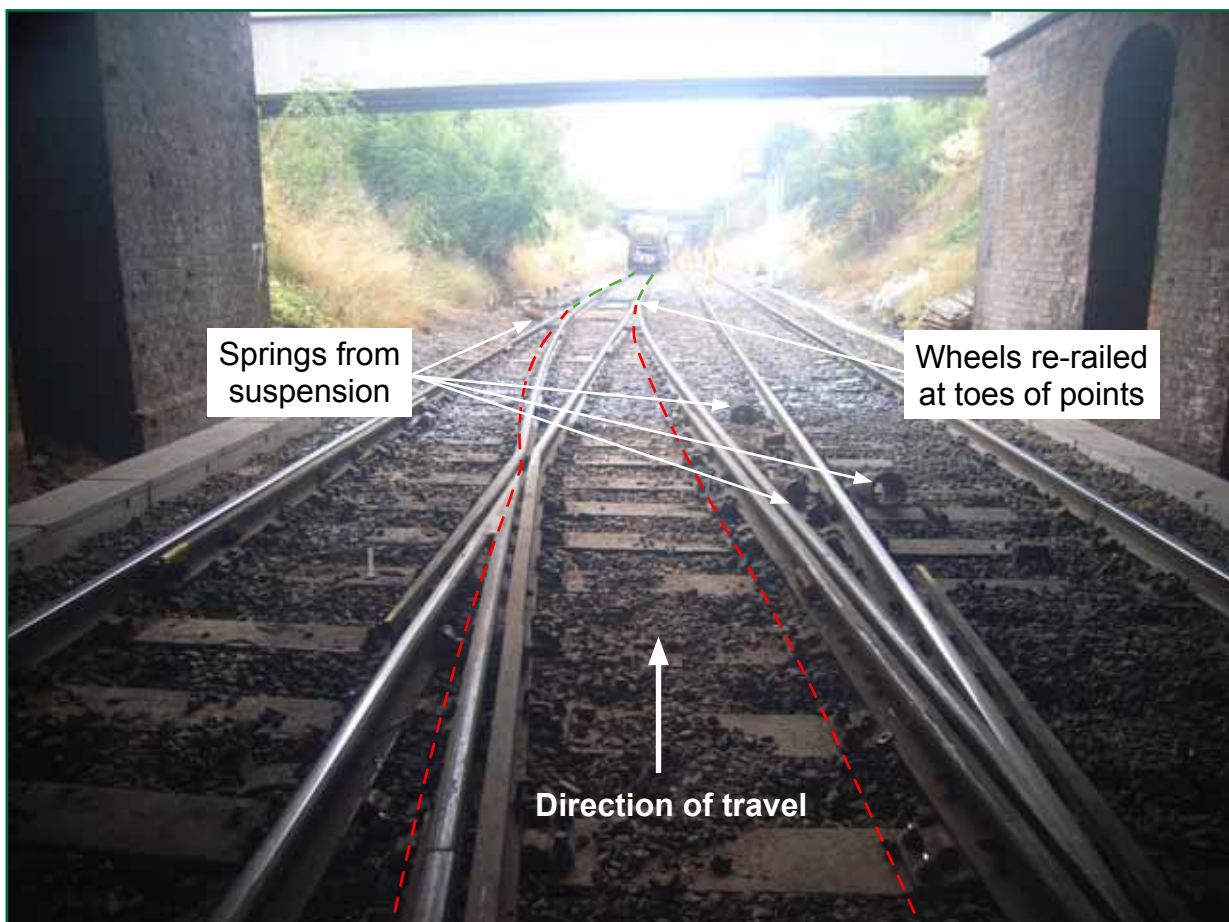


Figure 6: Crossing for 633A points where the wheels re-railed

- 31 As the train continued along the Up Camp Hill line, the driver realised that the train was slowing down and noticed that the train's *brake pipe* pressure was slowly falling, which was causing the brakes to apply. The driver attempted to release the brakes but the brake pipe pressure fell again so he brought the train to a stand. The train finally stopped at 00:45 hrs with the rear wagon about 33 metres from the toes of 633A points.
- 32 At the same time, train 6O46 was approaching on the Down Camp Hill at 11 mph (18 km/h) and was signalled onto the Up Main (Bordesley) line at the junction. The signal for the junction was showing a green aspect but this reverted to a red aspect in front of the train when 631 and 632 points were damaged. The driver of train 6O46 saw the signal aspect change and noticed clouds of dust obscuring the rear of train 6Z31. He immediately applied the brakes, brought his train to a stand alongside train 6Z31 and called the signaller to report what had happened.

Events following the accident

- 33 The signaller was already aware of a potential problem with train 6Z31 when he received the call from the driver of train 6O46. The signaller had observed on his panel that 632 and 633 points were not being detected in their correct positions and three *track circuits* were showing they were occupied by a train when they should not have been. The signaller took steps to confirm train 6O46 was now at a stand and instructed its driver not to move his train. He also confirmed that train 6Z31 was at a stand.
- 34 Meanwhile the driver of train 6Z31 also called the signaller as he wanted to examine his train. The signaller instructed him not to move train 6Z31 and advised him that train 6O46 had also been instructed not to move. The driver examined train 6Z31 and found that although the rear four wagons were on the rails, their wheels showed signs of having run derailed and there was damage to their suspension. He also walked back towards the junction and found damage to the track and various springs that had fallen from his train. He relayed this information back to the signaller.
- 35 Staff at Saltley power signal box advised Network Rail control of the derailment and control began mobilising staff to Bordesley Junction. The RAIB was advised at 01:37 hrs and deployed inspectors to the site; arriving at 03:45 hrs. A staged release of the train and track took place during the day; the train was released by 09:05 hrs and the whole site by 15:45 hrs.
- 36 Staff from DB Schenker and Wabtec carried out emergency repairs to the wagons on site and at 19:26 hrs train 6Z31 was authorised to move to sidings at Washwood Heath yard (figure 3) at a maximum speed of 20 mph (32 km/h). It arrived in the sidings at 19:57 hrs, where the rear five wagons were detached before the remainder of train 6Z31 continued to Barrow-on-Soar.
- 37 Network Rail staff carried out repairs to the track and signalling throughout 26 August, and the route from Saltley towards Leamington Spa was returned to service at 05:17 hrs on 27 August. After Network Rail completed further repair work, the route between Bordesley Junction and Kings Norton was reopened at 10:21 hrs on 28 August, but with a 20 mph (32 km/h) emergency speed restriction imposed by Network Rail on all routes over the junction.

The investigation

Sources of evidence

38 The following sources of evidence were used:

- witness interviews and staff reports;
- Network Rail's and DB Schenker's control logs;
- data from the *on-train data recorders* fitted to both trains;
- site photographs and measurements including surveys of the track geometry;
- detailed examination of the wagons' suspension components;
- maintenance records for the PHA wagons;
- maintenance procedures for the wagons;
- test reports and information relating to PHA wagons held by Network Rail's PWRAMG;
- Network Rail's maintenance records of track inspections and work carried out at Bordesley Junction;
- data recorded by Network Rail's *track geometry recording trains*; and
- a review of previous RAIB investigations that had relevance to this accident.

Key facts and analysis

Background information

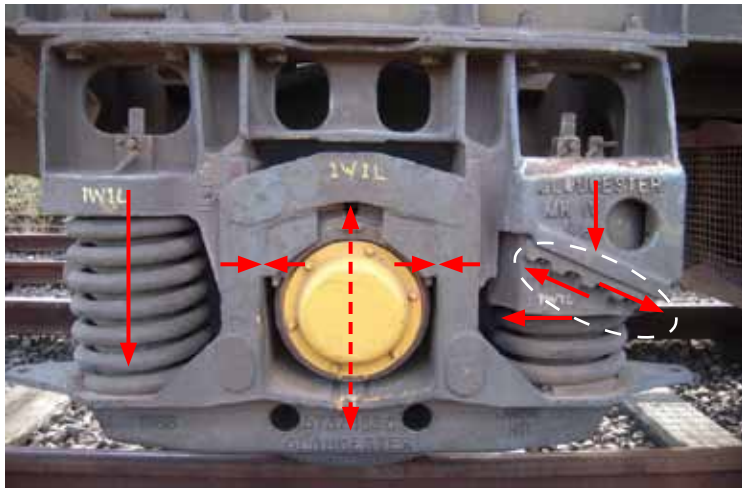
Track twist

- 39 *Track twist* is the variation in *cant* over a given distance, where *cant* is a measure of the height that one rail of a track is above the other. The amount of track twist is usually expressed as the rate of change of *cant*, or gradient, over this distance and expressed as a value of 1 in x. Ideally, the *cant* is measured when the track is under load from a train, so the *dynamic track twist* can be determined.
- 40 Network Rail standards and processes for track inspection and maintenance call for track twist to be measured over a base distance of 3 metres and all limits for track twist are based on this. For example, a track twist limit of 1 in 200 would represent a difference of 15 mm between two *cant* readings taken 3 metres apart.

PHA and KJA wagons

- 41 The PHA wagons were introduced in the late 1980s for the transfer of *ballast* and other aggregates between sites, into other wagons or directly onto the trackside. There is a rubber conveyer belt system running below the hopper of each PHA wagon, so material can be discharged from each wagon, onto the belt and deposited directly behind the train. Alternatively, it can be passed onto a KJA wagon which has a conveyor arm for unloading material at any site immediately adjacent to the track. It is also known as the *self-discharge train* (SDT) and its main uses are for moving aggregate between different Lafarge sites or to track renewals, track replacements or *earthworks* sites.
- 42 Powell Duffryn and Standard Wagon Company built the PHA wagons in 1988 and supplied them to Redland Aggregates Limited, which was purchased by Lafarge in 1997. The PHA wagons are still owned by Lafarge and operate on Network Rail's infrastructure under a private wagon registration agreement (paragraphs 47 to 52). They are often hauled by DB Schenker's locomotives and maintained on behalf of Lafarge by Wabtec at Barrow-on-Soar. At the time of this accident, there were 114 PHA wagons and 4 KJA discharge wagons registered for operation on Network Rail infrastructure.
- 43 The PHA wagon is a two axle vehicle with a hopper that sits on a rigid frame. There are four variants in the PHA fleet, with differing lengths, weights, distances between wheelsets and equipment for the conveyor belt system. The conveyor belt running under each hopper means that the wagons are semi-permanently coupled in sets of five or ten wagons, using *bar couplings*. Each set measures about 42 or 82 metres in length respectively. The outer wagons in each set are fitted with buffers and can be coupled to other sets or locomotives by *screw couplings*. The design gives the wagon a higher than usual centre of gravity for an aggregate hopper wagon.
- 44 The suspension used by the PHA wagon was manufactured by the Gloucester Railway Carriage and Wagon Company in 1987 and is known as a Mark 4 Floating Axle Suspension (figure 7). This suspension unit has a *pedestal* (also known as an axle horn guide) bolted to the underside of the frame. A *saddle* sits on the axle bearing and slots into the pedestal.

Forces within the suspension



Wedge between pedestal and damper pot to convert vertical force into a horizontal force which damps movement of the saddle

The suspension components

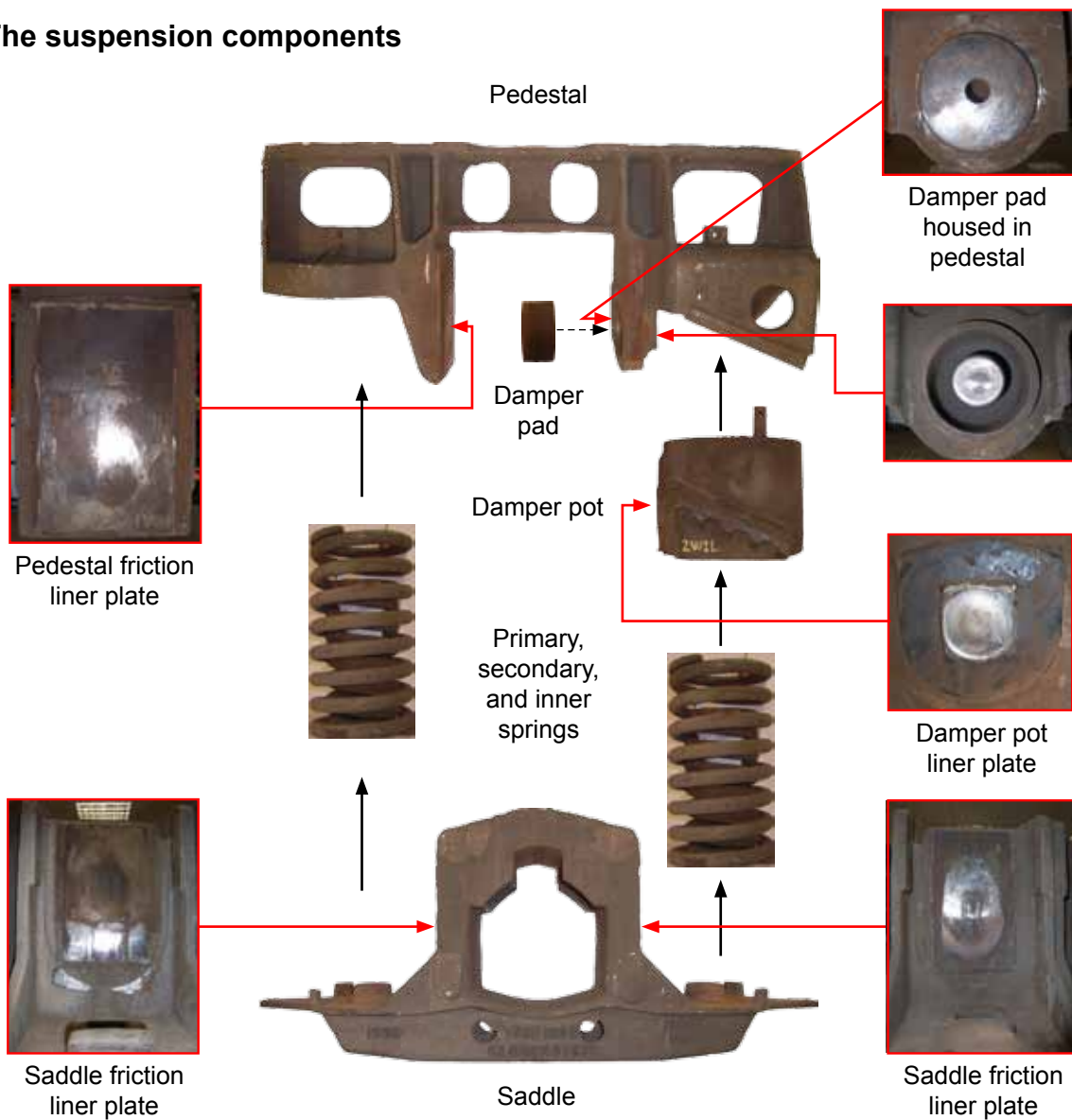


Figure 7: The Mark 4 Floating Axle Suspension

- 45 The saddle supports primary, secondary and inner top hat or 'cup' springs. The spring arrangement is fixed with a retaining pin known as an 'anti-separation pin' running through the centre. The springs are located between the pedestal and the saddle and are compressed by the weight of the wagon.
- 46 On the inner side of the saddle, a *damper pot* is located between the top of the springs and the pedestal. The weight of the wagon and its payload acts upon a pair of wedges between the pedestal and the damper pot. The damper pot converts the downwards force into a horizontal force which pushes a *damper pad*, housed inside a hole in the pedestal, against a friction liner plate on the saddle, to damp the vertical movement of the saddle. The damping force thus changes according to the load.

