Rail Accident Investigation Branch

Rail Accident Report

Freight train derailment at Hatherley, near Cheltenham Spa
18 October 2005

Department for Transport

Report 08/2006
July 2006

This investigation was carried out in accordance with:

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

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Contents

Introduction

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

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

3 English, Welsh and Scottish Railway (EWS) and Network Rail freely gave access to staff, data and records.

4 Appendices at the rear of the report contain Glossaries explaining the following:

- acronyms and abbreviations are explained in the Glossary at Appendix A; and
- certain technical terms (shown in *italics* where they first appear in the body of this report) are explained in the Glossary at Appendix B.

5 Throughout this report, vehicle and track components are described as 'left' or 'right' relative to the direction of travel of the derailed train.

Summary

Key facts about the incident

6 At 05:20 hrs on Tuesday 18 October 2005, freight train 6V19 was travelling between Bescot and Margam on the *Down* Birmingham to Bristol line when all the wheels of one of its wagons became derailed near Hatherley, just south of Cheltenham Spa station (Figure 1).

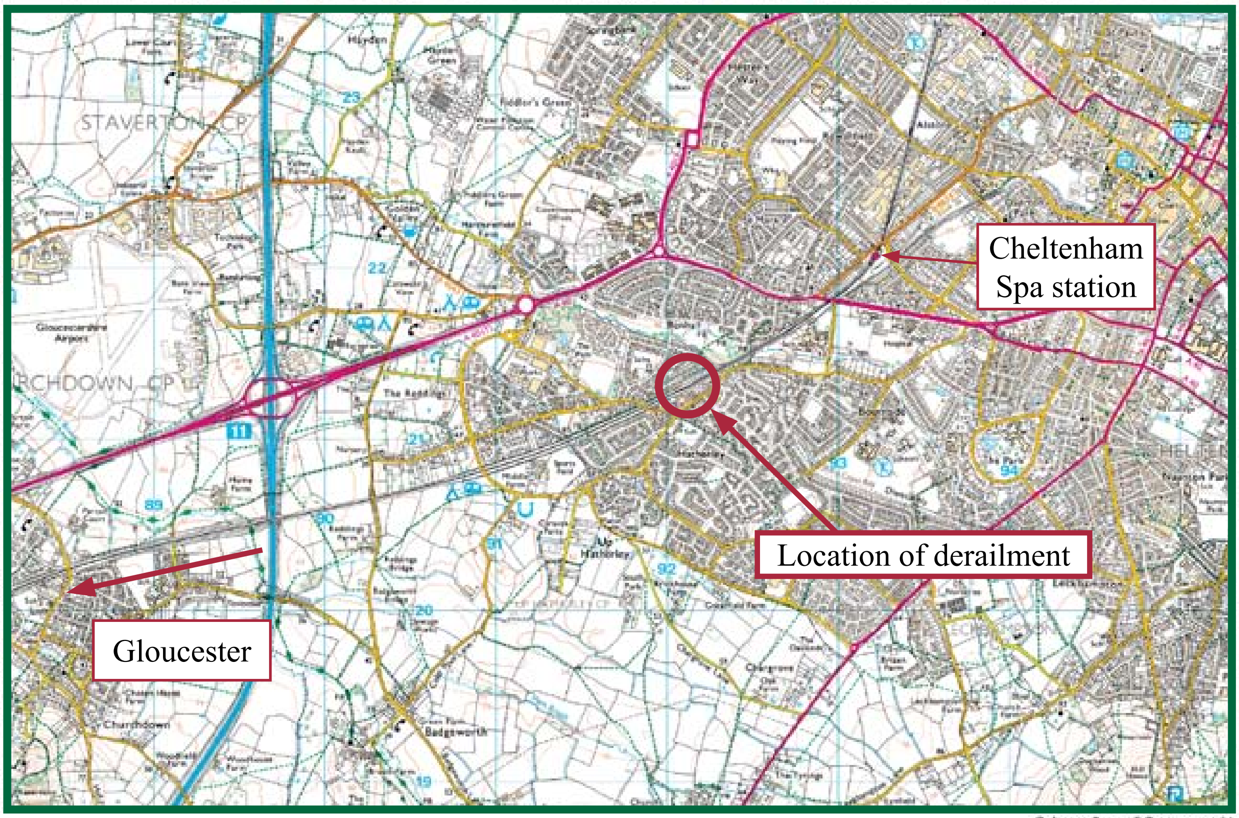

Figure 1: Extract from OS map showing location of derailment

7 The train was hauled by locomotive 66221 and comprised an unpowered locomotive, 60018, 5 empty BYA type wagons and 12 empty SSA type wagons. The derailed wagon, SSA 470028, was the 14th vehicle in the formation.

Immediate cause

8 The immediate cause of the derailment was the interaction between *false flanges* (Figure 15) which had developed on the leading wheelset of SSA 470028 and 673B *trailing points* at Hatherley. This resulted in the wheelset riding up over the railhead and derailing to the right *(six foot)* side, approximately 20 m further down the track.

9 The false flanges had developed as a result of the leading wheelset being dragged from its origin at Bescot Yard to the point of derailment with the handbrake applied.

Causal and contributory factors

10 The handbrake on SSA 470028 was not released during pre-departure train preparation at Bescot Yard, either because the train preparer did not adequately check the status of the handbrake on that vehicle, or because he did not confirm his belief that the handbrake was off by using the handbrake indicator or checking that the brake rigging was slack.

Contributory factors which are likely to have led to this error were:

- time pressure, either real or perceived, to complete the preparation of train 6V19, the locomotive for which had arrived 77 minutes late at Bescot and only 20 minutes before the booked departure time of train 6V19;
- the wagon's handbrake assembly had not been adequately maintained to ensure ease of operation, resulting in a stiff handbrake wheel which may have misled the train preparer into thinking that the handbrake was already off.

11 The applied handbrake was not detected during the roll-by examination as the train departed Bescot Yard. Contributory factors which are likely to have led to this were:

- insufficient illumination in the vicinity of the shunters' cabin at the north end of Bescot Yard to reliably detect dragging wheels that were not rotating freely, during hours of darkness;
- lack of any distinctive features or markings on the wheels to enable staff to reliably check whether the wheels of train 6V19 were rotating;
- confusion amongst ground staff at Bescot Yard about whether or not the roll-by examination was mandatory, which may have adversely affected the vigilance exercised that night.

12 The dragging wheelset was not detected during the subsequent 68 mile journey of train 6V19 between Bescot and the point of derailment. Contributory factors were:

- the incident occurred in the early hours of the morning when there were few people in the vicinity of the railway. Usually such problems are detected by railway staff who spot the tell tale signs such as smoke, sparks or noise from skidding wheels with *flats* on their rolling surface;
- the rear view mirror fitted to locomotive 66221 was not used during the journey; had it been used, it may have enabled the detection of any sparks emanating from the leading wheelset of SSA 470028 as it slid on the rails;
- there are no automatic track mounted devices for detecting dragging wheelsets, such as *hot wheel detectors* - HWDs (as opposed to *hot axle box detectors* - HABDs) on that route.

Severity of consequences

13 Following the derailment, the train remained coupled together and travelled for a distance of 4 miles, causing extensive track damage, before it was brought to a controlled stand at Signal G50, located on the approach to Barnwood Junction near Gloucester.

14 There were no collisions with structures or other trains and no injuries as a result of this derailment. No other trains were involved.

15 As a consequence of this incident, the Birmingham to Bristol railway line was partially blocked for eight days while the derailed train was recovered and track repairs were undertaken. During this period, single line working was implemented between Cheltenham Spa and Gloucester on the *Up* line.

Recommendations

16 Recommendations can be found at paragraph 176. They relate to the following areas:

- training and management of staff engaged in train preparation duties regarding procedures for checking handbrakes and conducting roll-by examinations (EWS);
- review of the effectiveness of roll-by examinations, the facilities provided for such inspections at despatch yards and the number of locations where they are mandated (Freight Operators);
- maintenance of handbrakes on SSA wagons and other freight fleets to ensure ease of operation and reliability of status indication. (Freight Operators);
- investigation of the optimum strategy for reducing the risk from vehicles with handbrakes left on entering traffic and consideration of changes to standards where appropriate (Freight Operators and Network Rail).

The Incident

The occurrence

17 On Tuesday 18 October 2005 at 05:20 hrs, freight train 6V19 was travelling between Bescot and Margam when all the wheels of one wagon became derailed at Hatherley, just south of Cheltenham Spa station, on the Down Birmingham to Bristol line.

18 Following the derailment, the train remained coupled together and travelled for a distance of 4 miles, causing extensive track damage, before it was brought to a controlled stand at Signal G50, located on the approach to Barnwood Junction near Gloucester. Figure 2 shows the derailed wagon and rear portion of the train.

Figure 2: SSA 470028 after derailment

19 There were no collisions with structures or other trains and no injuries as a result of this derailment. No other trains were involved.

20 As a result of this incident, the Birmingham to Bristol railway line was partially blocked for eight days while the derailed train was recovered and track repairs were undertaken. During this period, single line working was implemented between Cheltenham Spa and Gloucester on the Up line.

The parties involved

21 The infrastructure is owned, maintained and operated by Network Rail. The signaller at Gloucester signal box was an employee of Network Rail.

22 The train was operated by EWS. The hauling locomotive was owned by Angel Trains and leased to EWS and the derailed wagon was owned by EWS. The maintenance of both wagon and locomotive was the responsibility of EWS.

23 The driver of train 6V19 was employed by EWS.

24 The shunter who prepared the train at Bescot and other staff at Bescot Yard on duty at the time were employed by EWS.

The location

25 The route taken by train 6V19 on the morning of 18 October 2005 is shown in Figure 3. The Birmingham to Bristol line runs in a generally north-south direction between Ashchurch and Cheltenham, before turning south-west towards Gloucester. It is predominantly double track with a line speed of 95 mph (152 km/h). The *Engineer's Line Reference* (ELR) is BAG2.

26 Between Ashchurch and Cheltenham, there are several level crossings, including those at Swindon Road (84 miles 23 chains), Morris Hill (85 miles 0 chains) and Alstone (86 miles 20 chains).

27 A train travelling southwards over the Down Main line negotiates four sets of points in this area (Figure 3); 669A (*trailing*) and 668 (*facing*) forming the exit to Alstone Carriage sidings and a crossover between the main lines respectively, and 672 (facing) and 673B (trailing) forming the entrance and exit respectively to the Down Goods Loop near Hatherley.

28 The alignment between Ashchurch and Gloucester is nominally straight, with the exception of the right hand curve through Cheltenham Spa Station and reverse curves to the south of the station approaching Hatherley.

29 Trains are signalled under *track circuit block regulations*. Three or four aspect colour light signalling is provided throughout. The British Rail standard *Automatic Warning System* (AWS) is provided at all signals and *Train Protection and Warning System* (TPWS) equipment is provided at all signals where conflicting moves could take place. Gloucester signal box controls all movements in the area.

30 HABDs are provided at Spetchley and Churchdown, located 20 miles north and 2.5 miles south of Cheltenham Spa station respectively. A *Wheelchex* installation is located at Eckington, 12 miles north of Cheltenham Spa.

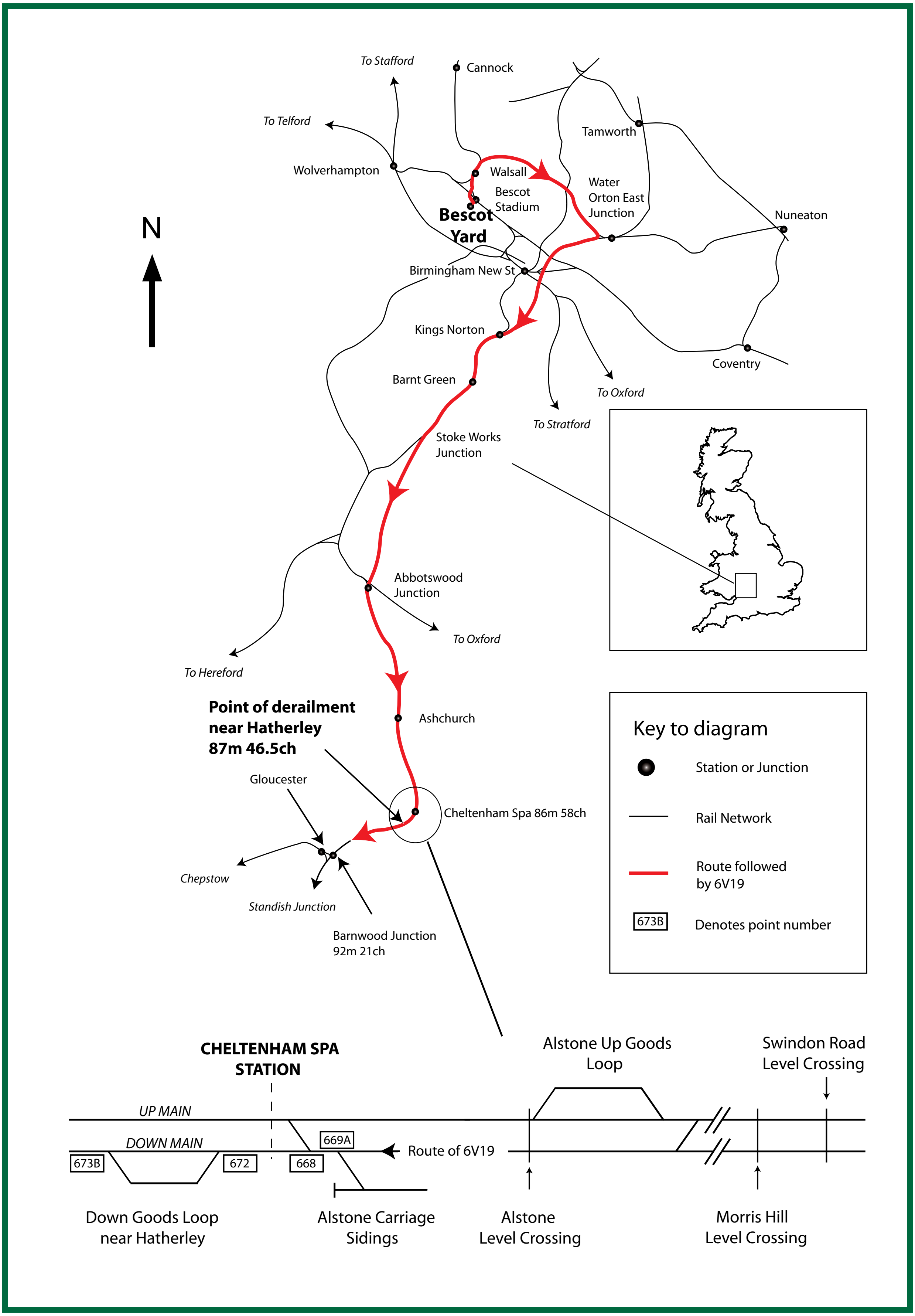

Figure 3: Map of the route taken by train 6V19

External circumstances

31 The weather on the morning of 18 October 2005 was cool (11ºC) with light winds and occasional light rain.

32 There were no geographical or environmental factors identified as having any bearing on this incident.

33 On the night of 17/18 October 2005, rail grinding train C21-03 operated by Serco Rail Operations, undertook work on the Down line between 74 miles 31 chains and 92 miles 70 chains within a possession. The site includes the section between Ashchurch and Barnwood where train 6V19 was finally stopped. Grinding was suspended through the level crossings and switch and crossing layouts, leading to minor variation in the rail head profile as is normal practice. Network Rail have confirmed that the grinding profiles were checked and were in accordance with their specification.

Train/rail equipment

34 Train 6V19 comprised locomotive 66221, unpowered locomotive 60018, five empty BYA type wagons and twelve empty SSA type wagons. The derailed wagon, SSA 470028, was the 14th vehicle in the train. A full listing of the wagons including their serial numbers and weights as registered on the train list can be found in Appendix C.

