Rail Accident Investigation Branch

Rail Accident Report

Derailment at Duddeston Junction, Birmingham 10 August 2007

Department for Transport

Report 16/2008
July 2008

This investigation was carried out in accordance with:

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

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Introduction

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

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

3 Access was freely given by Freightliner, Greenbrier and Network Rail to their staff, data and records in connection with the investigation.

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

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

5 References to left and right are made in relation to the direction of travel.

6 Mileages quoted are measured from a zero point at Derby London Road Junction.

Summary of the Report

Key facts about the accident

7 At around 02:20 hrs on Friday 10 August 2007, two wagons forming part of train 4O84, travelling from Freightliner's Lawley Street Terminal to the Isle of Grain, became derailed just outside the terminal (Figure 1).

8 During the derailment, which took place at just under 15 mph (24 km/h), all wheels of the seventh and eighth wagons from the locomotive left the rails. No one was injured in this accident.

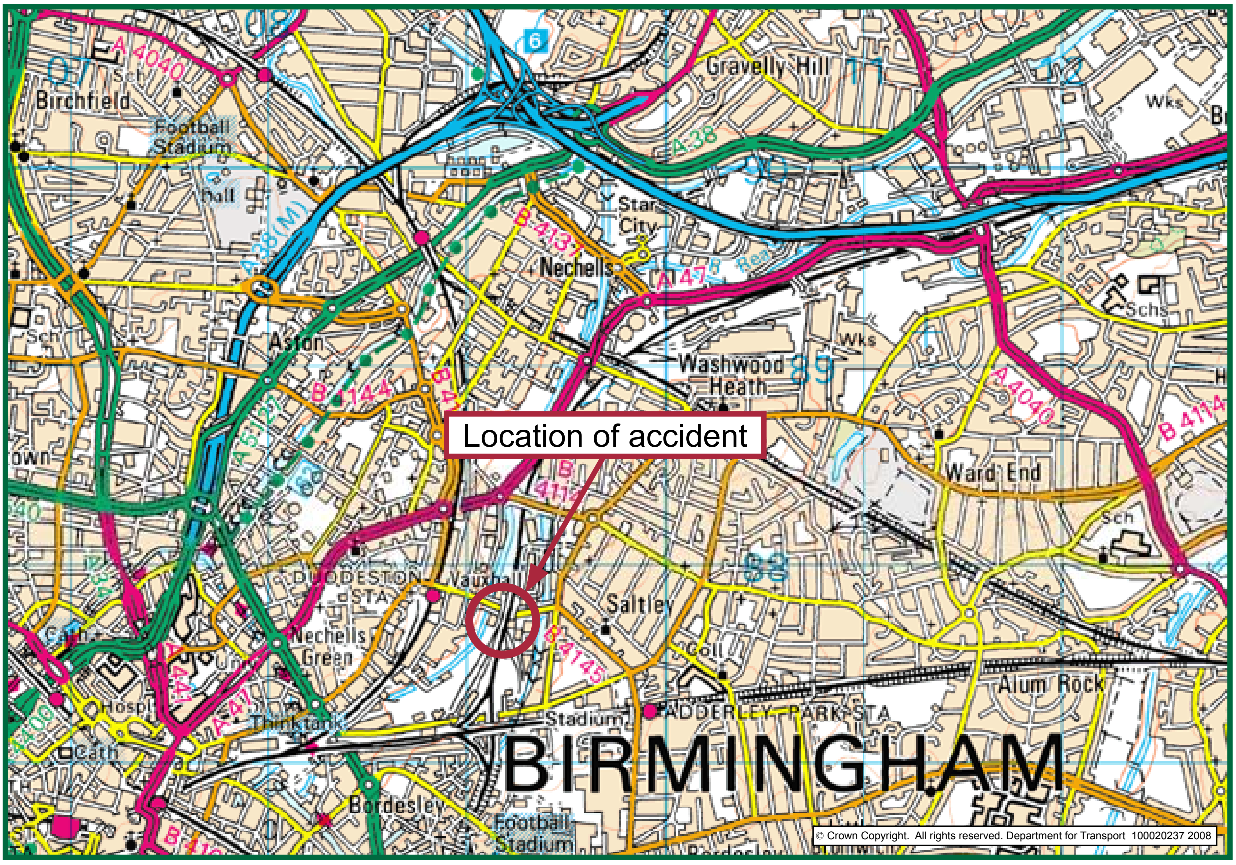

Figure 1: Extract from Ordnance Survey map showing location of accident

Immediate cause, causal and contributory factors, underlying causes

9 The immediate cause of the accident was the climbing of the front right-hand wheel *flange* of wagon 640 262 over the right-hand *closure rail* of 715B *points* as a result of the interaction between a combination of track twists and the unevenly loaded wagon (paragraph 144).

10 Causal factors were:

a. the presence of a significant twist fault that had not been detected and remedied;

b. the method of track inspection used was not capable of detecting the level of dynamic twist that had developed at this location;

c. wagon 640 262 was running loaded in a way that made it very susceptible to derailment over track twist faults;

d. the uneven distribution of load placed upon the wagon was beyond that for which it was designed in terms of derailment resistance;

e. the uneven distribution of load was not detected and remedied prior to the wagon departing from Lawley Street Terminal;

f. the placing of a 30.4 tonne, 20 ft container next to an empty 40 ft container in contravention of the Freightliner loading document, Management Instruction Engineering (MIE) 0767, limit of 24 tonnes for the 20 ft container in this configuration; and

g. a probable causal factor is that the 20 ft container load was likely to have been offset to the left.

11 The following factors were considered to be contributory:

a. The crossover could not readily be examined under traffic;

b. The crossover did not exhibit the usual tell-tale signs of voiding;

c. The traffic levels over the crossover were very low and ran at slow speed;

d. Low levels of lateral payload offset were not readily detectable;

e. There was a practice amongst some Freightliner loading staff of not strictly adhering to the loadings prescribed by MIE 0767;

f. Visual pre-departure checks of the train did not detect the level of uneven loading;

g. Standard methods that were used for detecting uneven loading of container wagons were not always reliable;

h. The computer systems used in container processing by Freightliner are not capable of detecting uneven loading beyond that allowed by standard MIE 0767 although they contain sufficient data to do so; and

i. The following factors were possibly contributory:

- Network Rail Vehicle Conformance Group (VCG) assumed that the wagons would be loaded reasonably evenly (that wagons should be loaded as uniformly as possible is a Railway Group Standards requirement) and thus they only required wheel unloading tests to be carried out for *tare* and fully laden wagons with no longitudinal or lateral load offset accounted for (longitudinal offsets were only considered as part of high speed VAMPIRE® simulations and not to the degree allowed by MIE 0767). Thus there was no independent demonstration of Greenbrier's assertion that the wagons were designed for all loadings on the technical specification drawing in terms of GM/RT 2141 Issue 2 'Resistance of Railway Vehicles to Derailment and Roll-Over' requirements; and
- Freightliner specified the FEA-B wagons' loading capacities to Greenbrier using an MIE 0767 type drawing and assumed that Greenbrier and VCG, the Vehicle Acceptance Body (VAB), would interpret them in the manner Freightliner intended. Greenbrier state that they did, the VAB did not.

12 The underlying causes were:

a. Network Rail deployed track maintenance resource in a way that past experience indicated to them was likely to lead to the maximum reduction in risk; and

b. a lack of understanding at various levels of Freightliner as to the content, use and interpretation of their single wagon loading standard MIE 0767.

Severity of consequences

13 No one was injured in this accident. Both derailed wagons suffered damage to their running gear and around 200 m of track required repair or replacement.

14 Containers became dislodged from their retaining *spigots*, one falling onto an adjacent track, which could, in other circumstances, have resulted in more severe consequences.

Recommendations

15 Recommendations can be found in paragraph 205. They relate to the following areas:

- the automatic detection of longitudinally unevenly loaded container wagons;
- loading staff understanding and application of loading standards;
- the documentary presentation of permissible container wagon loading configurations;
- the application of derailment resistance standards by the VAB;
- definition of permissible container wagon loads during procurement; and
- the re-evaluation of FEA-B wagon derailment resistance.

The issues relating to track maintenance in this accident are covered by a previous RAIB recommendation that resulted from an investigation into a derailment at King Edward Bridge, Newcastle Upon Tyne (report 02/2008).

The Accident

Summary of the accident

16 At around 02:20 hrs on Friday 10 August 2007, two wagons forming part of train 4O84, travelling from Freightliner's Lawley Street Terminal to the Isle of Grain, became derailed on 715B points, part of Duddeston Junction, just outside the terminal.

17 The train, comprising locomotive 66 541 and 24 container carrying wagons, was travelling at just under 15 mph (24 km/h). During the derailment, all wheels of the seventh and eighth wagons from the locomotive left the rails and the *brake pipe* ruptured, leading to the train being brought to a stop (Figure 2).

18 No one was injured in this accident. Both derailed wagons suffered damage to their running gear and around 200 m of track required repair or replacement. One empty container fell from the train onto the track.

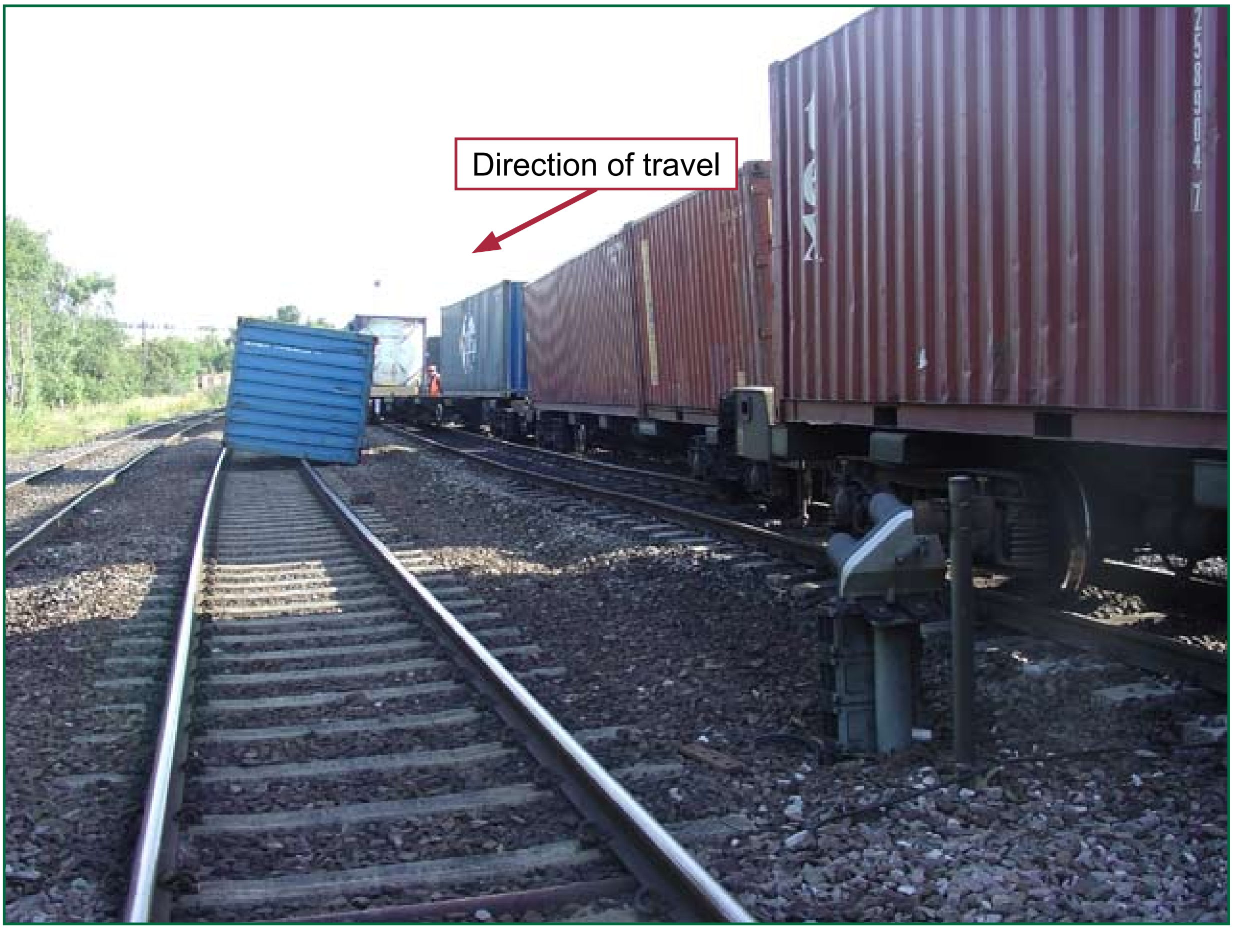

Figure 2: The seventh and eighth wagons of 4O84 derailed

The parties involved

19 Freightliner Group Limited operated the train, employed its driver and maintained the wagons.

20 The wagons were manufactured by Greenbrier in Poland.

21 The VAB involved in the approval of the wagons was Network Rail VCG. The role of the VAB is explained in paragraph 106.

