



Rail Accident Investigation Branch

Rail Accident Report



**Derailment of a road rail vehicle at Terryhoogan,
near Scarva, Northern Ireland
9 March 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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Derailment of a road rail vehicle at Terryhoogan, near Scarva, Northern Ireland, 9 March 2008

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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 Northern Ireland Railways (NI Railways), Northern Excavators, and McLaughlin and Harvey gave free access to their staff, data and records in connection with the investigation.
- 4 Orientations stated in this report relate to the direction of travel of the road rail vehicle at the time of the accident, for example leading, trailing, left and right-hand.

Summary of the accident

- 5 At 23:20 hrs on 9 March 2008, a road rail excavator and two road rail wagons derailed at Terryhoogan, near Scarva (Figure 1). The excavator ran down a steep embankment before overturning and coming to rest on its side with the driver still in its cab. Its descent derailed its wagons and pulled them part way over the embankment edge.
- 6 No-one was injured as a consequence of the derailment. The excavator and the wagons sustained damage to their running gear and bodywork, and there was minor damage to the infrastructure.

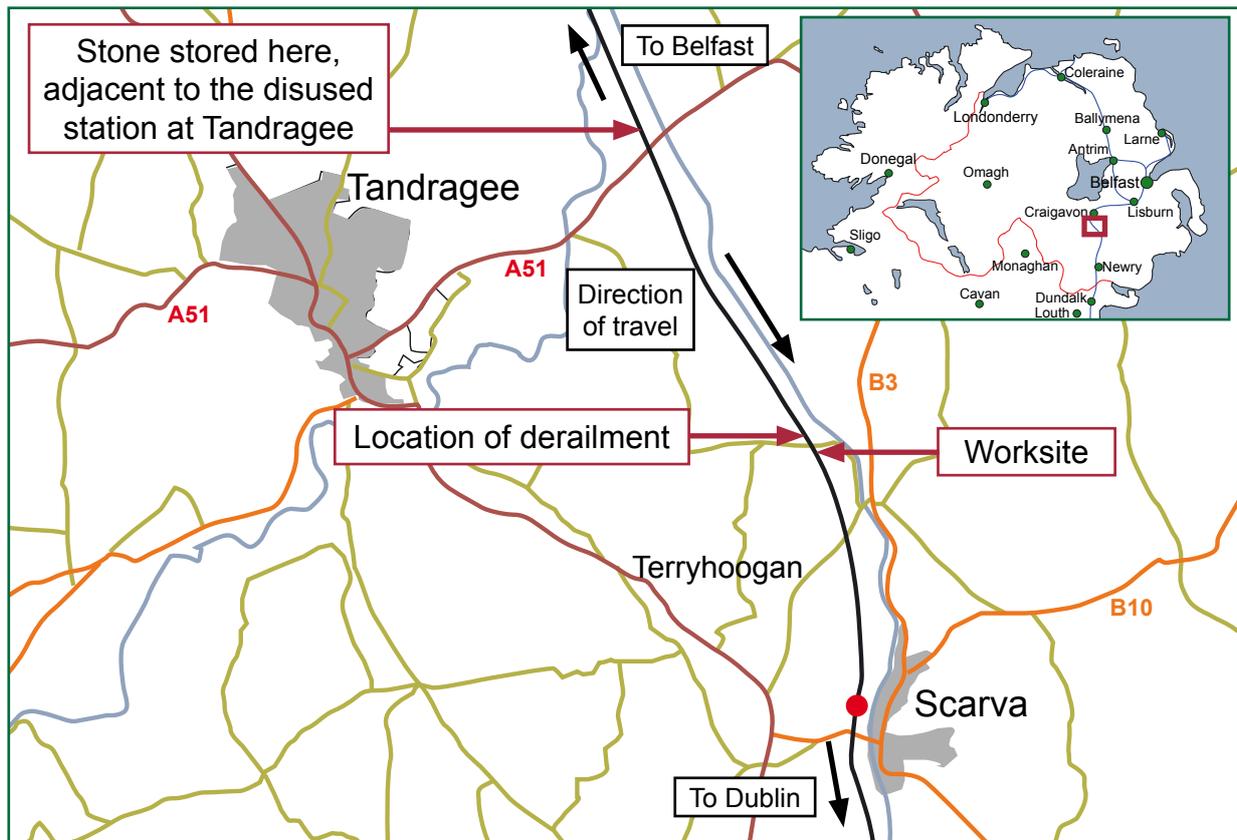


Figure 1: Map showing the location of the derailment

The parties involved

- 7 NI Railways is the owner of the infrastructure, including the worksite at which the derailment occurred. It was the employer of the engineering supervisor (the person responsible for the safety of vehicle movements in the worksite) and the person in charge of the possession (a possession is a period of time during which NI Railways block trains from one or more tracks so that their employees and contractors can work safely on or near the line).

- 8 McLaughlin and Harvey of Newtownabbey, County Antrim, is a building and civil engineering contractor and the employer of the track safety co-ordinator (a person responsible for arranging a safe system of work and carrying out safety briefings). NI Railways had contracted McLaughlin and Harvey to reinforce an embankment at Terryhoogan.