35 Train 6V19 is a service from Immingham to Margam, with various calling points en route including two in the Birmingham area, Bescot and Washwood Heath. The configuration of train 6V19 and its calling points vary from day to day, as does the composition of the train over different parts of the route.

Events preceding the incident

36 On the day of the incident, all the wagons and the unpowered locomotive comprising train 6V19 originated at Bescot. The hauling locomotive (66221) arrived at Bescot Yard with the inward working of train 6V19 from Immingham 77 minutes late. All of the incoming wagons terminated at Bescot. After uncoupling from those wagons, locomotive 66221 was coupled to locomotive 60018 and the 19 wagons that comprised the 'onward' working of train 6V19.

37 Train 6V19 departed Bescot Yard at 03:24 hrs, 18 minutes late, due to the late arrival of the locomotive but, as there were no further wagons to pick up at Washwood Heath, the train did not call there and it ran early from that point onwards.

38 Train 6V19 progressed southwards from Birmingham at a maximum speed of 60 mph (96 km/h), within the permitted speed for the line and wagons throughout. Once it had left Bescot, the train did not stop until the derailment occurred.

Events during the Incident

39 Neither the signaller in Gloucester signal box nor the driver of train 6V19 were initially aware that the train had derailed. There were no indications on the signaller's panel that anything was amiss and the signaller continued his duties by attempting to call a route to run from the Up line into Alstone sidings at Cheltenham for an empty stock train from Gloucester. However, when the signaller tried to set the route through 668 and 669 points into Alstone sidings, a light on the signaller's panel flashed to indicate that there was a fault on the points. The signaller called a technician.

40 At around this time, Churchdown HABD was activated by train 6V19. The alarm sounded in Gloucester signal box and the signaller immediately implemented a predetermined procedure by placing Signal G50, located at Barnwood, at danger to stop the train that had caused the alarm. He also placed signals on the adjacent line to danger, thereby ensuring that no train passed train 6V19. The driver of train 6V19 stopped at signal G50, having received a single yellow aspect at the preceding signal (ie the driver received a normal stopping sequence on the approach to signal G50).

41 The signaller identified which axle had initiated the HABD alarm from the printed record in the signal box and returned to the panel as train 6V19 was approaching Signal G50. He noted that train 6V19 had left *track circuit* DM90B down (ie showing occupied when it should normally have cleared). DM90B was two circuits to the rear of the one on which train 6V19 was now standing at G50 signal, and its electrical cables had been severed by the derailed wheels. The intervening track circuit had cleared normally.

42 The driver had opened his window on the approach to Signal G50 and could hear a loud banging noise from the train, which he assumed initially had been caused by *wheel flats*. When he looked back to the rear of his train, he also saw sparks from one part of the train.

43 The driver contacted the signaller on the signal post telephone at Signal G50 and the signaller explained that train 6V19 had activated the HABD alarm at Churchdown and left a track circuit occupied two sections in rear. The driver went back to examine his train, at which point he discovered the derailed wagon. He promptly informed the signaller, who assured him that he had afforded signal protection to the train (this was already in place by virtue of the signaller having originally thought that he needed to provide protection against a vehicle with a *hot axle box*). Subsequently, the driver also applied a *track circuit clip* to the Up line, once Network Rail and other personnel arrived on site, in order to ensure that they were properly protected from moving trains.

Fatalities, injuries and material damage

44 There were no fatalities or injuries as a result of this accident.

45 Pre-derailment infrastructure damage was caused to 669A points, 672 points and 673B points (Figure 3).

46 Post-derailment damage, which was confined to the Down line, was extensive from the point of derailment at 87 miles 46 chains until the train was brought to a stand at 91 miles 46 chains and comprised:

- approximately 10,000 concrete sleepers damaged;
- HABD destroyed at Churchdown (89m 08ch);
- track circuit tail cables severed;
- TPWS aerial grids destroyed.

47 All the significant damage to the train was confined to the derailed vehicle, SSA 470028. Vehicles following this wagon were struck by ballast debris thrown up by the derailed wheels, but the resulting damage was superficial.

48 SSA 470028 suffered extensive damage to the leading (handbraked) wheelset, each wheel of which had developed large flats and deep false flanges (Figure 15). Additionally, there was also some suspension damage.

Events following the incident

49 The signaller initiated the railway response to the incident, involving the despatch of mobile operations staff and technical personnel to site and notification to Regional Control at Swindon who disseminated the information to EWS Control. EWS instituted its own processes for arranging relief for the driver, and drugs and alcohol screening, which was undertaken at Newport. The signaller was also tested for drugs and alcohol. Such testing is undertaken routinely following a railway incident. The results for both the driver and signaller were negative.

50 At 13.30 hrs, EWS commenced re-railing operations following RAIB evidence collection on site; the leading wheelset was placed on *skate*s.

51 Train 6V19 left site for nearby Barnwood Junction sidings at 16.00 hrs, where SSA 470028 and the wagons at each end of it in the train formation were stabled for further examination.

52 Limited single line working was implemented between Gloucester (Barnwood Junction) and Ashchurch on the unaffected Up line from 12:20 hrs on 18 October, before SSA 470028 had been re-railed. A more intensive service over the Up line was possible from 16.30 hrs after train 6V19 was moved into Barnwood Yard. On 19 October, the single line working section was shortened, with Barnwood Junction and Cheltenham Spa (Alstone) representing the limits, following the repair of 669A points (Figure 3).

The Investigation

Investigation process

53 RAIB's investigation covered three principal aspects; track, operational issues and rolling stock, and was assisted by Network Rail, EWS, AEA Technology and Serco Assurance.

Sources of evidence

54 Evidence was gathered from a variety of sources:

- on site examination of the vehicles and track and a detailed inspection of the point of derailment (POD) and the damage leading up to it;
- interviews with personnel;
- train timing data from TRUST;
- the locomotive's data recorder (OTMR);
- visits to Bescot Yard during the day and night;
- detailed examination of the derailed wagon at EWS's Toton Depot and other wagons at Aldwarke Yard, Rotherham;
- maintenance and operational procedures;
- correspondence and consultation with EWS headquarters at Doncaster regarding policy issues about train preparation, the use of rear view mirrors and data on previous occurrences of handbrakes left on.

55 RAIB received good co-operation from EWS and Network Rail in terms of access to information, personnel and equipment. However, detailed investigation of the wagon was delayed by approximately 5 weeks, awaiting movement of the derailed wagon from Gloucester to a location where examination and testing could take place.

Key evidence - Track aspects

56 Having departed from Bescot Yard with the handbrake on, Wagon SSA 470028 ran with the leading wheelset dragging (ie not properly rotating). This had the effect of gradually wearing down the profile of the wheels, leading to an increased flange depth and allowing a false flange to develop as the centre part of the tread wore away (Figure 4). The normal profile of a rail wheel is such that it allows limited movement across the rail head. With the second (false) flange, the effect was for the wheel to 'clutch' the railhead, impacting with obstacles in its path. The majority of the flange loss indicated in Figure 4 occurred as the wheels ran on their flanges over ballast and sleepers for 4 miles post-derailment.

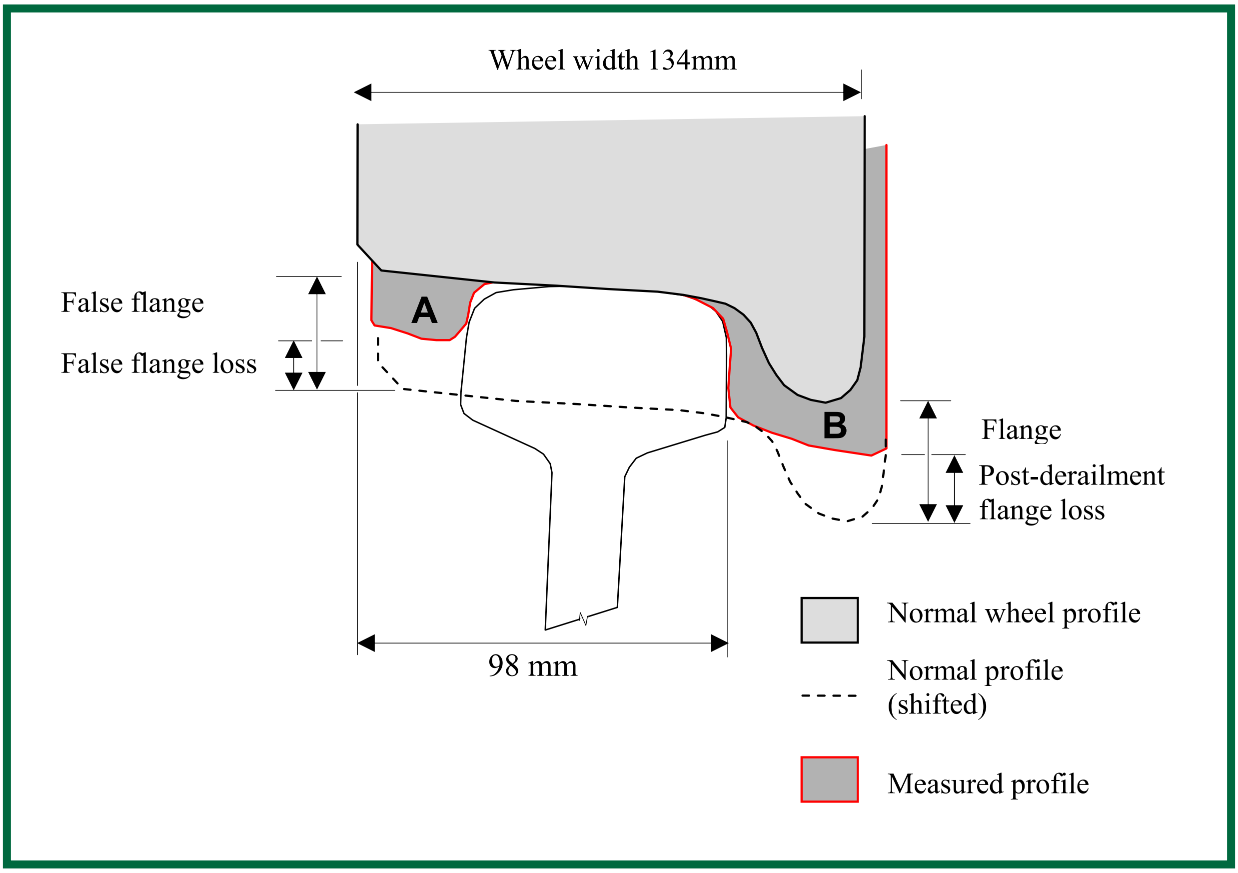

Figure 4: Profile of SSA 470028 Wheel 2A (leading left wheel) and illustration of flattened wheel profile wrapping around the rail head. The false flange is indicated at **A***, and the increased flange depth is shown on the opposite side at* **B***.*

57 The skidding wheel left longitudinal witness marks on the rail head, scuffing the newly ground railhead profile and these could be seen at the most northern location examined at Cleeve (83 miles 7 chains). At locations where clearances were insufficient to accommodate the distorted wheel profile, impact damage occurred. Witness marks, attributed to the low-running flange tips, were also observed on gauge (four foot) side clamped rail joints at Cleeve, indicating that a flat of at least 20 mm depth had developed at this location. Witness marks were also observed through the level crossing flangeways at Swindon Road (84 miles 26 chains), Morris Hill (85 miles 3 chains), and Alstone (86 miles 20 chains). At these locations, damage caused by the false flanges was also evident.

58 Evidence from wheel/rail contact marks indicated that wagon SSA 470028 had derailed momentarily whilst traversing 669A points (Figure 3) in the trailing direction. The mechanism of this partial derailment was similar to that observed further down the track at 673B points (paragraph 60). However, the resistance of the rails to overturning at 669A points was sufficient to prevent full derailment, and the leading wheelset rerailed itself as it passed beyond the toes of the points. 669A points comprise flat bottomed rail on concrete bearers.

59 The wagon continued through 668 points and Cheltenham Spa station platform without causing damage. The increased flange depth on the right wheel then made contact with and damaged track components at 672 points; the damage indicated that the wagon was not derailed at this position.

60 The derailment commenced as the leading wheelset passed through 673B points (trailing) which form the exit to the Down Goods Loop near Hatherley. The left wheel followed a similar path to that taken at 669A points, in that the false flange dropped between the left hand *stock* rail and *switch rail*, experiencing an increasing lateral force to the right as the rails converged (Figures 5 and 6).

61 The derailment sequence has been deduced from the damage and markings on site and is illustrated below. Sleeper 0 is located at the point of derailment (POD), which was identified as being at the toes of 673B points.

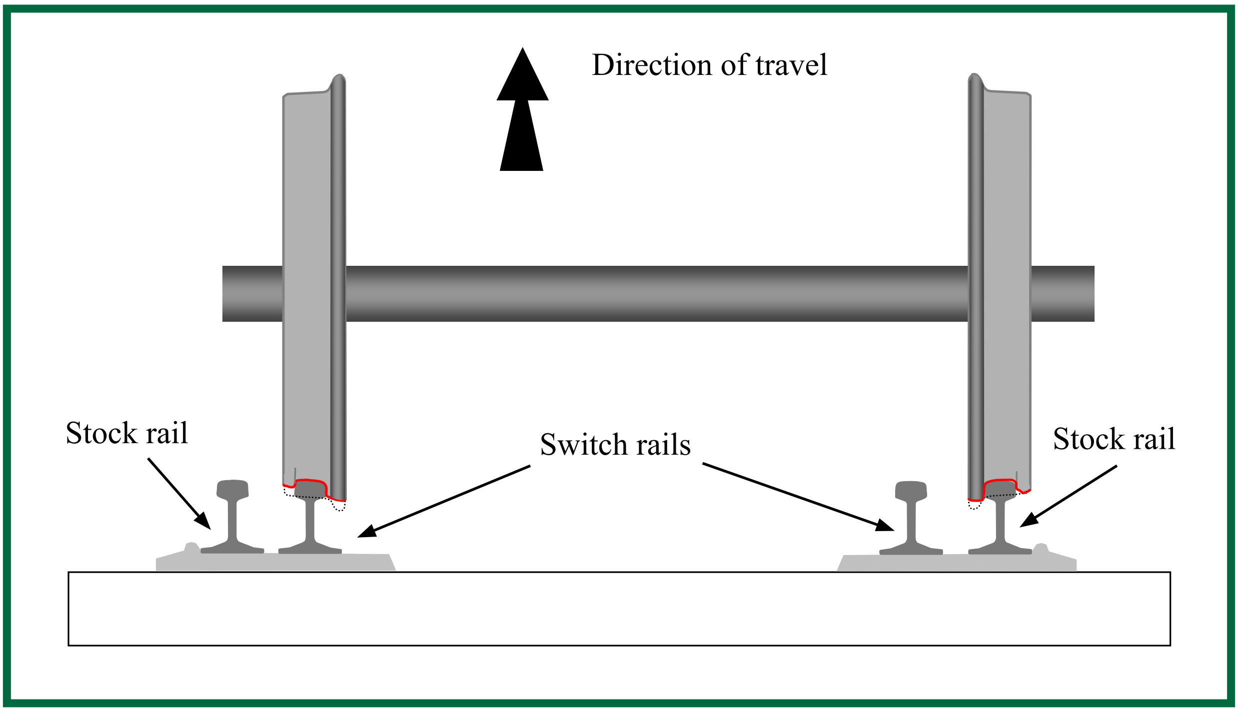

Figure 5: False flange on left wheel drops into gap between converging stock and switch rail at 673B points, 12 sleepers before point of derailment.