22 The wagons are owned by Porterbrook Leasing. As they had little involvement in the specification, approval and initial procurement of the vehicles, Porterbrook's involvement in this accident was peripheral.

23 The track on which the derailment took place is owned and maintained by Network Rail.

Location

24 The accident took place in the vicinity of the 40 ½ milepost on the Derby to Birmingham main line. The train was being routed out of Lawley Street Terminal on the *Up* goods line and being crossed onto the up main line via 715A (*facing*) and 715B (*trailing*) points (Figure 3).

25 The line speed limit over the crossover route is 15 mph (24 km/h) and the prevailing gradient is around 1:120, falling towards Derby.

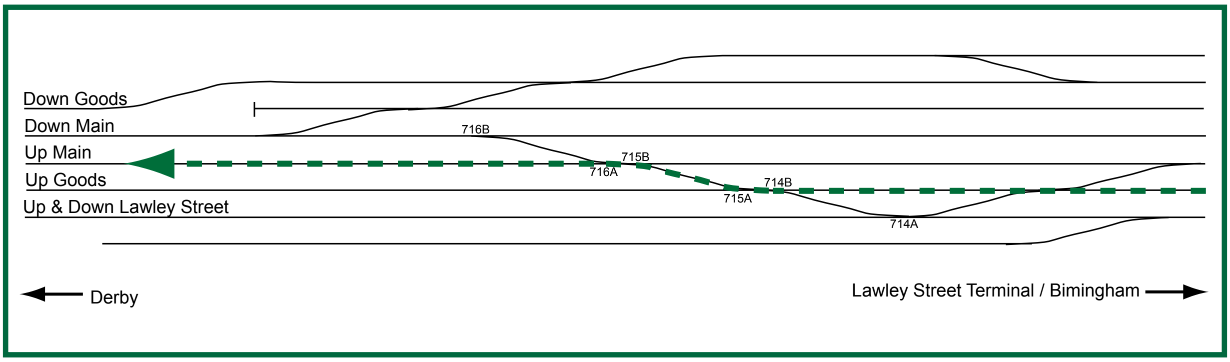

Figure 3: Relevant track layout around Lawley Street Terminal and train's route

26 The initial point of derailment (POD) was at 40 miles 32 chains, within 715B trailing points.

27 The line is signalled using *track circuit block* and colour light signals. 715 points are controlled from Saltley Power Signal Box.

External circumstances

28 The weather at the time of the accident was dry and clear.

The train

29 The train consisted of diesel-electric locomotive 66 541 and 24 container carrying wagons. The wagons were loaded either with containers or commodity tanks.

30 The derailed wagons, nos. 640 261 and 640 262, were a semi-permanently coupled pair of FEA-B, bogied container wagons of 82 tonnes maximum gross laden weight (GLW) (Figure 4). Their maximum operating speed is 75 mph (120 km/h).

31 FEA-B wagons have a 60 ft (18.5 m) long container carrying deck. They are equipped with spigots that enable combinations of 20 ft, 30 ft, 40 ft and 45 ft containers to be carried[1]; the spigots retain the containers in place on the wagon deck and are mounted on retractable hinged plates.

Figure 4: FEA-B container carrying wagons nos. 640 261 and 640 262

32 Both derailed wagons were carrying two containers. The leading wagon, 640 261, was carrying a 20 ft container to the front and a 40 ft container to the rear; both were empty. The trailing wagon, 640 262, was carrying a 40 ft container to the front and a 20 ft container to the rear; the 40 ft container was empty and the 20 ft container was carrying steel sheets.

33 This wagon type was approved to run on Network Rail infrastructure in September 2004.

[1] Throughout the report, container sizes are defined by their nominal length in feet with no metric equivalent quoted. This is standard industry terminology.

The track

34 715A and B points were of the *CV, 113 A flat-bottomed rail* design. The rails were mounted on timber *bearers*, supported on granite ballast. This was the standard design on British Rail from 1969 to the late 1980s.

35 The points are expected to be replaced as part of a re-signalling scheme between 2011 and 2012.

Events preceding the accident

36 On the evening of 9 August 2007, train 4O84 was loaded in two parts at Lawley Street Terminal. This occurred because the sidings are not long enough to accommodate a 24 wagon train and resulted in sixteen wagons being loaded on one siding and eight on another, before coupling to form the full train. The process of loading containers at Lawley Street is described in paragraphs 114 to 127.

37 It is likely that the sixteen wagon rake that ultimately came to form the back portion of the train was loaded under the supervision of a different *operations supervisor* to that of the eight wagon front portion. This is not unusual.

38 Once the train was loaded and formed, the operations supervisor who had supervised loading of the back portion of the train, walked around the train checking it against the Total Operating Processing System (TOPS) list and the first section of the Freightliner *PSD/0300 checklist*. Satisfied that the train was correctly loaded, he signed both lists.

39 Prior to departure, the train was examined and brake tested by a *shunter* who signed off the second section of the Freightliner PSD/0300 checklist.

Events during the accident

40 The driver received a copy of the signed TOPS list from the operations supervisor and carried out the static brake test in conjunction with the shunter. The signal at the terminal exit cleared and the *theatre route indicator* showed 'M' (to indicate a route set to a main line).

41 The train moved off and accelerated to just under 15 mph (24 km/h). Around two minutes after the start of the journey, the driver felt a severe jolt and observed that the brake pipe pressure was falling rapidly, which led to a full automatic brake application. Around ten seconds later the train came to a stand and the driver looked back and saw clouds of dust.

42 All wheels of the seventh and eight wagons back from the locomotive had become derailed in the vicinity of the 40 ½ milepost.

Consequences of the accident

43 Both derailed wagons suffered damage to their running gear and around 200 m of track required repair or replacement.

44 The unaffected parts of the train remained as routed on the up main line. The two derailed wagons were foul of the down main line and the 20 ft container on the front of wagon 640 261 fell off the wagon and onto the up goods line (Figure 5). The wagons and containers foul of the down main line could, in other circumstances, have been hit by a train travelling in the opposite direction on that line. The container on the up goods line would, in this case, have been protected by the signal that protected the junction over which train 4O84 was crossing when it derailed.

Figure 5: Wagon 640 261 with the fallen 20 ft and slewed 40 ft containers

45 The 40 ft container on the rear of wagon 640 261 came off all four spigots and slewed significantly to the right. The 40 ft container on the front of wagon 640 262 came off its front two spigots only and remained close to its running position, and the rearmost 20 ft container remained in position on all four spigots.

46 The rearmost container held steel sheets separated by wooden battens and secured with steel banding. The gross container weight was 30.4 tonnes. Figure 6 shows the load after the derailment; the steel banding has broken, the sheets have lozenged forward and the load is offset to the left of the container centre line.

47 It is likely that the banding broke and the load lozenged forward during the derailment. Given that this container remained upright on its spigots, it is likely that the centre line of the load was to the left of the centre line of the container at the time of derailment. This is supported by no obvious right to left slide marks being seen on the container floor. Estimates from photographs suggest the offset to be between 0.25 and 0.4 m.

Figure 6: Wagon 640 262 rearmost (20 ft) container load as found after the accident

Events following the accident

48 Once the train had come to a stand, the driver contacted the signaller using his cab radio and advised that he was going back to investigate the cause of the unsolicited brake application. On discovering that the train was derailed and foul of other lines, the driver contacted the signaller by mobile phone to arrange *signal protection*. The signaller immediately placed appropriate signals at *danger*.

49 The driver was tested for drugs and alcohol in accordance with normal industry practice and the results were negative.

50 Site investigation and track repairs continued through 10 August and into 11 August. Service resumed on the down goods line at 15:00 hrs on 10 August and on other lines at 06:00 hrs on 11 August.

The Investigation

Sources of evidence

51 The following sources of evidence were used as part of the investigation:

- the locomotive's On Train Data Recorder (OTDR);
- site surveys;
- witness testimony;
- Freightliner and Network Rail documents;
- wheel unloading testing and subsequent VAMPIRE® (Vehicle Dynamic Modelling Package in Railway Environment) modelling on the RAIB's behalf by DeltaRail Limited; and
- surveys of the derailed wagons on and off site.

Key Information

The derailment

52 The paragraphs below provide an outline of the derailment sequence that the RAIB considers most likely.

Point of derailment

53 Wheel flange marks on the railhead indicate that the initial POD was on the trailing 715B points. There is only one set of marks, indicating that only one wheelset derailed at this point. The marks indicate that a right-hand wheel flange climbed over the right-hand closure rail.

54 The nature of the consequent damage to the bar coupling between the two wagons and analysis of the derailment mechanism (paragraphs 67 and 68) indicate that the front wheelset of the rear wagon derailed first.

Subsequent derailment sequence

55 The derailed right-hand wheel ran between switch and *stock rail* until the *toe* of the points, where it climbed over the stock rail. Thereafter, with the left-hand wheel no longer restrained by the left-hand switch rail, the derailed wheelset tended to move to the right, increasing the *yaw* angle of the bogie and derailing the second wheelset to the right.

56 The train continued with only the front bogie of wagon 640 262 derailed to the right until the facing points 716A. At this point the derailed bogie diverged further to the right, tending to steer the rear bogie of that wagon to the diverging route. Rail marks indicate that both rear bogie wheelsets derailed over these points.

57 The increasing divergence of the rear wagon to the right led to the rear bogie of the front wagon, 640 261, being pulled and derailed to the right. By the time the vehicles had passed through 716 points, three out of four bogies on the two wagons were running derailed; all except wagon 640 261's leading bogie. The up main line and down main line were also being slewed towards each other by the action of derailed wheelsets.

58 The angle at which wagon 640 261 was moving forward was increasing at this time as a result of the front bogie remaining on the up main line and the rear bogie moving further to the right. This combined with the bouncing of the rear bogie of the front wagon finally lead to the front bogie derailing to the left around 40 m before the wagons came to a stop.

59 The brake pipe ruptured around 55 m before the wagons stopped and, as a result, the train speed started to fall from just under 15 mph (24 km/h) around 22 m later. The derailment of all wheelsets on both wagons took place at just under 15 mph (24 km/h).