Private Wagon Registration Agreement (PWRA)

- 47 Privately owned wagons have been operated on Britain's main line railway network since the 1840s. The present agreements governing the use of PHA wagons were implemented in the early 1990s and have remained in force after the privatisation of the railways. Currently, for any privately owned wagon to operate over infrastructure that is managed by Network Rail, it must be the subject of a private wagon registration agreement (PWRA). Railway undertakings that own wagons but also operate freight trains are subject to separate arrangements. To operate their wagons over infrastructure that is managed by Network Rail, these undertakings require safety certification under The Railways and Other Guided Transport Systems (Safety) Regulations 2006, which provide the regulatory regime for rail safety and are enforced by the ORR.
- 48 The use of private wagon registration agreements evolved during the late 1980s to encourage private wagon operators to use the rail network and ensure they all worked to common standards. A private wagon registration agreement is a legally binding contract between Network Rail and the private owner and can only be terminated with the agreement of both parties. The PWRA identifies the legal responsibilities and duties of private wagon owners and Network Rail. Private wagon owners must ensure that their wagons are maintained, repaired and tested in accordance with current regulations. They must also ensure that all new designs and modifications to their wagons are approved and notify Network Rail's PWRAMG of any changes.
- 49 Network Rail's PWRAMG comprises a small group of engineers. Although it is part of Network Rail, it is funded directly by the Department for Transport (with funding currently in place to the end of March 2014). Under the agreements, the PWRAMG:
- reviews the maintenance regimes that private wagon owners have for their wagons;
 - monitors the performance of these wagons, looking at any incidents or failures that happen when in service;
 - mandates the standards and regulations that must be complied with;
 - registers individual privately owned wagons under the agreement including their entry onto railway systems such as the national vehicle register;
 - acts as the expert engineer for technical investigations and for progressing investigation recommendations; and

- meets with the railway undertakings, who provide the locomotives and staff to operate privately owned wagons over the national network, as the railway undertakings' safety management systems for this type of work rely on the PWRAMG carrying out its duties and responsibilities.
- 50 Network Rail's PWRAMG also audits the owners and maintainers of private wagons. There is a biennial audit of the headquarters of each private wagon owner to confirm it has procedures in place to manage and maintain its wagons and is controlling their management and maintenance in accordance with the PWRA agreement. Similarly there is a bi-annual audit on the headquarters of each maintainer. There is also a biennial maintenance site audit to confirm that the maintainers have competent staff for undertaking safety critical work and that they have appropriate facilities, documentation, tools and equipment to enable them to meet their maintenance requirements. Finally, there is a bi-annual asset condition check audit which looks at the condition of a selection of wagons within a fleet against their approved maintenance plans. It also checks compliance with the appropriate parts of the PWRA, private owner circulation letters (POCLs), and railway group standards.
 - 51 POCLs are prepared, approved and distributed by the PWRAMG on an "as required" basis. POCLs are issued to private wagon owners and state the actions that must be taken in response to any changes to procedures, changes to railway group standards affecting their rolling stock or recommendations from incidents or investigations. Under the PWRA, the instructions within a POCL are mandatory, so all private wagon owners must comply with them.
 - 52 The current PWRAs, which were in place at the time of this accident, will need to change as a result of European Railway Safety Directive 2004/49/EC (as amended by European Railway Safety Directive 2008/110/EC) which will require all vehicles to be assigned to an entity in charge of maintenance. Consequently, the future relationship between Network Rail and such private wagon owners is currently the subject of ongoing discussion.

Identification of the immediate cause²

- 53 **The leading right-hand wheel flange on wagon REDA 16066 climbed onto the rail head and then derailed to the right. This was due to a combination of factors related to the suspension on wagon REDA 16066 and the track geometry at Bordesley Junction.**
- 54 The RAIB found marks on the right-hand running rail that showed a wheel flange had climbed and run along the top of the rail for 3.6 metres before derailing to the right (figure 8). The RAIB did not find any other derailment marks on the track before this point.
- 55 The RAIB found no evidence or damage to the preceding wagons to indicate that they had run derailed; none of the wagons before REDA 16066 had scuff marks on their wheels caused by running on ballast. Only the rear four wagons had damage to their suspension.

² The condition, event or behaviour that directly resulted in the occurrence.



Figure 8: Point of derailment on the approach to the junction

- 56 The track where the leading right-hand wheel of REDA 16066 derailed was on a left-hand curve, and also canted with the right-hand rail higher than the left-hand rail. Both of these factors alter the angle at which the wheel flange makes contact with the running rail and make the leading right-hand wheel more prone to a *flange climb* derailment. These same factors also make it very unlikely that the trailing right-hand wheel on this wagon was the first wheel to derail.
- 57 The RAIB examined the marks on the track after the initial point of derailment and the couplings on the wagons. This evidence indicates that the following wagons were pulled into derailment at the fixed crossing where the Down Main (Bordesley) intersects the Down Camp Hill line. There is no evidence that the wagons behind REDA 16066 pulled it into derailment.

Identification of causal³ and underlying factors⁴

- 58 The derailment occurred due to a combination of a factors related to the suspension on wagon REDA 16066 and the track geometry at Bordesley Junction. These factors are discussed in the following sections.

The suspension on REDA 16066

- 59 **The suspension of the trailing left-hand wheel on wagon REDA 16066 probably became locked-up (figure 9) when it passed over track geometry that increased the dynamic load on it, which then reduced the load on the leading right-hand wheel at the point of derailment. This was a causal factor.**

³ Any condition, event or behaviour that was necessary for the occurrence. Avoiding or eliminating any one of these factors would have prevented it happening.

⁴ Any factors associated with the overall management systems, organisational arrangements or the regulatory structure.

- 60 Before the point where it derailed, REDA 16066 passed over track geometry that would have caused its trailing left-hand wheel to carry increased dynamic load. It is probable that this occurred at a track twist that the RAIB found about 8 metres before the point of derailment. At this location, the RAIB measured a 3 metre dynamic track twist of 1 in 193 (cant difference of 16 mm) and a dynamic twist of 1 in 212 (cant difference of 23 mm) over the wheelbase of the wagon (which is 4.775 metres).
- 61 When a wheel is loaded, the suspension on a PHA wagon reacts by allowing the saddle that sits on the end of the axle bearing to be pushed up inside the pedestal (figure 10). This meant that the track twist measured 8 metres before the point of derailment would have pushed the saddle on this corner up inside the pedestal by 23 mm relative to the other corners.

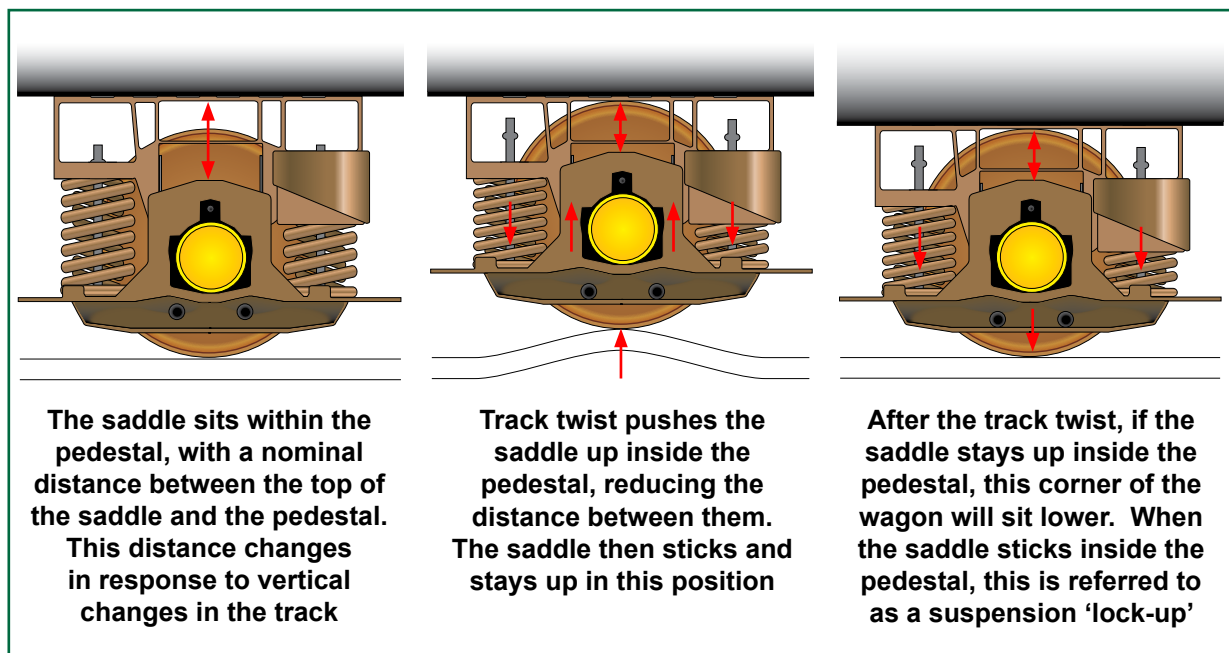


Figure 9: No vertical movement of the saddle within the suspension - a lock-up

- 62 When operating as designed, the saddle will move back down inside the pedestal as the dynamic wheel load reduces after the track twist. However, if the saddle sticks and stops moving inside the pedestal, this is commonly referred to as a suspension 'lock-up' (figure 9). All types of suspension which rely on friction to provide their damping have the potential to lock-up but the PWRAMG had investigated the specific problem of suspension lock-ups on PHA wagons after an accident at Ely Dock Junction (paragraph 147). The PWRAMG had identified a mechanism where a lock-up could occur on this type of suspension when the outer edge of the damper pad makes contact with a groove created by hollow wear on the saddle friction liner plate (figure 11). The damper pad could become wedged against the saddle friction liner plate, stopping the saddle from moving up or down.

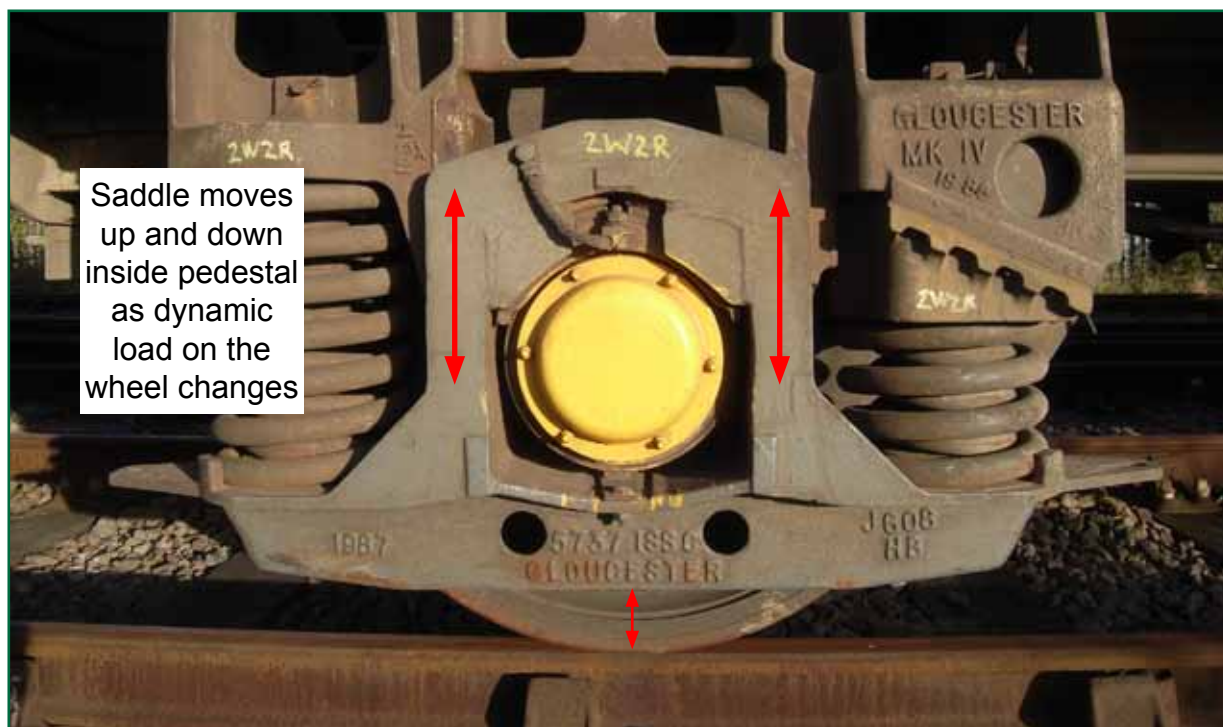


Figure 10: Vertical movement of the saddle within the suspension

- 63 The RAIB's examination of the suspension components on the trailing left-hand corner of REDA 16066 found a groove worn into the saddle friction liner plate to a depth of 1.8 mm, uneven wear on the damper pad's face and also wear on the damper pot liner wear plate that was beyond the permitted maintenance limit (figure 11). The wear found on these components was consistent with the previous findings of the PWRAMG, which showed that such wear patterns would probably have caused the saddle to stick inside the pedestal in the loaded position.