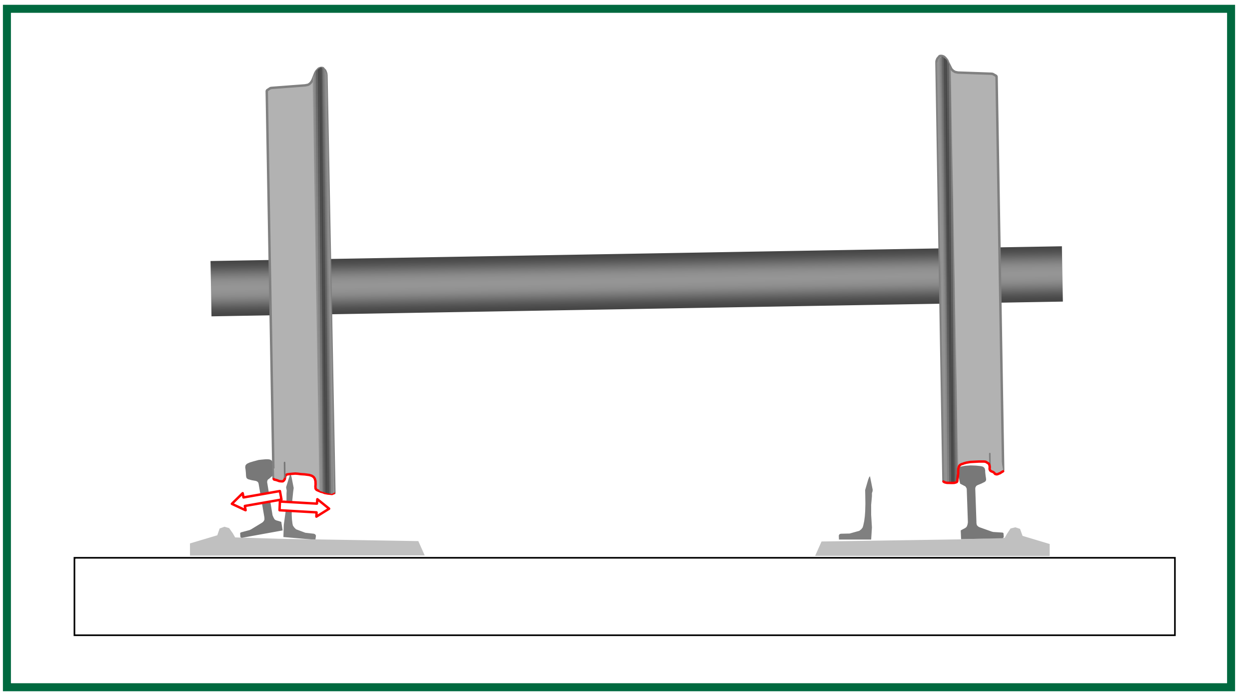

Figure 6: Six sleepers before point of derailment. As left-hand stock and switch rails converge, the stock rail is displaced to accommodate the false flange on this wheel. The left wheel is now running below the rail head.

62 673B points are constructed on timber bearers. Resistance to overturning was reduced by the action of coach screws being prised upwards and rail chairs pushing outwards (sideways movement) or fracturing. The track's ability to resist gauge spreading forces was consequently lower than at 669A points, allowing the left wheel to remain below the level of the railhead, rather than being sprung back into its correct position as the rail section regained its full profile beyond the toe of the points.

63 The leading wheelset continued to skid in this partly derailed configuration (Figure 7), with the tread (outer) face contacting the *gauge face* of the left rail. Gauge widening was accommodated by the partial overturning of the left rail, evidenced by lifted and fractured baseplates and displaced rail clips from the *gauge side* of the left rail (Figure 8). The resistance to gauge spreading forces on the next length of track was sufficient to prevent the left wheel descending onto the ballast, but not high enough to force the wheel back into the normal running position, as was the case beyond 669A points.

64 The position of the left wheel resulted in high lateral forces being imposed on the right rail by the right wheel flange, increasing the ratio of lateral flange forces in relation to the wheel load. This did not result in *flange climb* as the wheel was not rotating, and this also meant the speed of the train was not a major factor in this derailment mechanism.

65 The leading wheelset next encountered a set of *adjustment switches*, installed to protect 673B points from thermal stresses. These were located at 87m 46½ chains; 1 chain (22 yards) beyond the trailing switch tip of 673B points.

66 Rail markings showed that the right wheel flange made contact with the machined notch on the right hand rail (point C, Figure 9) as a result of the high lateral forces imposed on it. The wheel struck the notch and was catapulted into free flight for a distance of 700 mm, releasing the gauge spreading force which resulted in a lateral movement to the right (Figure 10). The flange landed on the rail head and lacking lateral restraint, descended onto the ballast (Figure 11) derailing to the *field side.*

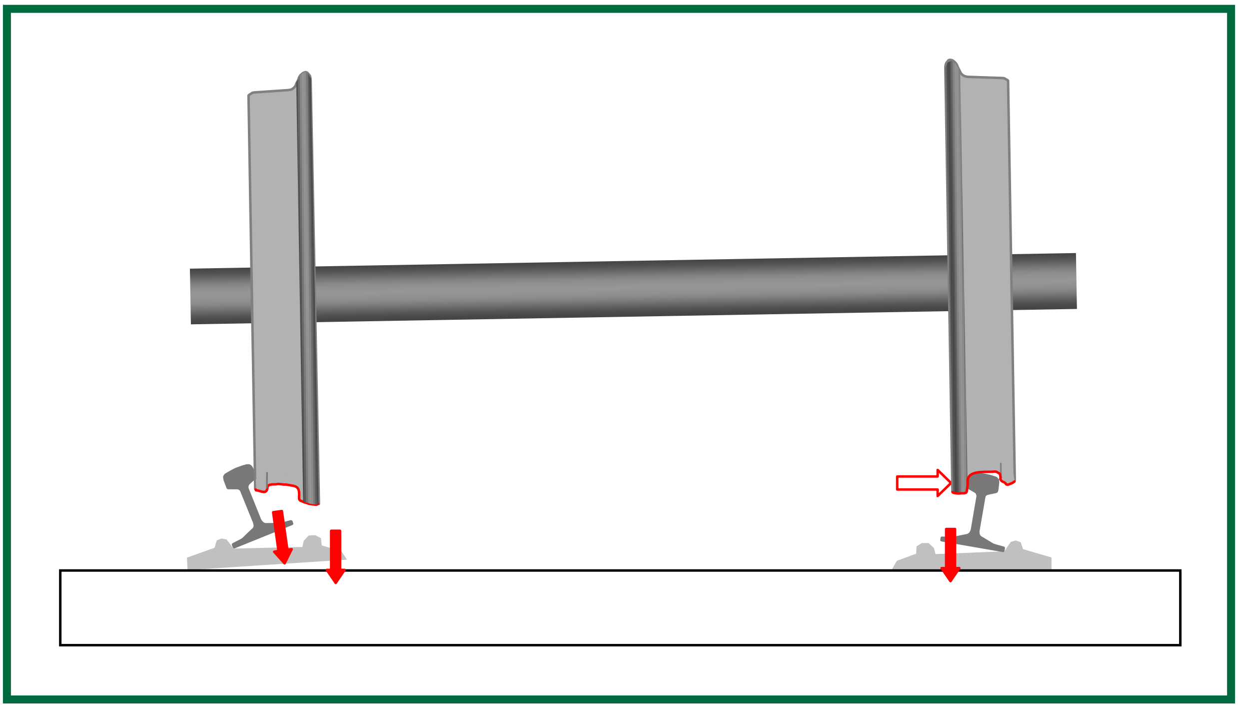

Figure 7: One sleeper after point of derailment. High lateral forces are developed by track's resistance to gauge spreading following partial derailment of left wheel. A 98 mm effective gauge increase was accommodated by lifting of baseplates and failure or displacement of 'Pandrol clips' (see Appendix B), resulting in outwards rotation of left rail.

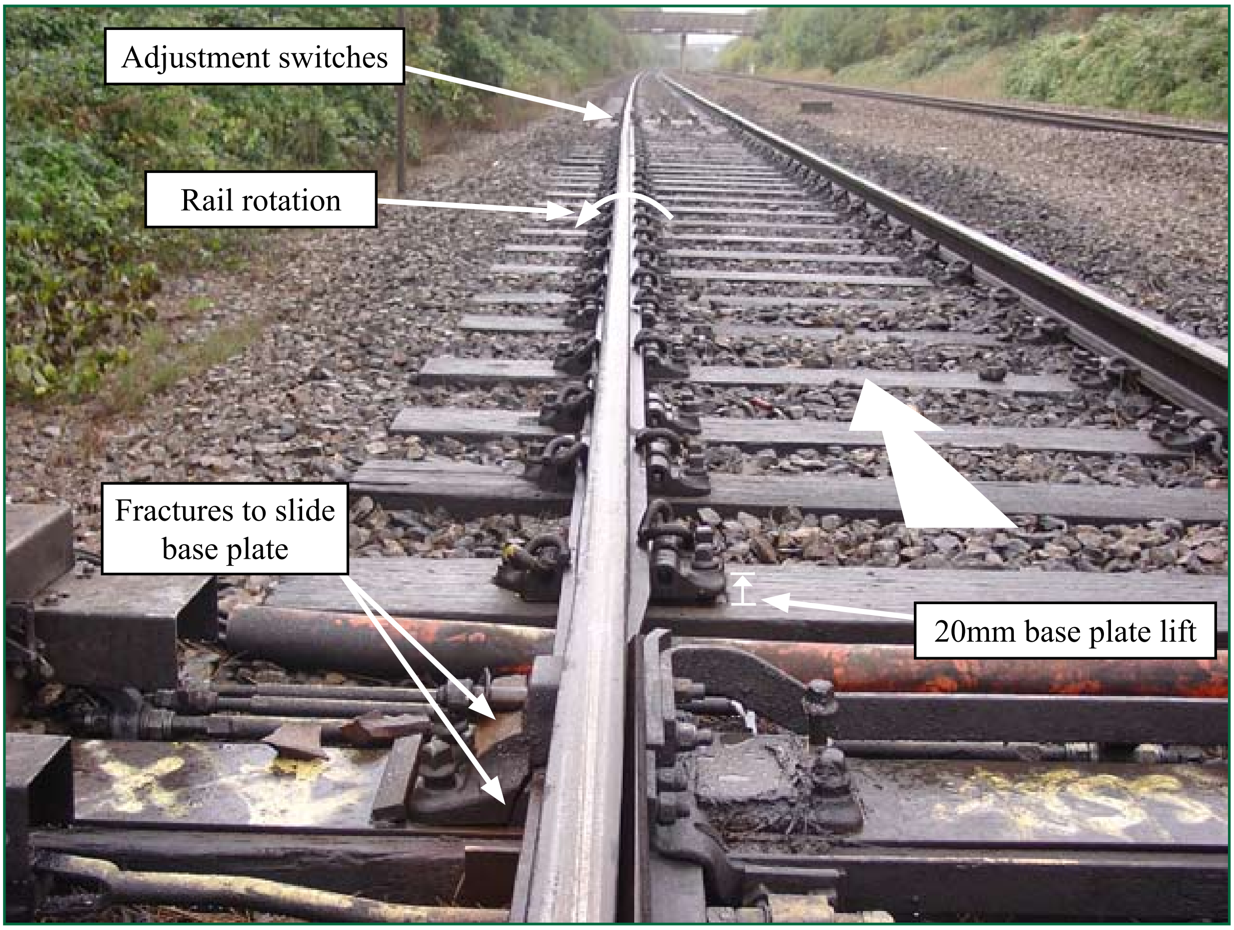

Figure 8: View along left hand rail in direction of travel from toes of 673B points showing rotated rail, lifted baseplates and displaced rail clips. The partially split points are visible in the foreground as a result of the action of the false flange at the point of derailment of the first wheel (sleeper 0). The adjustment switches, where full derailment occurred, are visible in the background.

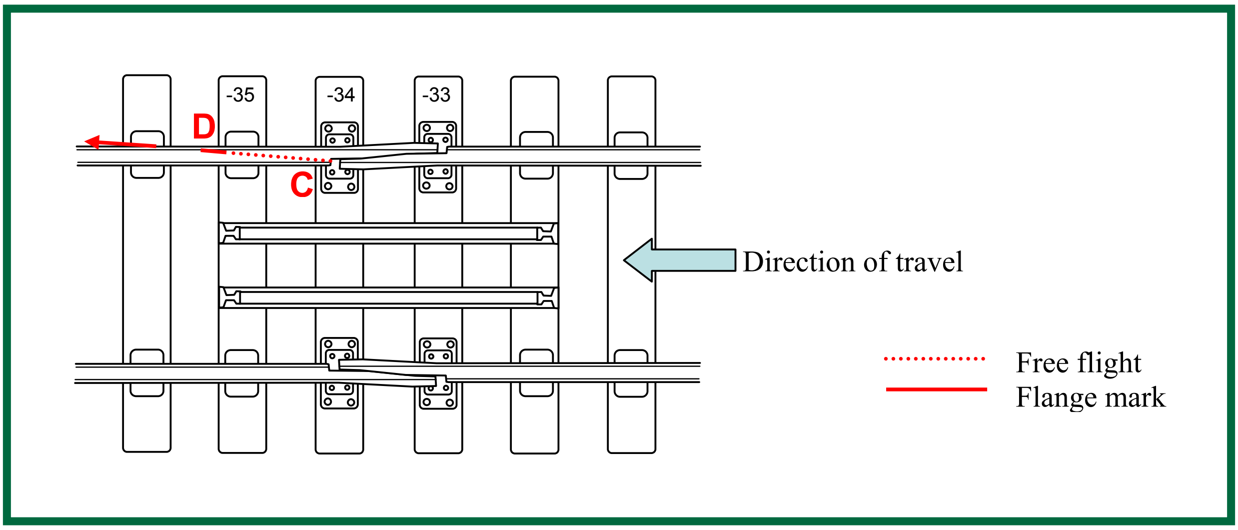

Figure 9: Full derailment triggered by impact of right wheel with machined notch in adjustment switch layout (**C**)*. Flange landed on rail head after free flight of approx 700 mm at* (**D**)*. Sleeper numbers are indicated. Figure 11 uses the same notation.*

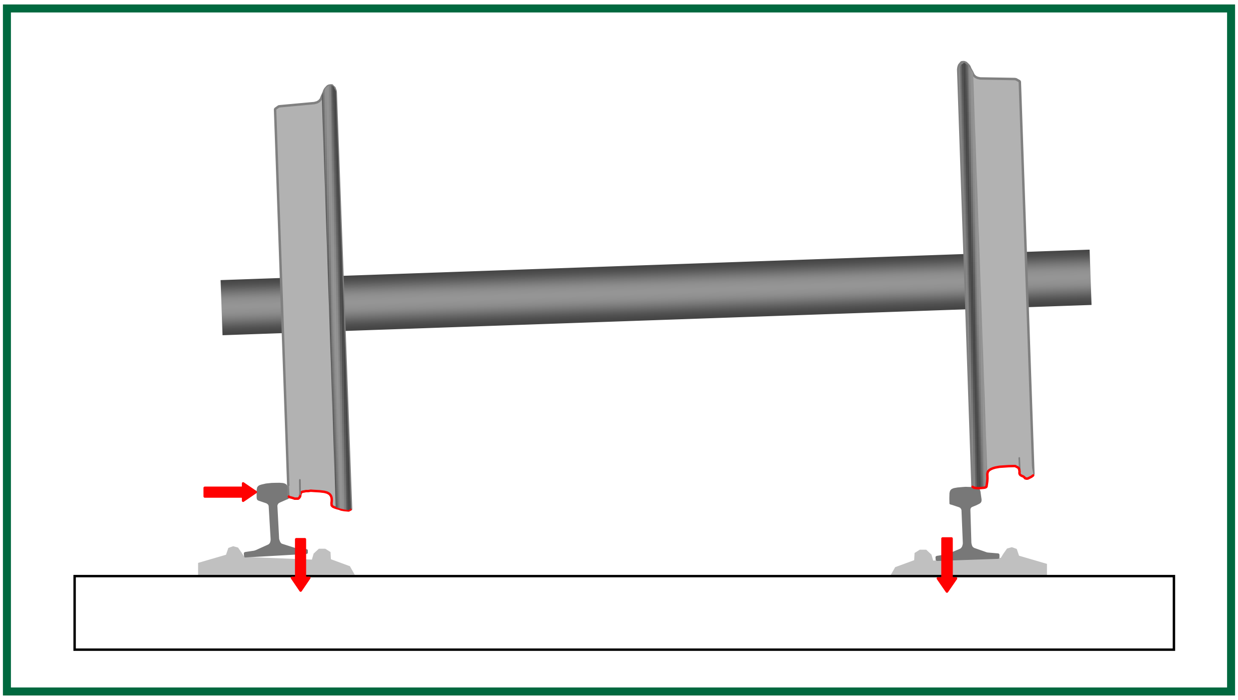

Figure 10: 35 sleepers after the point of derailment. As right wheel passes adjustment switches, it is catapulted into free flight. Resistance to gauge spreading forces exerted by the left rail caused the wheelset to be displaced sideways leading to full derailment to the right.