The derailment mechanism

60 Track surveys indicated that at the POD the *dynamic 3 metre twist* was around +1 in 237 (the positive sign denotes clockwise twist i.e. right rail moving down relative to the left rail). As the leading wheelset of wagon 640 262 passed this point, the rearmost wheelset was experiencing a dynamic 3 metre twist of around -1 in 103. The significance of these values in relation to Network Rail standards is explained in paragraph 75.

61 The front container on wagon 640 262 was empty and the rear container fully laden.

62 Railway Group Standard (RGS) GM/RT 2141 defines limits on the extent to which wheels can be allowed to unload when a rail vehicle is twisted. This can be tested by measuring the load remaining on a wheel when the other wheels are jacked up in a prescribed manner; that load must never reduce to less than 40 % of load measured before the other wheels were jacked up, a procedure known as wheel unloading testing. This should hold true for all conditions that are significantly representative of those encountered in traffic.

63 Wagon 640 262 underwent wheel unloading testing at Lawley Street Terminal, after the accident. The containers used during the testing were of the same size and GLW as those carried during the derailment. The load in the rear container was centrally positioned as far as could be determined by observation of the angle the container hung at when craned onto the wagon.

64 These tests suggested that the mechanism of derailment was flange climb of the right leading wheel and that amongst the cause was still open to conjecture, it was most probably a combination of:

- the combination of track twists;
- uneven longitudinal wagon loading; and
- possible inherent twists of the wagon body and bogie.

65 Physical twist of the wagon and bogies was measured and found to be far less than that suggested by the wheel unloading testing. This is almost certainly a result of the suspension not moving completely freely during the tests, possibly as a result of characteristics of the friction damping and damage suffered during the derailment.

66 In order to reach more definite conclusions as to which of the three factors exerted the most influence on the derailment, the derailment was modelled using the VAMPIRE® simulation package.

67 If conditions representative of those present at the derailment were applied and the centre of gravity of the load in the laden rear container was positioned 0.4 m to the left of the wagon centre line (paragraph 47), the model predicted that the leading right-hand wheel of wagon 640 262 would lift by around 25 mm at the POD, but not actually derail.

68 The model predicted a significant flange climb very close to derailment; in actuality, the wagon derailed. The model necessarily used some assumptions (for example bogie rotational stiffness, which cannot be reasonably measured after the accident, was assumed to be as measured on such wagons when new), which introduce inaccuracies and may explain the small difference between the very significant predicted flange climb and the derailment that occurred.

69 The action of the wagon suspension not moving completely freely and correctly as discussed in paragraph 65 was shown, if present prior to the derailment, to act such as to have resisted the derailment. As such, it was unlikely to have contributed to the derailment.

70 The VAMPIRE® modelling also showed it is likely that FEA-B wagons would, if tested now, comply with GM/RT 2141 when tare or fully laden, but not when loaded with a 30 tonne, 20 ft container next to a tare laden 40 ft container. When loaded in the same way as wagon 640 262 at the time of the derailment (i.e. with a lateral load shift as well), the wagon would theoretically derail when assessed against the GM/RT 2141.

Track maintenance

71 Track maintenance is prescribed by Network Rail Company Standard NR/SP/TRK/001, 'Inspection and Maintenance of Permanent Way', Issue 2. The first two paragraphs of section 11.4.2 state that:

- 'Measurement shall be by a track recording vehicle approved by Network Rail, except that on lines where the permitted speed is 20 mph or less manual methods may be used, subject to their being approved by the Area Track Engineer'; and
- 'Where it is not reasonably practicable to record certain running lines, loops, platform lines, crossovers, etc, at the required frequencies, approval shall be sought for alternative inspection methods. A register of the lengths of line concerned shall be maintained by the Track Maintenance Engineer'.

72 The crossover made up of 715A and B points falls within the second paragraph. Track recording vehicles did not run over it and the approved alternative inspection method was visual examination by track patrollers and supervisors. This length of line was not on the register maintained by the Track Maintenance Engineer (TME) as he deemed it impractical to put all crossovers in the area on such a list. He kept a list, but only included lengths of track he considered significant, mainly those covered by the first paragraph of section 11.4.2 of the standard.

73 The RAIB's review of the records and interview evidence indicates that the inspection regime being applied was compliant with NR/SP/TRK/001.

74 NR/SP/TRK/001 prescribes minimum action to be taken following detection of geometry defects. Applicable in this case is the requirement to correct any 3 m twists between 1 in 91 and 1 in 125, within 36 hours of discovery, and to correct any 3 m twists between 1 in 126 and 1 in 200 on curve radii < 400 m within seven days. Twists of 1 in 90 or worse require blocking of the line and correction as soon as possible. Track twists less severe than 1 in 200 are not considered as defects.

75 The combination of dynamic 3 metre twists associated with this accident was around +1 in 237 with -1 in 103 separated by approximately the length of the wagon wheelbase. The first is not considered as a defect by the standard, but the second requires correction within 36 hours of discovery. There was no evidence that the -1 in 103 fault had been found by anyone involved in the inspection of the points. As a consequence, the existence and ongoing development of this fault was unknown to Network Rail.

76 The values given in paragraph 75, and that were seen by the derailing wagon, are dynamic twist values. The associated static twists, i.e. those present when there is no vehicle on the track, were +1 in 312 and -1 in 176. The difference is accounted for by the presence of significant *voids*.

77 NR/SP/TRK/001 section 9.1, covering the general aspects of visual track inspection, states: 'Where practicable the opportunity shall be taken to observe track under traffic, particularly where there is any suspect condition'.

78 The number of traffic moves over 715A and B crossover is low and evidence indicates that as a consequence it was rarely, if ever, observed under traffic by those carrying out track inspections.

79 Observation of the points after the accident showed that the usual tell-tale signs of significant voids, such as *wet spots* or scoring on bearer sides, were not present. This is likely to be a result of both low levels and low speeds of traffic.

Wagon maintenance

80 Wagons' 640 261 and 640 262 wheel profiles and wheel flange back-to-back lengths were measured and found to be within specification.

81 The RAIB and Freightliner examined the *centre pivot liners* and *side bearers* when wagon 640 262 was lifted off its bogies which confirmed, as far as possible given the possibility of damage during the derailment, that the liners were of the correct type and in a serviceable condition prior to the derailment.

82 There was no evidence from post-accident examination of the wagons and the derailment site that there were any pre-exisiting suspension faults. Examination of the maintenance records showed that the wagons underwent their last Planned Preventative Maintenance on 6 April 2007. They were within their maintenance period and there was no previous indication of any relevant problems with them.

Container retention

General

83 There are two common types of container retention on railway wagons in Britain; *twistlocks* and spigots. The twistlock was the British Rail standard and, as the name implies, requires the manual twisting of the head of the lock through 90 degrees to hold the container down. Since around 1993, the Union Internationale des Chemins de Fer (UIC) design of spigot, used extensively in Europe over many years, has become more common in Britain. There is a third much less common type, a US designed spigot with a sprung latch.

84 A twistlock provides direct restraint in the longitudinal, lateral and vertical directions. It does, however, need to be manually engaged and disengaged and a further drawback is that forgetting to disengage prior to lifting a container from a wagon results in the wagon being lifted, and probably derailed. Spigots require no manual intervention beyond the usual craning of the containers on and off the wagons.

85 FEA-B wagons locate and retain containers using hinged spigots specified in UIC Codes. Figure 7 illustrates such spigots stowed, deployed and located within the *corner casting* of a container.

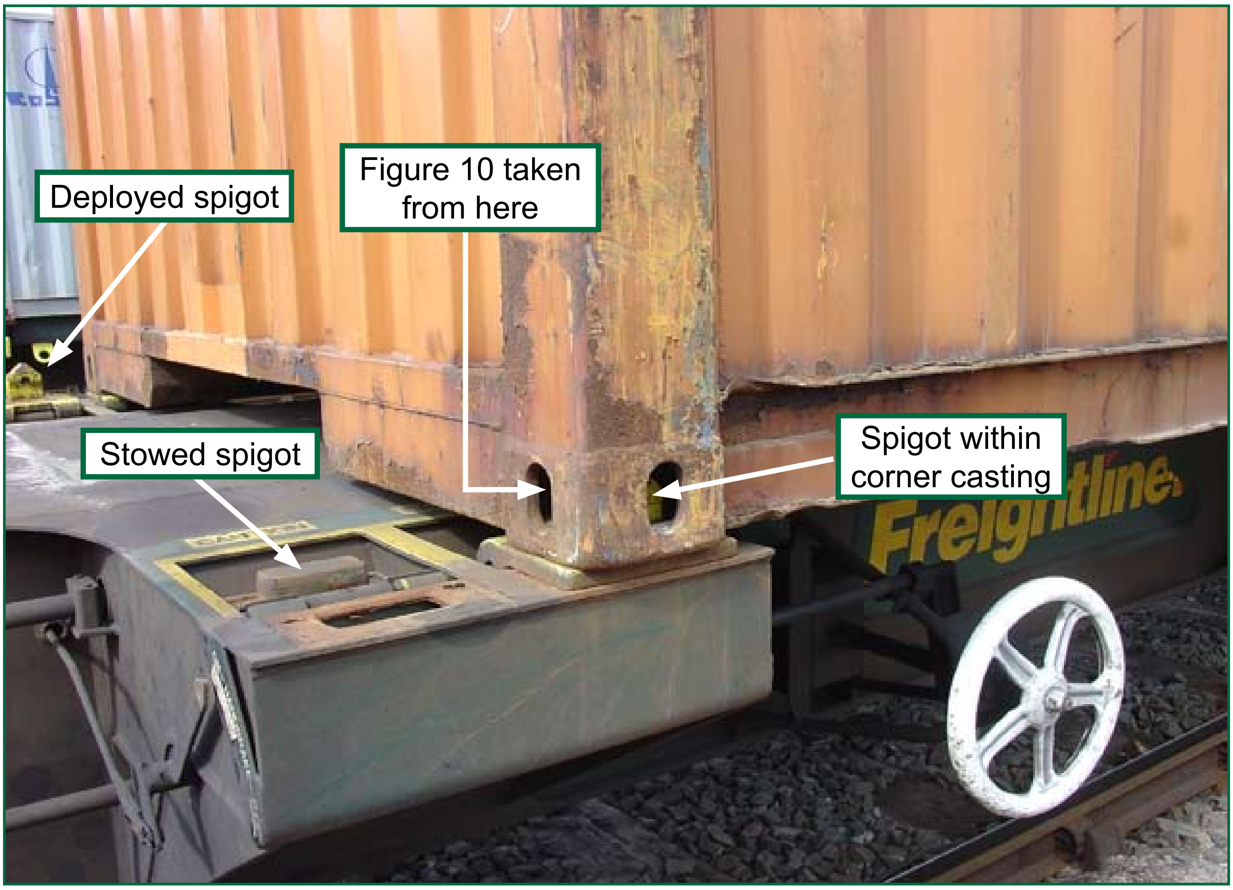

Figure 7: Examples of hinged spigots and container corner casting

86 The spigots are shaped and positioned in such a way that when containers are placed over them, they protrude into the corner castings (Figure 8). The corner casting is therefore directly restrained longitudinally and laterally, but not vertically. However, the relative shapes of the lower hole in the casting and the shoulders on the spigot are such that if there is lateral movement of the corner casting it should become vertically restrained (Figures 9 and 10).