- 9 Northern Excavators of Hillsborough, County Down, is a plant and equipment supplier. It owned and maintained the excavator and wagons, and employed the excavator operator. McLaughlin and Harvey had contracted Northern Excavators to supply it with equipment and operators for the work to reinforce the embankment.
- 10 Chieftain Trailers of Dungannon, County Tyrone, is a manufacturer of road and rail haulage equipment. It manufactured the wagons and converted the excavator for rail operation.

Location

- 11 The main line between Dublin and Belfast is double track, with lines that take trains 'up' to Dublin and 'down' to Belfast. The speed limit is 90 mph (145 km/h) on both lines.
- 12 The stone ballast used to reinforce the embankment was stored adjacent to the disused station at Tandragee, 1.4 miles (2.25 km) north of the worksite at Terryhoogan.
- 13 The excavator, with one wagon in front and one wagon behind, was 1.37 miles (2.20 km) from Tandragee station and travelling south on the down line to the worksite, when it derailed (Figures 1 and 2).



Figure 2: The excavator and the trailing wagon

- 14 At the point of derailment the line runs on a narrow and steep sided embankment. The track rises at 1 in 137 and is canted (banked) for a right-hand curve (Figure 3); as a result, vehicles that negotiate the curve at low speed move towards the inside of the curve, their right-hand rail wheel flanges running in contact with the right-hand rail.



Figure 3: The track is curved, canted (banked), and on a rising gradient in the direction of travel

External circumstances

- 15 The derailment occurred during the hours of darkness in high wind and heavy rain.

The excavator and wagons

- 16 Daewoo manufactured the road-going Solar 170 excavator in 1999. Northern Excavators owned it from new, first operating it in England where it worked on the Sunderland extension to the Tyne and Wear Metro.
- 17 In 2004, Northern Excavators brought the excavator to Northern Ireland where Chieftain Trailers converted it for 'low ride' rail operation. In low ride mode, a road rail vehicle's rail wheels lower onto the track and share the machine's weight with its road wheels. The rail wheels guide the excavator along the track while the road wheels provide the means of traction and braking (Figure 4).