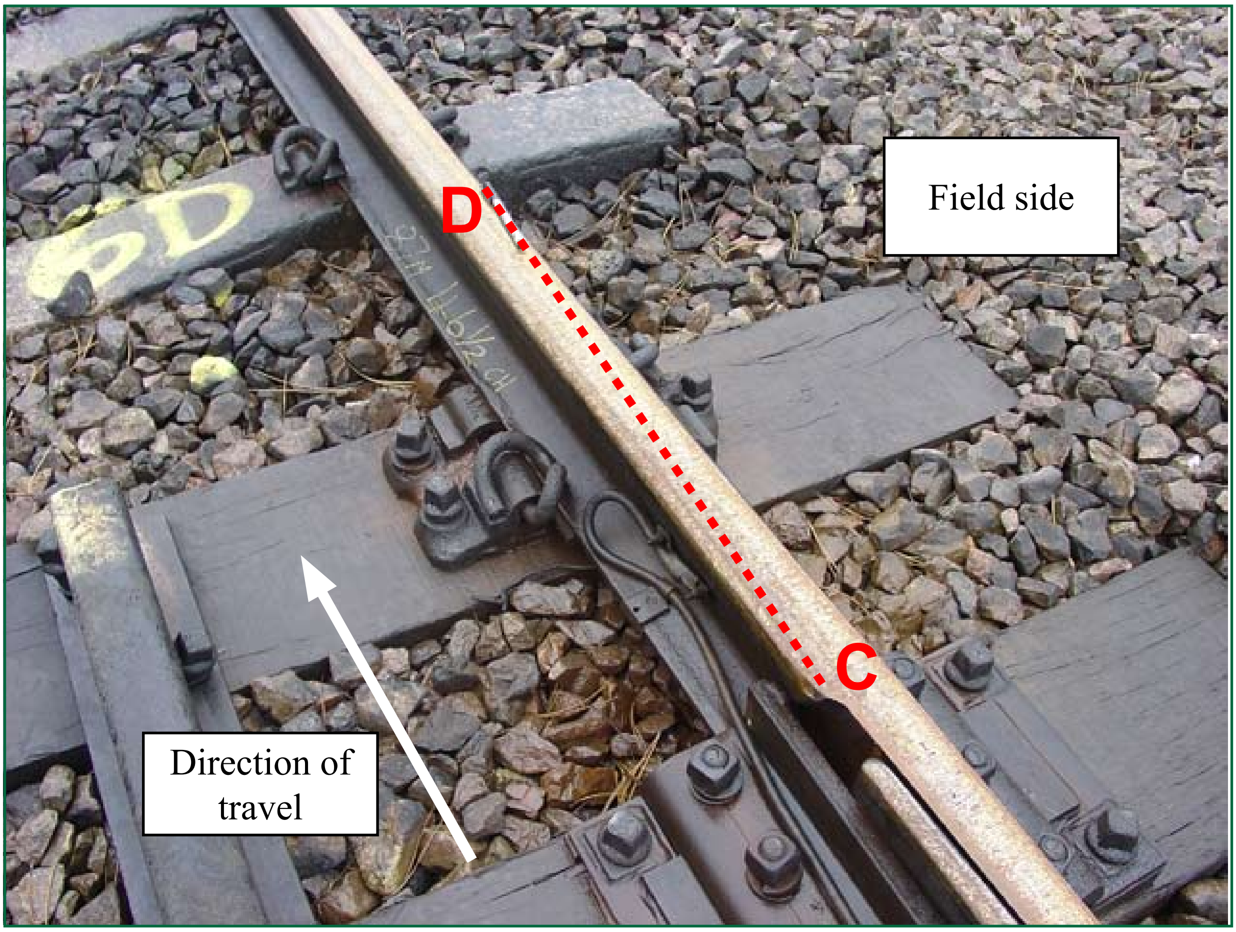

Figure 11: Photograph of adjustment switches showing point of impact with the machined notch (**C**) *and derailment mark indicated by the position of the pen on rail head* (**D**) *where right hand wheel landed after being in free flight for 700 mm* (*grinding marks are visible on the rail head, showing light corrosion following overnight rain*).

67 The trailing wheelset derailed after a further 100 yards due to the increased angle of attack between flange and rail once the leading wheelset was fully derailed. The wagon continued in this manner, fully derailed to the right until the train was stopped after travelling a further 4 miles.

68 The newly-ground rail head profile increased the roughness of the rail head and hence the coefficient of friction between the skidding wheel and the rail. The effect of this was to increase the rate of wear of the wheel, but this was a consequence of the wheel being locked and was not causal. Additionally, as the wheel was not rotating, the higher friction between wheel and rail due to the grinding did not increase the risk of flange climb. The rail grinding was therefore not contributory.

69 The track geometry records derived from Network Rail's New Measurement Train indicate that track geometry parameters lay within the limits for maintenance attention in the section leading up to the point of derailment which includes 673B points. Measurement runs for this line were undertaken on 25 August and 29 September 2005.

70 The track leading up to and including the point of derailment, was in satisfactory condition and there was no evidence to suggest that it had been a contributory factor to the derailment.

Key evidence - Operational aspects

71 The driver of train 6V19 described his involvement with the preparation of the train at Bescot, his journey to Gloucester and his actions upon discovering that his train had become derailed. The driver considered that train preparation activity at Bescot was normal and the journey from Bescot to Signal G50 was trouble-free. He had no indication of any problem with his train until the final approach to G50 signal, when he became aware of a banging noise and sparking as he looked out of the side window.

72 The signaller had no reason to suspect that train 6V19 might be derailed until it left a track circuit showing occupied after the whole train had passed through. Although train 6V19 had caused significant damage to 669 and 673 points (Figure 3), they had shown no immediate indication of any problem. It was only when the signaller attempted to call another route through 669 points that a light on the panel flashed to indicate a fault. Therefore, the activation of the HABD alarm (by which time train 6V19 had derailed) was the first indication of a problem with train 6V19, followed by the failure of track circuit DM90B to clear after the passage of the train. By this stage, train 6V19 was already on the approach to Signal G50, which had been placed to danger by the signaller in response to the activation of the HABD at Churchdown.

73 Three members of EWS staff were involved in preparing trains in Bescot Yard on the night of 17/18 October, but responsibility for preparing train 6V19 fell to only one of the three. Evidence was given to RAIB that the train preparer of train 6V19 believed he prepared it in accordance with standard procedures (paragraph 74) and that all handbrakes were released prior to departure. EWS procedures for Bescot Yard require that a roll-by test is undertaken as each train departs, as a final check that the train is fit to travel. The staff on duty stated they had performed a roll-by test on train 6V19 as it departed Bescot Yard.

74 Train preparation duties are detailed in the *White Pages* (GO/RM3056), with operational pre-departure checks listed in Section C4 of GO/RT3056 (refer Appendix D). Section C4 includes the requirement to make a physical examination of the train to ensure that all handbrakes are released. EWS's own procedures for train preparation are based on the White Pages and suitable instruction is provided to staff who are training in the role.

75 The competence of train preparation staff at Bescot is assessed by a programme of checks as follows:

- Biennial formal assessment of the operational aspects of train preparation duties.
- Four-monthly 'on the job' assessments in which an Operations Manager watches each staff member perform their duties. These checks are complementary to the biennial examination and, when taken in conjunction with that examination, comprise a two-yearly cycle of theoretical and practical competency assessments.
- Biennial assessments of the technical aspects of the train preparer's task, ie those relating to the rolling stock technician element such as condition of running gear.

There is also a route knowledge competency focused on familiarity with the yard and its operations. This is the subject of self-certification and should be signed annually by the individual concerned. This competence is therefore not assessed by the individual's manager, although the manager does maintain a record of the annual self-certification.

76 An adequate structure was found to exist for establishing and maintaining the competence of train preparers at Bescot. The train preparer for train 6V19 on the night of 17/18 October was current on his biennial competence examination (undertaken on 23 August 2004) and on the four-monthly observational competence assessments (the two assessments prior to 18 October 2005 were undertaken on 6 April 2005 and 28 July 2005). The train preparer had been tested on the competencies required for the rolling stock technician element of the job on 16 September 2005. In all cases, the train preparer had been deemed competent to perform the designated tasks. However, the train preparer's route knowledge competence check was out of date (last signed on 21 March 2004) but this is not considered causal or contributory to this incident.

77 Information was obtained from the OTMR equipment carried on locomotive 66221. This confirmed that the train had not stopped between departure from Bescot Yard and arrival at Signal G50. Recordings of the conversations between the driver of train 6V19 and the signaller at Gloucester were also reviewed and showed a good standard of communication, with a clear understanding being reached as to the situation and the actions that needed to be taken.

78 A number of documentary sources were examined, principally to confirm the composition of the train (TOPS train list), which corresponded with the wagons actually found within the formation of train 6V19 on site and to establish key passing times after its departure from Bescot Yard (TRUST data). TOPS data was also used to establish the movements of SSA 470028 in the few days before its derailment at Hatherley.

79 It was necessary to establish whether it was possible for a wagon with a handbrake applied, to depart from Bescot Yard without the fault being apparent to the person(s) undertaking the roll-by test. With the co-operation of EWS, this was assessed during the evening of 16 November 2005, when a number of roll-by tests were observed at Bescot Yard from a vantage point outside the north end cabin (the same location where the roll-by test for train 6V19 is said to have taken place on the morning of 18 October 2005). The tests were undertaken with a small rake of IGA wagons (SSAs were not available), which are bogied flat-bedded vehicles. Although from a different type of wagon, the results are considered relevant to SSA wagons. It was apparent from these tests that:

- It is difficult, but not impossible, to establish whether wheels are turning. However, one would need to be focusing on each wheel from the optimum angle to determine whether it was turning. Casual observation would not be sufficient. Additionally, the low level of ambient lighting during the hours of darkness and the lack of any distinguishing marks on the wheels makes this task more difficult.
- It would be virtually impossible to see if a wheel on a SSA wagon was turning when examining it from a side-on perspective because the view of the wheel is obstructed by the suspension. It is slightly easier to see the wheel from a 45 degree angle as it approaches.
- The noise a locked wheelset makes depends on the level of friction between the wheel and rail at that time. When friction is high a loud squealing noise can be heard, when friction is low the noise is diminished. EWS undertook their own tests on 7/8 November and found that an SSA wagon with handbrake applied could pass the shunter's cabin at the north end of Bescot yard with little apparent noise over and above that of the passing train. This is not surprising because the rails in that area tend to be greasy and the train speed is slow. The cabin is adjacent to the exit road from the yard and audibility is not affected to any significant extent by ambient noise from the nearby M6 motorway.

80 One final area for investigation related to graffiti found on the side of the derailed wagon. SSA 470028 was the only wagon on train 6V19 to have been affected and the possibility that the vandal who painted the graffiti also tampered with the handbrake was considered. The origin of the graffiti was investigated with the help of British Transport Police's graffiti squad. Although they were unable to find a match for the graffiti on the side of SSA 470028 with any information held on their database, they advised RAIB that it is highly unusual for someone engaged in spraying graffiti to tamper in any other way with railway property. The implausibility of vandal interference in this incident was supported by other evidence:

- Train preparation duties were completed a matter of minutes before the train departed and there was insufficient time for another party to paint the graffiti and apply the handbrake.
- None of the train preparation staff nor the driver of train 6V19 saw any unauthorised person in Bescot Yard during the night of 17/18 October. Indeed, none of those interviewed recalled any incidents of trespass or vandalism at Bescot Yard.
- EWS staff at Bescot stated that trespass and vandalism are unusual occurrences within the yard.

Key evidence - Rolling stock aspects

Vehicle description

81 SSA 470028 is a two-axle steel scrap carrier wagon with a gross laden weight of 51 tonnes and a tare weight of 15.5 tonnes. The steel wagon features a high-sided box body integrally mounted on an underframe (Figure 12). It was originally built in the early 1980s as a hopper wagon, then converted circa 1985 to a box body and then re-bodied again with a stronger superstructure in 1997.

Figure 12: SSA 470028 after recovery to Toton Depot with wheel skate (marked C1) used to move the wagon with its damaged wheelset after the derailment

82 The suspension system is a friction damped pedestal type and comprises a cast steel pedestal mounted to the underframe at the four wheel positions and a cast steel saddle on which the wheelset is mounted. The wheelsets comprise 953 mm diameter wheels (when new) with a P6 profile and wheel mounted brake discs. Each axle end is fitted with a 150 mm cartridge bearing.

83 Each wagon has a single pipe air brake system and a handbrake on one wheelset which is operated by handbrake wheels located on both sides of the vehicle (Figure 13). Indicators are provided adjacent to each handbrake wheel to show whether the handbrake is on or off.

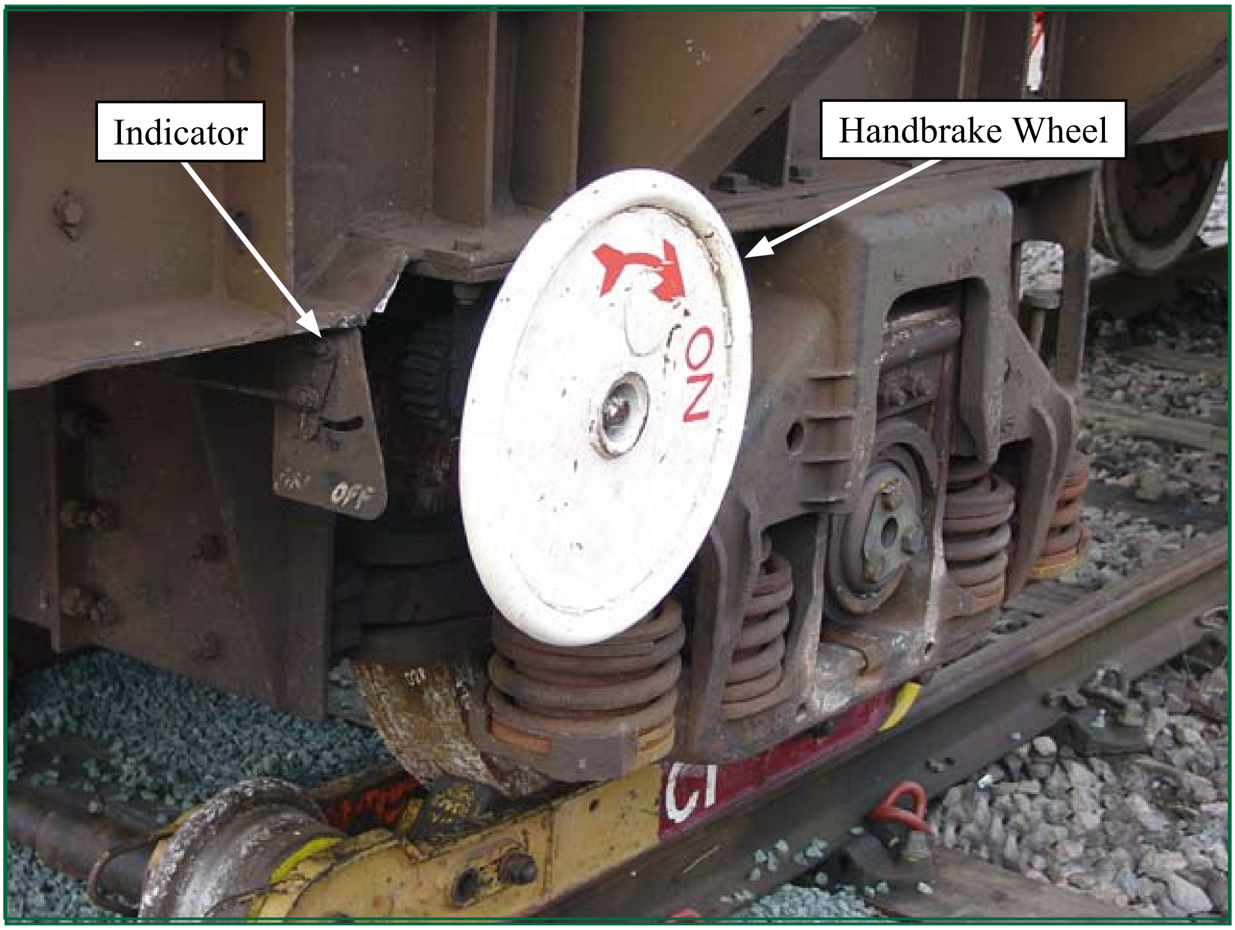

Figure 13: Handbrake wheel and indicator on SSA 470028

84 SSA wagons, in common with most other freight vehicles, do not feature a handbrake interlock. These devices prevent the train's automatic brake from being released until the handbrakes on all vehicles fitted with interlocks have been released; their fitment is not currently a mandatory requirement.