Figure 8: Corner casting 20 ft container thrown from 640 261

Figure 9: Spigot corresponding to Figure 8 corner casting

Figure 10: Example of a corner casting on top of spigot

87 However, sufficient vertical acceleration with no significant lateral component will result in the corner casting lifting off the spigot; this is what happens when the container is lifted off the wagon by crane.

88 The issue is implicitly recognised by RGS GO/RT3056, Working Manual for Rail Staff: Freight Train Operations (the 'White Pages'), which stipulates that no load unit with a GLW of less than 1.6 tonnes should be carried on vehicles fitted with spigots. In the case of this accident, the minimum load unit weight was that of an empty 20 ft container, 2.3 tonnes.

89 Both wagons' container retention spigots were checked against UIC Code 571- 4 and Freightliner Vehicle Maintenance Instruction MIE 07/FEA/01 Issue 2. The following were noted:

- the Freightliner Instruction does not require the same dimensions to be checked as the UIC code;
- the wagons' spigots comply with the Freightliner Instruction, but not with the UIC Code; and
- the UIC Code implicitly requires that spigots cannot rotate inwards once deployed, whereas the FEA-B wagon spigots are outboard of their hinges and not retained in the deployed position in a way that stops rotation inwards.

These issues were not explored further as part of this investigation as they are included in the RAIB investigation of containers blown off FEA wagons at Hardendale and at Cheddington on 1 March 2008.

The detachment of containers from spigots

90 Paragraphs 44 and 45 describe how each of the two containers on the forward wagon came off all four associated spigots, and the forward container on the rearmost wagon came off its front two spigots.

91 Impact marks made by the bogie frames on the wagon bodies indicated unusually large movements of the bogies relative to the bodies. These in turn show that significant forces were transmitted upwards from the wheelsets during the derailment sequence.

92 The OTDR showed that the train maintained a constant speed until the last 33 m before coming to a stop (paragraph 59). It is likely therefore, that the period of most significant forces on the wagons was between 50 and 100 m before coming to a stop, because speed was still at the maximum, wheelsets were derailing over crossings and the up main and up goods lines were being slewed by the action of the derailed bogies.

93 Significant vertical accelerations would have occurred during this time which, if corresponding lateral accelerations were low (i.e. the wagon was bouncing), would have probably caused the containers to come off any UIC spigots. If the corresponding lateral accelerations were more significant (i.e. the wagon was rolling as well), the ease with which containers came off the spigots would have been increased by the across wagon spigot spacings being outside UIC tolerances and the spigots being able to rotate inwards. As such, the increased probability of worse consequences was contributed to by the use of spigots, rather than twistlocks, on the derailed wagons.

94 Once off all their spigots, the containers on the forward wagon then bounced inch by inch across the wagon deck as the wagon travelled over sleepers and rail clips. The front container finally fell off the wagon around 15 m before it came to a stop. The marks in the wagon paintwork shown in Figure 11 illustrate this bouncing effect.

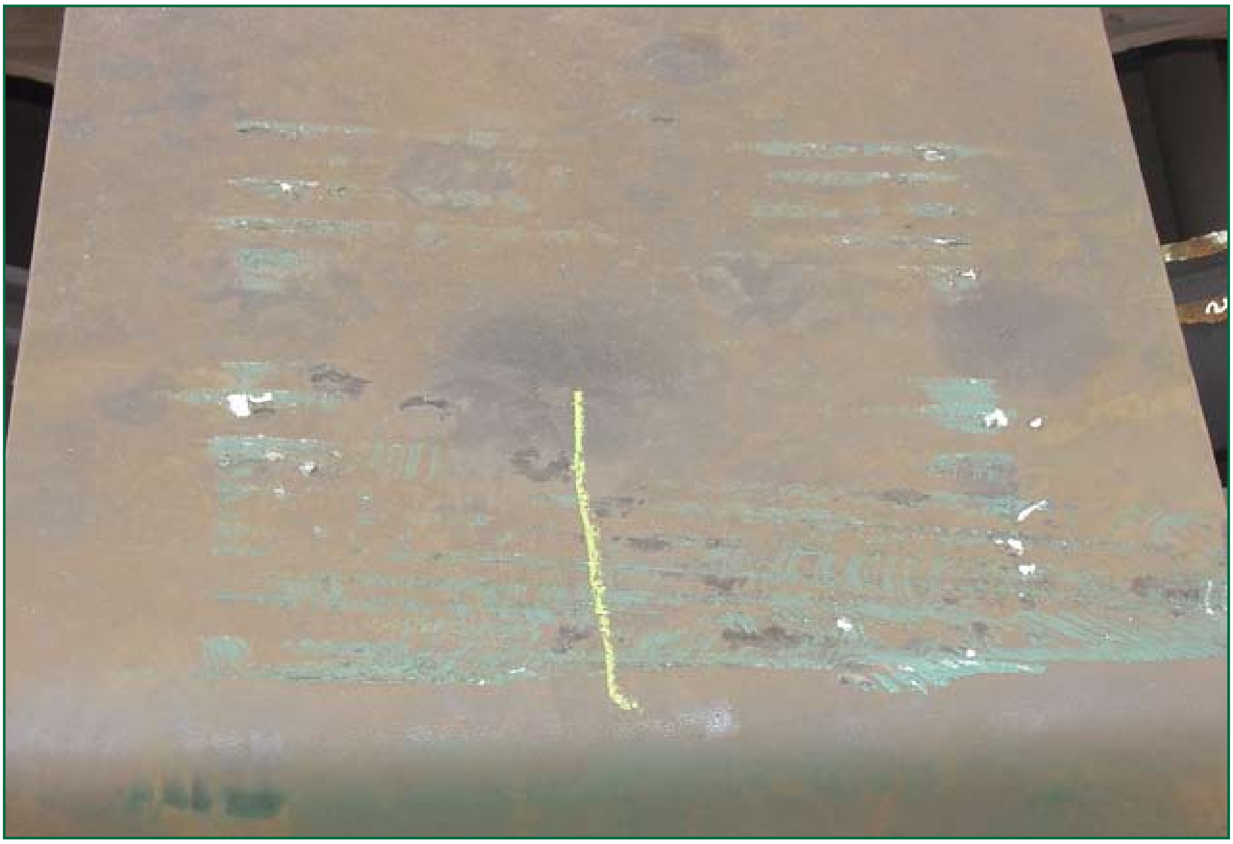

Figure 11: Marks on 640 261 paintwork adjacent to rear bogie indicating bouncing of rear container (the yellow chalk mark was added post-incident)

Bogie/spigot interaction

95 Figure 12 shows the right trailing corner on the leading wagon, 640 261. The rear right-hand spigot, off which the 40 ft container came, is deployed, and another spigot that should have been stowed, is deployed with the container partially on top of it.

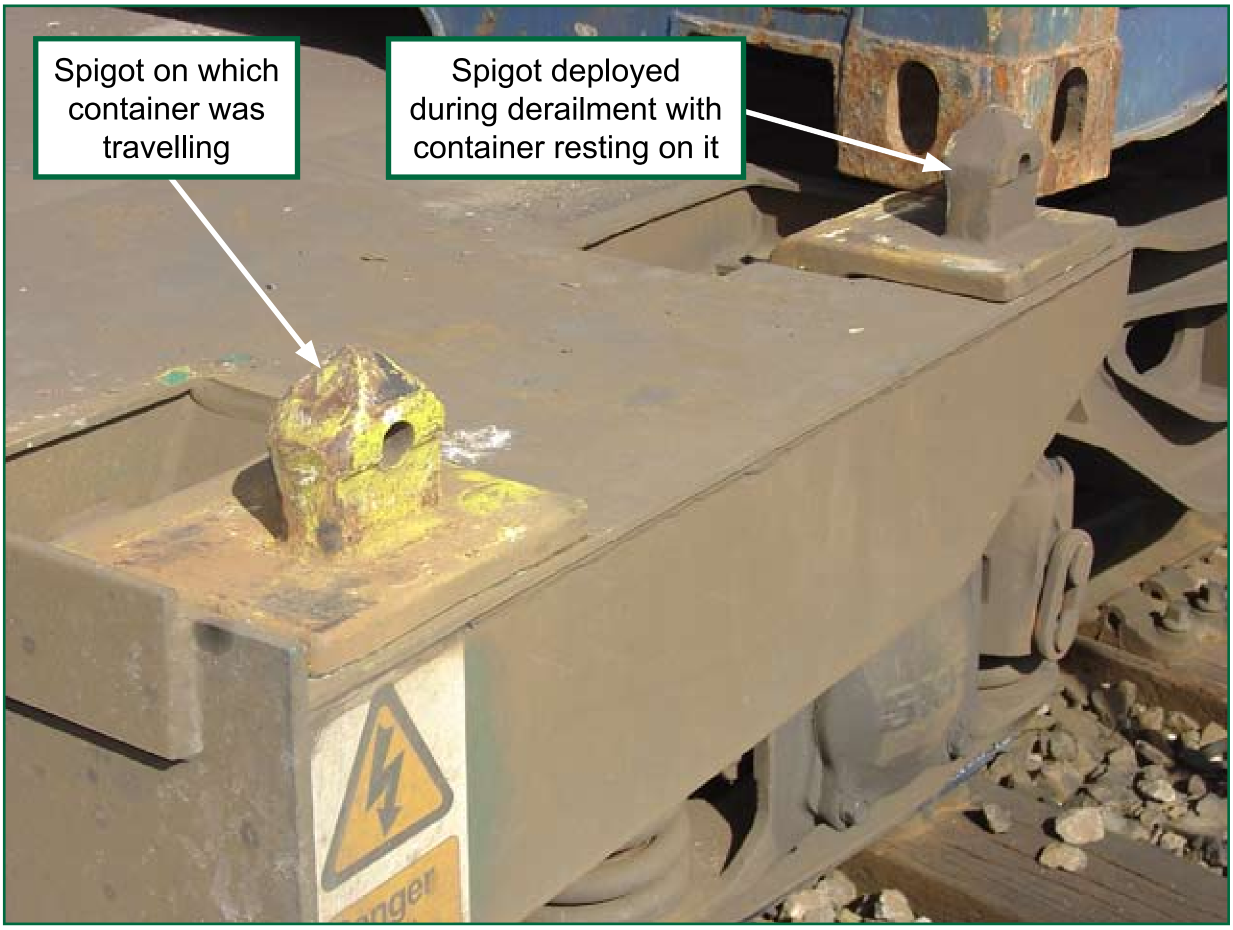

Figure 12: 640 261 front 40 ft container rear RH corner as found

96 Marks on the spigot and the adjacent bogie demonstrate that the bogie, when pitching and yawing underneath the wagon during the derailment sequence, struck the stowed spigot and knocked it up into the deployed position.

97 Figure 13 demonstrates how this occurred and also the greatest extent to which the spigot base plate can be pushed upwards while it is still in contact with the bogie.

98 It is not likely that this mechanism played a part in lifting a corner casting off a spigot because:

- the extent to which the spigot base can lift while it is still in contact with the bogie is not great;
- no significant corresponding mark was found on the container concerned; and
- of the ten corner castings that came off spigots in this accident, only one was possibly influenced by this mechanism.