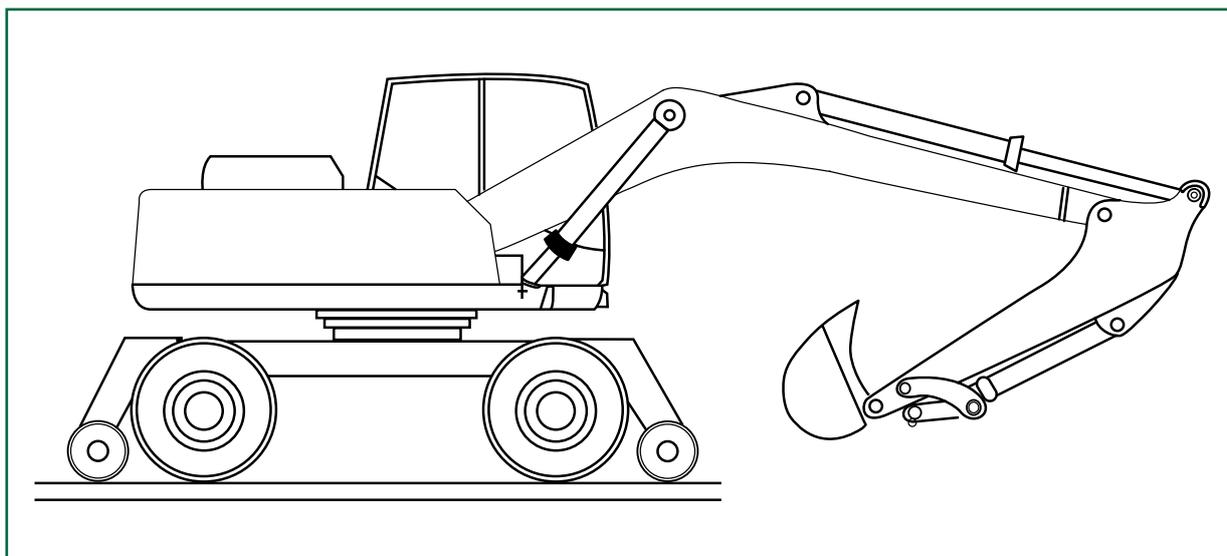


Figure 4: A 'low-ride' vehicle

- 18 On this excavator, the operator changes from road to low ride mode by:
- throwing a switch forwards or backwards to enable the operation of the front or rear rail wheels (Figure 5);
 - using a joystick to operate hydraulic rams that raise or lower the rail wheels (Figure 5);
 - observing left and right-hand indicator lights that illuminate when the front and rear rail wheels are in their pre-set, fully deployed position, as determined by a position sensor (Figures 6 and 7);
 - releasing the joystick; and
 - returning the switch to neutral to lock the rail wheels in place.

