RAIB
Rail Accident Investigation Branch

Rail Accident Report

Passenger train derailment near Fisherground on the Ravenglass & Eskdale Railway 12 May 2007

Department for Transport

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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 accidents, and improve railway safety.

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

3 Access was freely given by the Ravenglass and Eskdale Railway (R&ER) to their staff, data, records and facilities for the purpose of this investigation.

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

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

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

Summary

6 On 12 May 2007, a steam locomotive hauled passenger train, fully laden with passengers, was travelling from Dalegarth to Ravenglass when the leading wheelset of the trailing bogie on the third coach derailed at Hollin How near Fisherground. The derailment occurred while the train was travelling at between 5 and 7 mph (8 and 11 km/h). There were no passenger injuries or significant damage to the train or the track.

7 The cause of the derailment was *flange climb* of the leading right hand wheel of the trailing bogie on the third coach. This resulted directly from the prior collapse of the suspension on the left hand side of the leading bogie due to a *compensating bar* becoming detached, probably because the bar had not been fitted correctly when the bogie was reassembled three weeks earlier following safety inspections and the vehicle had entered service with the fault undetected.

8 The RAIB has made two recommendations regarding the implementation of independent checking of safety critical work not only on bogies but also, more generally, on other aspects of R&ER's operations.

Accident Details

9 The R&ER is a seven mile long narrow gauge heritage railway which has been operating passenger trains on 15 inch (381 mm) gauge track since 1915. A route map and location of the derailment site are shown in Figure 1. The single line has three passing loops at Miteside, Irton Road and Fisherground. Turntables are located at Ravenglass and Dalegarth to turn locomotives around.