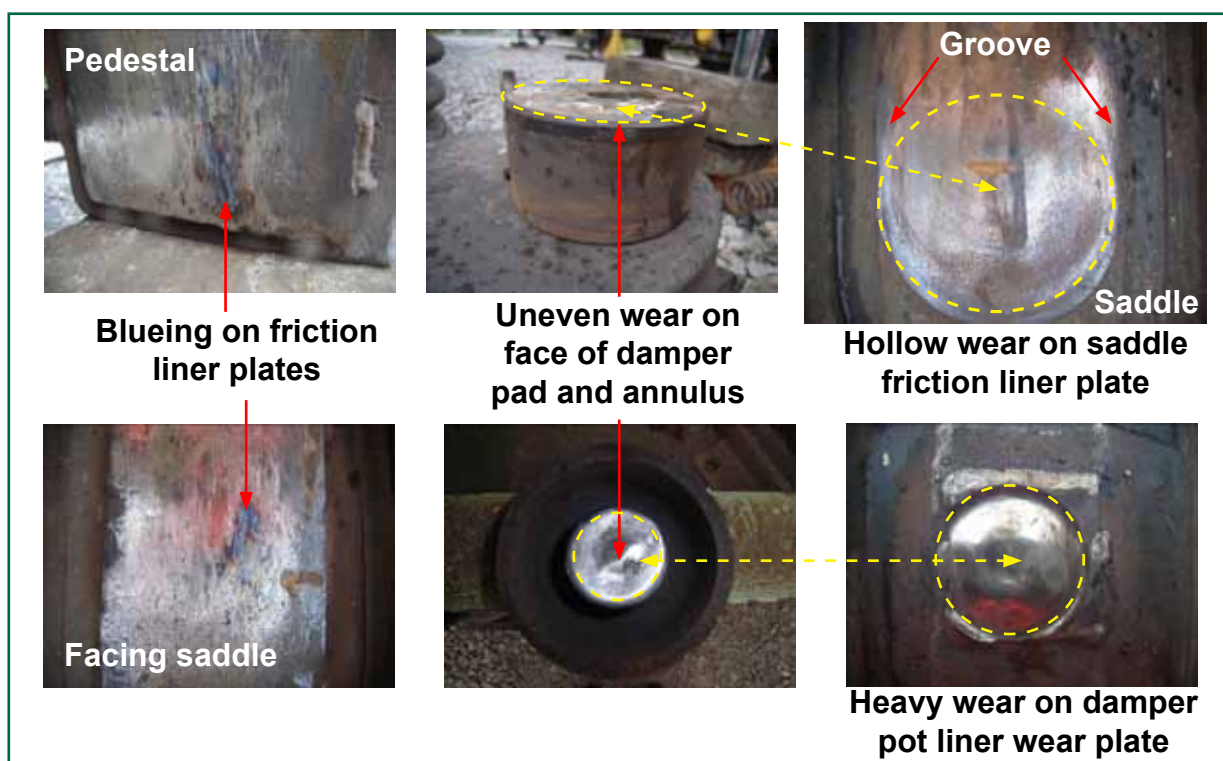


Figure 11: Components found on REDA 16066's trailing left-hand corner suspension

- 64 The RAIB also found blueing on the pedestal friction liner plate and facing saddle friction liner plate (figure 11). This occurs when the material becomes heated to a temperature of about 300°C. Friction heating can occur when the two surfaces are pushed hard against each other and rub under load. It is a sign that the suspension had not been working normally and is often found after a wheel has run derailed.
- 65 Calculations showed that when a suspension lock-up occurs, the stiffness of the PHA wagon's frame allows wheel load to be transferred from the locked-up and diagonally opposite corner to the other two corners. As a consequence, if the suspension on the trailing left-hand corner of REDA 16066 locked-up in a loaded state, load will be transferred away from it and also the wagon's leading right-hand wheel (figure 12). With a reduced load on the leading right-hand wheel of REDA 16066, this wheel is then much more susceptible to derailing when a track twist is encountered that further reduces the load on it.

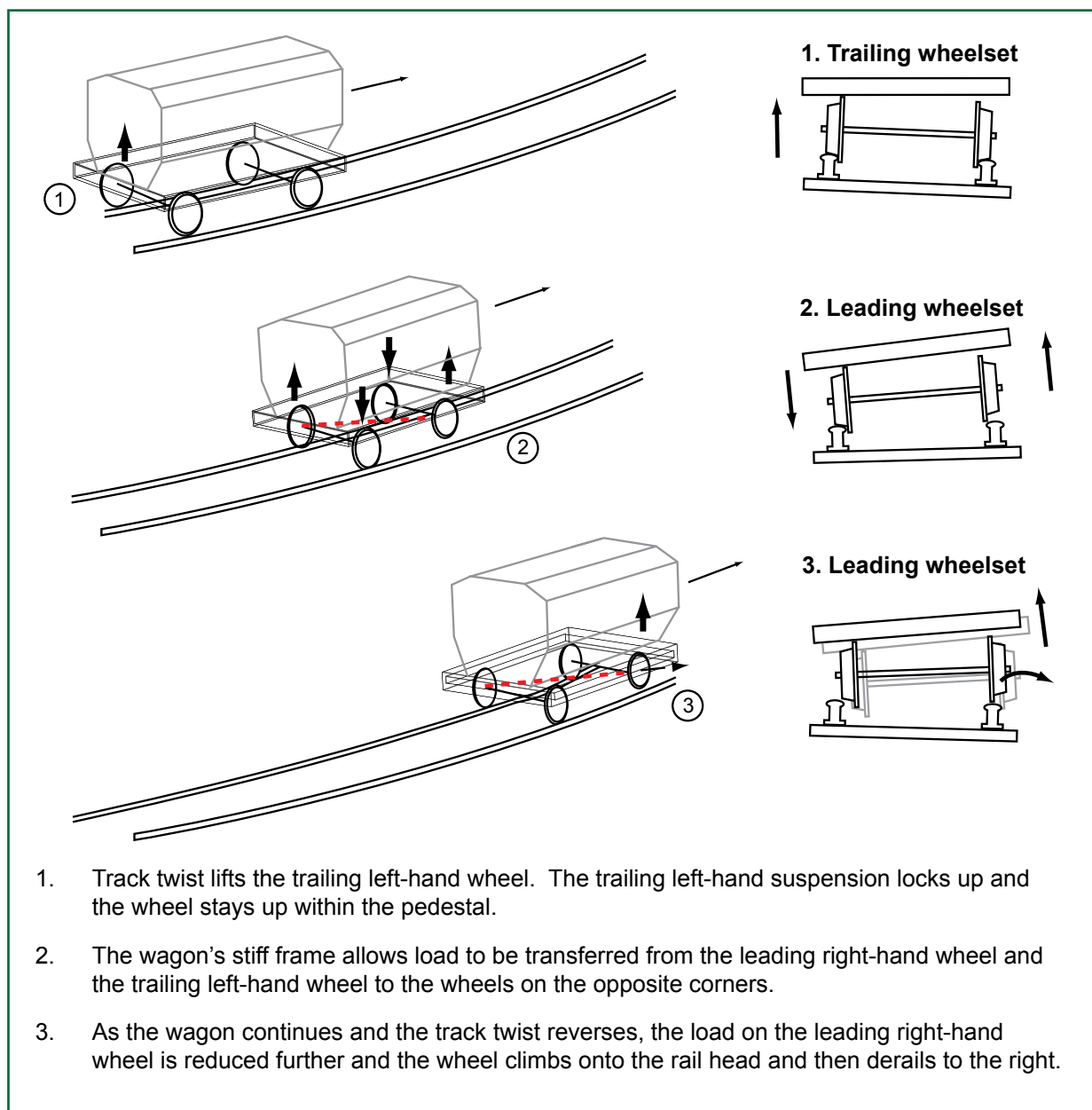


Figure 12: Transfer of wheel load on REDA 16066

- 66 The RAIB discounted the possibility that the suspension on any of the other corners of REDA 16066 had caused the wheel unloading because no evidence of a defect or unusual wear was found during a detailed examination of their components.
- 67 Other factors that were discounted as a cause of wheel unloading were:
- frame twist - the RAIB measured 4.5 mm of twist in the frame of REDA 16066, which would not have had a significant effect on the load on the wheel and was below the maintenance limit of 6 mm that required any action to be taken; and
 - offset load - the wagon's hopper was completely empty.

Maintenance of the suspension on PHA wagons

68 The maintenance process for the suspension of REDA 16066 did not detect and rectify the worn suspension components on the trailing left-hand corner. This was a causal factor.

- 69 The maintenance records for REDA 16066 show that this wagon was being maintained by Wabtec in accordance with its maintenance plans⁵. The wagons undergo an annual *vehicle inspection and brake test* (VIBT) and two *planned preventative maintenance* (PPM) examinations every four months in between. The vehicles also have a *balanced maintenance* (BM) examination about every two years. The BM examination is mileage based and aims to identify components that require attention or returning to a nominal condition during their time in service, avoiding the need for a major repair during the wagon's life.
- 70 Wabtec maintenance staff follow instructions for each type of examination. The PPM and VIBT examinations instructions call for specific components within the suspension to be examined. However, some were not fully visible or could not be measured unless the suspension was disassembled by lifting the wagon and taking the wheelset out. This is something that only happens routinely during a BM examination or can happen if a problem requiring the wagon to be lifted is found during a VIBT or PPM examination.
- 71 REDA 16066 was last lifted in October 2010 during a PPM examination, to allow work to be done on the leading and trailing suspensions on the right-hand side. There is no record of any work being done to the trailing corner on the left-hand side, which Wabtec designate as corner 3. Wabtec's records show the last time corner 3 was examined was during a BM examination in February 2010. All components passed their examination except for the damper pot liner wear plate, which was renewed.
- 72 When the wagon is not lifted, staff assess the overall amount of wear within the suspension by taking a single measurement between the pedestal casting and the damper pot (figure 13). This distance is referred to as the damper pad clearance and the instructions allow a minimum distance of 8 mm. In February 2010 the clearance was 16 mm, and marked as a pass when the last VIBT and PPM examination took place. After the accident, the clearance was measured as 15 mm. However, post-accident repairs to the suspension to allow the wagon to be moved, meant this measurement was not representative of the condition before the derailment.

⁵ Lafarge contract Wabtec to maintain the PHA wagon fleet. Under this contract, Wabtec document the maintenance regime to be followed in a series of maintenance plans, which are reviewed by the PWRAMG and certified by a *vehicle acceptance body*.

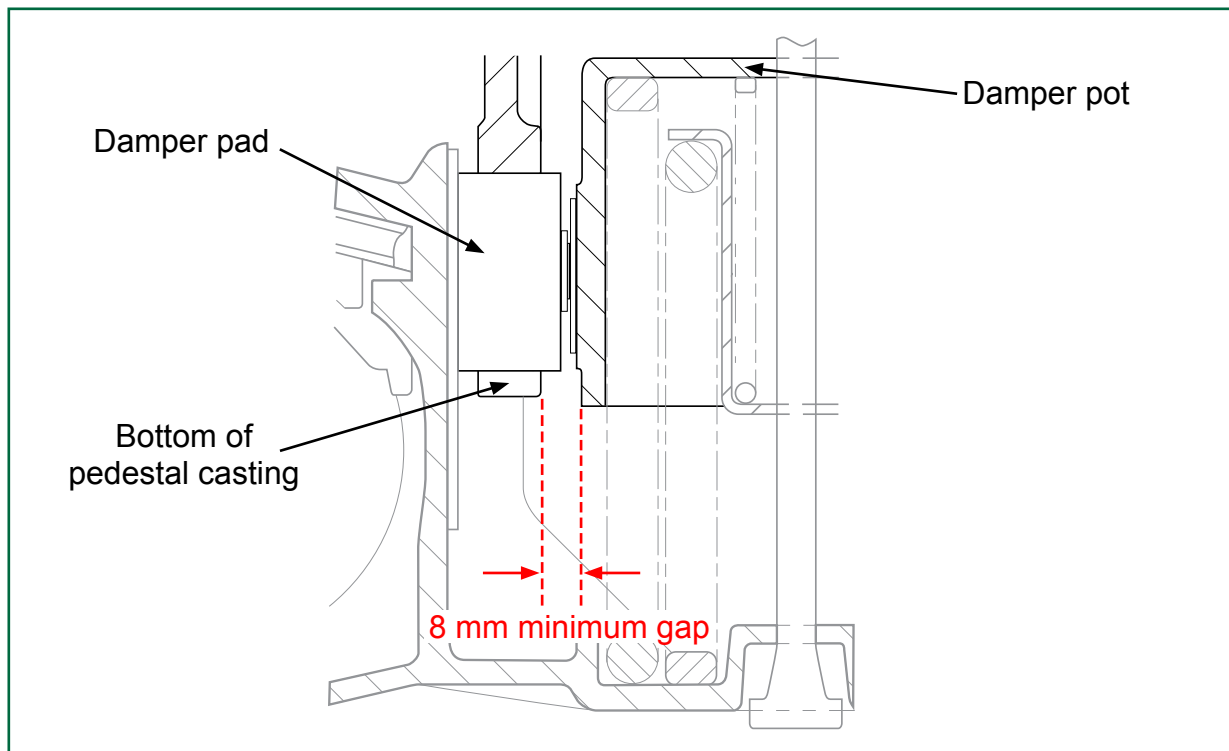


Figure 13: Damper pot clearance measurement

- 73 When the RAIB examined the suspension components on each corner of REDA 16066 in detail, most of the components were within their prescribed maintenance limits except for the damper pot liner wear plate on the trailing left-hand wheel's suspension which was worn beyond its maintenance limit. On this suspension, the RAIB also found hollow wear on the saddle friction liner plate where the damper pad rubbed against it and uneven wear on the damper pad face, with more wear towards its outer edge (paragraph 62). The maintenance instructions give overall limits for wear but do not specifically mention limits for hollow wear or uneven wear.
- 74 While the prescribed maintenance process for REDA 16066 was being complied with, this did not lead the maintainers to identify and change worn components within the suspension before this wear increased the likelihood of the suspension locking-up.

Actions taken after the accident at Ely Dock Junction

- 75 **No changes had been made to the suspension on REDA 16066 or the way in which it was operated or maintained, following testing in 2009 which showed that the suspension on PHA wagons was prone to locking-up. This is a causal factor.**
- 76 The RAIB investigated an accident at Ely Dock Junction⁶ (paragraph 147) and issued a report in January 2009 which included a recommendation (paragraph 160) that recommended that Network Rail and PHA wagon owners should look at the risk of the PHA wagon's suspension locking-up and then causing a derailment. This led to Network Rail's PWRAMG initiating a programme of testing work to investigate how often, and for how long, the suspension on the PHA wagons might lock-up when running in service.

⁶ See RAIB report 02/2009, Derailment at Ely Dock Junction 22 June 2007.

- 77 During 2009, Network Rail's PWRAMG commissioned Serco to measure the movement of the PHA wagon's suspension when in running in service. Lafarge gave its permission for instrumentation to be fitted to five wagons within a set of ten. A transducer was fitted to each corner of the five wagons (figure 14) which measured the vertical movement of the saddle within the pedestal in steps of 0.1 mm. The data from each transducer was recorded by a data logger that was housed on one of the wagons. The logger also included a *global positioning system* (GPS) device so that date, time, location and speed information could be recorded at the same time.



Figure 14: Instrumentation fitted to the PHA wagons that were tested (image courtesy of Serco)

- 78 The instrumented wagons were released for general use within the rest of the fleet from mid June 2009 to the start of August 2009, and were typically used for two journeys each week. Serco regularly downloaded the data and analysed it to look for instances where the transducer was recording 0 mm movement. Algorithms were used to filter the data as shown in table 1.

Filter	Criteria for data to be excluded	Reason
1	Train speed less than 20 mph (32 km/h)	Remove any data where train may have been in a siding rather than out on a running line
2	Train speed decreasing when speed above 20 mph (32 km/h)	Remove any data when the train may have been braking as the suspension's movement is affected when the brake blocks are clamped against the wagon's wheels
3	Any instances of no movement that lasted for less than 10 seconds	There must be no vertical movement of the saddle within the pedestal for at least 10 seconds for it to be counted as a suspension lock-up

Table 1: Filtering applied to the data to look for instances of suspension lock-up

- 79 The filtered results were published in a report issued by Serco in December 2009. They showed 656 instances during 14 journeys in which a suspension had locked-up. The results also showed that some could last for a long time: one lock-up lasted for 178 seconds. No pattern could be found to suggest when a suspension would lock-up. Lock-ups happened over a range of speeds, when a wagon was loaded or empty and when travelling in either direction.
- 80 Witness evidence from staff within the PWRAMG, Lafarge and Wabtec indicated surprise at the number of lock-ups that were recorded and from December 2009, they set about identifying and agreeing changes that could be made to the suspension components and the maintenance regime. However, by the time of the accident in August 2011:
- no modifications had been made to the suspension on REDA 16066;
 - the way in which the PHA wagon fleet was operated on the national network had not been reassessed; and
 - no formal changes had been made to the wagons' maintenance regime.