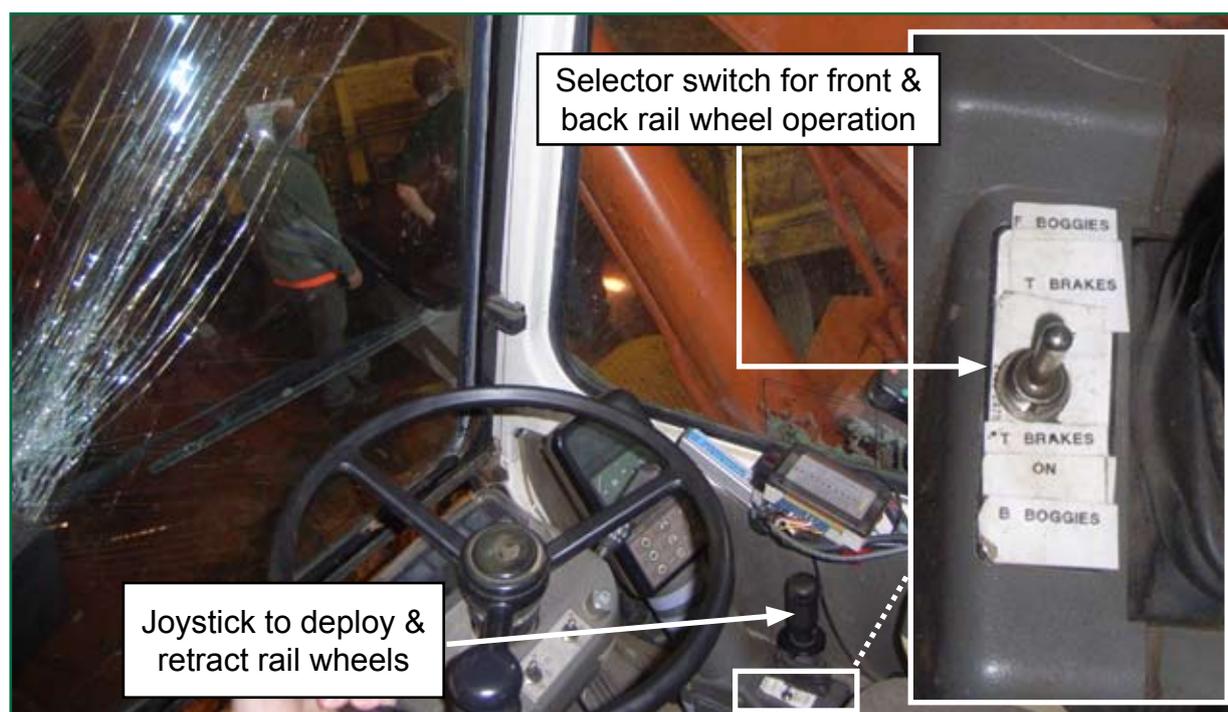


Figure 5: The excavator's cab controls for raising and lowering the rail wheels

- 19 The excavator's road wheels were fitted with tractor tyres that had a coarse, deep tread. Over time, the tread had become locally worn by contact with the railhead, which progressively reduced the weight applied by the road wheels to the rail and consequently the traction available to the excavator in its pre-set low ride mode. A review of the excavator's documentation indicated that it had only one road tyre replaced since its conversion to a road rail machine in 2004; there was no information on its mileage or hours of use over this time.



Figure 6: The sensor for detecting that the rail wheels are fully deployed

- 20 In addition to converting the excavator for rail use, Chieftain Trailers increased its lifting capability, adding ballast weight by fitting steel blocks beneath the cab and a counter weight behind. The conversion increased the excavator's weight from 17.3 tonnes to 21.4 tonnes. Chieftain Trailers converted only one machine for rail use to this design, making this excavator unique.
- 21 In 2005, NI Railways inspected the excavator, in particular the locking of its rail wheels, its braking, lights and horn, and concluded that it could be used in possessions on their infrastructure.
- 22 At the time of the accident, there were two other Daewoo Solar 170 road rail excavators in operation in Great Britain. Rexquote of Taunton, a manufacturer of road/rail excavators, converted both machines for 'high ride' rail operation (Figure 8).