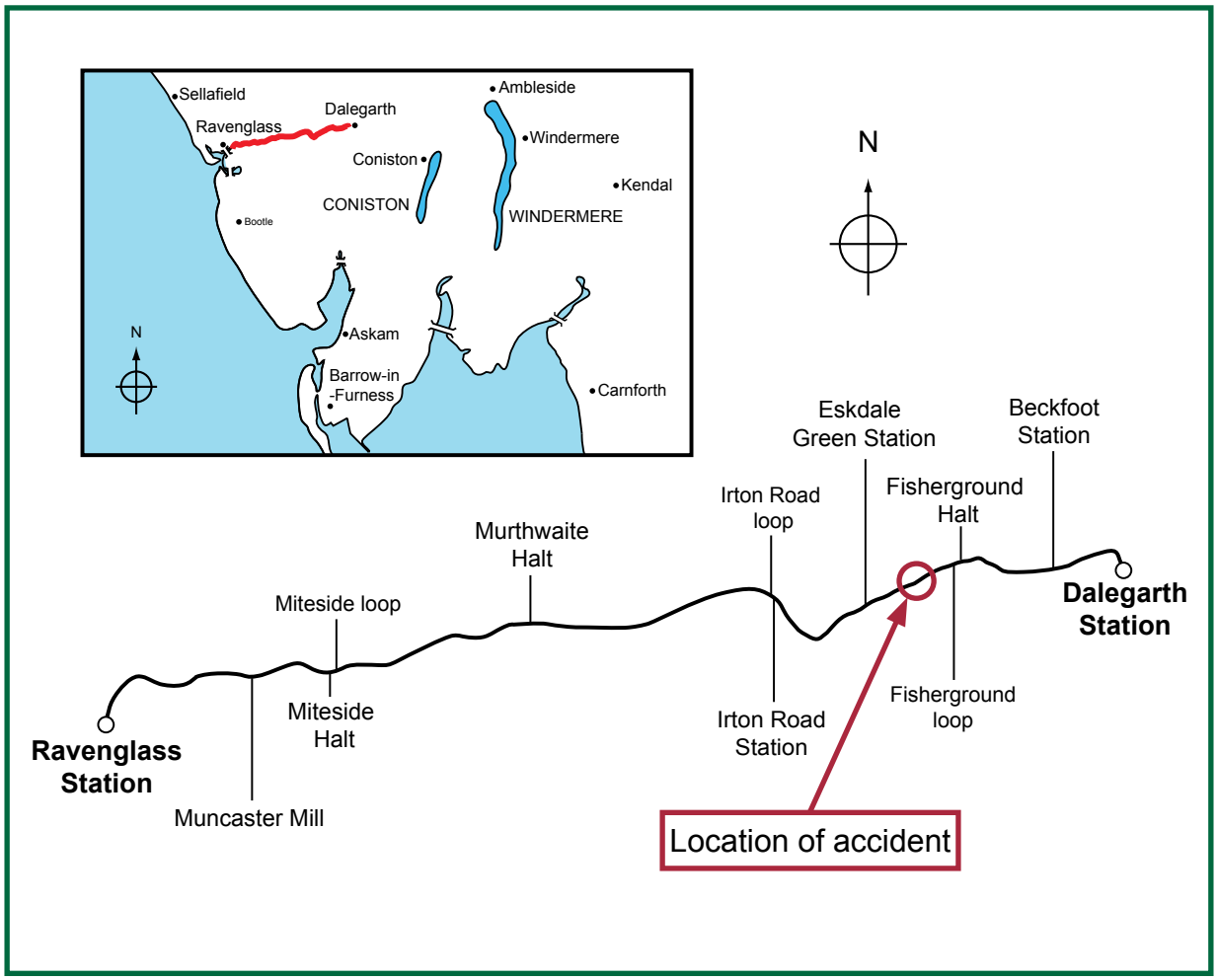

Figure 1: Route map of the Ravenglass & Eskdale Railway and the location of the Hollin How derailment site

10 The infrastructure and rolling stock, except for the hauling locomotive (paragraph 14), were owned and operated by R&ER. All the personnel involved in operating the railway at the time of the incident were full time employees of R&ER, except for the guard who was a volunteer.

11 The site of the derailment was on a left hand curve (Figure 2) which has a radius of approximately 700 ft (213 m). The track is constructed from 35 lb/yd (17.4 kg/m) rail fastened by *elastic spikes* or *coach screws* onto hardwood sleepers spaced every 3 ft (0.91 m) and laid on a foundation of limestone ballast.