85 Each handbrake wheel is connected to one end of the handbrake shaft (on one side via a reversing gear). Turning the handbrake wheel clockwise rotates the shaft driving the actuation links which apply the brake pads to the discs (Figure 14). Slots in the handbrake actuating rods ensure that the airbrake and handbrake are independent; therefore, an application of the airbrake cannot cause the handbrake to apply, as proved subsequently by tests (Paragraph 113). Slack adjusters are fitted to each brake actuator to take up wear of the pads and discs. One of the actuation links also drives the 6 mm diameter handbrake indicator push rods, one of which is cranked to avoid pipework (Figure 14). On SSA 470028 the indicator push rods were operable.

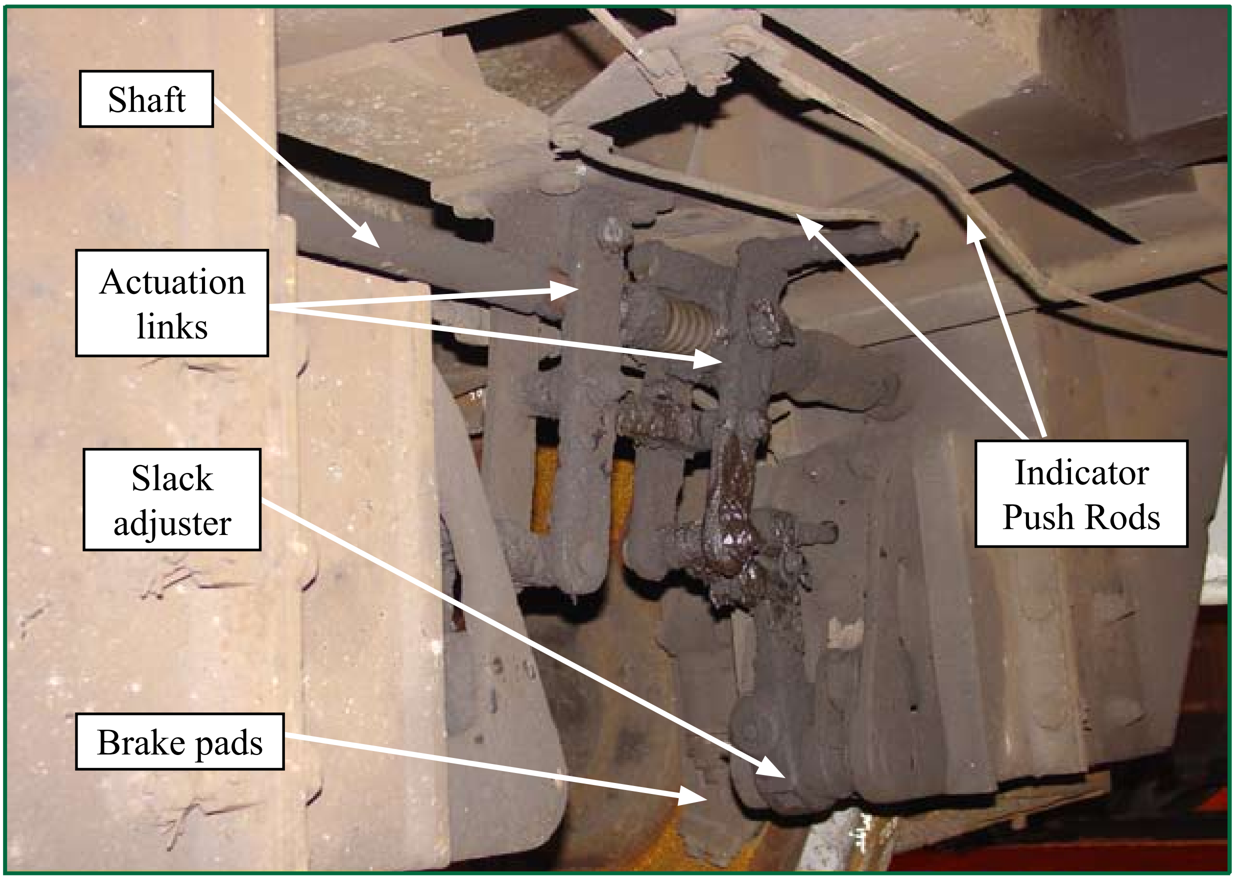

Figure 14: SSA 470028 handbrake components below the underframe.

Maintenance of SSA 470028

86 The prescribed maintenance interval for SSA Wagons since the late 1990s has been an annual Vehicle Inspection and Brake Test (VIBT), interspersed with six-monthly Planned Preventative Maintenance (PPM). Both types of maintenance checks include a functional test of the vehicle's air and hand brake systems. Neither test is normally performed over a pit road, but the relevant brake system components are easily accessible.

87 Following two previous incidents in 2005, one of which involved another SSA wagon, EWS took the decision on 17 October 2005 to reduce the VIBT interval from 365 days to 122 days and remove the PPM requirement. This transition was completed on 7 December 2005.

88 The maintenance records for SSA 470028 show a PPM was carried out on 27 June 2005 at Cardiff Tidal Sidings Depot when the brake pads and handbrake wheel, which had been damaged during loading of scrap steel, were renewed. The brake rigging was also eased. There was no report of a stiff handbrake at this exam although the applicable maintenance specification requires this to be checked. Previous engineering checks on the brake system were carried out on 4 and 18 June 2005 at Plymouth to rectify excessive leakage of air from the brake pipe and also on 2 June 2005 as part of a fleet check. Repairs to part of the suspension were undertaken on 1 March 2005 and a VIBT was carried out on 1 Dec 2004 when an air leak was rectified and the inter-vehicle rubber hoses were renewed. However, none of those repairs are considered relevant to this derailment.

89 In addition to the above maintenance, the TOPS record shows five other dates between 28 February and 25 June 2005 when the vehicle was flagged for repair but subsequently released without any work being carried out. EWS were unable to explain the absence of records for these instances other than that they were likely to be errors made by staff when entering data into the TOPS system.

On site vehicle examinations

90 Following the derailment, a preliminary examination was carried out on site. The leading wheelset, fitted with the handbrake, had very large flats, approximately 300 mm long on the running surface of the wheels and deep false flanges (Figure 15).

91 The handbrake indicator on the left side of the vehicle clearly showed the handbrake was 'on'. On the right side the indicator was approximately halfway between 'on' and 'off' and the lettering was not clearly legible. A check of the brake rigging on site confirmed the pads were firmly up against the discs. Tests on the left hand handbrake wheel also confirmed that the handbrake was almost fully on; it was 5 ¾ turns towards 'on', with the maximum possible number of turns on this vehicle being 5 ⅞. Additionally, the handbrake wheel was found to be noticeably stiff to turn in both directions.

92 The initial conclusion was that the large flats had been caused by the wheelset having been dragged with the handbrake on for some considerable distance.

93 SSA 470028 and the two adjacent SSA vehicles 470061 and 470091 (for comparison) were examined in more detail on 19 October at Barnwood Junction. Wheel profiles of all three wagons were measured. These confirmed that only the leading wheels of 470028 had lost their profile, having a significant groove around three quarters of the circumference, in addition to the flat and false flange (paragraph 102).

Other wagons in the SSA Fleet

94 The torque required to operate the handbrake wheels of 11 SSA wagons and their general maintenance condition were investigated at Aldwarke sidings near Rotherham on 23 November 2005. The torque was found to vary widely; some were relatively easy to operate (torque values 5 - 25 Nm) and others, like the handbrake on SSA 470028, required significant physical effort, (torque values 50 - 70 Nm). The EWS maintenance specification requires that the handbrake is tested for 'ease of operation' but it does not specify a value of torque.

95 The general maintenance condition of the handbrake assemblies also varied significantly. Seven of the eleven wagons had some form of defect on the handbrakes such as bent or missing indicators, bent indicator push rods (resulting in incorrect indication), bent actuation shafts and lack of or dirty lubrication. Whilst such defects would not have rendered the handbrakes inoperable, they could adversely affect the ease and reliability of operation for ground staff.

Detailed examination of SSA 470028

96 Examination over a pit and testing of SSA 470028 was undertaken at EWS's Toton Depot by RAIB and EWS. The objective was to determine if there was any vehicle defect or design flaw which may have been a causal or contributory factor in the sequence of events leading up to the derailment.

97 Detailed examinations of the wheelset and handbrake shaft were undertaken by Serco Assurance in Derby to determine the cause of the wheel wear patterns and the observed stiffness of the handbrake.

98 Key findings from the tests are summarised in the following paragraphs.

Wheelset

99 The principal features of the leading wheelset were the large flats, approximately 300 mm in length and deep false flanges which had developed on the wheels, as shown in Figure 15.

100 The distance required to create such large flats is dependant on many factors and there is no rigorous method for evaluating the distance dragged. However, it has been estimated by Serco Assurance, based on evidence from previous incidents in which wheelsets have run in a seized condition for long distances, that this wheelset had been dragged a distance consistent with an origin at Bescot. It is therefore unlikely that the handbrake had been left on prior to arrival at Bescot Yard. The previous occasion when the handbrake could have been applied was at Washwood Heath on 17 October.

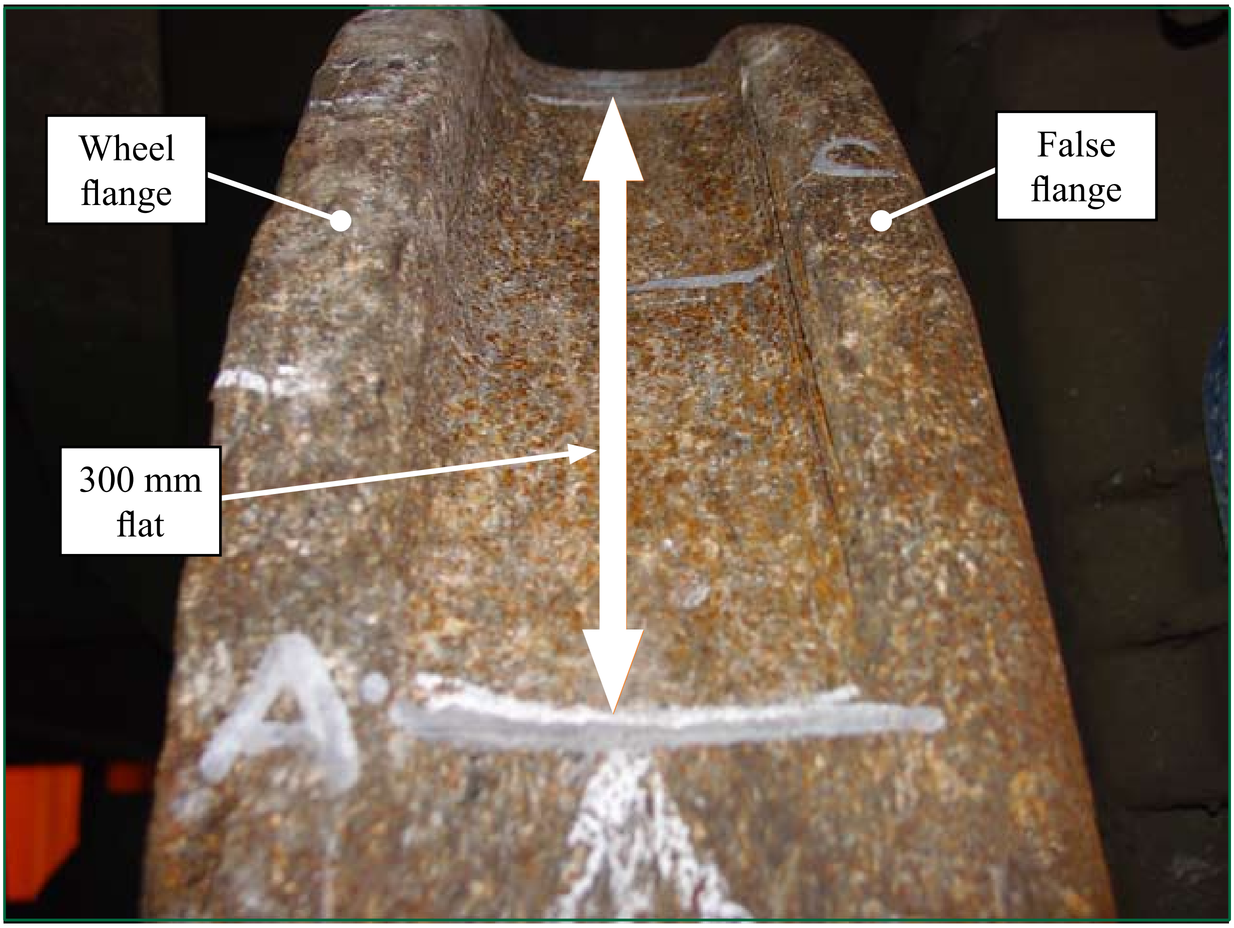

Figure 15: Large wheel flat and false flange on right leading wheel of SSA 470028

101 The profiles of the two wheels are shown in Figures 16 and 17. The different depths of the two false flanges, measured at the centre of the flats, is attributed to post derailment impact damage; the left wheel suffering more damage than the right. Some of this damage may have resulted from impacts with track components before derailing as explained in paragraph 57.