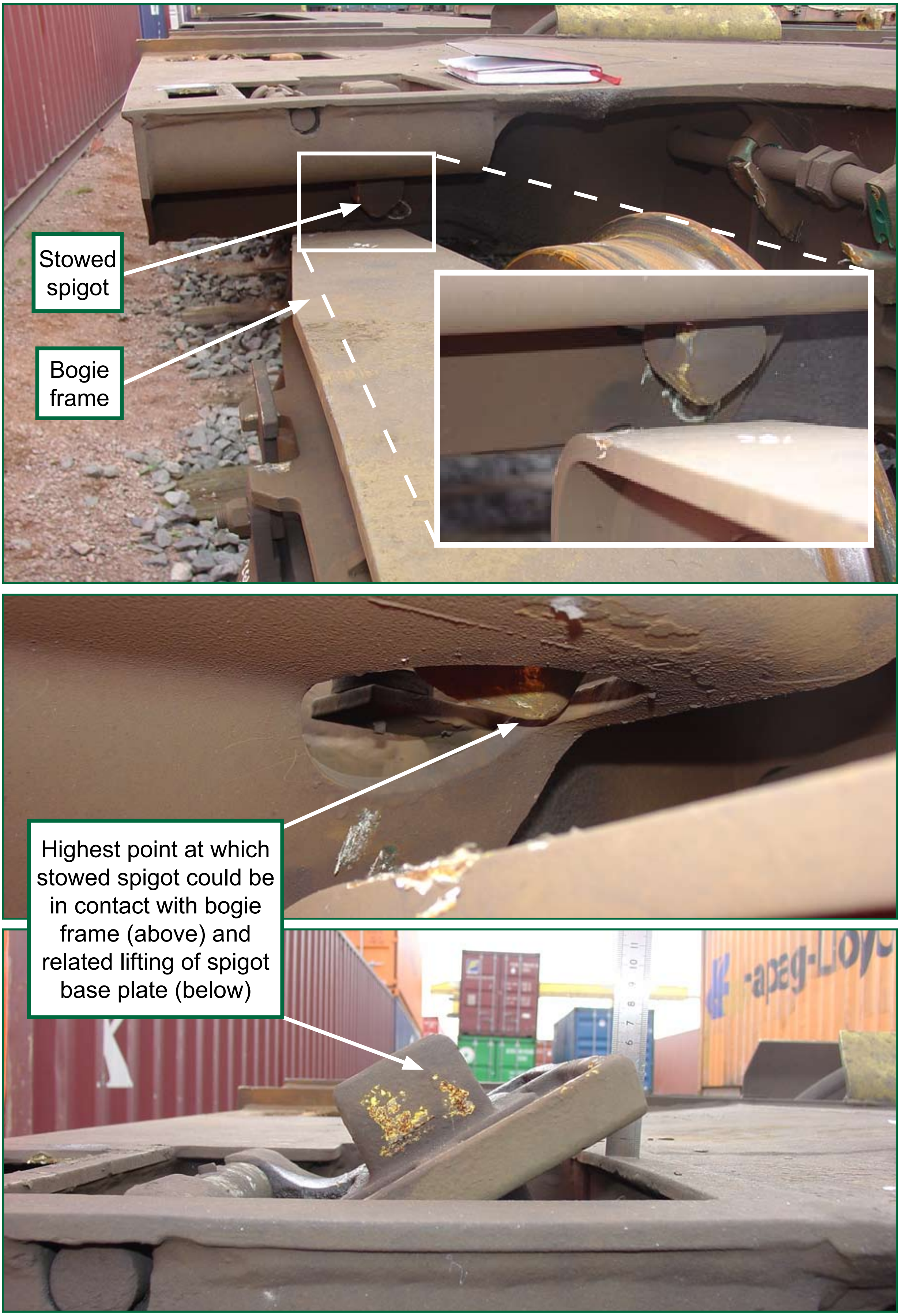

Figure 13: Wagon 640 261 - interaction of stowed spigot and bogie

Wagon procurement and acceptance

Procurement

99 Freightliner Group includes an engineering department which supports their commercial procurement processes. However, Freightliner do not become involved in the engineering detail of wagon design and production. Freightliner procured FEA-B wagons against a high level specification, and required that the wagons complied with Railway Group Standards.

100 Freightliner were looking to procure wagons of similar design to the FSA/FTA fleet that they already operated, and entered into discussions with Greenbrier on that basis. In early 2002, Freightliner sent Greenbrier a diagram taken from their internal loading document MIE 0767 (paragraphs 128 to 136) showing the permissible loading of an FSA wagon and stating that this is what would be required, 'from a design brief point of view' for the new wagons.

101 Using this information, Greenbrier then developed a technical specification for the wagons that included a similar, but not identical loading configuration drawing to that provided by Freightliner.

102 Freightliner and Greenbrier agreed terms and Greenbrier produced the wagons to the technical specification.

103 Freightliner conducted inspections on the first few wagons, but did not undertake any engineering assessments themselves.

104 Greenbrier have stated that the wagon was designed:

- with an understanding of the loading configuration drawings that is the same as that of Freightliner's engineering department (paragraph 132); and
- to meet Railway Group Standards' requirements under all the loading conditions shown in their technical specification drawing (paragraph 101).

Acceptance

105 Both the bogie manufacturer, Eisenbahnlaufwerke Halle (ELH), and the wagon manufacturer Greenbrier, contracted with VCG as the VAB. As there was an overlap of roles, and Greenbrier were the main contractor to Freightliner, VCG carried out most of their activities through Greenbrier.

106 VABs are bodies who are certified as competent by the Railway Safety and Standards Board (RSSB) to conduct assessments on new or modified vehicles. The assessment process is primarily aimed at ensuring that Railway Group Standards are complied with.

107 The acceptance process for FEA-B wagons was broken down into three areas: design scrutiny, construction conformance and maintenance regime review. At the end of the process, VCG issued certificates of conformance for each area and thereafter an overall Engineering Acceptance certificate. Under the process current at the time, that certificate represented a part of the process that allowed the wagons to be registered in the *Rolling Stock Library* and thereby run on Network Rail infrastructure.

108 There is no evidence that construction conformance (other than possibly in relation to UIC spigots, which will be dealt with as part of another investigation) and maintenance regime are factors in this accident. However, design scrutiny would have been expected to, and did, include an assessment of the ability to resist derailment.

109 RGS GM/RT 2141 Issue 2 defined requirements relating to *derailment resistance*. It allowed three methods of demonstrating compliance, all requiring some form of on-track ride testing. Greenbrier and VCG opted for 'Method 1'; static measurement of wheel unloading (outlined in paragraph 62), plus measurement of bogie rotational resistance, and on-track ride testing.

110 Greenbrier had wheel unloading tests conducted in tare and fully laden conditions and the wagons complied with the standard in these conditions. They also had bogie rotation (commonly known as X-factor) tests conducted and again, the wagon complied.

111 Because of the cost of on-track testing, and because these wagons were expected to have good derailment performance as had the similar, but not identical FSA/FTA wagons before them, VCG submitted a deviation request to the *Traction and Rolling Stock Subject Committee* of the Rail Safety and Standards Board (RSSB). They proposed a programme of VAMPIRE® simulations in lieu of the on-track tests. This proposal was accepted by the Committee and a derogation from the standard granted.

112 Knowing it to be a possible risk area, VCG wanted to check high speed ride performance when the wagon was loaded such that its *laden springs* could just become engaged during dynamic bounce. They simulated the following conditions at high speed against a defined test track profile:

- tare;
- a 20 ft container empty (2.3 tonnes) on one end and a 20 ft container of 6 tonnes GLW on the other; and
- three 20 ft containers, each of 20 tonnes GLW.

They were able to demonstrate that under these conditions, considered by VCG as worst case, the wagons met the standard.

113 VCG received information on load configurations from Greenbrier and Freightliner, including the loading drawing from the Greenbrier Technical Specification. However, they did not interpret the drawing as Freightliner Engineering intended, and as Greenbrier have stated that they themselves had (paragraph 104). VCG's interpretation was that the drawings only denoted maximum loads, primarily for use in structural calculations; not that the drawings allowed wagons to be loaded with significant offsets in longitudinal load distribution. There is no evidence that this was noticed or challenged by Freightliner or Greenbrier.

Wagon loading at Lawley Street

The process

114 The function of the terminal at Lawley Street is to transfer containers from road vehicles to trains and vice versa. Freightliner operates at other terminals, ports and railheads where containers are transferred to and from trains to other modes of transport. The process described below relates to the transfer of containers from road vehicles to trains at Lawley Street Terminal, as relevant to the derailment.

115 Laden and empty containers arrive at Lawley Street Terminal on road vehicles. As well as being locked, laden containers are security sealed such that terminal staff are unable to see the contents. However, the International Maritime Organisation Guidelines for Packing of Cargo Transport Units (CTUs), states: ‘stowage planning should take account of the fact that CTUs are generally designed and handled assuming the cargo to be evenly distributed over the entire floor area’ and ‘the centre of gravity of the packed cargo should be at or near the longitudinal centre line of the CTU’.

116 The road vehicle driver hands over paperwork detailing the container size, the container number, the customer, the destination and the weight to Freightliner staff at the gatehouse. They enter the information into a computer programme known as ERIC and write the customer, container number and weight on a ‘dilly’.

117 A ‘dilly’ is a plastic block with a magnet attached that is sized to represent the container. This can then be stuck to the ‘dilly board’ that represents the trains being loaded in the terminal (Figure 14). The ‘dilly board’ is structured by the trains’ destinations.

Figure 14:The Lawley Street terminal ‘Dilly Board’

118 ERIC then produces a list of containers to be loaded onto a given train. This list is taken by the operations supervisor, with a copy for the crane driver. The list gives no indication where on a train each container should go, nor is it necessarily complete when loading starts, because containers for that train may still be arriving by road as the train is being loaded.

119 Road vehicles are sent straight to the loading area if the related train is currently being loaded or to the storage area if the container is to be loaded later.

120 The crane driver loads the train in accordance with the list. Although experienced crane drivers will generally know where to load containers to achieve reasonably even weight distributions over a wagon, it is not their responsibility to ensure that loading is correct; that rests with the operations supervisor.

121 Once the train has been loaded, the operations supervisor walks round it and completes a sheet detailing the train number, the wagon numbers and the associated container numbers. The operations supervisor takes this list and hands it to the 'dilly board' controller. He in turn arranges the 'dillies' on the trains depicted on the 'dilly board'. The supervisor and controller can then see at a glance what containers are where, and what the load distribution is on each wagon.

122 Two documents govern the distribution of load on Freightliner container wagons: RGS GO/RT 3056, and MIE 0767. The Railway Group Standard requires that 'loads should be distributed as uniformly as possible to ensure all wheels are evenly loaded'. The MIE requirements for FEA-B wagons are detailed in paragraph 128 to 130.

123 Based on knowledge of these documents the 'dilly board' controller and the operations supervisor are able to judge whether the wagons depicted on the board are loaded correctly, and if not, have the crane driver move containers around on the train to ensure that they are.

124 The board controller then enters the final position of the containers into ERIC, which in turn feeds the information to TOPS, a nationwide freight train information and checking system. The TOPS list is printed and the operations supervisor walks round the train, conducting a pre-departure exam in accordance with checklists mandated in Freightliner's operational procedure PSD/0300.

125 The pre-departure exam includes a TOPS list check to ensure that the wagons and the containers on them correspond to those indicated on the list. Of relevance to this incident, it also includes checks that:

- 'all containers are engaged on 4 spigots';
- 'drawbars are not in contact with the vehicle structure and are reasonably even';
- 'buffer face centres are within the tolerance'; and
- 'all vehicles appear to have been loaded evenly'.

The operations supervisor judges whether a wagon is reasonably evenly loaded visually using cues such as the attitude of the coupling between wagons, relative heights of adjacent wagon buffers, the relative compression of suspensions and an estimation of any slope over the wagon's width and length.

126 Having completed these checks, the operations supervisor signs the appropriate part of the pre-departure form and the TOPS list, a copy of which is handed to the train driver.