Modifications to the suspension

81 Modifications that had been shown to reduce the frequency of lock-ups had not been made to the suspension on REDA 16066.

- 82 At the end of 2009 and beginning of 2010, the Network Rail PWRAMG had identified a number of changes that could be made to the suspension components on a PHA wagon to reduce the likelihood of the suspension locking-up. These were:
- reducing the width of the saddle friction liner plate by 20 mm; and
 - reducing the size of the weld bead used to hold this plate onto the saddle from 6 mm to 3 mm.
- 83 By making these changes, the saddle friction liner plate width was reduced to a size similar to the diameter of the damper pad, which stopped a hollow groove from being worn into the plate. The weld bead was reduced in size to stop the damper pad from making contact with the weld material, as this could affect the friction damping within the suspension (the weld material will work harden over time and because it has different friction characteristics to the plate it could interfere with the damper pad's movement).
- 84 In April 2010, the suspension modifications were made to two PHA wagons in the set of ten wagons used for the first set of tests. The suspension components on two other wagons in this set were also replaced with unmodified ones, so their suspensions were also in an unworn state to allow a like for like comparison to be made. Serco instrumented the two modified and two unmodified wagons and this set was then released for general use within the fleet. Data recorded at the same time for these four wagons, during four separate weeks between May and September 2010, was downloaded and analysed. The data was filtered using the same algorithms used for the first set of tests (see table 1). The analysis was then repeated using data when the train was travelling faster than 15 mph (24 km/h).

- 85 The filtered results were published in a report issued by Serco in December 2010. The results showed that the modifications had not eliminated the problem of suspension lock-ups, as they were still happening on the modified wagons. However, the number of lock-ups was reduced by up to 75% compared with the unmodified wagons. The average duration of a lock-up on a modified wagon was also reduced by up to 24% when laden, but the duration was about the same on both modified and unmodified wagons when in their unladen condition.
- 86 At the request of Lafarge, the modified wagons were left to run in service before a fleet wide implementation of the modifications took place. This was to allow for assessment of any longer term consequences of making these changes, and assurance that the modified suspension would continue to work as expected without unforeseen longer term problems. Lafarge had wanted the modified wagons to be instrumented so their performance in service could be tested but this did not take place. Instead the PWRAMG decided to carry out a visual inspection of the modified suspension components to assess their performance. Neither the PWRAMG nor Lafarge set a timescale for this assessment to be completed, so by the time of the accident no other PHA wagons had modified suspensions.
- 87 In January 2012, after about 18 months of running in service, the PWRAMG assessed the suspension components on the wagons which had been modified and found no problems with them. Lafarge subsequently decided that the wagons' suspensions should be modified ahead of any wear limits being reached and instructed Wabtec to source a float of suspension components and plan a campaign change to the fleet (paragraph 145).

Reassessment of continued operation

88 Neither Lafarge nor Network Rail's PWRAMG assessed the risk of continuing to operate the PHA wagon fleet while the work to develop, test and implement the modifications was outstanding.

- 89 From December 2009, both Lafarge and Network Rail's PWRAMG knew from the testing that these wagons were prone to suspension lock-ups, but the PHA wagon fleet continued running in service.
- 90 Both parties, along with Wabtec, held meetings to discuss the cause of the lock-ups and identify what engineering changes could be made to address the problem. There are no records from these meetings to show that the risk of continuing to operate the PHA fleet was discussed in any detail. From the discussions that did take place, it appears that there was no quantified assessment of the ongoing risk and no action was taken. Lafarge expected the PWRAMG or Wabtec to alert it to any action it needed to take, but nothing was said so the fleet continued to operate as before. The PWRAMG was focused solely on engineering changes to the suspension and wanted to better understand the cause before mandating any major fleet wide changes that could have had the potential to increase the risk or introduce an unknown risk.
- 91 Lafarge and the PWRAMG continued to manage the in-service performance of the PHA fleet at quarterly performance review meetings, looking at incidents and in-service failures. Based on the incident and failure data for the fleet, they decided that no further action was needed.

Formal changes to the maintenance regime

92 **Network Rail's PWRAMG had identified new maintenance checks for suspension component wear but these had not been mandated before REDA 16066's last maintenance examination.**

93 In late 2009, as part of the work to address the RAIB recommendation from Ely Dock Junction (paragraph 76), Network Rail's PWRAMG also identified two new maintenance checks that could be carried out to identify worn components which it believed were the likely cause of suspension lock-ups. One check was to look for a minimum gap of 3 mm between the back of the damper pad and the damper pot (figure 15). The second check called for hollow wear on the saddle friction liner plate to be measured. If the hollow wear was deeper than 1.5 mm the friction liner plate was to be replaced.

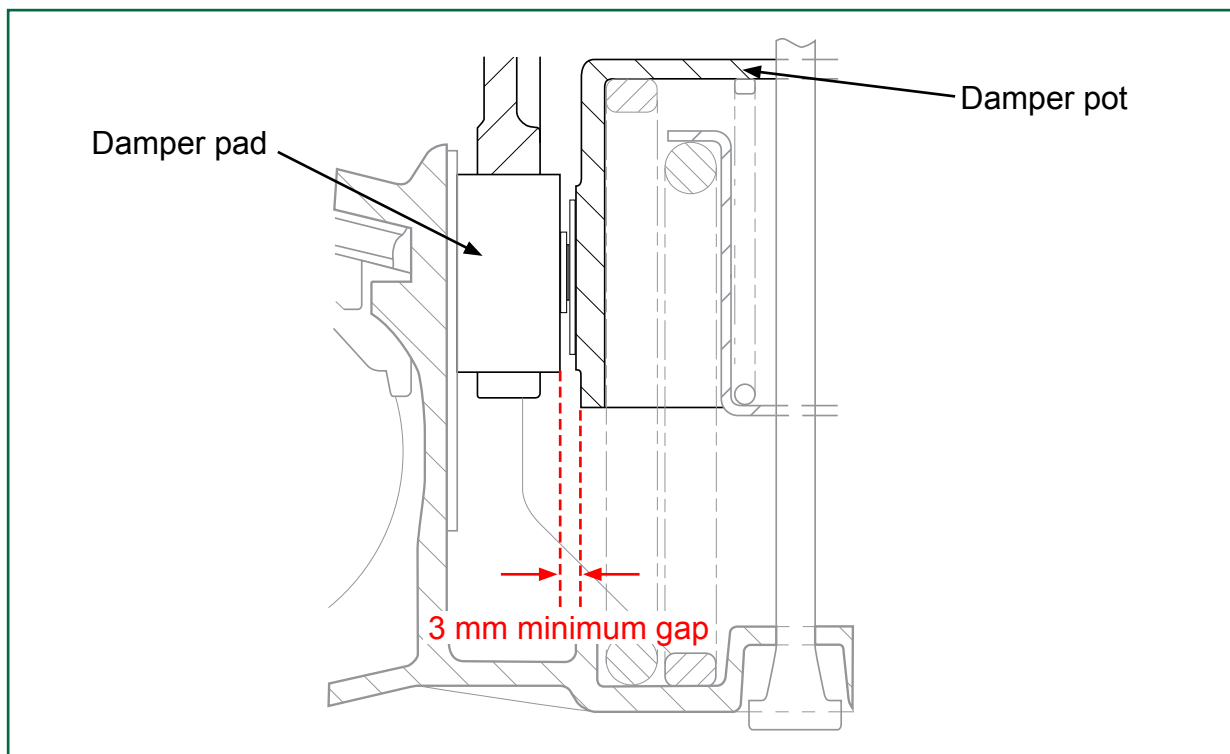


Figure 15: Additional check of the gap between the back of the damper pad and the damper pot

94 On 18 December 2009, the PWRAMG issued a letter to all private wagon owners outlining its initial findings from the work on the problem of suspension lock-ups. The letter provided details of the proposed engineering changes and the new maintenance checks. The letter explained that this information was provided for consideration, pending the issue of a POCL. It did not mandate that the maintenance checks should be carried out.

95 Wabtec's maintenance staff were aware of the proposed new checks through the letter and their attendance at meetings. Witnesses have indicated that Wabtec adopted these new maintenance measures from about the middle of 2010. Therefore REDA 16066 may have had these new checks carried out on it in October 2010 (PPM examination), February 2011 (VIBT examination) and June 2011 (PPM examination), but no records exist to show whether or not this happened. Wabtec had not, however, included the new checks within the maintenance plans or on any of the documentation that is filled in when an examination takes place.

- 96 From mid 2010, maintenance records show that Wabtec did not identify any worn components on the trailing left-hand suspension of REDA 16066 which may have caused it to lock-up while running in service.
- 97 The PWRAMG can mandate maintainers to carry out maintenance checks by issuing a POCL. During 2010, the PWRAMG began drafting POCL 651, Additional Maintenance Requirements for Gloucester MKIV Floating Axle Pedestal Suspensions. This POCL included both the new maintenance checks and an instruction that the suspension modifications should be carried out once any of the prescribed wear limits had been reached.
- 98 The PWRAMG planned to issue POCL 651 after validating the proposed suspension modifications by testing them on two wagons in traffic. This testing was completed in December 2010, but the PWRAMG did not finalise the POCL until four months later after obtaining technical information from Wabtec relating to the modified welding process for attaching the friction liner plate to the saddle.
- 99 Once the POCL was finalised, it then followed the standard process⁷ of being sent to the private wagon owners for consultation, before a final version was issued in July 2011. At this point, the maintenance checks became mandatory, nineteen months after they were first proposed by the PWRAMG.

Ownership of the PHA wagon suspension problem

100 Once the PHA wagons were known to have a suspension that was much more prone to locking-up than expected, no organisation took overall ownership of the resolution of the problem. This is an underlying factor.

- 101 After testing had shown the suspension on the PHA wagons locked-up while running in service (paragraph 79):
- Lafarge assumed that its PHA wagon fleet could continue to operate and be maintained as before unless told otherwise by the PWRAMG or Wabtec (paragraph 90);
 - Wabtec continued to maintain the PHA wagon fleet to the approved maintenance plan, as they were contracted to do, because they expected the PWRAMG or Lafarge to instruct them to do otherwise if needed; and
 - the PWRAMG continued to give its agreement for the PHA wagon fleet to operate over the national network, as its primary role was to check the requirements of the PWRA were being met.
- 102 The initial testing had indicated the extent of the problem with the suspension locking-up, but there is no evidence that any organisation or group of organisations assessed what risks to safety this represented. Therefore no one assessed what priority and resource should be assigned to the remedial actions and there is no evidence of a target date being set for implementing the modifications:
- After the second series of tests showed the proposed modifications gave up to a 75% reduction in the number of lock-ups, it was agreed between Lafarge and the PWRAMG in December 2010 that there would be a period of running in service to review if there were any longer term problems with the changes. No date was set for this review. It happened in January 2012 before the wagons went back into service after undergoing a VIBT examination.

⁷ The PWRAMG can issue a POCL immediately, without the need to consult private wagon owners, if it deems a problem to be an urgent safety issue so any actions can be mandated straight away.

- The new maintenance checks to look for worn components within the suspension were first identified in December 2009. However they were not mandated until POCL 651 was issued in July 2011, which was 19 months after the extent of the problem had been identified (although Wabtec may have informally begun to apply them from the middle of 2010).
- 103 The RAIB's recommendations on the actions that it believes are needed to improve railway safety have to be addressed, by law⁸, to the relevant safety authorities and other public bodies as appropriate, even though they may not be the end implementer. The RAIB's recommendation from its Ely Dock Junction investigation relating to PHA wagons (paragraph 160) was addressed to the Office of Rail Regulation (ORR), which was responsible for ensuring that Network Rail considered and took appropriate action to implement it. In late 2009, the PWRAMG informed the ORR what work had taken place to implement this recommendation (paragraph 76) and indicated that it would be issuing a POCL by the end of 2009. In May 2010 the ORR wrote to the RAIB to say it had accepted the PWRAMG response that the remaining work to implement the recommendation would be done. The ORR reported that it had confidence that this work would be done, so it would not be carrying out any inspections to check. The ORR concluded in the letter that it considered this RAIB recommendation had now been implemented. Consequently, there was no further communication between the PWRAMG and ORR about it, even though the PWRAMG had not set a deadline for issuing POCL 651 and not given the ORR any timescale for completing the work.

The track geometry at Bordesley Junction

104 A 3 metre track twist more severe than 1 in 200 reduced the load on the leading right-hand wheel, causing the flange to climb onto the rail head. Although trains were permitted to operate over track with this degree of track twist, the derailment is unlikely to have occurred in its absence. It is therefore considered to be a causal factor.

- 105 The marks found by the RAIB showing where the flange of the leading right-hand wheel of REDA 16066 had climbed onto the rail head coincided with the location of abnormal track twist (figure 16). At this location, the RAIB measured a 3 metre dynamic track twist of 1 in 200 (cant difference of 15 mm) which increased to 1 in 140 (cant difference of 21 mm) over the next four sleepers. The most severe dynamic twist over the wheelbase of the wagon (4.775 metres) measured by the RAIB was 1 in 172 (cant difference of 28 mm) at the sleeper before the point of derailment. The direction of this track twist caused a further reduction of the vertical load on the leading right-hand wheel; the load on this wheel was already reduced by a suspension lock-up on the trailing left-hand wheel (paragraphs 59 to 65).
- 106 The RAIB's survey of the track discounted the track gauge and the track alignment as being factors. Track component failure was also discounted as a factor because no broken rails, loose or broken *fastenings*, or other broken track components, were found before or at the point of derailment.

⁸ The Railways and Transport Safety Act 2003 and its associated implementing regulations, the Railways (Accident Investigation and Reporting) Regulations 2005, give the RAIB its powers to make recommendations. Under the Act and Regulations, the RAIB can direct recommendations to any organisation or person it thinks is best placed to implement the changes required. The recommendations are also addressed to the relevant safety authorities, or to other public bodies where appropriate, who are required to ensure that recommendations are duly considered and where appropriate acted upon.