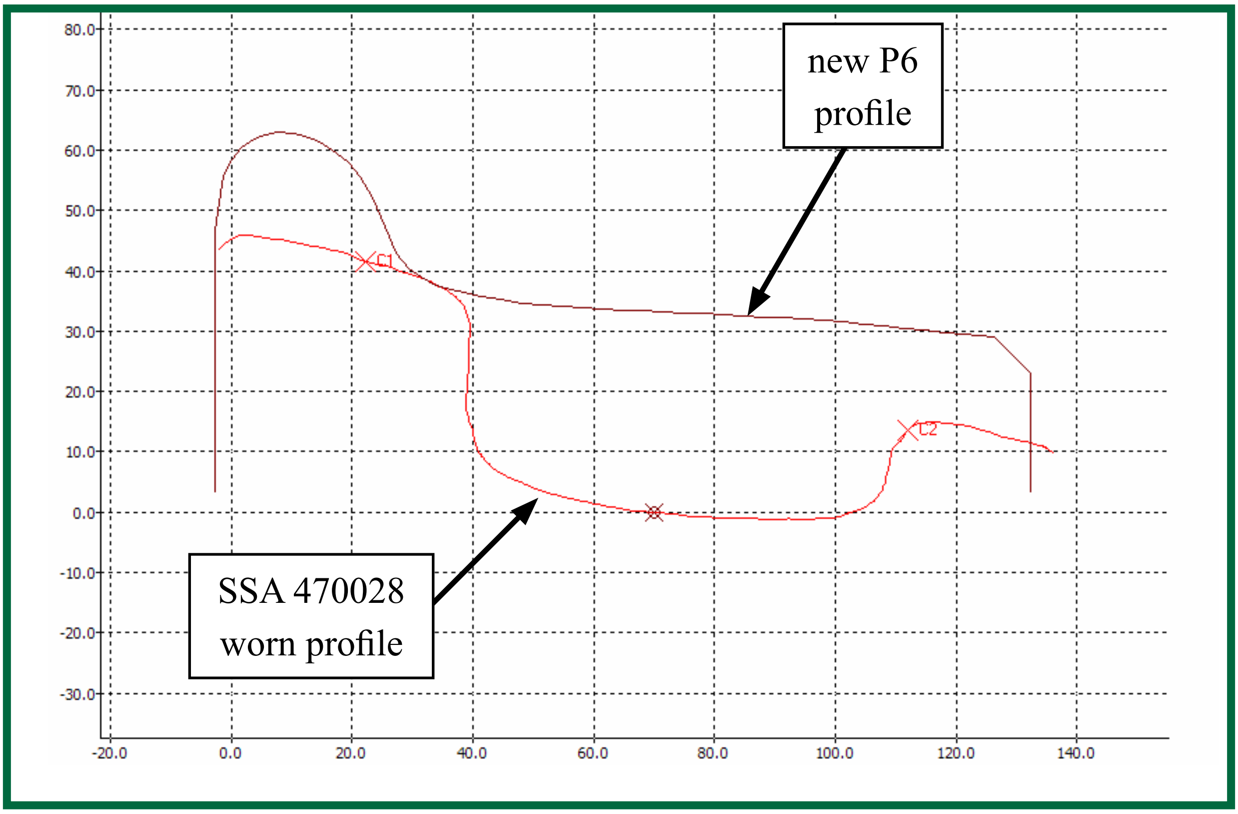

Figure 16: Profile of left leading wheel near centre of large flat

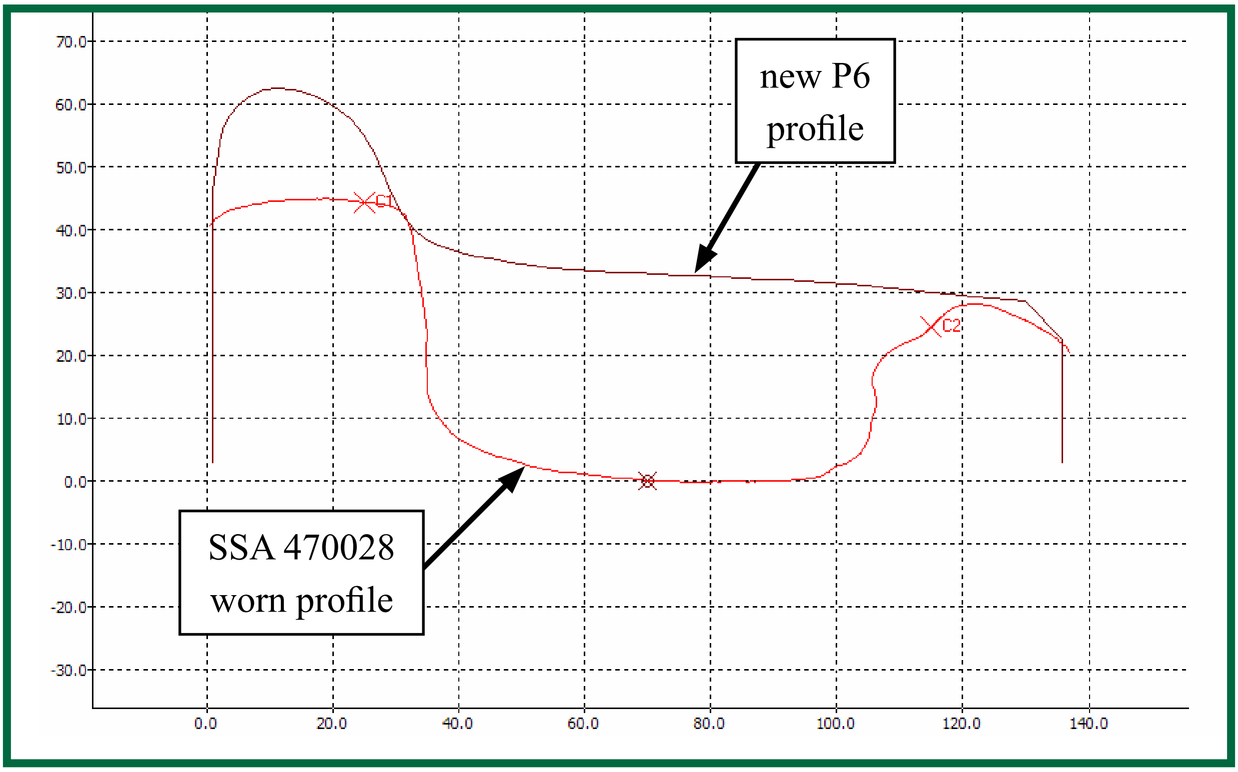

Figure 17: Profile of right leading wheel near centre of large flat

102 Each wheel of the leading wheelset also exhibited a uniform 'groove' similar in appearance to hollow wear, approximately 2-3 mm deep, around three quarters of the circumference (Figure 18). Over the remaining quarter, the depth of this groove increased in depth up to the trailing edge of the large flat.

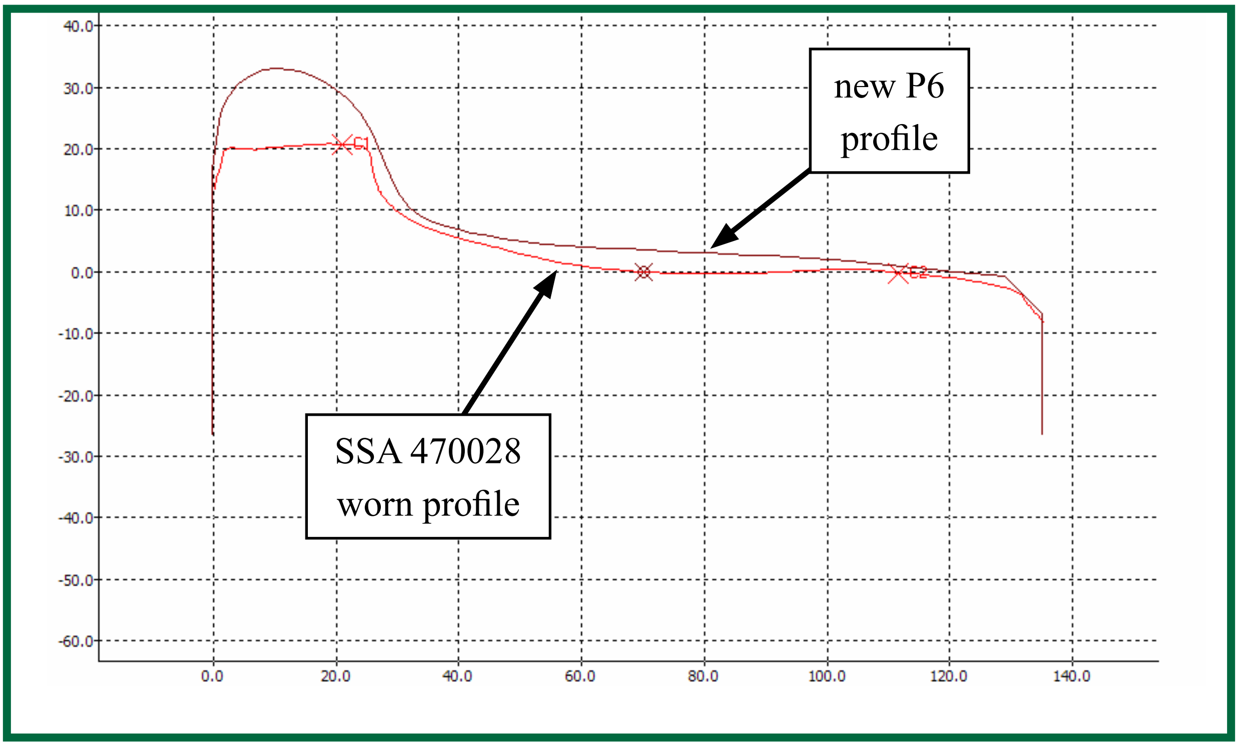

Figure 18: Profile of right leading wheel showing uniform groove pattern due to slow rotation and wear during early part of journey.

103 The uniform groove appears to be unique to this wheelset; it was not observed on the trailing wheelset of SSA 470028, which had been fitted at the same time as the leading wheelset; nor on any of the SSA wagons inspected on site at Barnwood or Aldwarke. Additionally, EWS have indicated that there have not been any previous hollow wear problems in this fleet, which could have explained the groove.

104 The last time the wheel profiles were closely examined was the PPM on 27 June 2005 (paragraph 88). EWS do not specify limits for hollow wear in their SSA wagon maintenance specification but, given the rarity of such wear on SSA wagons, had it been to the extent shown in Figures 18 and 19 at this examination, EWS state that it would have been flagged as a failure. No such wear problems were reported. Therefore, the presence of the uniform groove indicated a different wear mechanism from that normally attributed to hollow wear (ie steady running on a narrow band of the wheel's circumference).

105 It is considered that the leading wheelset was initially locked (due to the handbrake being left on) when it began its journey from Bescot Yard, based on evidence from skid tests as explained later in paragraph 117. However, as the journey progressed the wheels appear to have crept round against the brake pads. This resulted in gross slip and wear at the wheel/rail interface around the whole circumference of the wheels and the formation of the uniform groove. Detailed examination of the surface of the groove (Figure 19) revealed evidence of metal flow consistent with this.

Figure 19: Surface the uniform groove, visible after gentle burnishing.

106 The mechanics of how the leading wheels, which were initially locked up, began to creep round against the brake pads and then lock up again until the large flat was formed is not completely clear. It is possible that as the wheelset ran on the main line (where the wheel/rail friction would be higher than in Bescot Yard due to less contamination from oils and grease), the static friction between the discs and pads was overcome and the wheels began to creep round. Over many revolutions, the uniform circumferential groove was formed by the mechanism described in paragraph 105. Ultimately, prolonged heating at the wheel/rail interface increased the bulk temperature of the wheels and brake gear, causing thermal expansion and increasing the brake force until the wheels locked up again. From then on, all the slip and wear occurred over one portion of each wheel's circumference, and the large flats were formed.

107 Once a large flat is formed, a wheel will tend to remain in that position unless severe impact forces cause it to rotate again. The significant surface damage to both wheels around their circumferences indicated they had been rotating post derailment.

108 Both axle bearings were found to rotate freely although the left side bearing had sustained damage to the inboard edge which was judged to be post-derailment. Therefore, bearing seizure did not cause or contribute to the wheelset locking up.

109 In all other respects, the wheelset appears to have been in good serviceable condition prior to the incident.

Handbrake system

110 The handbrake on SSA 470028 was tested three times from each side (six in total), turning the wheel through its full range. On each test, the wheel was found to be stiff to operate, requiring torques of between approximately 50 and 70 Nm to turn it from 'off' to within two turns from 'on'. Thereafter it rose sharply, over the final two revolutions. There is no specification for the allowable maximum torque in the maintenance procedure. Figure 20 shows the variation of torque with number of turns. The position the handbrake was found at Barnwood is also shown.

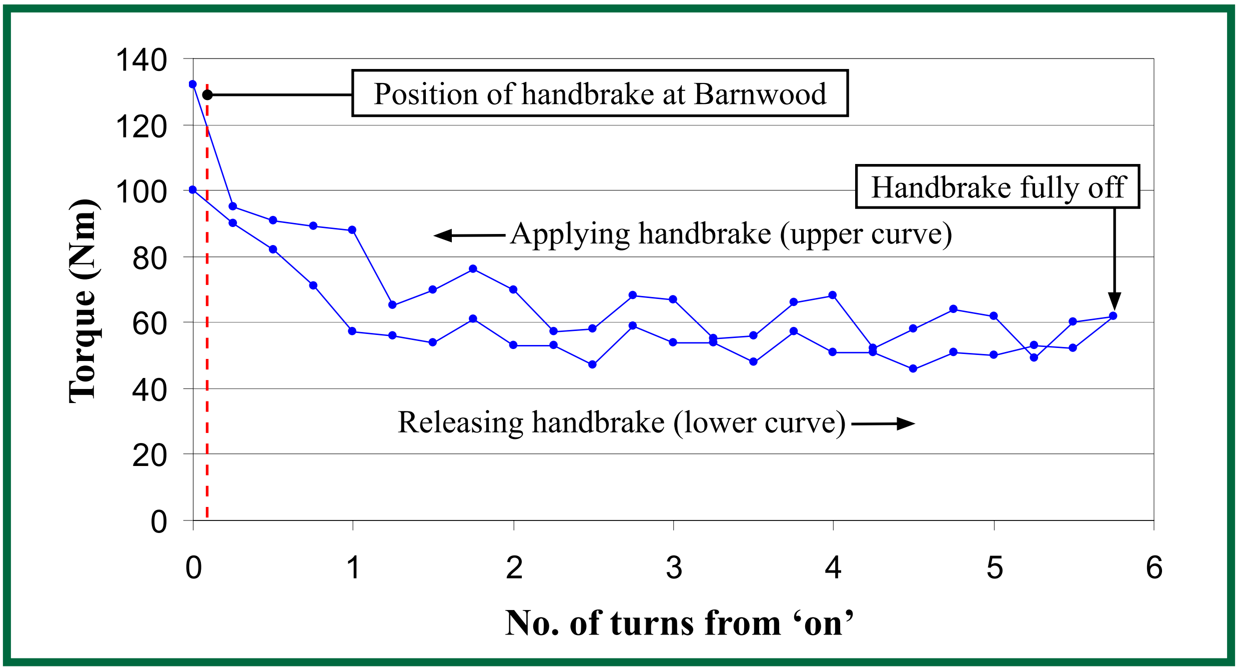

Figure 20: Observed variation of applied torque with turns of the handbrake wheel on SSA wagon 470028

111 The torque was also found to vary cyclically within a revolution of the handbrake wheel, particularly when applying the handbrake (upper curve in Figure 20). The possibility was considered that this cyclic variation could have led ground staff, reliant on the sense of feel alone, to believe that a handbrake was 'off' when it was actually 'on'. However, at the position found post-derailment, the handbrake wheel did not exhibit cyclic variation and the wavelength of the variation elsewhere was too short to cause confusion if the correct handbrake release routine was used. Nevertheless, it is conceivable that if the handbrake wheel was briefly checked by turning to the 'off' position only (ie contrary to standard practice), the stiffness of the handbrake wheel could lead a train preparer to incorrectly believe the handbrake was 'off'. The handbrake indicators were rechecked and found to be the same as noted on site (see paragraph 91)

112 The reason for the stiff handbrake (paragraph 110) was traced to the handbrake shaft. This was found to be bent by approximately 10 mm near one end, which caused the shaft to rotate eccentrically when the handbrake wheel was turned. The cause of the deformation is not known but, from the pattern of detritus, it appears to have been in this condition for some time.

Air brake system

113 Tests revealed that the airbrake system was working correctly before the derailment. A number of air leaks were found but these were located in areas damaged by ballast following derailment.

114 The tests also confirmed there was no interference between the air and handbrake systems and the slack adjusters operated correctly. There was no evidence of a fault condition that could have given rise to an application of the handbrake in transit.

Suspension, buffers and drawgear

115 These parts of the vehicle had remained largely intact. The small amount of damage found was consistent with having occurred post-derailment and there was no evidence to suggest any malfunction or unusual event such as spring failure or buffer locking had played a role in the derailment.