127 Immediately prior to departure, the shunter completes final checks, including a *static brake test* and signs a different part of the pre-departure form.

Freightliner document MIE 0767

128 MIE 0767 is the single document within Freightliner defining allowable loading configurations for container wagons. It was produced and is maintained by the engineering department.

129 The document defines its purpose as: '…..sets out, in a common format for operating purposes, the maximum permissible loading for various types of wagons operated by Freightliner Ltd'.

130 The document takes the form of a series of diagrammatic appendices, one for each wagon type. The diagrams in the appendices 'indicate the maximum permissible load for various combinations of container length'. Appendix G, Issue 1, Revision D current at the time of the accident relating to FEA-B wagons is reproduced in Figure 15. This is of identical form and almost identical content to the FSA loading diagram issued to Greenbrier when the FEA wagons were being procured (paragraph 100).

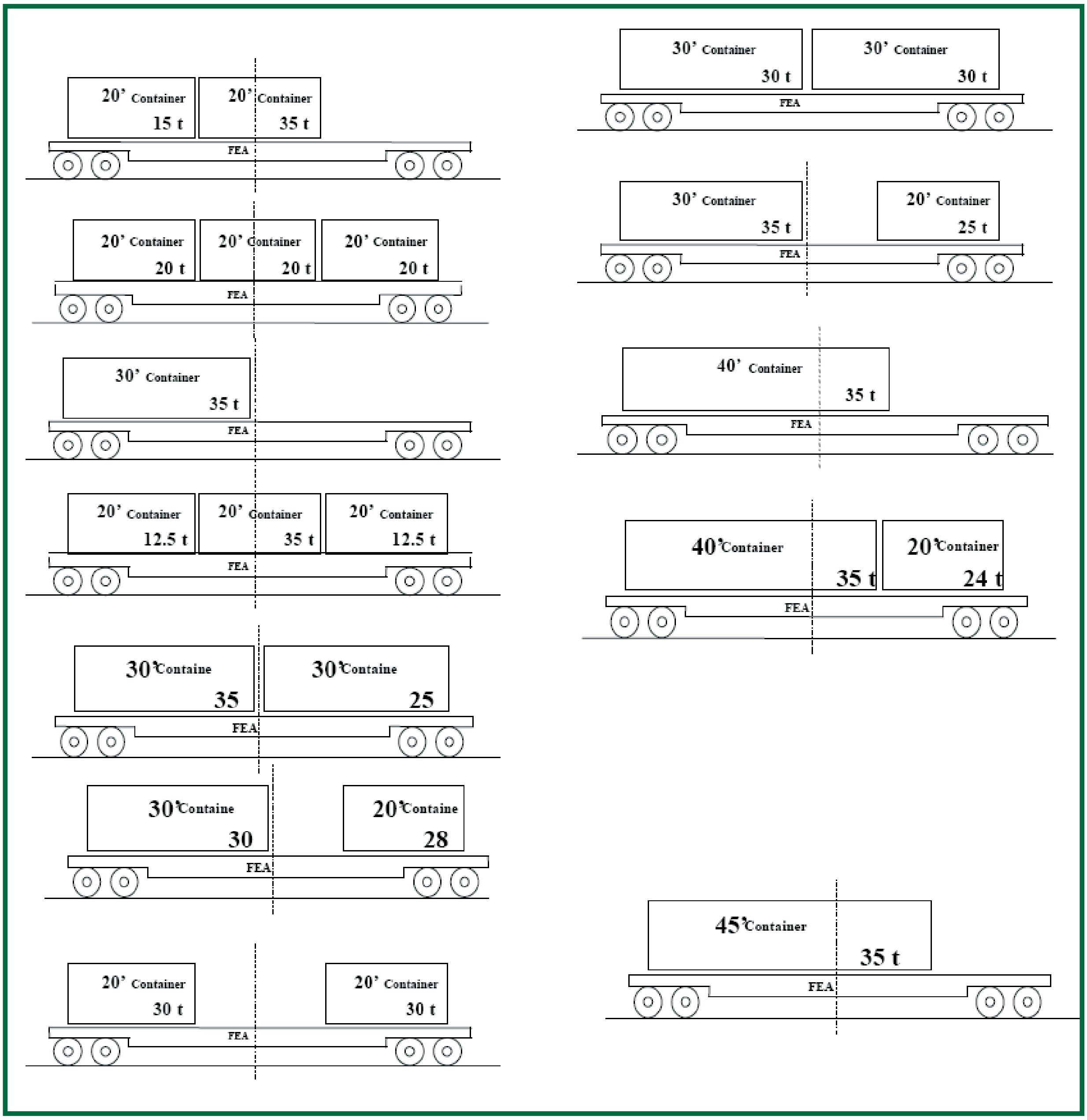

Figure 15: Extract from MIE 0767 Appendix G

131 At Lawley Street Terminal copies of MIE 0767 are held in the library, the shift manager's office, the operations supervisors' office and by operations supervisors individually.

132 Freightliner engineering department's intention was that MIE 0767 appendices should be interpreted as meaning that for the container configuration shown in each figure, each container can have a gross weight between the tare weight and the maximum weight indicated, irrespective of the load in any other container on the wagon.

133 For the 20 ft with 40 ft configuration involved in the derailment, this interpretation would allow the 40 ft container to be anywhere between tare (as it was) and 35 tonnes, and the 20 ft container to be anywhere between tare and 24 tonnes. It in fact weighed 30.4 tonnes and thus was not compliant with the loading standard.

134 Witness evidence suggests that when the standard was issued to operations supervisors at Lawley Street, there was a discussion on interpretation of these figures. However, since then, detailed understanding of the standard had not been assessed.

135 Despite the intended interpretation, a number of others existed. Some staff at Lawley Street Terminal understood that the use of the words 'maximum load' in the MIE combined with the RGS requirement for even loading would permit, for example, the 20 ft and 40 ft container configuration to allow up to 30 tonnes in each container.

136 Immediately after this accident, Freightliner enforced the intended interpretation rigorously. They found that containers that were previously being transported on a given train were having to be left behind, indicating that different interpretations and non-compliance had been occurring regularly.

Previous occurrences of a similar character

137 Over time, numerous derailments have been caused by the interaction of significant track twist and wagons that were particularly susceptible to derailment over such twists.

138 In the year prior to this derailment, the significant main line derailments of this type were:

- Washwood Heath, Birmingham (8 September 2006, RAIB report reference 39/2007)[2]. This is particularly relevant as it took place within around half a mile of this accident, the points concerned were maintained by the same staff as 715B points and the dynamic 3 m twist fault of 1 in 108 had not been detected before the derailment. The vehicle contribution was primarily related to high bogie rotational stiffness, rather than uneven loading.
- King Edward Bridge, Newcastle Upon Tyne (10 May 2007, RAIB report reference 02/2008) where the vehicle contribution was related to twisted wagon frames.
- Ely (2 June 2007, RAIB report yet to be published) where the vehicle contribution was related to twisted wagon frames and high friction forces within the suspension.

[2] All the reports referenced are available on the RAIB website www.raib.gov.uk/publications

Analysis

Identification of the immediate cause

139 Marks at the point of derailment indicate that one wheelset derailed as a result of flange climb (paragraph 53).

140 The nature of the consequent damage to the bar coupling between the two wagons and analysis of the derailment mechanism indicate that the front wheelset of the rear wagon derailed first (paragraph 54). The derailment of seven other wheelsets followed this event and was a consequence of it (paragraphs 55 to 58).

141 The location of the POD on a closure rail removes any possibility that the flange climb was caused by the lateral movement of the rail under the wheel as a result of the points being switched.

142 Site observations, wheel unloading testing and subsequent VAMPIRE® analysis (paragraphs 67 and 68) indicate that the derailment mechanism was flange climb of the front right-hand wheel of wagon 640 262 to a degree that the vertical load on the wheel was insufficient to hold the flange inside the rail in the face of the lateral forces associated with negotiating the curve.

143 The results of the VAMPIRE® modelling were marginal which suggests that all the known significant factors needed to be present for the derailment to occur. The fact that such derailments are relatively rare supports this. These factors were:

- a 1 in 103, 3 m anticlockwise track twist fault under the rear bogie;
- a 1 in 237, 3 m clockwise track twist under the front bogie;
- a tare laden 40 ft container on the front and a 30.4 tonne GLW 20 ft container on the back of the wagon; and
- a shift to the left of around 0.4 metres of the rear container payload.

Thus, the unloading of the leading right-hand wheel of wagon 640 262 was a result of a combination of the two 3 m track twists occurring over the wheelbase of a wagon which was unevenly loaded both longitudinally and laterally.

144 The immediate cause of the accident was the flange climbing of the front right-hand wheel of wagon 640 262 over the right-hand closure rail of 715B points as a result of the interaction between the combination of track twists and the unevenly loaded wagon.

Identification of causal and contributory factors

Causal and contributory factors associated with the track

Causal factor

145 Track surveys indicated that at the POD, the dynamic 3 m twist was around +1 in 237. As the leading wheelset passed this point, the rearmost wheelset was experiencing a dynamic twist of around -1 in 103. The former is not considered a fault and as such, Network Rail would not be expected to take any action to detect or repair it. The -1 in 103 twist fault is both a significant fault that should be corrected within 36 hours of detection (paragraph 74) and by far the most significant part of the combination of twists resulting in the unevenly loaded wagon derailing. It had neither been detected nor remedied.

146 As shown in paragraph 143, the combination of twists was required to be present in combination with the unevenly loaded wagon, for the derailment to occur.

147 The presence of a significant twist fault that had not been detected and remedied is a causal factor.

148 The crossover route concerned was not included in the programme of measurements conducted by track recording vehicles (paragraph 72). Such vehicles measure dynamic track twist under load and their recorded output is used to direct remedial works in accordance with NR/SP/TRK/001 as described in paragraph 74.

149 NR/SP/TRK/001 accepts that not all turnout routes need to be covered by measurement trains (on the grounds of impracticability), and that approved alternative inspection methods may be used. At Duddeston Junction, the Area Track Engineer (ATE) had agreed that 715B points would be inspected visually and a gauge would be used if the visual inspection suggested the presence of significant twist.

150 The ability of a person to detect a track twist by eye is dependent upon where the twist falls in relation to other features, the experience and diligence of the observer and the presence of other tell-tale signs.

151 These twists had not been detected and were not known about by Network Rail. A static twist of + 1 in 312 is not significant and is thus not considered as a defect in NR/SP/TRK/001. The fact that it was not detected by eye is understandable and would generally be inconsequential. The more significant static twist of -1 in 176 may still not be detectable by eye, particularly on the curve within the turnout and with no other tell-tale signs present, as was the case with 715B points.

152 It is also the case that the track recording vehicle measurements for the through lines can, particularly when two routes share the same bearers, sometimes indicate a problem with the turnout route. However, it did not do so in this case.

153 Alternative methods that could have been used were a manual track trolley to accurately measure static twist, or if rapidly developing voids were suspected, the manual trolley in combination with *void meters* under passing trains. The first approach would have detected any static twist as it became worse than 1 in 200 and resulted in remedial action within one week. Assuming the twists and voids were not growing at an abnormal rate, this would have prevented dynamic twist reaching -1 in 103. The second method would have detected dynamic twist as it became worse than 1 in 200 and remedied it within a week.

154 That the inspection method used was not capable of detecting the level of dynamic twist that had developed at this location is a causal factor.