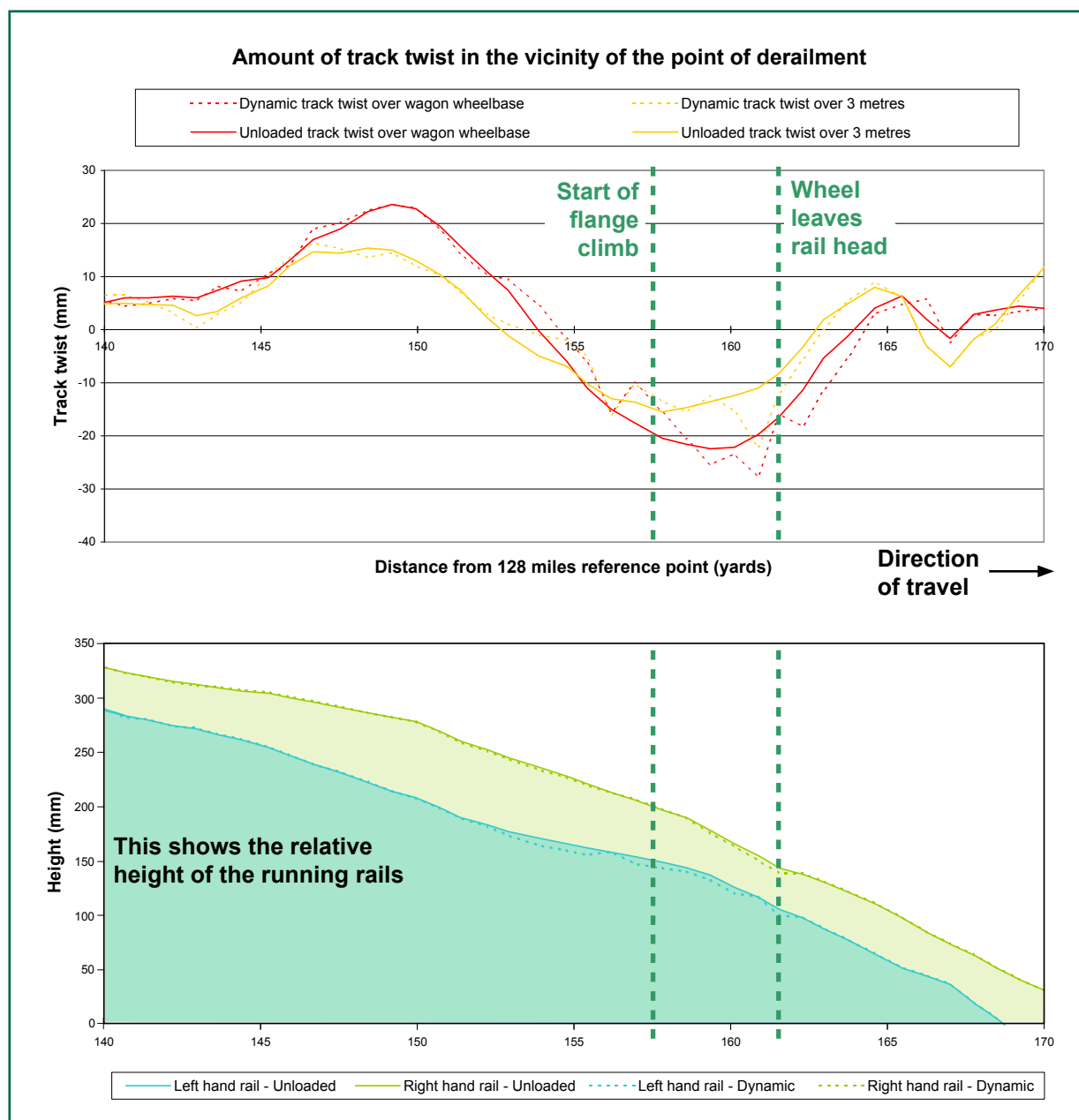


Figure 16: Graph showing the amount of track twist and relative change in height of the running rails

Track twist at this location

107 On the Down Main (Bordesley), the RAIB measured two track twists close to each other (paragraphs 60 and 105). Network Rail maintenance staff are responsible for inspecting the track in accordance with Network Rail company standard NR/L2/TRK/001, Inspection and maintenance of permanent way, to identify any track twist beyond the limits prescribed in the standard. To comply with NR/L2/TRK/001 Network Rail was required to inspect the Down Main (Bordesley) line:

- every week by maintenance staff on foot;
- every 12 weeks by a track geometry recording train although in practice this took place every 4 weeks;
- every 13 weeks by a supervisor from the cab of a train;
- every 16 weeks by a supervisor on foot;

- every 26 weeks by the track maintenance engineer from the cab of a train; and
- every 104 weeks by the track maintenance engineer on foot.

108 Network Rail's records of the inspections by staff on foot or from the cab of a train contained no reports of track twists on the approach to the junction. Witness evidence from this and other RAIB investigations states that track twists of this size can be very difficult to see by eye, especially when the track is canted and curved. Witness evidence states they are also very difficult to feel during a cab ride, especially at low speed (the permitted speed over the junction was 20 mph (32 km/h)) and in modern passenger rolling stock (its suspension gives a relatively smooth ride).

109 Automated track geometry recording by a train is Network Rail's primary method of finding track twists such as those at Bordesley Junction. These two track twists were being found regularly by this type of inspection, as explained in the following section.

Length of time the two track twists had been present

110 The track twists in the vicinity of the point of derailment had been present for a long time. Network Rail staff had attended to them six times during 2011, but carried out work in the wrong place. This is a causal factor.

111 About once a month during 2011, one of Network Rail's track geometry recording trains had recorded the track geometry on the Down Main (Bordesley) line in the vicinity of the point of derailment. On six of the seven runs before this accident, it had measured 3 metre track twists that required maintenance action. The RAIB compared the track geometry data from each run and found that these two track twists were consistently being found in the same places. Details of the most severe track twists that were measured are given in table 2, with those that required maintenance intervention shown in red.

Date	3 metre track twist before the point of derailment		3 metre track twist at the point of derailment		Distance offset in data (with adjusted location shown in green text)
	Maximum size	Location	Maximum Size	Location	
29/07/2011	15.4 mm (1 in 195)	128 miles 147.7 yards	14.7 mm (1 in 204)	128 miles 158.8 yards	
24/06/2011	15.6 mm (1 in 192)	128 miles 135.3 yards (147.5 yards)	14.9 mm (1 in 201)	128 miles 146.8 yards (159.0 yards)	12.2 yards behind July run
27/05/2011	14.5 mm (1 in 207)	128 miles 152.2 yards (147.7 yards)	15.4 mm (1 in 195)	128 miles 163.3 yards (158.8 yards)	4.5 yards ahead of July run
29/04/2011	15.4 mm (1 in 195)	128 miles 140.2 yards (147.0 yards)	14.5 mm (1 in 207)	128 miles 152.0 yards (158.8 yards)	6.8 yards behind July run
25/03/2011	14.4 mm (1 in 208)	128 miles 126.3 yards (147.4 yards)	13.7 mm (1 in 219)	128 miles 137.7 yards (158.8 yards)	21.1 yards behind July run
25/02/2011	15.6 mm (1 in 192)	128 miles 146.1 yards (147.6 yards)	16.1 mm (1 in 186)	128 miles 157.2 yards (158.7 yards)	1.5 yards behind July run
28/01/2011	15.9 mm (1 in 189)	128 miles 142.4 yards (147.4 yards)	15.5 mm (1 in 194)	128 miles 153.8 yards (158.8 yards)	5.0 yards behind July run

Table 2: Most severe track twists measured by track geometry recording trains in 2011

- 112 Each track twist that was measured to be 15 mm or more (the cant gradient was steeper than 1 in 200 over a distance of 3 metres) was classified by Network Rail as a level 2 fault. Network Rail company standard NR/L2/TRK/001 required these faults to be corrected within 14 days but no effective repairs were being carried out by Network Rail's maintenance staff.
- 113 Each time the track geometry recording train finds a fault that requires intervention, the type of fault together with a mileage for its location, is included on an action sheet issued to the local maintenance team. Network Rail's records show that a maintenance team was going out to fix these faults and they were being signed off as repaired within 14 days. The RAIB analysed the track geometry data from 2011 and aligned the waveforms for cant (figure 17) to take account of offsets in both the cant and mileage. This showed that the location information for the same track twist varied from one track recording run to the next. The mileages recorded for the same track twists differed over a range of 25.6 yards (23.4 metres).
- 114 When the faults were signed off, the maintenance team recorded that the track twists had been repaired by measured shovel packing. This requires the track geometry to be measured, the track is then lifted up and a set amount of chippings are placed underneath each sleeper. This is a standard method used by Network Rail staff for repairing track twists.
- 115 From witness evidence and analysis of the track geometry data, the RAIB concluded that the repair work was being carried out in the wrong place, either side of the track twists. The maintenance team were carrying out measured shovel packing repairs at a track joint before the first track twist and at the joints within the switches and crossing for the junction after the second track twist (figure 18). Figure 17 shows the cant waveforms measured by the track geometry recording trains in 2011. The cant reaches a peak of about 70 mm, with it changing at a rate of about 1 in 200 either side of this peak, which is just on the threshold for a reportable track twist (paragraph 112). The aligned cant waveforms for the section of track with the track twists did not change throughout 2011, but it did change over time in the vicinity of the joints which was as a result of the work done by the maintenance team.
- 116 The maintenance team had carried out similar repairs at these joints several times in the past. When the team had gone out to do the repairs, they had measured and found changes in the cant at these joints, so that was where they did the work to lift and pack the track. They did not measure the cant in the section of plain line between the joints, so they did not find the reported track twists. Therefore the track twists went unrepaired.

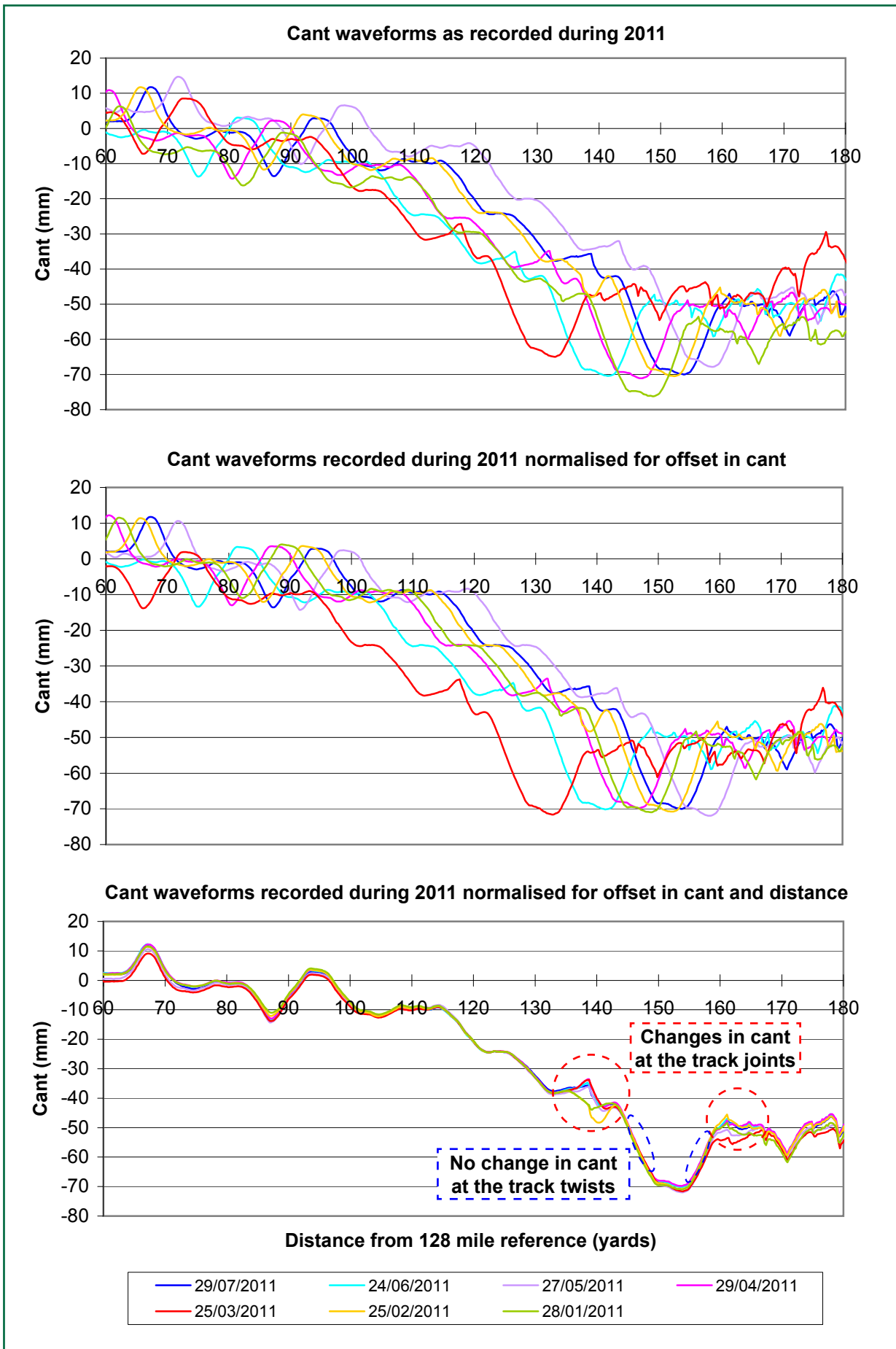


Figure 17: Graphs showing how cant changed during 2011

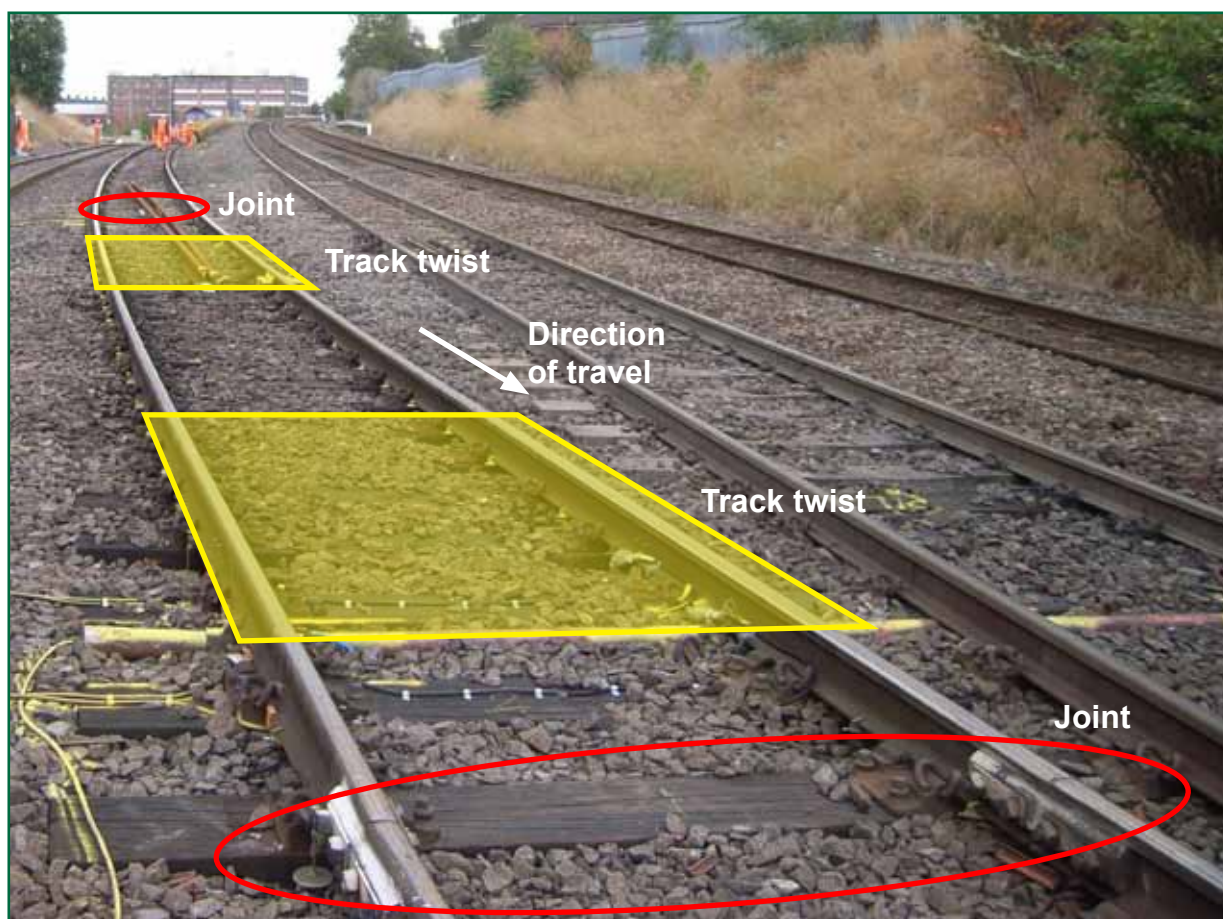


Figure 18: Locations of track twists and where repair work took place at track joints

Monitoring of repeat track twists

117 The track twists at Bordesley Junction were identified as repeat track geometry faults but no action was taken to investigate why these faults were recurring. This is a causal factor.