Skid tests

116 Following rebuilding of the vehicle suspension and replacement of the wheelsets, a series of skid tests were undertaken to indicate to what degree the handbrake would have to be on to cause the wheelset to stop rotating. The original brake pads were fitted for these tests but the brake discs were new. The condition of the rail head was dry and clean and there was no visible contamination.

117 The leading wheelset of SSA 470028 was found to lock and skid if the handbrake was within a half turn of its fully 'on' position. When found on site at Barnwood, the handbrake was within ⅛ turn of fully on. Therefore, although the point at which skidding starts is dependant on the variable friction levels between wheel and rail and between pad and disc, the evidence indicates that, when leaving Bescot, the wheels were likely to have been skidding. Subsequently, as explained in Paragraph 105, there is evidence of a slow rotational creep of the wheels, causing uniform slip and wear at the wheel/rail interface.

Structure twist

118 SSA 470028's underframe frame was measured and found to be twisted (ie the amount one corner was vertically offset from a plane containing the other three corners) by 9 - 10 mm which exceeded the permissible limit of 6 mm. The excess twist, which is considered to have been pre-existing, is not considered causal or contributory to this incident but could result in an increased risk of derailment under certain track conditions.

Vehicle weight

119 The tare weight of SSA 470028, in common with other SSA wagons is 15.5 tonnes. It was recorded as empty on the train list but was later weighed at 18.25 tonnes. The extra weight was attributed to collected rain water (due to drain holes being blocked), approximately 200 mm deep, some remnants of steel scrap and sediment and was not causal or contributory.

Previous occurrences of a similar character

120 EWS provided data covering incidents from April 2001 to November 2005, where their wagons and locomotives have departed from yards with handbrakes left on. There were no derailments attributable to handbrakes being left on during this period, apart from the derailment that is the subject of this report.

121 However, the data supplied show that there are, on average, 150 incidents each year of EWS operated trains either being stopped en route or arriving in yards/sidings with vehicle handbrakes on. This equates to an average of three occurrences per week. RAIB also received data from another freight operator on similar incidents. Taking account of the different scale and type of operation, the number of incidents were roughly proportionate to those experienced by EWS and provided further evidence of the scale of the issue nationally.

122 Although it is not possible, based on the data supplied by EWS, to be definitive about the number of wagons that have departed from Bescot Yard with handbrakes left on during this period, the statistics indicate there are on average five occurrences per year.

123 Of the 770 incidents of handbrakes left on recorded during the period under review, SSA wagons have been implicated in 14 (1.8 per cent), with a peak of 5 incidents during the year April 2003 to March 2004. The 100 SSA scrap carrying wagons represent 0.8 per cent of EWS's total fleet and undertake a similar number of trips annually as the fleet average. A simple comparison of the above percentages does not indicate that SSA wagons are significantly more prone to having handbrakes left on than other wagons in the fleet.

Analysis

Identification of the immediate cause

124 The preceding paragraphs have provided details of the investigation that was undertaken in to the derailment of wagon SSA 470028 at Hatherley on 18 October 2005. It was apparent from an early stage of the investigation that SSA 470028 had suffered severe flats on the leading wheelset and the handbrake was fully applied. Additionally, the possibilities of a track fault or obstacle strike were ruled out as there was no evidence to support this.

125 The immediate cause of the derailment was found to be the interaction of the false flange which had developed on the leading wheelset of SSA 470028 and 673B points at Hatherley. This resulted in the leading wheelset riding up over the railhead and derailing to the right (six foot side) after travelling a further 20 yards when a set of adjustment switches were encountered.

126 The false flange had developed as a result of the leading wheelset having been dragged the 68 miles from its origin at Bescot to the point of derailment with the handbrake applied.

Identification of causal and contributory factors

127 Having established that the immediate cause of the derailment was the severe wheel flats arising from the handbrake being applied, it was necessary to determine why the handbrake had been left on. Three possibilities were considered:

- a fault condition with the wagon's brake system such that the handbrake was applied by the air brake;
- action by a third party between Bescot and the point of derailment;
- a 'procedural' error at Bescot Yard.

128 A brake system fault (other than a stiff handbrake) on the wagon can be discounted on the evidence of the wagon tests during which repeated applications of the airbrake were made with the handbrake applied by different amounts. These proved that there was no fault condition or design flaw which could have caused the air brake and handbrake to interfere and the handbrake to self-apply.

129 Action by a third party between Bescot and the point of derailment can be discounted because the train did not stop after leaving Bescot Yard. Although train 6V19 was scheduled to call at Washwood Heath after departure from Bescot, it did not do so as there were no wagons to drop off or pick up at that location. Furthermore, the OTMR download and the driver's evidence proved that the train did not stop after leaving Bescot Yard until it reached Signal G50. It would not therefore have been possible for a person to apply the handbrake on the wagon after it left Bescot Yard.

130 The possibility of vandals applying the handbrake between preparation of the train and its departure has been ruled out (paragraph 80). Even if this had happened the non-rotating wheels should have been detected during the roll-by test.

131 Therefore, a procedural error within Bescot Yard appears to have led to the handbrake being left on. This is discussed further in the following paragraphs which develop the causal chain.

Actions within Bescot Yard on the night of 17th/18th October

132 For train 6V19 to depart from Bescot with the handbrake on SSA 470028 applied, two omissions needed to occur:

- during train preparation, the handbrake on SSA 470028 was not released;
- during departure of train 6V19 from Bescot, the applied handbrake was not noticed.

Each of these is considered in turn.

Not releasing the handbrake on SSA 470028

133 There are a number of possible reasons why the handbrake on SSA 470028 was not released before departure from Bescot Yard:

(a) the Train Preparer did not check the handbrake on SSA 470028 because he assumed it would be in the 'off' position;

(b) the Train Preparer did not check the handbrake on SSA 470028 because the indicator on the wagon showed that it was in the 'off' position;

(c) the Train Preparer inadvertently applied the handbrake when he thought he was releasing it;

(d) the Train Preparer did check the handbrake on SSA 470028 but concluded, erroneously, that it was already in the 'off' position;

(e) the Train Preparer did not check the handbrake on SSA 470028 because of an oversight;

Each of these possibilities is discussed below.

134 Causes (a) to (e) in paragraph 133 represent errors of omission or commission in the preparation of train 6V19 on the morning of 18 October. The train preparer was sure he had checked the handbrake on both sides of every wagon. In describing how he checks handbrakes, he indicated that he always tries to turn each handbrake wheel clockwise initially, which would have the effect of putting the handbrake on, and then anti-clockwise to release it as far as it will turn. Using this approach, if the handbrake was already fully applied, it would not be possible to turn the wheel any further clockwise and it could then be turned in the opposite direction to release it.

135 If the Train Preparer had followed all of the steps described above, none of the errors of omission or commission identified in paragraph 133 (a) - (e) would be possible. Nevertheless the handbrake had been left on and the only plausible explanation, given that the Train Preparer had been assessed as competent (paragraph 76), is that a mistake had been made during the preparation of train 6V19. Each possibility is discussed in the following paragraphs.

136 Did the Train Preparer assume that the handbrake on SSA 470028 was in the 'off' position? It is known that several other wagons were added to the formation of train 6V19 after SSA 470028 had arrived in Bescot Yard at 11.41 hrs on 17 October. When securing a rake of wagons, operating procedures require a specified number of handbrakes to be applied. It is unlikely that the Train Preparer guessed which wagons would have handbrakes applied and which would not because he was off duty when SSA 470028 arrived at Bescot Yard. An unwarranted assumption was therefore discounted as a causal factor.

137 Was the handbrake not checked because the handbrake indicator was in the 'off' position and the wheel was not turned to verify its status? Following the correct procedure a Train Preparer should not rely solely on the position of the handbrake indicator. When the wagon was examined on site at Barnwood, the handbrake indicator was showing 'on' on the left side and approximately half way between 'on' and 'off' on the right side. It is unlikely that someone who checked both indicators could have been misled into believing the handbrake was 'off' and, therefore, most likely, the indicators on SSA 470028 were not examined as part of the train preparation of train 6V19. Additionally, there is evidence to indicate that handbrake indicators are generally not trusted because they are sometimes damaged and give false indications and that rigorous checking of the indicators (as required in the procedures) is not always practiced as an integral part of the handbrake checking process. Misleading handbrake indication is discounted as a causal factor.

138 Did the Train Preparer inadvertently apply the handbrake when he thought he was releasing it? Given that SSA 470028 was located in the middle of a number of wagons of similar type, it is considered highly unlikely that an experienced Train Preparer could have become confused about which direction to turn the handbrake wheel. This is not therefore considered to be a causal or contributory factor.

139 Did the Train Preparer check the handbrake but conclude, erroneously, that it was in the 'off' position? Had he followed his own train preparation routine, he would immediately have established that the handbrake was in the 'on' position as he would not have been able to turn the wheel to the right. However, if the handbrake wheel was stiff to turn, as it was found to be, it is possible that the Train Preparer, having tried to turn the wheel anti-clockwise only (ie departing from normal procedure), may have believed that it was already 'off' and left it alone because he had to press on to minimise the increasing delay to train 6V19. Hence, the stiffness of the handbrake is considered a possible contributory factor.

140 This leaves the possibility that the handbrake was not checked because of an oversight by the Train Preparer. This seems the most plausible explanation, especially given the late running of train 6V19. In recalling the events of the morning of 18 October, the Train Preparer was unsure as to how long he had taken to prepare the train. For the tasks that need to be undertaken on train 6V19, a review undertaken by RAIB in Bescot Yard during the evening of 16 November indicated a preparation time of approximately 30 minutes would be required.

141 Preparation of the train did not start until the locomotive was placed on the train and this occurred around 02.55 hrs, approximately 11 minutes before the booked departure time. Train 6V19 departed at 03.24 hrs (18 minutes late). However, after train preparation duties were completed, it was necessary for the Train Preparer to walk to the shunters' cabin and obtain permission for the train to depart. This process may have taken slightly longer than usual on the morning of 18 October, because it had originally been the intention for train 6E20 to precede train 6V19 out of the yard. However, there had been a problem with the TOPS list for train 6E20 and eventually it was decided that train 6V19 would depart first. It seems, therefore, that the preparation of train 6V19 was achieved in a shorter period of time than might have been expected given the number of wagons in the formation.

142 Whilst it has not been possible to establish, definitively, why the handbrake on SSA 470028 was not released prior to the departure of train 6V19 from Bescot Yard, the balance of probability suggests that oversight or a lack of thoroughness was the most likely cause. Although none of the staff interviewed at Bescot cited time pressure as an issue of concern on that night, the late running of train 6V19 and the excessive stiffness of the handbrake are considered to be likely contributory factors.

Not detecting the applied handbrake on departure

143 Not releasing the handbrake on SSA 470028 alone should not have mattered because the oversight should have been detected during the roll-by test as train 6V19 departed from Bescot Yard. Why was the failure to release the handbrake not detected in the roll-by test?

144 The roll-by test forms part of the training that Train Preparers undergo when learning their duties at the EWS training school. The Train Preparer is instructed to check, as each train departs, that all wheels are turning freely, that the brakes sound as if they are clear of the wheels and that the wheels sound normal on the rail head (skidding wheels can sometimes make a distinctive sound, but this is not always the case as noted in Paragraph 79).

145 All three Train Preparers on duty at Bescot when train 6V19 departed, stated that they watched it move out of the yard from the front of the shunter's cabin. However, there was inconsistent evidence regarding how many shunters were outside the cabin and where they were standing.

146 There was no agreement amongst the Train Preparers as to whether a roll-by test is mandatory:

- the training material says it must be undertaken, 'where possible';
- some EWS management and train preparation staff consider that it is mandatory;
- one Train Preparer stated that a roll-by test would only be undertaken if uncertainty had arisen about the condition of a wagon during the train preparation procedure.

147 For the reasons stated in the two preceding paragraphs, it is considered unlikely that a thorough roll-by test was performed on train 6V19 on the morning of 18 October, thereby allowing the dragging wheelset to depart undetected. This is therefore a causal factor.

148 Contributory factors are considered to be the apparent confusion amongst the staff about the importance of the roll-by test, which may have adversely affected vigilance, and the level of ambient lighting adjacent to the north end shunters' cabin at Bescot Yard, which is considered insufficient to enable staff to carry out a thorough roll-by test.

Severity of consequences

149 Train 6V19 departed from Bescot Yard with the handbrake applied and travelled a distance of approximately 68 miles before derailing at Hatherley. Why did this result in a derailment when there are, on average, 150 incidents of handbrakes being left on annually?

150 In the first instance, the handbrake on Wagon SSA 470028 was fully on. This meant that the wheel was unable to rotate for the greater part of the journey, thereby causing severe wheel flats and false flanges. Many of the 150 incidents that occur annually involve partially applied handbrakes.

151 Secondly, the applied handbrake was not spotted as the train travelled between Bescot and Hatherley. In approximately 50 per cent of the 150 incidents annually, problems with a wagon are detected by railway personnel or others. The remainder are either detected by HABDs (approximately 30 per cent) or are found at their destination (20 per cent). Train 6V19 was travelling in the early hours of the morning and the number of railway operating staff around to witness the train's passing would be relatively few.

Response of others

152 Appropriate personnel from Network Rail and EWS attended site in a timely manner. The recovery process and arrangements for the operation of trains past the incident site were achieved in a manner which minimised disruption of the operational railway.

153 The detailed examination of the derailed wagon was subsequently delayed, awaiting its movement from Gloucester to EWS's Toton depot.

Other Factors for consideration

154 Is it possible that the problem with the handbrake could have been detected before derailment occurred? The train locomotive, 66221, was equipped with a 'rear view' mirror. In May 2004, EWS had taken the decision to equip its Class 66 fleet with mirrors to enable the driver to detect incidents such as shifted loads, dragging wheels or hot axle boxes. Their original plan was to brief all drivers in the use of these mirrors in January 2006 following an update of the EWS Traincrew Manual. However, because of delays in printing the Manual, EWS issued a Traction Digest Advice to its drivers on 3 March 2006, stating:

'Rear view mirrors must be used to observe the passage of your train to make sure that it is following in a safe and correct way when:

- *leaving a Yard or terminal;*
- *leaving any point en route when your train has been brought to a stand;*
- *negotiating curves.*

You should also make use of them to increase your awareness of other persons working or walking in engineering worksites or sidings.'

155 The driver of train 6V19 stated that he did not use the mirror during the journey and was unaware of its presence. In October 2005, EWS drivers had not been briefed on the use of the mirrors. The driver reported seeing sparks when he looked back through his side window as he approached signal G50 (paragraph 42).

156 In the context of the 150-plus incidents of handbrakes left on annually on the national network and the knowledge that severe derailments can result, risk can be reduced by;

- Measures in freight yards to prevent trains leaving with handbrakes left on (operational measures such as roll-by tests which will remain subject to human error and technical measures such as handbrake interlocks on wagons). Currently, handbrake interlocks are not mandated in Railway Group Standards although some new wagons are fitted with them.
- Measures at appropriate locations on running lines, to detect dragging wheels caused by handbrakes being left on, eg infrastructure mounted HWDs. Neither the Wheelchex installation at Eckington nor the HABD at Spetchley detected the dragging wheel on train 6V19. Wheelchex requires wheel rotation to determine abnormal impact forces on the rail. HABDs are aimed specifically at the axle bearings and although they have sometimes identified dragging brakes, they are not designed to do so.