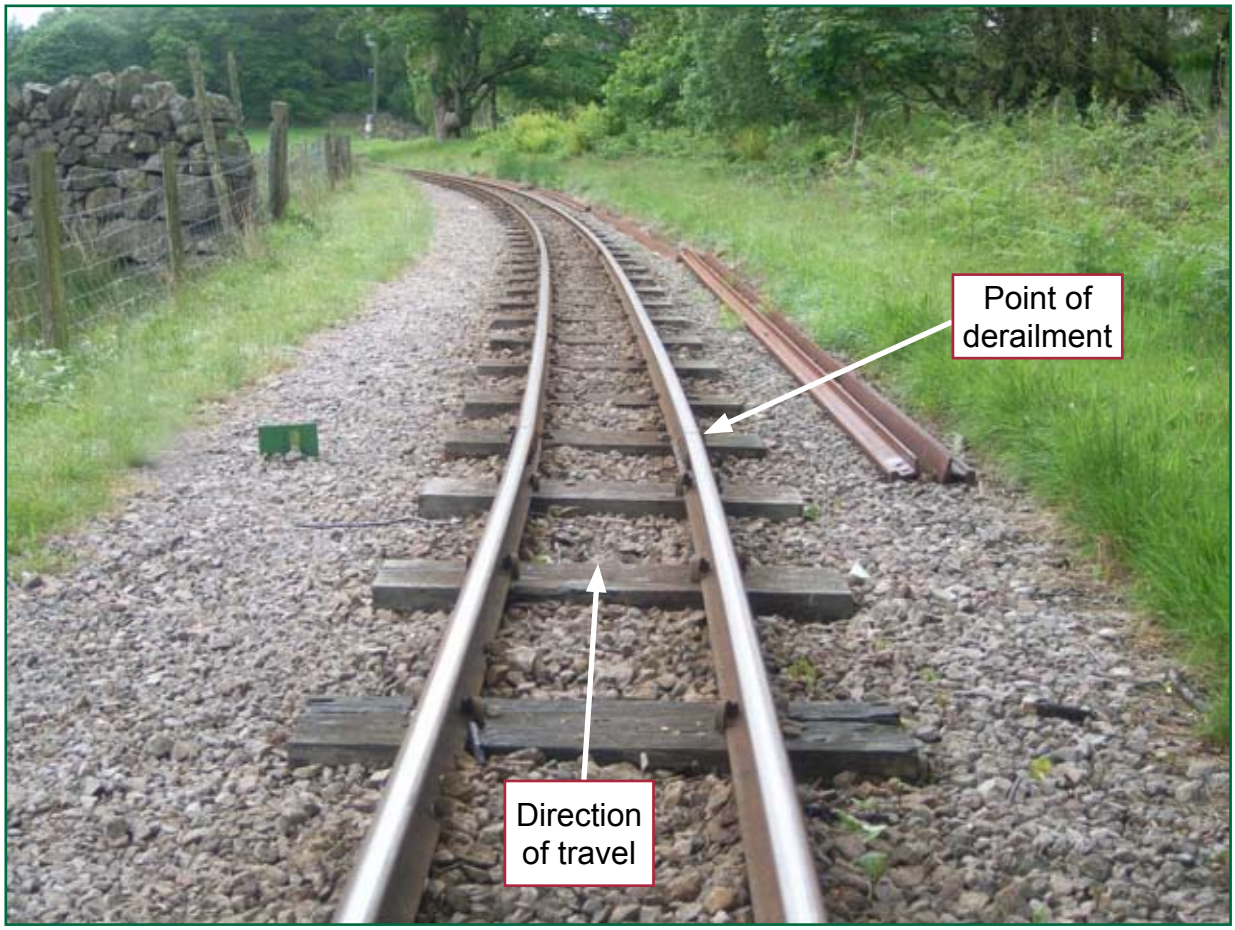

Figure 2: Site of derailment at Hollin How

12 The line speed approaching the point of derailment (POD) is 15 mph (24 km/h), which is the general maximum speed limit currently applied on the R&ER. Starting just before the POD was a temporary speed restriction of 10 mph (16 km/h) over a section of lower quality track that is awaiting renewal work, planned for the winter of 2007/8.

13 The weather at the time of the derailment was warm and dry and the rail head condition was clean and dry.

14 The train comprised a visiting steam locomotive, 'Wroxham Broad', from the Bure Valley Railway in Norfolk, hauling two semi-open coaches (serial numbers 109 and 117) and five 'Maxi' coaches (serial numbers 131, 132, 133, 134, 135). The derailed coach, Maxi 131 (Figure 3), is one of six 'Maxi' coaches in the total passenger fleet of 46 vehicles and was fully laden with 24 passengers at the time of the derailment.

15 The train was scheduled to make a round trip from Ravenglass to Dalegarth and back; the first trip of the day for the Maxi coaches and the second for the visiting locomotive. R&ER's safety officer, drove the train for both the outward journey from Ravenglass to Dalegarth, and the return trip to the time of the derailment. He was accompanied by a visiting driver. Up to that time the journey was uneventful.

16 On the return journey the R&ER driver reported that steam was shut off at Fisherground loop and the train was allowed to coast down the falling gradient towards Eskdale Green station. As it approached the left hand curve at Hollin How the train speed was estimated at between 5 and 7 mph (8 and 11 km/h).

Figure 3: Maxi coach 131 with leading end (nearest) on skidder unit

17 Whilst negotiating the curve, the guard, who was in coach 133, noticed something (later identified as a compensating bar and springs from the bogie suspension) fall off from coach 131. The coach then began bouncing. The guard applied the train brake, bringing the train to a stop in about three coach lengths, checked on the welfare of passengers and informed the driver of the derailment. No one was injured in the derailment. R&ER's control was informed of the accident and the RAIB was notified immediately.

18 With the RAIB's permission, the locomotive and leading two coaches were detached and used to carry out three shuttle runs to Irton Road loop where a recovery train was waiting. When all the passengers had been evacuated to Irton Road loop, the locomotive and leading two coaches from the derailed train were attached to the recovery train and hauled to Ravenglass with all the passengers on board, arriving at Ravenglass at about 19:00 hrs.

19 The derailed coach was detached from the trailing coaches and the leading bogie was placed on a skidder unit (Figure 3). The trailing bogie was rerailed. The five remaining vehicles on site, including coach 131, were recovered back to Ravenglass later that evening.

20 R&ER stopped further running of the 'Maxi' coaches until the cause of the derailment was understood.

21 There was no significant damage to the track in the accident. The derailed wheels had marked the rail head and hardwood sleepers but these did not require repair. Consequential damage to the rolling stock was also minor.

The Investigation

22 The track was photographed and surveyed to measure track *cant* and *gauge* and *voiding* in the area was checked. The derailed vehicle was examined and tested to determine the effects of the collapsed suspension, using R&ER's weighbridge facility at Ravenglass. Other Maxi bogies were also checked for signs of compensating bars coming adrift and relevant staff were interviewed.

Key Evidence

Train operation

23 The driver of the train has been a full time employee of the R&ER since 1996 and has been authorised to drive trains on that railway for seven years. He had driven the visiting locomotive on the R&ER annually since 2004 and was authorised to drive it on this occasion.