118 Within Network Rail, the Saltley track maintenance engineer is responsible for the track infrastructure at Bordesley Junction. Following each track geometry recording run over his area, the Saltley track maintenance engineer held a review meeting, which was also attended by his assistant and the relevant track section manager. The meeting looked at the following output from the track geometry recording train:

- the overall track quality for each eighth of a mile;
- the *track geometry trace*; and
- the discrete track geometry faults that had been found.

119 Prior to each meeting, a senior technical officer marked up the track geometry trace by highlighting the locations where overall track quality was poor and track geometry limits had been exceeded. The senior technical officer also provided a summary sheet for the status of the discrete faults, which included an entry for locations where repeat track geometry faults had been recorded. He had written on each sheet for the runs during 2011 that there were repeat faults at Bordesley Junction. The senior technical officer identified these faults as repeats using a database he maintained for managing the repair of discrete track geometry faults.

- 120 Similarly, the review meetings checked whether the faults had been signed off within the required time but no one took any action to look at why repeat faults were happening at Bordesley Junction. There was a general acceptance that the track formation in the vicinity of Bordesley Junction was poor which led to track geometry faults regularly being recorded there. The meeting attendees also knew that *tamping* work was planned to take place at the junction in August 2011 (paragraph 123).
- 121 The RAIB analysed the available track geometry data for the Down Main (Bordesley) line back to 2005. This showed that the track geometry where the track twists were found had deteriorated to the condition in which it had been at the time of the derailment by August 2009, but had not worsened since then (figure 19).

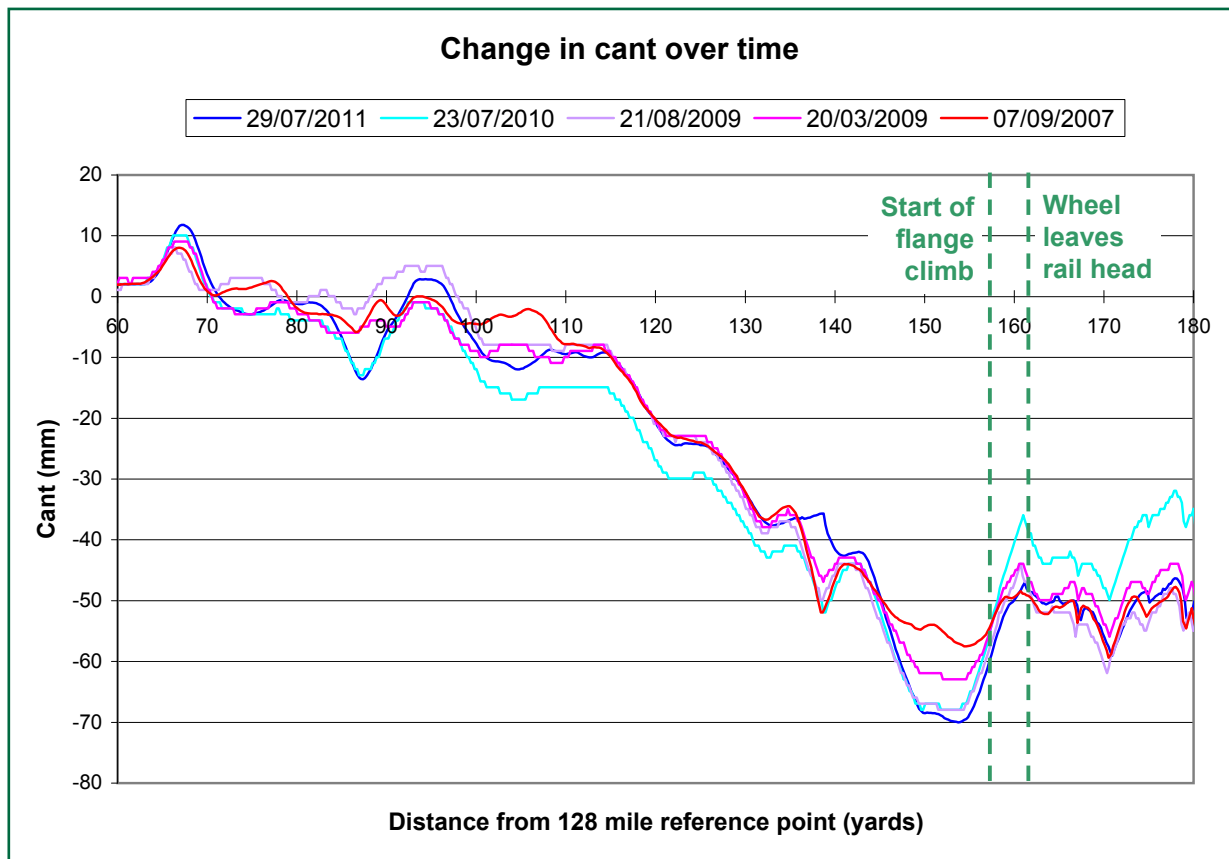


Figure 19: Change in cant over time at Bordesley junction

Tamping work at Bordesley Junction

122 The track on the Down Main (Bordesley) close to the junction was not tamped as planned during overnight work on 21 and 22 August 2011. This is a causal factor.

123 Network Rail maintenance had arranged for a tamping shift to take place at Bordesley Junction during an overnight engineering possession on 21 and 22 August. Tamping had been requested by the local maintenance team and its aim was to improve the overall track quality at the junction. The planned work was for two *tampers* to work in parallel over the junction, then continue onto the main (Bordesley) lines as far as Bordesley curve (figure 2). Witness evidence indicated that this was the first tamping work to happen at this location since at least 2004.

- 124 The tamping shift did take place that night but it ran short of time so not all of the planned work could be done. The work started over two hours later than planned as the tampers did not get to their starting places at Bordesley Junction until 02:45 hrs. The tampers had been delayed while engineering plant and machines were moved into position within other areas of the possession. There was also a minor delay caused by the control systems on the tampers not being able to communicate with each other. For two tampers to work in parallel, the control systems on the tampers are normally connected so they can automatically lift the track at the same time. However, the two machines provided for this shift were not compatible so parallel lifts were controlled through instructions to an operator on each machine.
- 125 During the tamping, a Network Rail track quality supervisor was on each tamper. Their role is to control the work that is carried out by instructing the tamper's operator what to do and where to do it. Due to the lost working time, the track quality supervisors needed to deviate from planned work as there was insufficient time to complete all of it.
- 126 They decided to tamp over the junction along the Camp Hill lines, travelling in the direction from Sattley towards Kings Norton, with one tamper working on each line (figure 4). They then reversed back over the junction. The tamper on the Up Camp Hill line worked back over the junction leading towards the Down Main (Bordesley) line, to harden up the formation under the switches and crossings at the junction by squeeze tamping as it went (squeeze tamping is when the tamper places its *tines* in the ballast and vibrates the stone but the track is not lifted up). This tamper finished working just after the end of the crossing.
- 127 The Down Main (Bordesley) line on the approach to the crossing, where the track twists were, was not tamped as planned. The assistant track maintenance engineer, who had planned the tamping shift, had expected the track twists to be corrected by this work. However, the track quality supervisors were not given any priorities for the work that night or a specific briefing to make sure they tamped the Down Main (Bordesley) line to address the track geometry faults. They were told the mileages that they should work between and given a general remit to tamp the track over the junction. Based on this information, they gave priority to the parallel tamping work at the junction itself. If their brief for the shift had included information about the track geometry faults on the Down Main (Bordesley) line that were less than 20 metres from the crossing, the track quality supervisors could have decided to include this short section of track within the revised work plan.

Track condition

128 The track twists on the Down Main (Bordesley) line had formed due to the deteriorating condition of the formation. This is a causal factor.

- 129 The RAIB observed that the ballast in places at Bordesley Junction was contaminated with dirt and dust, especially near to the overbridge by 633 crossover, but was much cleaner in the vicinity of the derailment. Witness evidence suggested that the overall ballast condition at the junction was poor.

- 130 Witness evidence also suggested that the formation beneath the track bed at the junction is poor due to water discharging from the drains on the overbridge onto the track at the junction. This water and the poor ballast condition are thought to be the reasons why discrete track geometry faults are frequently found. However, the overall track quality for vertical alignment for the eighth of a mile over the junction, as measured by the track geometry recording train, is rated satisfactory. Because of this, and the relatively low permitted speed over the junction, it is not a priority for renewal.
- 131 The RAIB found localised problems with the track at the junction. The track twists on the approach on the Down Main (Bordesley) line had formed due to changes in the cant. The designed cant for the track as it curves to the left to cross over the Down Camp Hill line is 50 mm, with the outer right-hand rail on the high side. However, the RAIB found the cant was excessive, being measured up to 18 mm more than this. The RAIB measured the track *voiding* on this line. For the six sleepers before the point of derailment, there was 0 to 2 mm of voiding under the right-hand rail but 6 to 7 mm under the left-hand rail. The excessive cant and voiding was most likely due to the support under the lower left-hand rail failing over time as a result of the deteriorating condition of the formation.

Track features at point of derailment

132 Particular track features which were present on the Down Main (Bordesley) line increased the likelihood of the leading right-hand wheel flange climbing.

- 133 When the flange on the leading right-hand wheel of REDA 16066 climbed, it was on the outside of a left-hand curve. The measured cant, including voiding, reached a maximum of 68 mm which is excessive for a line with a maximum permitted speed of 20 mph, although by the start of the flange climb, it had reduced to 52 mm. The designed cant of 50 mm was necessary for the transition at the crossing with the Down Camp Hill line.
- 134 The RAIB found that the right-hand running rail was *side worn* (figure 20). The maximum side wear reading that was measured was step 9: a rail with no side wear would read step 18 and the permitted maintenance limit is a reading of step 0. Although the rail was well within its maintenance limit, the side wear changed the contact angle between the wheel flange and the rail head (figure 20). This increased the likelihood of the flange climbing onto the rail head.
- 135 A reduction in the level of friction between the wheel flange and rail can also reduce the likelihood of a wheel flange climbing onto the rail head. A *flange lubricator* is located on the right-hand rail of the Down Main (Bordesley) line on Bordesley curve (figure 2) which applies grease to the wheels of passing trains in order to reduce wear on both the wheels and rails on curved track. There were some grease deposits from this lubricator found on the inside face of the right-hand running rail (figure 20). However, the effectiveness of this grease in reducing the level of friction between the wheel flange and the rail was limited by its position low down on the inside face. It was also the case that at the time of derailment the rails were dry, and therefore the level of friction was higher than it would have been if they were wet.



Figure 20: Side worn rail and contact angle between the rail and the wheel

Factors affecting the severity of consequences

A train on the adjacent line

136 The rear four wagons of train 6Z31 ran foul of the adjacent line until they re-railed themselves at 633A points. Train 6O46 was approaching on the Down Camp Hill line at slow speed but it stopped before the junction (paragraph 32). The two trains stopped alongside each other, with the leading cab of the locomotive of train 6O46 next to the fifth wagon from the rear of train 6Z31. By this time there was no longer a risk of collision as train 6Z31's rear four wagons were no longer foul of the line on which train 6O46 was running. However, had train 6O46 been passing over the junction when train 6Z31 derailed, there would have been a collision between the two trains. This would have had the potential to injure the driver of train 6O46 and cause significant damage to both trains.

Summary of conclusions

Immediate cause

137 The immediate cause of the accident was that the leading right-hand wheel flange on wagon REDA 16066 climbed onto the rail head and then derailed to the right. This was due to a combination of factors related to the suspension on wagon REDA 16066 and the track geometry at Bordesley Junction (**paragraph 53**).

Causal factors

138 The causal factors were:

- a. The suspension of the trailing left-hand wheel on wagon REDA 16066 probably became locked-up (figure 9) when it passed over track geometry that increased the dynamic load on it, which then reduced the load on the leading right-hand wheel at the point of derailment (**paragraph 59, Recommendations 1, 2 and 3**).
- b. The maintenance process for the suspension of REDA 16066 did not detect and rectify the worn suspension components on the trailing left-hand corner (**paragraph 68, Recommendation 2**).
- c. No changes had been made to the suspension on REDA 16066 or the way in which it was operated or maintained, following testing in 2009 which showed that the suspension on PHA wagons was prone to locking-up (**paragraph 75, Recommendations 1, 2 and 3**).
 - i. Modifications that had been shown to reduce the frequency of lock-ups had not been made to the suspension on REDA 16066 (**paragraph 81, Recommendation 3**).
 - ii. Neither Lafarge nor Network Rail's PWRAMG assessed the risk of continuing to operate the PHA wagon fleet while the work to develop, test and implement the modifications was outstanding (**paragraph 88, Recommendation 1**).
 - iii. Network Rail's PWRAMG had identified new maintenance checks for suspension component wear but these had not been mandated before REDA 16066's last maintenance examination (**paragraph 92, Recommendation 2**).
- d. A 3 metre track twist more severe than 1 in 200 reduced the load on the leading right-hand wheel, causing the flange to climb onto the rail head. Although trains were permitted to operate over track with this degree of track twist, the derailment is unlikely to have occurred in its absence (**paragraphs 104 and 143 to 144**).
- e. The track twists in the vicinity of the point of derailment had been present for a long time. Network Rail staff had attended to them six times during 2011, but carried out work in the wrong place (**paragraphs 110 and 153 (Santon Recommendation 6 www.raib.gov.uk)**).