Contributory factors

155 The reason why visual inspection was unable to detect the high level of 3 m dynamic twist at this location was that the crossover could not readily be examined under load and the turnout did not exhibit the usual signs of voiding (paragraph 79). These two factors were in turn a result of the low traffic levels and speeds over the crossover. All three factors are contributory.

Causal and contributory factors associated with the wagons

Causal factors

156 The running of wagon 640 262 with sufficient longitudinal and lateral load offsets to make the wagon susceptible to derailment over track twists is a causal factor (paragraph 143).

157 The reasons the wagon was running in this susceptible state were that the distribution of the load placed upon it was beyond that for which it was designed in terms of derailment resistance and that such distribution of load was not detected and remedied prior to the wagon departing from Lawley Street Terminal. These two factors are also causal.

158 Longitudinal offset of the load was as a result of the placing of a 30.4 tonne, 20 ft container next to an empty 40 ft container in contravention of the MIE 0767 limit of 24 tonnes for the 20 ft container in this configuration. This is a causal factor.

159 Figure 6 indicates it is likely that the load in the rear container on wagon 640 262 was offset to the left prior to the accident. This is a probable causal factor.

Contributory factors - loading

160 Although large lateral offsets in container loads can be detected by experienced crane and *reach-stacker* operators, smaller offsets are not readily detectable. To do this would require load cells associated with the lifting of each of the four top corner castings. The cranes at Lawley Street Terminal detect overall lifted weight to activate overload alarms, and are not designed to automatically detect offsets in lateral load. That low levels of lateral load offset were not readily detectable is a contributory factor.

161 Provision of such detection on all container handling cranes in the country would be difficult and expensive. Unless and until such provision is made, associated container wagons should be designed to accommodate such lateral offsets in load as they are reasonably likely to encounter as a result.

162 Paragraphs 135 and 136 indicate that there was a lack of knowledge and understanding of MIE 0767 amongst Freightliner loading staff and that, in part as a result of this lack of understanding, there was a practice of not strictly adhering to MIE 0767. This is a contributory factor.

163 Given the system of container handling at Lawley Street, there are other possible contributory factors that may have occurred. These are:

- there was an error entering the container weights on the 'dillies';
- there was an error in placing the 'dilly' on the correct wagon; and
- the weight distribution of the derailed wagon was not checked on the 'dilly' board.

Paragraph 171 shows the lack of an independent automated check is a contributory factor (such that if the human errors above did in fact occur, and as they sometimes will, they could be detected by other means). As a result, these possibilities are not considered further.

Contributory factors – detection of load distribution

164 Wagon 640 262 was not loaded in accordance with MIE 0767.

165 The paperwork relating to the visual pre-departure check by the operations supervisor was correctly completed and there is no evidence to suggest that these checks were not carried out.

166 However, the visual departure check of the wagon (paragraph 125) did not detect the level of uneven loading and the wagon was allowed to start its journey. This is a contributory factor.

167 There are a number of reasons why diligently carrying out these checks would probably not have found that the wagon loading contravened MIE 0767. These are:

- the wagon has *nested springs* so the suspension characteristic is very non-linear;
- the sidings at Lawley Street Terminal do not have a good standard of vertical alignment; and
- the 6.4 tonne difference in GLW between that allowed for the 20 ft container (24 tonnes) and the actual weight (30.4 tonnes) will not have a significantly different effect on the lowering of the rear suspension of a wagon designed for 82 tonnes maximum GLW.

168 It is a contributory factor that the standard methods that Freightliner used for detecting uneven loading of container wagons were not reliable.

169 The TOPS list is produced using the output from ERIC (paragraph 124). In this instance the TOPS list included the correct total weight for wagon 640 262. This indicates that the correct container weights had been put into ERIC.

170 The computerised systems were aware of the wagon number and the individual container weights and could, had they had the capability, have been used to check that weights of the containers on the wagon were outside those allowed by MIE 0767.

171 It is a contributory factor that the computer systems used in container processing by Freightliner are not capable of detecting uneven loading beyond that allowed by standard MIE 0767, although they contain sufficient data to do so.

Contributory factors – wagon design and approval

172 The distribution of the load placed upon wagon 640 262 was beyond that for which it was designed in terms of derailment resistance. This was in part a result of the significant offset in the centre of gravity longitudinally. MIE 0767 in effect prescribes what the maximum offset in centre of gravity can be longitudinally, excepting longitudinal imbalances within the container payloads.

173 MIE 0767 was not written with the effects on derailment resistance in mind and Freightliner did not know whether the FEA-B wagon was capable of sustaining MIE 0767 loads in terms of GM/RT 2141 derailment resistance requirements or not. The RAIB have chosen not to make this determination, recommending instead that Freightliner do so (paragraph 205).

174 It is thus possible that the wagon was not capable of sustaining MIE 0767 loads in terms of GM/RT 2141 derailment resistance requirements.

175 The reasons that this may have been the case are that:

- VCG assumed that the wagons would be loaded reasonably evenly (as wagons should be loaded 'as uniformly as possible' is a 'White Pages' requirement) and thus they only required wheel unloading tests to be carried out for tare and fully laden wagons with no lateral load offset accounted for (longitudinal offsets were only considered as part of high speed VAMPIRE® simulations and not to the degree allowed by MIE 0767 – paragraph 112). Thus there is no independent validation of Greenbrier's assertion that the wagons were designed for all loadings on the technical specification drawing (paragraph 101) in terms of GM/RT 2141 requirements; and
- Freightliner specified the FEA-B wagons' loading capacities to Greenbrier using an MIE 0767 drawing and assumed that Greenbrier and VCG would interpret them in the manner Freightliner intended. Greenbrier stated that they did, VCG did not.

These two factors are thus possibly contributory.

Identification of underlying causes

Underlying cause relating to track twists

176 NR/SP/TRK/001 allows crossovers not to be measured by track recording vehicles on the grounds of impracticability. Although it is not explicitly stated in the standard, Network Rail expect responsible staff to judge the balance of risk with costs and resources when considering what alternative inspection method to undertake.

177 There was no history of derailments or particular problems at 715B points.

178 A derailment had occurred on points close by at Washwood Heath in September 2006 (paragraph 138) in which undetected dynamic track twist contributed. However, it was believed that the reason for the related static twists not being detected by eye was because of the significant *cant* and curvature, and differing levels at each end of the crossover. Such features make the visual identification of twist faults more difficult. As a result of that derailment, local management have decided that the Washwood Heath crossover and those in the same area with similar configurations that develop significant voids are now inspected using a manual trolley and void meters.

179 The same features (particularly rapid cant reversals) did not exist at Duddeston Junction, nor do they at most of the very large number of other crossovers in the West Midland and Chilterns Area of which it is a part.

180 After this accident, 715 points are now inspected using a manual trolley.

181 Before the accident Network Rail staff had no historical data to suggest any unusual problems with 715 points and they had no ongoing indications of problems. There are a large number of points in a similar configuration in the same area that were operating with few apparent problems.

182 Local staff judged that the crossovers at Duddeston Junction constituted a low risk and were satisfied that the standard inspection regime was sufficient. Track trolleys, and in some circumstances, void meters were used elsewhere in the area where the track was perceived to constitute a higher risk.

183 It is an underlying cause that Network Rail deployed track maintenance resource in a way that past experience indicated to them was likely to lead to the maximum reduction in risk.

Underlying cause relating to wagon loading

184 MIE 0767 was used for a number of purposes and was open to a number of interpretations. There existed more than one interpretation at Freightliner management level and further interpretations at lower levels. Greenbrier has stated that they interpreted the document in the same way as Freightliner engineering management. VCG had a different interpretation.

185 Many of the confirmed causal and contributory factors relating to the longitudinal distribution of load on wagon 640 262 relate back to this issue. An underlying factor is therefore a lack of understanding at various levels of Freightliner as to the content, use and interpretation of their single wagon loading standard MIE 0767.

Severity of consequences

186 The chance of more severe consequences of this accident was increased by the two containers on wagon 640 261 coming off all their locating spigots; the 40 ft container slewing to the right and further fouling the down main line and the 20 ft container falling off the wagon to the left and fouling the up goods line.

187 It is unlikely that the containers would have come off twistlocks in such a low speed derailment. As such, the increased probability of worse consequences was contributed to by the use of spigots, rather than twistlocks, on the derailed wagons.

188 There is evidence of spigot retained containers being blown off trains in Europe in high winds. Crosswinds exert forces that tend to roll the wagon and container akin to the rolling which may have occurred in this derailment as described in paragraph 93.

189 On 1 March 2008 two incidents of containers secured by spigots falling from moving FEA-B wagons occurred, at Cheddington and Hardendale. The factors common to the two incidents were high cross winds, train speed, wagon type, container retention by spigots and light container loads.

190 The RAIB is investigating the effectiveness of such spigots as part of the investigation into the 1 March 2008 incidents.

Conclusions

Immediate cause

191 The immediate cause of the accident was the climbing of the front right-hand wheel flange of wagon 640 262 over the right-hand closure rail of 715B points as a result of the interaction between a combination of track twists and the unevenly loaded wagon (paragraph 144).

Causal factors

192 Causal factors were:

a. the presence of a significant twist fault that had not been detected and remedied (paragraph 147);

b. the method of track inspection used was not capable of detecting the level of dynamic twist that had developed at this location (paragraph 154);

c. wagon 640 262 was running loaded in a way that made it very susceptible to derailment over track twist faults (paragraph 156 & Recommendation 2);

d. the uneven distribution of load placed upon the wagon was beyond that for which it was designed terms of derailment resistance (paragraph 157 & Recommendation 2);

e. the uneven distribution of load was not detected and remedied prior to the wagon departing from Lawley Street Terminal (paragraph 157 & Recommendation 1);

f. the placing of a 30.4 tonne 20 ft container next to an empty 40 ft container in contravention of the MIE 0767 limit of 24 tonnes for the 20 ft container in this configuration (paragraph 158 & Recommendation 2); and

g. a probable causal factor is that the 20 ft container load was likely to have been offset to the left (paragraph 159).

Contributory factors

193 The following factors were considered to be contributory:

a. The crossover could not readily be examined under traffic (paragraph 155);

b. The crossover did not exhibit the usual tell-tale signs of voiding (paragraph 155);

c. The traffic levels over the crossover were very low and ran at slow speed (paragraph 155);

d. Low levels of lateral payload offset were not readily detectable (paragraph 160);

e. There was a practice amongst some Freightliner loading staff of not strictly adhering to the loadings prescribed by MIE 0767 (paragraph 162 & Recommendation 2);

f. Visual pre-departure checks of the train did not detect the level of uneven loading (paragraph 166 & Recommendation 1);

g. Standard methods that were used for detecting uneven loading of container wagons were not always reliable (paragraph 168 & Recommendation 1);

h. The computer systems used for container processing by Freightliner are not capable of detecting uneven loading beyond that allowed by standard MIE 0767 although they contain sufficient data to do so (paragraph 171 & Recommendation 1);

i. The following factors were possibly contributory (paragraph 175):

- VCG assumed that the wagons would be loaded reasonably evenly (as this is a 'White Pages' requirement) and thus they only required wheel unloading tests to be carried out for tare and fully laden wagons with no longitudinal or lateral load offset accounted for (longitudinal offsets were only considered as part of high speed VAMPIRE® simulations and not to the degree allowed by MIE 0767). Thus there was no independent validation of Greenbrier's assertion that the wagons were designed for all loadings on the technical specification drawing in terms of GM/RT 2141 requirements; and
- Freightliner specified the FEA-B wagons' loading capacities to Greenbrier using an MIE 0767 type drawing and assumed that Greenbrier and the VAB would interpret them in the manner Freightliner intended. Greenbrier state that they did, the VAB did not (paragraph 175).