24 The operation of the train leading up to the derailment was uneventful. The speed of the train was maintained below the general line speed and the upcoming temporary speed restriction of 10 mph (16 km/h) at the POD.

The track

25 Track marks found shortly after the derailment showed that the leading right hand wheel of the trailing bogie on Maxi coach 131 had derailed by flange climb toward the outside of the curve (Figure 4), possibly aided by the prevailing dry wheel/rail conditions. The trailing wheelset of this bogie did not derail.

Figure 4: Derailed leading wheelset on trailing bogie of Maxi coach 131 on site at Hollin How (courtesy of R&ER)

26 Although the POD was at the start of a stretch of track which was awaiting renewal, there was no evidence of track vertical or lateral alignment problems nor voiding in the immediate vicinity of the POD, which could have directly caused or contributed to the derailment.

27 There was a rail joint in the sleeper bay just before the POD which had a dip of 4-5 mm on the right hand rail and 2-3 mm on the left hand rail causing a slight track twist at this point. A right rail dip of 4-5 mm is considered by R&ER to be at the upper range of acceptability given that the track was approaching relaying and already had a temporary speed restriction. Although the track twist at the rail joint was insufficient to have caused the derailment, it would have exacerbated any wheel unloading arising from a suspension collapse (paragraph 35).

Maxi Coach 131

28 The compensating bar and the four coil springs on the left side of the leading bogie had fallen off 14 sleepers before the POD, causing the suspension on that side to collapse but without causing derailment of the leading bogie.

29 Each end of the compensating bar has a spigot which normally sits in a shallow locating recess on the top of the *axlebox* (Figure 5). The spigot at the leading end of the left hand compensating bar was severely scored with signs of overheating where it had been rubbing on the adjacent axle. The top of the axlebox also had signs of wear indicating that the spigot had been riding outside its recessed seat. The axle end showed corresponding signs of heavy wear confirming that the detachment of the bar and the subsequent drop onto the track was the initiating event rather than consequential.