- f. The track twists at Bordesley Junction were identified as repeat track geometry faults but no action was taken to investigate why these faults were recurring (**paragraphs 117 and 153 (Santon Recommendation 7 www.raib.gov.uk)**).
 - g. The track on the Down Main (Bordesley) close to the junction was not tamped as planned during overnight work on 21 and 22 August 2011 (**paragraph 122, Recommendation 4**).
 - h. The track twists on the Down Main (Bordesley) line had formed due to the deteriorating condition of the formation (**paragraphs 128 and 143 to 144**).
- 139 Particular features of the track at Bordesley Junction also increased the likelihood of the leading right-hand wheel flange climbing (**paragraph 132**). These features were the track curving to the left, the dynamic cant being more than the designed cant, side wear on the right-hand running rail that changed the contact angle between the wheel flange and rail, and dry rails giving a higher level of friction between the wheel flange and rail (paragraphs 133 to 135).

Underlying factor

140 The underlying factor was:

- a. Once the PHA wagons were known to have a suspension that was much more prone to locking-up than expected, no organisation took overall ownership of the resolution of the problem (**paragraph 100, Recommendation 1**).

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

Actions reported that address factors which otherwise would have resulted in a RAIB recommendation

POCL 651

141 In July 2011, the PWRAMG issued POCL 651 which mandated that additional maintenance checks and measurements must be carried out on the suspension of PHA wagons. It also explained what modifications needed to be made to the suspension. This POCL was reissued in December 2011 to clarify that the suspension checks and measurements must be carried out every time a wagon has a PPM, VIBT or BM examination, and that if any of the prescribed wear limits were reached, the suspension modifications as described in the POCL must also be carried out during that examination.

142 In addition, the reissued POCL now requires maintenance staff to quarantine any friction liner plates found with signs of heavy scoring or blueing on them and report the findings to the PWRAMG. It also prohibits the rotation of saddles to prevent hollow worn saddle friction liner plates from being placed against pedestal friction liner plates.

Track repairs

143 On 23 September 2011, the track geometry recording train measured a track twist of 1 in 158 on the Down Main (Bordesley) line, just where train 6Z31 had derailed (figure 21). This was the first track geometry recording run after the accident.

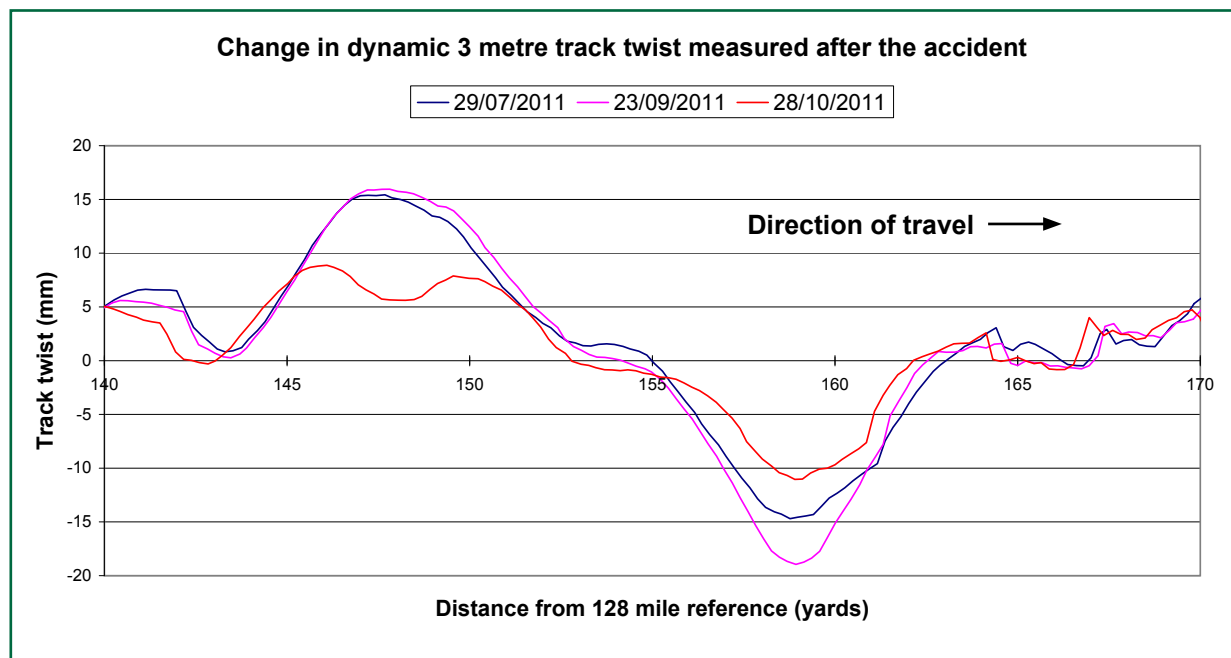


Figure 21: Changes in the measured track twist after the accident at Bordesley junction

144 A fault report was issued which required Network Rail maintenance to repair this fault within 14 days. Maintenance records show that measured shovel packing repair work took place over this mileage on 29 September. The next track geometry recording train run took place on 28 October and the amount of track twist that was recorded was reduced (figure 21). This indicates that on this occasion the repair work had been carried out in the correct place, as the track geometry had been improved, and it did not require further maintenance intervention after four weeks of traffic passing over it. Since Network Rail has carried out work to reduce the track twists on the Down Main (Bordesley) line, there is no need for the RAIB to make a recommendation about this.

Actions in progress and relevant to this report

Lafarge

145 Under instruction from Lafarge, Wabtec began a programme of work in August 2012 to implement the suspension modifications, as defined in POCL 651, on the PHA wagon fleet. Lafarge expects this work to be completed within 18 months.

Network Rail

146 Network Rail has stated it will be commencing a briefing reminder through meetings with its staff which will cover a number of issues relevant to this investigation. The issues to be covered will include repeat track geometry faults, carrying out repairs in the correct location, observing the track under traffic and measuring voids, the correct planning of tamping work and contingency planning in the event of the partial completion of a tamping shift.

Previous occurrences of a similar character

- 147 The last similar accident on a running line happened on 22 June 2007 at [Ely Dock Junction](#). The 15th PHA wagon, in a train from Barrow-on-Soar to Chelmsford, derailed on the approach to a bridge over a river near Ely. The derailed wagon was dragged onto the bridge where it, and other wagons that subsequently derailed, caused considerable damage to the bridge. The railway was closed for six months, and the river for three months, which caused significant disruption to the local community and tourism in the area. There were no casualties. The RAIB investigated this accident and made sixteen recommendations, one of which is relevant to this investigation (paragraphs 160 to 164). The report also describes similar accidents prior to June 2007.
- 148 REDA 16066 was one of the wagons in the train involved in the accident at Ely, but was near the rear of the train and was not derailed or damaged. The RAIB has identified one other incident involving this wagon since then. This happened on 15 July 2008 when REDA 16066 derailed in the sidings at Barrow-on-Soar. The industry report for this derailment cited poor track condition as the cause. Wabtec examined REDA 16066 and found only minor damage. The wagon's frame was also checked for twist and found to be within limits that required no action to be taken.
- 149 The RAIB identified four other minor accidents where PHA wagons had derailed since the accident at Ely in June 2007. For three of these accidents the industry investigation attributed the cause to track faults. For the fourth accident, the cause was unknown although industry reported that the track condition was poor.
- 150 The RAIB carried out a search of the national rail industry system for recording safety related events for derailments since June 2007 of PGA hopper and PCA tank wagons fitted with the same Gloucester Mark 4 Floating Axle Suspension. No incidents of PGA wagons derailed were found but three PCA wagon derailments were. All were minor and in two cases the industry investigations attributed the cause to track faults. The industry investigation report for the third derailment has not yet been issued. None of the industry reports explain whether the derailed wagons were examined to understand why it was that particular wagon which derailed.
- 151 While this investigation was in progress, a further derailment of PCA tank wagons happened at Craiginches yard, Aberdeen on 9 May 2012. The train involved was train 6B32, the 16:52 hrs Craiginches Yard to Oxwellmains service, operated by Freightliner. As the train of 25 empty PCA wagons was leaving the sidings, the flange of the leading left-hand wheel on the 19th wagon climbed onto the rail head on plain line within the yard. The derailed wagon was dragged for about 200-metres, overturning onto its side, before stopping foul of the running line the train was joining (figure 22).



Figure 22: Train 6B32 derailed on exit to Craiginches Yard, Aberdeen (images courtesy of Network Rail)

152 Network Rail surveyed the track, and voiding was measured before and at the point of derailment. This revealed a large dynamic 3 metre track twist of 1 in 96 just before the point of derailment. The RAIB examined the wagon after it was recovered and found hollow wear on the saddle friction liner plate in excess of 2 mm on the leading left-hand corner (figure 23). This pattern of wear was consistent with that found on REDA 16066 and the previous findings of the PWRAMG. Although the industry investigation of this accident is in progress, so its cause has not yet been formally confirmed, the wear patterns found indicate that the saddle on this corner would be susceptible to sticking inside the pedestal (paragraph 63).



Figure 23: Hollow wear on the saddle friction liner plate on the leading left-hand corner

RAIB recommendations relevant to this investigation

Santon, near Foreign Ore Branch Junction, Scunthorpe

153 The RAIB previously made two recommendations to Network Rail following its investigation of a freight train derailment at Santon, near Foreign Ore Branch Junction, Scunthorpe ([RAIB report 10/2009](#)), which address factors also identified in this investigation:

Recommendation 6

Network Rail should take measures to improve the accuracy of location information for track geometry faults recorded by all track geometry recording runs and inspection staff, and provide maintenance staff with the ability to use this information to precisely locate the identified faults.

Status of actions taken as reported by the Office of Rail Regulation

154 The ORR reported to the RAIB in August 2009 that Network Rail had rejected this recommendation as it considered that the system that it was using at the time was adequate and enabled identification of the line and mileage to an accuracy that allowed the local maintenance team to implement corrective actions. In April 2010 the ORR asked Network Rail to provide further information and advised that it would write again to the RAIB once a response was received. In July 2012, the ORR indicated to the RAIB that this recommendation had in fact been implemented. Since the accident at Bordesley Junction, Network Rail has taken measures to improve fault location information by fitting GPS to some of its track geometry recording trains and providing maintenance staff with equipment to use GPS coordinates. Network Rail has confirmed that trials using GPS and workshops for staff are progressing well. The ORR believes that these measures are a fully effective and robust solution which should improve the ability to record and find the location of track geometry faults.

Relevance to this investigation

155 This investigation found that mileages recorded by track geometry recording trains for exactly the same faults can vary by up to 25 metres (paragraph 113) and that maintenance staff were not locating the identified faults and as a consequence were carrying out repair work in the wrong place (paragraph 115).

156 As the findings of this investigation are very similar to those in RAIB report 10/2009, and as the ORR has not yet formally accepted Network Rail's response, this recommendation is not remade in this report. However, the RAIB is waiting for the ORR to confirm that Network Rail has taken actions to fully implement recommendation 6 of RAIB report 10/2009.

Recommendation 7

Network Rail should implement processes to investigate and monitor the effectiveness of repairs to repetitive track geometry faults, so that when a track geometry fault recurs, the reason for it coming back can be established, an appropriate repair method can be chosen and monitoring can be carried out to determine whether the second attempt to repair it has been successful.

Status of actions taken as reported by the Office of Rail Regulation

157 The ORR reported to the RAIB in August 2009 that Network Rail considered its track geometry report system already contained an operational repeat faults report and that more use should be made of it. The ORR also reported Network Rail's response which stated that processes and expectations for using this system will be reviewed and restated as a competence and training issue, with a timescale for completion by the end of March 2010. In April 2010 the ORR requested Network Rail to provide further information and advised that it would write again to the RAIB once a response was received. In July 2012, the ORR informed the RAIB that Network Rail was now developing a system that uses current technology to support the investigation and monitoring of the effectiveness of repairs to repetitive track geometry faults. Network Rail is planning to trial this system between August and December 2012 with the intention of implementing it nationally in 2013 and 2014. In the interim, Network Rail has made changes to its standards and briefed maintenance staff on the management of repeat track geometry faults.

Relevance to this investigation

- 158 This investigation found that repeat track geometry faults were being identified, albeit using a locally maintained database, but no action was being taken to investigate why these faults were recurring (paragraphs 117 to 121).
- 159 As the findings of this investigation are very similar to those in RAIB report 10/2009, and as the ORR has not yet accepted Network Rail's response, this recommendation is not remade in this report. The ORR plans to monitor progress of the trials and implementation of this new system before being able to confirm that recommendation 7 of RAIB report 10/2009 has been implemented.

Ely Dock Junction, near Ely

160 The RAIB previously made a recommendation to Network Rail following its investigation of a freight train derailment at Ely Dock Junction (RAIB report 02/2009), which addresses factors also identified in this investigation.

Recommendation 3

Network Rail and PHA wagon owners should review the risks arising from the derailments of these vehicles and whether in light of the Ely incident the current mitigation measures are adequate in respect to the compliance of the PHA wagon and the suspension characteristics of the PHA wagon against the requirements of GMRT/2141⁹, including the effects of contamination and frictional breakout. If appropriate, Network Rail's Private Wagons Registration Agreement department should require the owners of these wagons to take such steps as are necessary to ensure they comply with its requirements.

⁹ Railway Group Standard GM/RT2141, Resistance of Railway Vehicles to Derailment and Roll-Over, mandates requirements for rolling stock to ensure acceptable resistance against flange climbing derailment and against roll-over induced by overspeeding. It also defines the criteria by which acceptable derailment resistance of vehicles is to be demonstrated.

Status of actions taken as reported by the Office of Rail Regulation

- 161 The ORR reported to the RAIB in May 2010 that this recommendation had been implemented, as Network Rail's PWRAMG had provided the ORR with details of the work it had carried out to date to review the risk of the PHA wagon's suspension locking-up and then causing a derailment (these actions are discussed in detail in paragraphs 76 to 99). The ORR accepted Network Rail's PWRAMG response that it would be delivering the remaining work needed to implement the findings of the review. The ORR reported it had confidence that this further work would be done so it would not be pursuing this matter through inspection work.
- 162 The ORR has since informed the RAIB that it recognises that the steps taken by Network Rail's PWRAMG have not resulted in action by the owners and/or maintainers to modify the fleet of PHA wagons. However, the ORR has also stated that issues such as maintenance instructions for freight wagons were not strategic safety priorities for the ORR, and that it believes that its response to this recommendation was proportionate and appropriate.

Relevance to this investigation

- 163 The RAIB has found that the PWRAMG had completed work to review and quantify the problem of PHA wagon suspensions locking-up but no action had then been taken to reduce the derailment risk from this cause while the wagons were in service. Proposed modifications to the suspension had been tested and shown to reduce the problem of locking-up, but they had not been made to any other wagons in the fleet at the time of the accident (paragraphs 81 to 86). Planned changes to the maintenance regime for the wagons were not formally introduced until July 2011, although they may have been carried out from about the middle of 2010 (paragraphs 92 to 99). If so, they did not lead maintenance staff to identify the worn suspension components.
- 164 Recommendations 1, 2 and 3 of this report address the need for the PWRAMG to review the actions it has taken to meet the objectives of Recommendation 3 of RAIB report 02/2009.