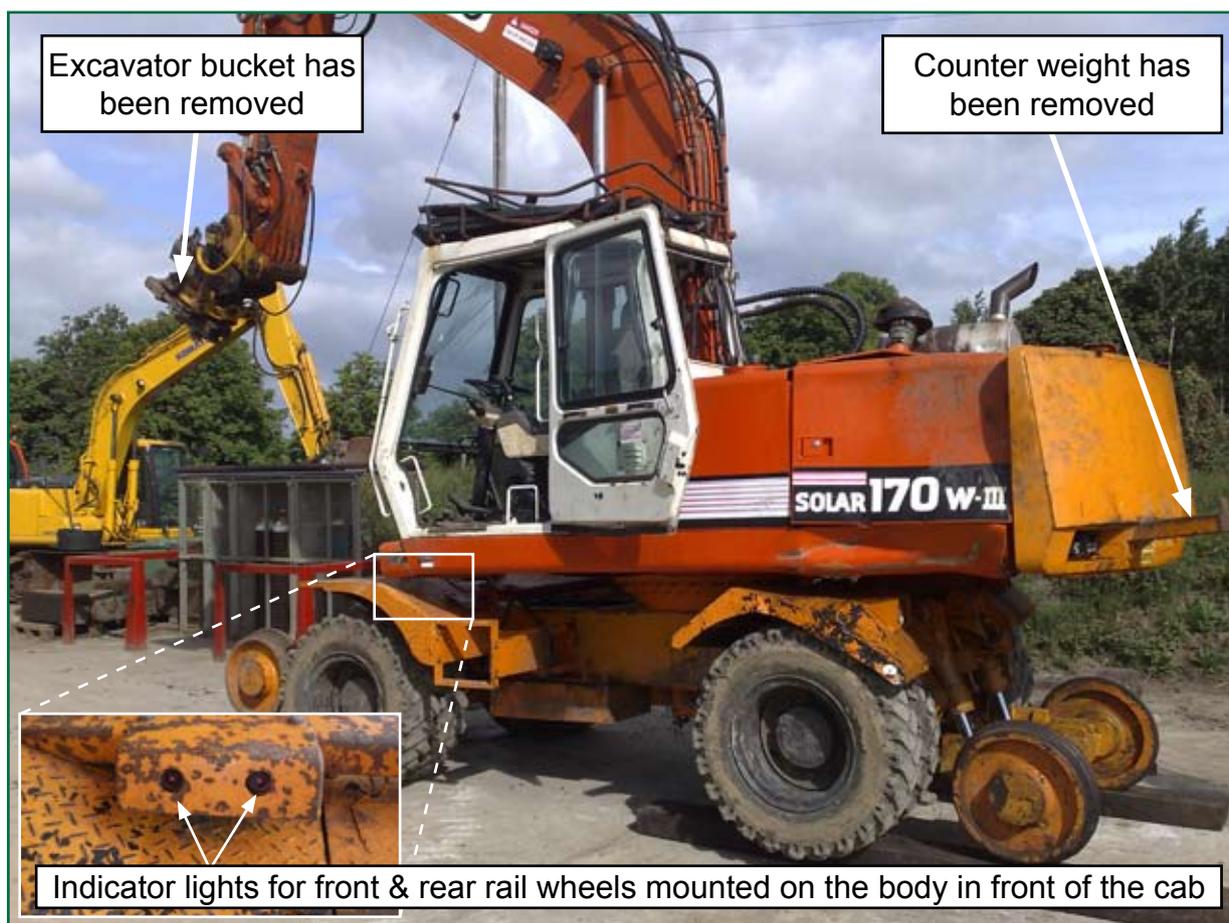


Figure 7: The excavator and its lights that indicate when the rail wheels have fully deployed