(Recommendations 3, 4, 5, and 6).

Underlying causes

194 The underlying causes were:

a. Network Rail deployed track maintenance resource in a way that past experience indicated to them was likely to lead to the maximum reduction in risk (paragraph 183); and

b. a lack of understanding at various levels of Freightliner as to the content, use and interpretation of their single wagon loading standard MIE 0767 (paragraph 185, Recommendation 3).

Other factors affecting the consequences

195 The fact that the derailed wagons used spigots to locate and secure the containers, rather than twistlocks, exacerbated the possible consequences of this accident.

Additional observations

196 At the time of the accident Freightliner had not yet completed the actions required by National Incident Report (NIR) 2084 which related to an incident on 9 November 2005 that had shown that an FEA-B wagon bogie and a stowed UIC spigot could interact with each other at high angles of bogie rotation (paragraphs 95-98). A temporary restriction on minimum curve radii to be negotiated remains in force, but no long term solution has been implemented (Recommendation 7).

197 The first two paragraphs of standard NR/SP/TRK/001 Issue 2, clause 11.4.2 are not entirely clear and the apparent requirement for all crossovers not measured by a track recording vehicle to be kept on a list may be impractical for areas with complex layouts (paragraph 71, Recommendation 8).

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

198 Freightliner has briefed all operations managers on the intended interpretation of the appendices of MIE 0767. The related briefing of all loading staff is ongoing. A random programme of audits on laden container wagons is to be introduced to measure compliance with MIE 0767. They also issued NIR 2336 on 21 December 2007 to alert other container wagon operators to the issue.

199 Freightliner is evaluating the risk of derailment of an FEA-B wagon carrying a 20 ft laden and a 40 ft empty container, using a validated VAMPIRE® model.

200 Freightliner is looking into modernising the existing ERIC container loading software. Part of that development includes defining the allowable load configurations for containers on a wagon with regard to the position and weight of each container. This is a long term project and is not likely to be delivered until 18 to 36 months time.

201 Freightliner is developing a revised maintenance specification and measurement methods for UIC spigots.

202 Network Rail has introduced a track trolley to the inspection regime at Duddeston Junction.

203 Network Rail is in the process of revising NR/SP/TRK/001 section 11.4.2.

204 Network Rail and Freightliner have undertaken a formal investigation. It recommends, among other things, that they should jointly review the risk assessments undertaken when spigots were introduced into British freight wagons, to ensure that the assumptions made are still valid.

Recommendations

205 The following safety recommendations are made[3]:

Recommendations to address causal, contributory and underlying factors

The following recommendation was made by the RAIB as a result of the investigation into a derailment at King Edward Bridge, Newcastle Upon Tyne (report reference 02/2008 Recommendation 4):

'*Network Rail should include guidance in NR/SP/TRK/001 section 11.4.2 to seek to ensure that additional consideration is given to geometry monitoring frequency and methodology for locations where dynamic track geometry is more likely to deteriorate and exceed maintenance limits, without otherwise being detected. This may occur because of the proximity of the design to the geometry maintenance limits, where there is difficulty identifying the geometry or where the geometry deterioration rates are high*.'

Among other things, it addresses the factors listed in paragraphs 192a, b, 193a, b, and c of this report. It is not remade to avoid duplication.

1 Freightliner should investigate the possibility of modifying current, or developing new, software, to give warning if containers are loaded onto a wagon in a way that contravenes company loads standards with regard to the distribution of load. Appropriate solutions should be implemented (paragraphs 192e, 193f, g, and h).

2 Freightliner should take steps, including re-briefing and assessment, to ensure that loading staff clearly understand and can apply the company's rules on permissible loading of container wagons. Freightliner should monitor compliance with their loading standards to provide assurance that such rules are being complied with (paragraphs 192c, d, f, and 193e).

3 Freightliner should re-examine how they present information on permissible container wagon loads. They should aim to present the information in a clear unambiguous way that suits the needs of the user of the information, be they terminal staff, Freightliner management, wagon manufacturers or approval bodies. This will involve the modification of MIE 0767 and the possibility of generating other related documents suited to the particular needs of the recipients (paragraph 193i and 194b).

continued

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

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

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

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

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

4 Network Rail Vehicle Conformance Group should put in place procedures so that when considering derailment resistance during the approvals process of wagons, they determine the full range of loads and their distributions that can legitimately be encountered in service, and consider the sensitivity of the wagon to likely longitudinal and lateral offsets in loading. They should take these factors into account when deciding what testing and calculations need to be undertaken to demonstrate compliance with applicable derailment resistance standards (paragraph 193i).

5 Freightliner should put in place procedures so that when procuring wagons, they unambiguously define to manufacturers and approvals bodies the full range of loads and distribution of loads that can reasonably expected to be encountered by the wagon in service (paragraph 193i).

6 Freightliner should arrange that the FEA-B wagon wheel unloading performance is re-evaluated taking into account the full range of load conditions they permit (currently defined in MIE 0767) to confirm compliance with GM/RT 2141. This should consider sensitivity to longitudinal and lateral offsets in load that can reasonably be encountered in service (paragraph 193i).

Recommendations to address other matters observed during the investigation

7 Freightliner should act upon and close NIR 2084 (paragraph 196).

8 Network Rail should amend NR/SP/TRK/001 section 11.4.2 to make clear into which regime, areas that are not covered by measurement vehicles but are operated at less than 20 mph (32 km/h), fall. They should also clarify under what conditions it is mandated for the TME to maintain a list of areas of track not covered by measurement vehicles (paragraph 197 and 203).

206 Recommendation 4 may apply to other VABs and, as such, Recommendation 6 may apply to other container wagons and operators. Recommendation 1 may also apply to other operators.

Appendices

Glossary of abbreviations and acronyms — Appendix A

ATE	Area Track Engineer
CTU	Cargo Transport Unit
ELH	Eisenbahnlaufwerke Halle
GLW	Gross Laden Weight
OTDR	On Train Data Recorder
NIR	National Incident Report
POD	Point of Derailment
RGS	Railway Group Standard
RSSB	Rail Safety and Standards Board
TME	Track Maintenance Engineer
TOPS	Total Operations Processing System
UIC	Union Internationale des Chemins de Fer
VAB	Vehicle Acceptance Body
VAMPIRE®	Vehicle Dynamic Modelling Package in Railway Environment
VCG	Network Rail Vehicle Conformance Group

Glossary of terms **Appendix B**

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

113 A flat-bottomed rail	A standard rail profile weighing 113 lbs/yard with a flat bottom.
Bearers	A term used to describe a wooden or concrete beam used to support the track.*
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 applied the brakes, as a consequence if the pipe is broken the brakes apply.
Cant	The design amount by which one Rail of a Track is raised above the other Rail, measured over the Rail centres. Valid values of Cant currently in force on the National Railway Network (NRN) are zero to 180 mm in increments of 5 mm (previously ¼" (6.35 mm)). Cant is applied to negate lateral forces caused by curved Track.*
Centre pivot liners	The consumable lining which acts as a bearing surface at the centre pivot point of a bogie allowing rotational movements between wagon body and bogie.
Closure rail	In a switch and crossing layout, the rail between the switch rail and the common crossing.*
Corner casting	The hollow steel casting at each corner of a standard freight container with holes on the three exposed walls not accept retaining devices.
CV	In switch and crossing terminology the 'C' defines a rate at which the two routes diverge, in essence the length of the turnout. The 'V' indicates that the rails are mounted vertically.
Danger	Red aspect of a signal or handlamp.*
Derailment resistance	The ability of a rail vehicle to maintain its wheels on the rails, defined by a the results of a series of standard tests, such as wheel unloading tests.
Dynamic 3 metre twist	A measure of the difference in cross-level (relative heights of running rails) at 2 points 3 metres apart expressed as 1 in x, whilst the track is under load from a train. The static twist is the same measure when the track is not loaded.
Facing (points)	See 'Points'.
Flange	The extended portion of a rail wheel that provides it with directional guidance.*
Laden springs	The stiffer of the nested springs.

Nested springs	Two coil springs, one inside the other with differing stiffness. When the wagon is lightly loaded only the lower stiffness spring is engaged. As the wagon load is increased beyond a threshold, the stiffer spring also comes into play.
Operations Supervisor	Member of Freightliner staff who is responsible amongst other things, for the safe loading of trains.
Points	A track device allowing trains to be switched between one track and another. Facing points, face towards the normal direction from which trains approach; trailing points face the opposite way.
PSD/0300 checklist	Freightliner Rail Operations standard PSD/0300 contains checklists detailing what items should be checked as compliant with the standard before a train is allowed to depart.
Reach-stacker	A wheeled machine, similar to a very large fork lift truck, that lifts and transports containers around a freight facility.
Rolling stock library	A system linked to TOPS and containing details of all rolling stock approved by Network Rail for operation on its infrastructure.*
Shunter	A person whose duties are directing and controlling shunting, including coupling and uncoupling.*
Side bearers	Corresponding bearing surfaces on each side of a bogie and a wagon that support wagon weight while allowing the bogie and wagon to rotate relative to each other.
Signal protection	Placing signals at danger to stop trains entering and area where other trains, people or objects may be on the track.
Spigot	A peg, in this case retractable, shaped to retain containers on the wagon deck.
Static brake test	A test conducted on a stationery train, after being formed and prior to moving.
Stock rail	The fixed rail in half set of switches (as opposed to the movable switch rail).
Tare	Carrying no payload.
Theatre route indicator	An indicator using multiple lamps or fibre optics, mounted close to a signal, that displays a letter that indicate to a driver where the train is routed.
Toe	The moveable end of a switch rail.*
Track circuit block	A signalling system where a length of line from one signal to a distance beyond the next, by passing current through the rails to detect whether a train axle is present.
Traction and rolling stock subject committee	A committee within the Rail Safety and Standards Board who amongst other things decide whether to allow derogations from Railway Group Standards.

Trailing (points)	See 'Points'.
Twistlock	A device fitted to container vehicles are used to retain the containers in place in transit. A vertical pin, onto which the container fits, has a rotating upper part. Hole and pin are oval, so rotation of the pin locks the container in place.*
Up	Towards Derby, away from Birmingham.
Void meters	A device that measures the vertical deflection of the track under passing trains and hence the size of the voids under the sleepers or bearers.
Voids	Spaces under sleepers or bearers in the packing area, often caused by inadequate packing or differential settlement between sleepers. Tell tale signs include rounded pale ballast on top of the sleeper ends and pronounced vertical deflection of the track under passing trains. It is voiding that is responsible for track faults, such as twist faults, that only appear when the track is loaded.*
Wet spots (wet beds)	Areas of ballast contaminated with slurry. Such wet spots spread under the action of passing traffic and can cause twist faults in extreme cases.*
Yaw	Rotation about a vertical axis.

Key standards current at the time — Appendix C

GM/RT 2141 Issue 2	Resistance of Railway Vehicles to Derailment and Roll-Over
GO/RT3056/J	Part of the Working Manual for Rail Staff: Freight Train Operations ('White Pages')
MIE 07/FEA/01 Issue 2	Freightliner Vehicle Maintenance Instruction
MIE 0767 Rev E	Permissible Loading For Freightliner Intermodal Wagons
NR/SP/TRK/001 Issue 2	Inspection and Maintenance of Permanent Way
PSD/0300 Issue 3	Freightliner Rail Operations Standard
UIC Code 571- 4	Standard Wagons - Wagons for combined transport - Characteristics

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