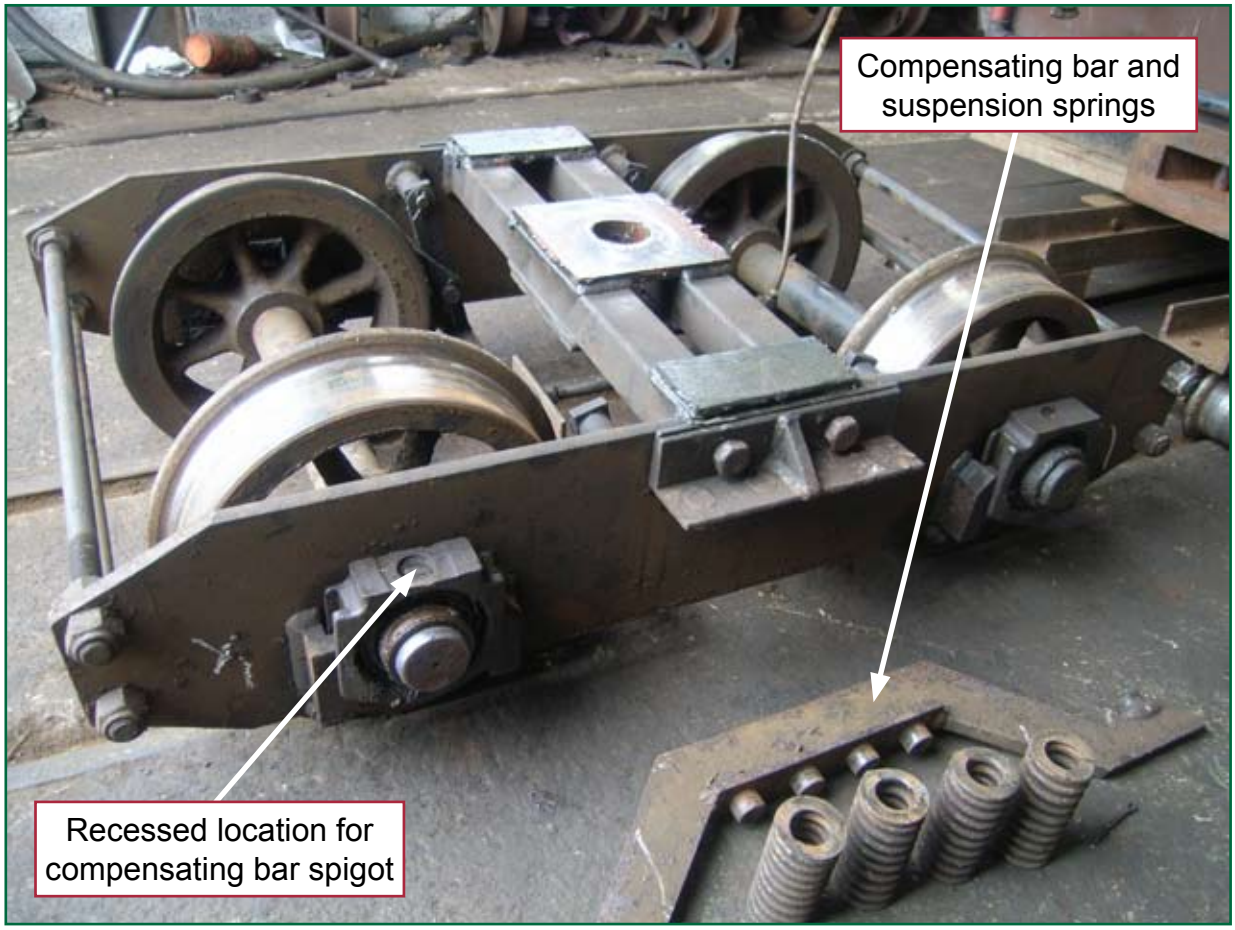

Figure 5: Derailed leading bogie from Maxi coach 131 with compensating bar detached from left-hand side

30 Fleet checks undertaken by R&ER after the derailment revealed that a bogie from another Maxi coach, number 134, which had also been dismantled, inspected and reassembled, had a compensating bar which had a spigot riding outside its locating recess on the axlebox.

31 Maxi coach 131 was last maintained on 14 February 2007 when it went through its annual check and brake test. Nothing unusual was noted at that time. Subsequently, on 26 April 2007, its bogies were stripped down to check the clearance between the axleboxes and horn guides. This fleet check was performed on all six Maxi coaches and other locomotive tender bogies of similar design in response to an RAIB recommendation following a previous derailment (Reference 1). Since then, coach 131 had completed 23 miles including the outward journey from Ravenglass to Dalegarth on the day of the derailment.

32 Interview evidence indicated that the most likely cause of the compensating bar coming adrift at Hollin How was that it had not been properly seated in its axlebox locating recess when the bogie was reassembled. The work had been carried out under some time pressure due to the high workload at the time and the R&ER maintainer, who had over 20 years experience on this type of work, had not spotted the problem when the bogie was fitted to coach 131. The task sheet for the inspection contained only the result tables to be filled in as measurements were taken. There was no checklist for reassembly or any requirement for an independent check to be done following reassembly of the bogie.

33 Even with the spigot of the compensating bar sitting on the outer edge of the axlebox, the bogie can still be reassembled and will appear to run normally. However, in this condition the bar can shuffle along and fall off onto the axle end where it could ride for some time before falling off completely. This sequence of events appears to have been what happened in the lead up to the derailment and was confirmed by testing the bogie on coach 134 which was also found to have a displaced compensating bar. When suspension movements were induced by swaying the coach body from side to side, the compensating bar moved toward the outboard edge of the axlebox and had it been tested further, would have fallen onto the axle end.

34 The other Maxi coaches were also tested to check if correctly fitted compensating bars could become dislodged in service by *swaying* the bodies from side to side to induce vertical suspension movements in excess of what would normally be seen on track. None of the compensating bars came adrift, confirming that compensating bars do not work loose when correctly fitted. Additionally there is no fleet history of such a problem.

35 A reconstruction of the suspension collapse on coach 131 was carried out to check how a collapsed suspension on the leading bogie affected the trailing bogie. The test was done with trailing bogie on a weighbridge. The tests proved that when the left compensating bar of the leading bogie falls off and the suspension on that side collapses, the right hand wheels of the trailing bogie unload completely with the vehicle in the empty (tare) condition. During the incident, the leading right hand wheel of the trailing bogie would have been subject to lateral curving forces at Hollin How and when its vertical load dropped, it would have been very vulnerable to a flange climb derailment.

Previous occurrences of a similar character

36 There were two derailments on the R&ER in May and July 2006, neither causing injury. Both were investigated by the RAIB (Appendix C - reference 1). The first also involved a Maxi coach which derailed while exiting a curve in a different location. On that occasion the initiating event was the restricted movement of one of the axleboxes on the leading bogie which led to a flange climb derailment and subsequent collapse of the suspension on that bogie. The second involved a different bogie design and is not relevant to this report.