Summary of the causal chain

157 A summary of the causal chain analysis undertaken is shown in Figure 18. Working downwards from the derailment, each box contains the reason why the preceding event occurred or is considered to have occurred. The colour coding of the boxes is as follows:

based on factual evidence

considered the most probable reason

possibilities considered in the analysis but discounted (see below)

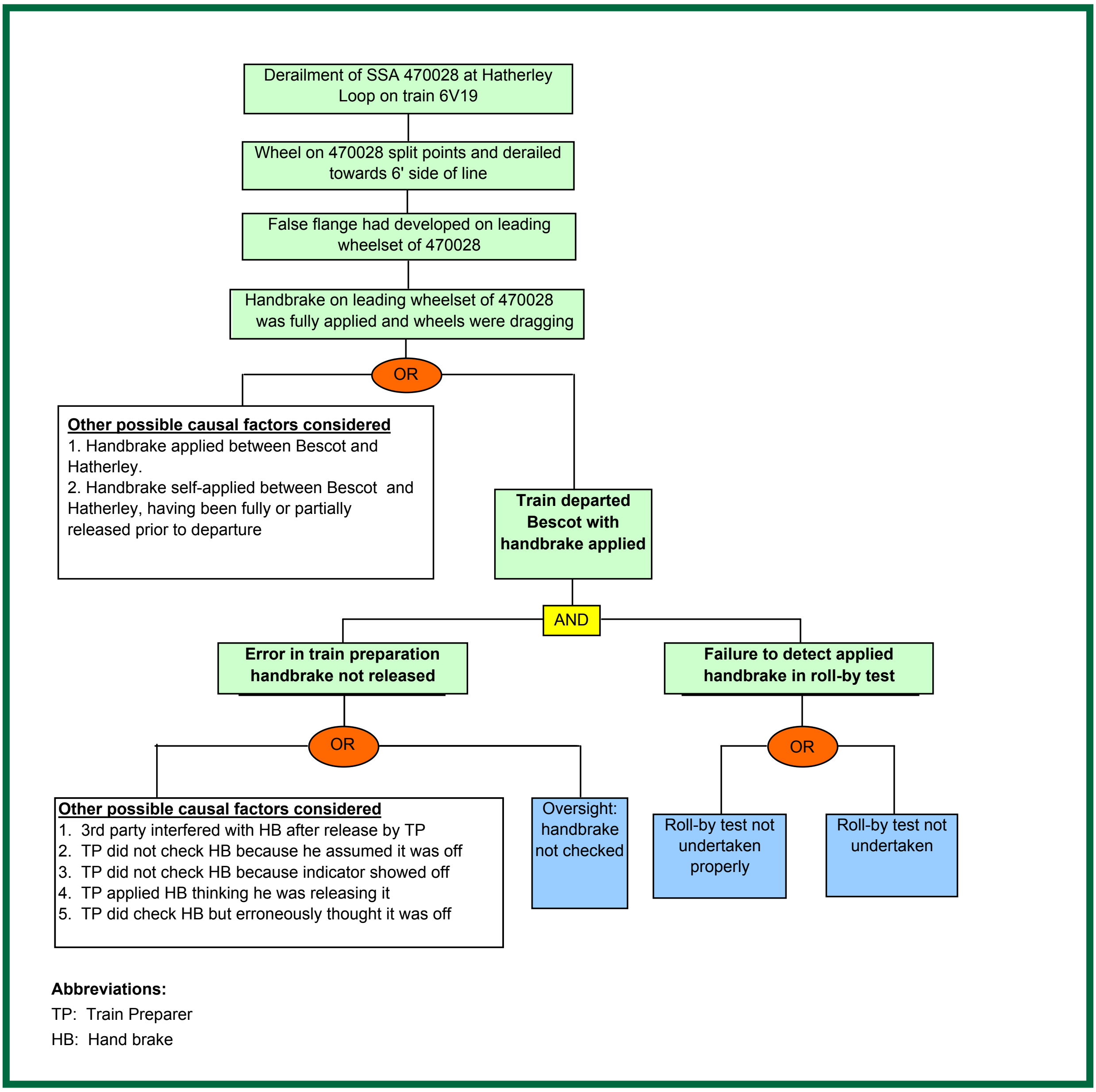

Figure 21: Causal analysis diagram

Conclusions

Immediate cause

158 The immediate cause of the derailment was the interaction between false flanges which had developed on the seized leading wheelset of SSA 470028 and 673B trailing points at Hatherley. This resulted in the leading wheelset riding up over the railhead and derailing to the right (six foot) side, approximately 20 m further down the track.

159 The false flanges had developed as a result of the leading wheelset being dragged from its origin at Bescot Yard to the point of derailment with the handbrake applied.

Causal factors

The causal factors were:

160 The handbrake on SSA 470028 was not released during train preparation at Bescot Yard either because the train preparer did not check the status of the handbrake on that vehicle or did not confirm his belief that the handbrake was off by using the handbrake indicator (which was working correctly) or by checking that the brake rigging was slack (Recommendation 1).

161 The applied handbrake was not detected during the roll-by examination as the train departed Bescot Yard (Recommendations 2 and 3).

162 The dragging wheelset was not detected during the subsequent journey of train 6V19 between Bescot and the point of derailment (Recommendation 5).

Contributory factors

In addition, several likely contributory factors were identified:

Regarding not releasing the handbrake:

163 Time pressure, either real or perceived, to complete the preparation of train 6V19, the locomotive for which had arrived 77 minutes late at Bescot and only 20 minutes before the booked departure time of train 6V19.

164 The wagon's handbrake assembly had not been adequately maintained to ensure ease of operation, resulting in a stiff handbrake wheel which may have misled the train preparer into thinking that the handbrake was already off (Recommendation 4).

Regarding not detecting the dragging wheel during departure from Bescot Yard:

165 Insufficient illumination in the vicinity of the shunters' cabin at the north end of Bescot Yard during the hours of darkness (Recommendation 3).

166 Lack of any distinctive features or markings on the wheels to enable staff to reliably check whether the wheels of train 6V19 were rotating (Recommendation 3).

167 Confusion amongst ground staff at Bescot Yard about whether or not the roll-by test was mandatory which may have adversely affected the vigilance exercised that night such that the examination was not effective (Recommendation 2).

Regarding not detecting the dragging wheelset during transit between Bescot Yard and Hatherley:

168 The time of the incident was in the early hours of the morning when there are relatively few people in the vicinity of the railway. Usually such problems are detected by railway staff who spot the tell tale signs such as smoke, sparks or noise from skidding or flatted wheels.

169 The rear view mirror fitted to locomotive 66221, was not used during the journey; had it been used it may have enabled the detection of any sparks emanating from the leading wheelset of SSA 470028 as it slid on the rails.

170 There are no automatic track mounted devices for detecting dragging wheelsets, such as HWDs (as opposed to HABDs) on that route (Recommendation 5).

Additional observations

171 It was noted that SSA 470028's frame was twisted in excess of the permissible limit. Although not considered causal or contributory, this twist could result in a mal-distribution of static wheel load, depending on suspension set up, and an increased risk of derailment under certain track conditions. However, no recommendation is made regarding this, as it is a single occurrence and EWS, the duty holder, has been notified separately.

172 There have been approximately 150 incidents each year since 2001 involving wagons running in service with handbrakes on. RAIB's recommendations are drawn up with this total in mind, not just the Hatherley incident.

Actions already taken or in progress

173 In May 2004, EWS took a decision to fit rear view mirrors to its Class 66 fleet to enable the driver to detect incidents such as shifted loads, brake drag or hot axle boxes. They planned to brief all drivers in January 2006 following an update of the EWS train crew manual. However, due to delays in printing the manual, EWS issued a briefing note to its drivers on 31 March 2006 in its Traction Digest Advice.

174 On 17 October 2005, EWS made the decision to reduce the VIBT interval for SSA wagons from 365 days to 122 days and remove the PPM requirement. The transition was completed on 7 December 2005.

175 In 2004, Network Rail took the decision to fit HWDs for the purpose of reducing risk from dragging brakes and skidding wheels. There is currently a rolling programme of installing combined HWD and HABD units at all existing HABD locations on the network. So far, 23 out of 202 sites have been fitted with HWDs. Remaining sites are due to be upgraded by end 2008. The performance of the HWDs is currently being assessed and therefore the decision has not yet been taken to activate the detectors to provide alarms at signal centres if dragging wheelsets are detected. HWDs are due to be fitted on the route taken by 6V19 at Eckington and Spetchley by September 2007.

Recommendations

176 Implementation of the recommendations below is the responsibility of the organisations identified in each one. When they have considered the recommendations, the organisations should establish a priority and timescale for the necessary work, taking into account their health and safety responsibilities and the safety risk profile and safety priorities within their organisations.

1 EWS should put in place a system to ensure all staff engaged in train preparation duties are re-briefed and regularly assessed on the requirement to carry out checks on every wagon, by using the handbrake indicator and brake rigging as appropriate to the vehicle design, in addition to operating the wheel or lever, to confirm that the handbrake is fully released, in accordance with GO/RT3056 sect C4.1 & E6.4 (White Pages) (paragraph 160).

2 EWS should put in place a system to ensure all staff engaged in train preparation duties are re-briefed and regularly assessed on the requirement for performing the roll-by examination on departure of each train from yards where such examinations are mandated (paragraphs 161 and 167).

3 Freight Operators should undertake a review of the effectiveness of the roll-by examination as a safeguard against the risk of trains departing from designated freight yards in an unfit condition and, where reasonably practicable, implement measures identified as a result. The review should include, as a minimum, consideration of whether:

- facilities provided to assist with the examination, particularly during hours of darkness, such as additional lighting and wheel markings, should be improved;
- the current list of locations, where staff are made available to conduct roll-by tests, should be increased.

(paragraphs 161, 165 and 166)

4 Freight Operators should:

- determine appropriate limits for handbrake application force, consistent with the requirement for ease of operation;
- put systems in place to ensure that handbrakes on SSA and other fleets are maintained to these limits; and
- put systems in place to ensure that handbrake indicators are maintained to provide reliable indication to staff.

(paragraph 164).

5 Freight Operators and Network Rail should jointly investigate the optimum strategy to reduce the risk from vehicles with handbrakes left on entering traffic, considering a combination of measures including:

- mandating roll-by tests at freight yards;
- fitting handbrake interlocks to freight wagons;
- locating HWDs to pick up skidding wheels or dragging brakes on vehicles emerging from freight yards in order to reduce the residual risk from any vehicles not fitted with handbrake interlocks;

and instigate changes to appropriate standards so as to ensure consistent practice across the UK.

(paragraphs 160, 161 and 162)

Appendices

Glossary of abbreviations and acronyms — Appendix A

BYA	A bogied, covered freight wagon used to carry steel coil.
ELR	Engineers Line Reference (see Appendix B).
EWS	English, Welsh & Scottish Railway Ltd.
HABD	Hot axle box detectors (see Appendix B).
HWD	Hot wheel detector (see Appendix B).
IGA	A bogied, open flat freight wagon.
OTMR	On-train monitoring recorder which captures and logs critical parameters of a train's journey, such as speed and use of train controls.
PPM	Planned Preventative Maintenance.
SSA	A two-axle freight wagon used to carry scrap steel.
TOPS	'Total Operations Processing System' - a prime source of train consist and movement information within the national rail network.
TPWS	Train Protection Warning System (see Appendix B).
TRUST	Computer system that records details of train running times as compared to schedule.
VIBT	Vehicle Inspection and Brake Test.

Glossary of terms — Appendix B

Adjustment switches	A device which allows longitudinal movement to dissipate thermal forces when continuously welded rail is adjacent to jointed track or other feature not designed to withstand thermal forces.
Automatic Warning System	A safety system for alerting drivers about the signal aspect or speed restriction ahead, sounding a horn in the cab for a red, single or double yellow aspect or a bell to indicate a green signal.
Down	The line taking trains away from London (generally).
Engineer's Line Reference	A unique reference, used by railway engineers, given to each route on the national network.
Facing (points)	Points where two routes diverge in the direction of travel.
False flange	An undesirable lip of metal which forms on the outer edges of a wheel tread due to the wheel being worn down by skidding on the rail for long distances, or due to excessive wear of the central running portion of the wheel tread while rotating.
Field side	The outer edge of each running rail of a line
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 supported and this could result in derailment.
Flat(s)	Damage to a rail wheel caused by skidding on the rail when it is prevented from normal rotation.
Four foot	The space between the rails of one line
Gauge face	The inner edge of each running rail (within the four foot) closest to where the wheel flanges run.
Gauge side	The side of a running rail in the four foot.
Hot Axle Box Detector	Infrastructure-based devices which detect excess heat from axle bearings which may be symptomatic of a developing fault.
Hot Wheel Detector	A track mounted sensor which detects heat from skidding wheels or dragging brakes.
Pandrol clips	A type of fastening used to secure the rail to some types of concrete sleepers.
Possession	A section of line which is under exclusive occupation of an engineer for maintenance or repairs.
Six foot	The space between one line and another. This distance may be less than six feet wide.
Skate(s)	A device to enable a vehicle with damaged wheelsets to be moved on the rails at slow speed as part of a recovery operation (see Figure 12)
Stock rail	The fixed rail at each side of a set of points

Switch rail	The moving portion of a rail on each side of a set of points.
Track circuit	An electrical device using rails in an electric circuit which detects the absence of trains on a defined section of line. A track circuit is said to be occupied when there is a train on the section of line and clear when there is no train.
Track circuit block regulations	Regulations that govern the signalling of trains by the track circuit block system.
Track circuit clip	A safety device comprising two metal clips which are manually clipped onto each rail connected by a length of electrical cable. The device short circuits the track circuit, simulating the presence of a train, thereby automatically setting the signals behind to danger and providing protection.
Trailing (points)	Where lines converge in the direction of travel.
Train Protection and Warning System	A safety system that is installed at some signals on the network, comprising infrastructure and vehicle mounted components. It detects trains that are travelling too quickly on the approach to signals at danger and trains that have passed signals at danger, intervening in both cases to apply the train's brakes.
Up	The line taking trains towards London (generally).
Wheelchex	A track mounted monitoring system designed to measure the vertical wheel loads of passing trains and flag trains causing excessive damage due to wheel flats.
Wheel flats	A form of wheel damage caused by the wheel skidding on the rail instead of rotating.
White pages	The working manual for rail staff engaged in freight train operations which sets out the mandatory tasks to ensure for the safe operation

Formation of train 6V19 **Appendix C**

Position in rake	Vehicle No.	Mass from train list (tonnes)
1	66221 (loco)	126.0
2	60018 (unpowered loco)	129.0
3	BYA 966231	26.0
4	BYA 966219	26.0
5	BYA 966246	26.0
6	BYA 966250	26.0
7	BYA 966249	26.0
8	SSA 470057	15.5
9	SSA 470092	15.5
10	SSA 470142	15.0
11	SSA 470168	15.0
12	SSA 470005	15.5
13	SSA 470061	15.5
14	**SSA 470028**	15.5
15	SSA 470091	15.5
16	SSA 470077	15.5
17	SSA 470036	15.5
18	SSA 470146	15.5
19	SSA 470045	15.5
20	SSA 470076	15.5
21	SSA 470043	15.5

C4 Operational pre-departure check

C4.1 Prior to departure a physical examination of the train must be made to ensure that:

- Vehicles are coupled correctly
- Vehicle couplings that are not in use are correctly stowed
- Automatic brake equipment is coupled correctly throughout the train
- **All handbrakes are released**
- Any goods/passenger changeover levers are in their correct position
- All load securing equipment in use on loaded vehicles appear to be correctly tensioned
- Securing equipment that is not in use is correctly stowed
- Any vehicle which requires Load Examination has been correctly labelled
- Vehicle sheets are correctly secured and not torn
- Vehicle and load unit doors and curtains are closed and secured
- Load units mounted on spigots and twistlocks are correctly secured
- Loaded vehicles appear to have their weight correctly distributed
- End caps on tank vehicles are correctly fitted and secure
- Manlids on tank vehicles appear to be secure and correctly fitted
- All cabinet doors on LPG vehicles are locked
- Ledges and flat surfaces are free of debris and loose material
- Vehicle defect label permits movement
- A working tail lamp is fitted correctly to the rear vehicle of the train

C4.1 A brake continuity test is to be carried out

Staff must not put themselves at risk whilst carrying out these checks

E6.4 All handbrakes must be fully released before a vehicle is moved. Staff must visually ensure that the brake has fully released, either by checking

a) Indicators, where fitted

b) That the brake rigging is “slack”

c) The wheel/lever is fully released

Whenever vehicles are stabled, they must **NOT** be left with their bufffers compressed

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