The role of the ORR in following up progress on RAIB's recommendations

- 165 The RAIB recognises that the technical issues linked to the design of the PHA wagons were complex and the legal responsibilities of the various parties ill defined. Nevertheless, the RAIB is concerned that it has taken the railway industry parties involved so long to address recommendation 3 of RAIB report 02/2009 (Ely Dock Junction, published in January 2009), despite clear evidence of a risk of derailment in the interim. Similarly, the RAIB has observed the slow progress of steps to address recommendations 6 and 7 of RAIB report 10/2009 (Santon, published in April 2009).

- 166 An apparent slow rate of progress of actions taken in response to RAIB recommendations has been identified in a number of current and recent investigations. In its Annual Report for 2010, the RAIB raised a general concern about the number of accidents that are still occurring, despite the risk having been identified in an earlier RAIB recommendation. This will again feature in the forthcoming Annual Report for 2011.
- 167 The ORR has stated that the extent to which it follows up progress with the implementation of RAIB recommendations is dependant on their judgement of the risks to be addressed and the duty holder's general approach to safety. In early 2010 the ORR introduced a process which aimed to exercise more control over the timescale for the duty holder to implement RAIB recommendations. This process requires the ORR to agree an appropriate implementation timescale with the duty holder and also requires the duty holder to notify the ORR should this timescale become subject to risk, or exceeded. This provides the ORR the opportunity to agree new timeframes or take action as it sees appropriate to expedite.
- 168 In the light of the above, the RAIB will continue to keep under review:
- the time taken to implement recommendations; and
 - the number of accidents that occur despite previous recommendations that have addressed the same risk.

Recommendations

169 The following recommendations are made¹⁰:

- 1 *The intent of this recommendation is to reduce the risk of operating a privately owned wagon over the national network once a fleet wide problem has been identified. It aims to improve the likelihood that the Network Rail Network Certification Body (previously known as the PWRAMG), in conjunction with private wagon owners, will implement short term measures, such as additional maintenance checks, to manage the risk in advance of a longer term solution.*

Network Rail through its Network Certification Body¹¹ should review its own processes to make sure that the risks of continuing to operate a fleet of wagons are managed once a fleet wide problem is discovered. The review should consider including processes for:

- assessing the risk of continued operations and identifying the need for any immediate measures that need to be taken to control the risk;
- identifying the long term measures that need to be taken to resolve the fleet wide problem; and
- assigning responsibilities, priorities and timescales for implementing and managing both the immediate and long term measures.

Once the review has identified what reasonable improvements can be made to the processes, the Network Certification Body should implement them (paragraphs 138a, 138c, 138cii and 140a).

continued

¹⁰ Those identified in the recommendations, have a general and ongoing obligation to comply with health and safety legislation and need to take these recommendations into account in ensuring the safety of their employees and others.

Additionally, for the purposes of regulation 12(1) of the Railways (Accident Investigation and Reporting) Regulations 2005, these recommendations are addressed to the Office of Rail Regulation to enable it to carry out its duties under regulation 12(2) to:

- (a) ensure that recommendations are duly considered and where appropriate acted upon; and
- (b) report back to RAIB details of any implementation measures, or the reasons why no implementation measures are being taken.

Copies of both the regulations and the accompanying guidance notes (paragraphs 200 to 203) can be found on RAIB's website www.raib.gov.uk.

¹¹ Since this accident the Network Rail Private Wagon Registration Agreement Management Group has been renamed the Network Certification Body. Its role is also due to change in the future, when its responsibilities for private wagons change under European Railway Safety Directive 2004/49/EC (paragraph 52). Therefore the responsibility for implementing this recommendation should pass to the entities in charge of maintenance responsible for privately owned wagon fleets.

- 2 *The intent of this recommendation is to prevent a PHA wagon from entering into service with worn suspension components, which can increase the likelihood of the suspension locking-up, increasing the risk of a derailment. This can be achieved through a detailed review, from first principles, of how the suspension components on a PHA wagon wear. The maintenance plan should then be revised as necessary. The review should also address the current anomaly in the PPM & VIBT maintenance plans which calls for certain components to be examined when they cannot be seen if the wheelset is in place.*

Network Rail through its Network Certification Body, and in conjunction with Lafarge Aggregates Ltd and Wabtec Rail Limited, should lead a fundamental review of how the suspension of the PHA wagon is maintained. The review should call upon relevant technical expertise to:

- look at how the suspension works as a whole and understand the role that each individual component performs; and
- use this knowledge to document the actions for maintaining a fully functioning suspension, which may include monitoring, measuring and setting limits for the permitted overall amount of wear in the suspension and also individual component wear, including specific actions and limits set to account for those components that are not fully visible when the wheelset is in place.

Once the review has decided what actions it is reasonable to take, they should be implemented in the maintenance plans for the PHA wagon fleet (paragraphs 138a, 138b, 138c and 138ciii).

- 3 *The intent of this recommendation is to reduce the risk of operating the PHA wagon fleet by implementing modifications that have been tested and shown to reduce the number and duration of suspension lock-ups on these wagons. It will also require Lafarge to set a timescale for rolling out the modifications to all of its PHA wagons.*

Lafarge Aggregates Ltd should, with reference to POCL 651, implement suspension modifications to its fleet of PHA wagons as soon as practicable to reduce the likelihood of suspension lock-ups (paragraphs 138a, 138c and 138ci).

continued

- 4 *At present, Network Rail track quality supervisors will only be told the lines and mileages to be worked on during a shift, although sometimes they may be asked to give priority to part of the planned mileage. If their brief included information on what the work was aiming to achieve (eg to improve the general track quality, address a number of discrete track geometry faults, etc), Network Rail's track quality supervisors could make better informed decisions on what work to prioritise if the planned work needs to be changed at short notice (eg time is reduced due to a late start).*

Network Rail should review and implement changes to its processes for briefing staff responsible for controlling the work carried out by *on-track machines*, so that their briefings will include information on whether any part of the work should be given priority over another and the reasons for such prioritisation (paragraph 138g).

Note: Recommendations 2 and 3 may also apply to other organisations.

Appendices

Appendix A - Glossary of abbreviations and acronyms

BM	Balanced Maintenance
ESPA	Entities in charge of maintenance Service Provision Agreement
GPS	Global Positioning System
ORR	Office of Rail Regulation
POCL	Private Owner Circulation Letter
PPM	Planned Preventative Maintenance
PWRA	Private Wagon Registration Agreement
PWRAMG	Private Wagon Registration Agreement Management Group
SDT	Self-Discharge Train
VIBT	Vehicle Inspection and Brake Test

Appendix B - Glossary of terms

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

Bar coupling	A semi-permanent rigid connector between two wagons.
Basic visual track inspection	A visual inspection of the track, carried out on foot, which aims to identify any immediate or short term actions that are required. Often referred to as a track patrol.
Balanced maintenance	An additional maintenance examination for rail vehicles that takes place after a defined mileage or time (eg 90,000 miles or 2 years) which identifies components that require attention or returning to nominal condition, eliminating the need for major overhaul during the vehicle's life.
Ballast	Crushed stone, nominally 48 mm in size and of a prescribed angularity, used to support sleepers or bearers both vertically and laterally. The stone used is generally granite, but limestone has been employed. Not to be confused with the traditional construction grade of ballast, which is largely ungraded.*
Bearer	A wider than normal sleeper designed to support the track at switches and crossings.
Brake pipe	A pipe running the length of a train that controls, and sometimes supplies, the train's air brakes. A reduction in brake pipe air pressure applies the brakes.
Cant	The amount by which one rail on the track is raised above the other.
Chain	A unit of length equal to 66 feet or 22 Yards (20.1168 metres). There are 80 chains in one standard mile.*
Continuous welded rail	A rail of length greater than 36.576m (120'), or 54.864m (180') in certain tunnels, produced by welding together standard rails or track constructed from such rails.*
Crossing	An assembly that permits the passage of wheel flanges across other rails where tracks intersect.*
Crossover	A route between two parallel tracks that allows a train to cross to the other track.
Damper pad	A component within the suspension that is housed within the pedestal and is pushed against the saddle. The amount of force applied to it determines the amount of friction damping.
Damper pot	A component within the suspension that converts the vertical force on the corner of a vehicle into a horizontal force that pushes on the damper pad to provide the suspension's damping.

Dynamic track twist	The change of cant along a track measured over a specific distance, while the track is under load from a train. The static twist is the measure when the track is not loaded.
Earthworks	A collective term for cuttings, embankments and natural slopes.
Emergency speed restriction	A speed restriction imposed for a short time, at short notice, generally for safety reasons.*
Fastening	The components of the track which hold the rail in place.
Flange	The extended portion of a rail wheel that provides it with directional guidance.*
Flange climb	A situation where the flange of a rail wheel rides up the inside (gauge) face of the rail head while rotating. If the wheel flange reaches the top of the rail head, the wheelset is no longer laterally constrained and this usually leads to derailment.
Flange lubricator	A lubricator mounted on the track and arranged to apply grease to the wheel backs, flange tip or flange face, to reduce wear between the wheels and the running rail or check rails.
Four aspect colour light signal	Railway signal which uses four coloured lights to indicate whether the driver has to stop, needs to be prepared to stop or can proceed without restriction. The lights may show: <ul style="list-style-type: none"> ● Green - proceed, the next signal may be displaying green or double yellow; ● Double yellow - caution, there are two signal sections to the stop signal, the next signal may be displaying a single yellow; ● Single yellow - caution, the next signal may be displaying a stop signal; and ● Red - stop.
Fourfoot	The space between the rails of a track.
Global positioning system	A space based satellite system that provides location and time information to a receiver on or near the Earth, provided the receiver has an unobstructed line of sight to four or more GPS satellites.
Hopper wagon	A wagon which discharges its load through doors in the bottom area of the wagon.
On-track machine	Any piece of specialist railway plant which moves only on the rails and is normally self propelled.
On-train data recorder	Equipment fitted on-board the train which records the train's speed and the status of various controls and systems relating to its operation. This data is recorded to a crash-proof memory and is used to analyse driver performance and train behaviour during normal operations or following an incident or accident.

Pedestal (or axlebox horn)	The vertical guide placed either side of a saddle (axlebox) to restrain it laterally but permit vertical movement of the axle.*
Permitted speed	The maximum speed at which trains may safely negotiate a section of track, as published in the Network Rail's operating publications that contain essential information about the line.
Plain line	Track without switches and crossings (S&C).*
Planned preventative maintenance	Maintenance for rail vehicles which is planned to take place on regular basis. It is based on a prescriptive schedule of component replacement, eg brake blocks, or service activities and adjustments, which aim to reduce the incidence of failures in service.
Points	A section of track with moveable rails that can divert a train from one track to another, consisting of a set of switches and a crossing.
Power signal box	A large signal box where points and signals over a wide area are controlled.
Rail head	The bulbous upper part of a rail section.*
Saddle (or axlebox)	The axle bearing housing which connects the wheelset to a rail vehicle via the primary suspension. There is one saddle (or axlebox) at each end of a wheelset.*
Screw coupling	A variety of coupling used to connect rail vehicles together. It consists of a pair of loops connected by a threaded bar with left and right-hand threads on opposite ends, allowing the coupling to be lengthened and shortened as required when connected between the coupling hooks of the vehicles.*
Self-discharge train	(Tradename) Previously pioneered by Redland Aggregates, and now operated by Lafarge Aggregates Ltd, a train consisting of a discharge wagon and a number of special hopper wagons equipped with conveyors to move material to one end of the train. The hopper wagons come in sets of five or ten, giving a minimum capacity of 185 tonnes, and a maximum capacity (in 30 hoppers) of 1100 tonnes. The system can cope with any size of aggregate, from sand up to normal ballast, and can discharge out to a radius of 15 metres (50 feet).*
Side worn	A reduction in rail head width due to wear caused by flange contact with the rail as trains round a curve.
Sleeper	A beam made of wood, pre- or post-tensioned reinforced concrete or steel placed at regular intervals at right angles to and under the rails. Their purpose is to support the rails and to ensure that the correct distance is maintained between the rails.*

Switch	An assembly of two movable rails (the switch rails) and two fixed rails (the stock rails) and other components (baseplates, bolts, distance blocks, soleplates, stress transfer blocks and stretcher bars) used to divert vehicles from one track to another. Generally referred to as a set of switches. One switch rail and one stock rail together make a switch half set.*
Tamping	The operation of lifting the track and simultaneously compacting the ballast beneath the sleepers. This is operation has largely been mechanised.*
Tamper	An on track machine that can (generally) lift and slue the track and simultaneously compact the ballast under the sleepers. Most machines employ some system to smooth out and average track faults, and apply predetermined lifts and slues to the track. The most advanced add some degree of computing power to further increase the effective measurement baseline (thus averaging the errors all the better), the pinnacle being GPS guided machines and those capable of reading positional data from datums at the lineside. The machine's full title is more properly tamping and lining machine.*
Tines	The spade ended tool used to compact the ballast under a sleeper.*
Toe (of points)	The movable end of a switch rail.*
Track circuit	An electrical or electronic device using the rails in an electric circuit that detects the absence of a train on a defined section of line.
Track circuit block	A signalling system where the line beyond each signal is automatically proved clear to the next signal, and sometimes beyond it, using track circuits. Track circuit block can also be implemented using any automatic train absence detector system.*
Track geometry recording train	A specially equipped train that automatically measures and stores track geometry information for the lines that it runs over.
Track geometry trace	A graphical output from a track geometry recording train that shows the features of the track that have been recorded, such as its horizontal and vertical alignment, including cant.
Track twist	The change of cant along a track measured over a specific distance (normally 3 metres on Network Rail's infrastructure). It can be recorded as the difference in cant, in mm, between the two points (eg 15 mm). It can also be recorded as a gradient or rate of change of cant between the two points (eg a difference in cant of 15 mm between two points that are 3 metres apart would be recorded as 1 in 200).

Train preparation	The activities carried out by a train preparer whose duties include checking the train for compliance with the train document and physically checking all vehicles to ensure that they are properly coupled (including brake pipe and any electrical connections); the necessary lamps are provided on the train; all vehicles appear safe to travel and all handbrakes are released.*
Vehicle acceptance body	A railway industry body whose role is to ensure that new or modified railway vehicles do not present a hazard.
Vehicle inspection and brake test	A periodic maintenance activity to ensure that a rail vehicle is in a serviceable condition and its brakes are functional.
Voiding	A track fault consisting of spaces under sleepers or bearers in the packing area, often caused by inadequate packing or differential settlement between sleepers. It is voiding that is responsible for dynamic track faults, such as twist faults, that appear or worsen when the track is loaded.*
Wheelset	Two rail wheels mounted on their joining axle.

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