37 Prior to that, there were three other derailments, since about 1992, which are summarised in reference 1. These were never fully investigated at the time and the cause of these was not established; however two involved Maxi coaches.

Conclusions

38 The immediate cause of the derailment was flange climb of the leading right hand wheel of the trailing bogie on Maxi coach 131 as it unloaded whilst negotiating the left hand curve at Hollin How. The unloading resulted directly from the prior collapse of the suspension on the left hand side of the leading bogie as confirmed by tests (paragraph 35).

39 A very low vertical wheel load in the presence of normal lateral curving forces would have induced the wheel flange to climb. Additionally the slight twist at the rail joint just before the POD (paragraph 27), would have contributed to the wheel unloading and explains why the bogie derailed at that particular location. The dry rail head conditions may also have contributed to the derailment.

40 The reason that the suspension collapsed on the leading bogie was that the left hand compensating bar fell off, probably because it had not been fitted correctly when the bogie was reassembled on 26 April 2007. Testing of the coaches (paragraphs 34 and 35) and previous service experience on the R&ER confirm that correctly fitted compensating bars do not work themselves out of their recessed housing on the axleboxes. The incorrect assembly of the compensating bar was therefore a causal factor. Time pressure due to the high workload at the time may have been a contributory factor (paragraph 32).

41 R&ER did not, at the time of the derailment, have a requirement for an internal independent check to be carried out on each bogie following reassembly and the incorrect installation of the compensating bar went unnoticed. Additionally, once the bogie is installed under the vehicle, the top of the bogie is not visible. The lack of a correctly implemented independent check following bogie reassembly was therefore also a causal factor (Recommendation 1).

42 More generally, independent checks by competent persons following safety critical work are not an intrinsic part of R&ER maintenance procedures, which have, until recently, been based on custom and practice over more than 40 years of operation with the current owners. It is considered that this was an underlying factor in the derailment (Recommendation 2).

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

43 R&ER have carried out the following actions since the derailment:

- Modified their bogie maintenance procedure to include an independent safety check by a competent person following bogie reassembly.
- Commenced fitting of retaining brackets to Maxi coach bogies and other bogie designs which feature compensating bars. The brackets are designed to keep the bars in place if they become dislodged from their axlebox housing for any reason.

44 R&ER have accepted and are working towards implementing a previous recommendation made by the RAIB which called for the implementation of a vehicle maintenance regime based on the assessment of hazards identified not only from past experience but also an analysis of possible future failure modes (Appendix C - Reference 1, Recommendation 3). The failure mode which came to light in this derailment was not previously known and emphasises the urgency of this recommendation.

Recommendations

45 The following safety recommendations are made[1]:

Ravenglass and Eskdale Railway should:

1. Review and identify safety critical elements of engineering work on their bogies, including the re-fitting of compensating bars, and implement work procedures which include:
   - a primary check by the person undertaking the work; and
   - a secondary independent check signed off by a competent R&ER person to ensure that any problems are detected before entering service (paragraph 41).
2. Review their safety management system and operational procedures to identify if there are other areas where safety critical maintenance or design work is undertaken, or decisions are made, which should be subject to independent checking, and implement appropriate changes to procedures (paragraph 42).

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

Appendices

Glossary of abbreviations and acronyms — Appendix A

R&ER	Ravenglass & Eskdale Railway
POD	Point of derailment

Glossary of terms — Appendix B

Axlebox	The axle bearing housing which connects the wheelset to the bogie via primary suspension. There is one axlebox at each end of a railway wheelset.
(track) Cant	The amount by which the high rail on a curve is raised above the low rail.
Coach screws	A form of rail fastener used on wooden sleepers.
Compensating bar	A part of the Maxi coach bogie suspension which comprises a swan-neck shaped steel beam connecting the axleboxes on each side of the bogie and supporting the suspension springs.
Elastic spikes	A form of rail fastener used on wooden sleepers.
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.
(track) Gauge	The specified distance between the rails of a railway track. On the R&ER this distance is 381 mm and 387 mm on straight and curved track respectively.
Sway(ing)	The roll (side to side) motion of a rail vehicle.
Voiding	A track fault caused by gaps in the ballast reducing the vertical support provided to one or more sleepers. It manifests itself in the form of abnormally high vertical deflection of the rail when a train passes by.

References Appendix C

1. RAIB Report 07/2007, 'Passenger train derailments on the Ravenglass and Eskdale Railway, 29 May and 5 July 2006', published March 2007.

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