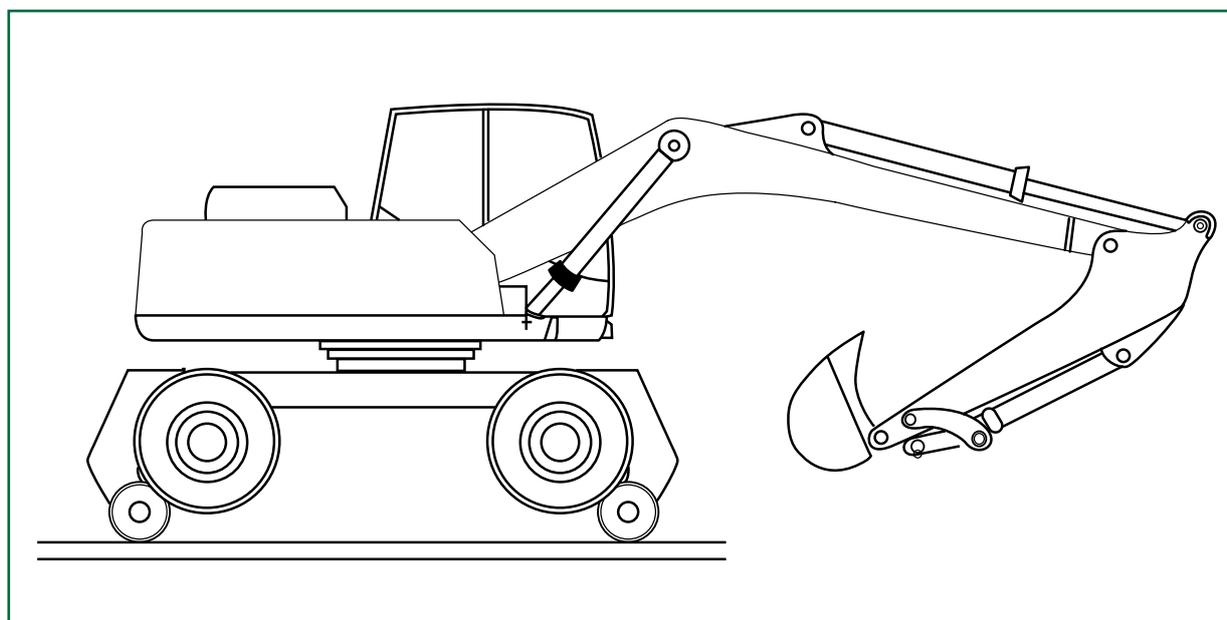


Figure 8: A 'high ride' vehicle

23 In high ride mode, rail wheels lower onto the track and then raise the road wheels up and off it. Each road wheel then contacts its adjacent rail wheel to provide traction and braking. The derailment mechanism that applied at Terryhoogan could not apply to a high ride excavator and so this report does not make any further reference to these machines.

- 24 Chieftain Trailers designed and manufactured the wagons for road and high ride rail operation. They have an unladen weight of 3.8 tonnes and a gross laden weight (i.e. the maximum weight of the wagon plus its load) of 18 tonnes. Both wagons displayed their unladen and gross laden weights on their wagon sides.

Training and Competence

- 25 'Sentinel' is a database of competencies of people who work on the Network Rail infrastructure in Great Britain. At the time of the derailment, the operator was competent to operate the excavator and, although not an NI Railways requirement, held valid certification from Sentinel, the Construction Plant Competence Scheme and BCL Rail Services. He had operated this excavator and similar road rail vehicles on the railways of Great Britain and Northern Ireland since 2000.

Events preceding the accident

- 26 Work to reinforce the embankment began on 3 March 2008; it was carried out during night time possessions when trains were not running. On the night of 9 March 2008, the possession commenced at 21:30 hrs and work started shortly after this time.
- 27 The operator drove the excavator onto the track at Tandragee station, put it into low ride mode on the down line, coupled it to its wagons and put them into high ride mode. Then, the excavator, in conjunction with a tracked excavator, loaded stone ballast onto the rear and front wagons respectively.
- 28 With the wagons fully loaded, the excavator did not have enough traction through its road wheels to drive itself and haul its wagons (paragraph 19) so the operator used the cab controls to transfer the machine's weight from its rail to its road wheels and thus increase traction.
- 29 The excavator then hauled its wagons to the worksite where it and another tracked excavator unloaded the stone for compacting by road roller. The excavator and the empty wagons then travelled back to Tandragee.
- 30 That night the operator made three return trips from Tandragee to the worksite in dry weather. Rain began to fall as he returned to Tandragee on the fourth trip. The excavator set off for the fifth run at approximately 23:10 hrs. At this time, the weather was worsening; wind speed was increasing and rainfall was becoming heavier.

Events during the accident

- 31 The operator estimated that he was travelling at approximately 10 mph (16 km/h), the permitted speed for the excavator, as it climbed the gradient on the way to the worksite. The engineering supervisor observed the excavator as it passed and agreed with the operator's estimate of its speed¹.

¹ The excavator was not fitted with a speedometer.

- 32 As the excavator negotiated the canted right-hand curve the driver felt it veer to the right; less than a second later and before he had time to react, it ran down the embankment. At the point of derailment, the right hand rail bore the flange marks of the trailing right hand rail wheel that had derailed before going on to damage three sleepers (Figures 9 and 10).

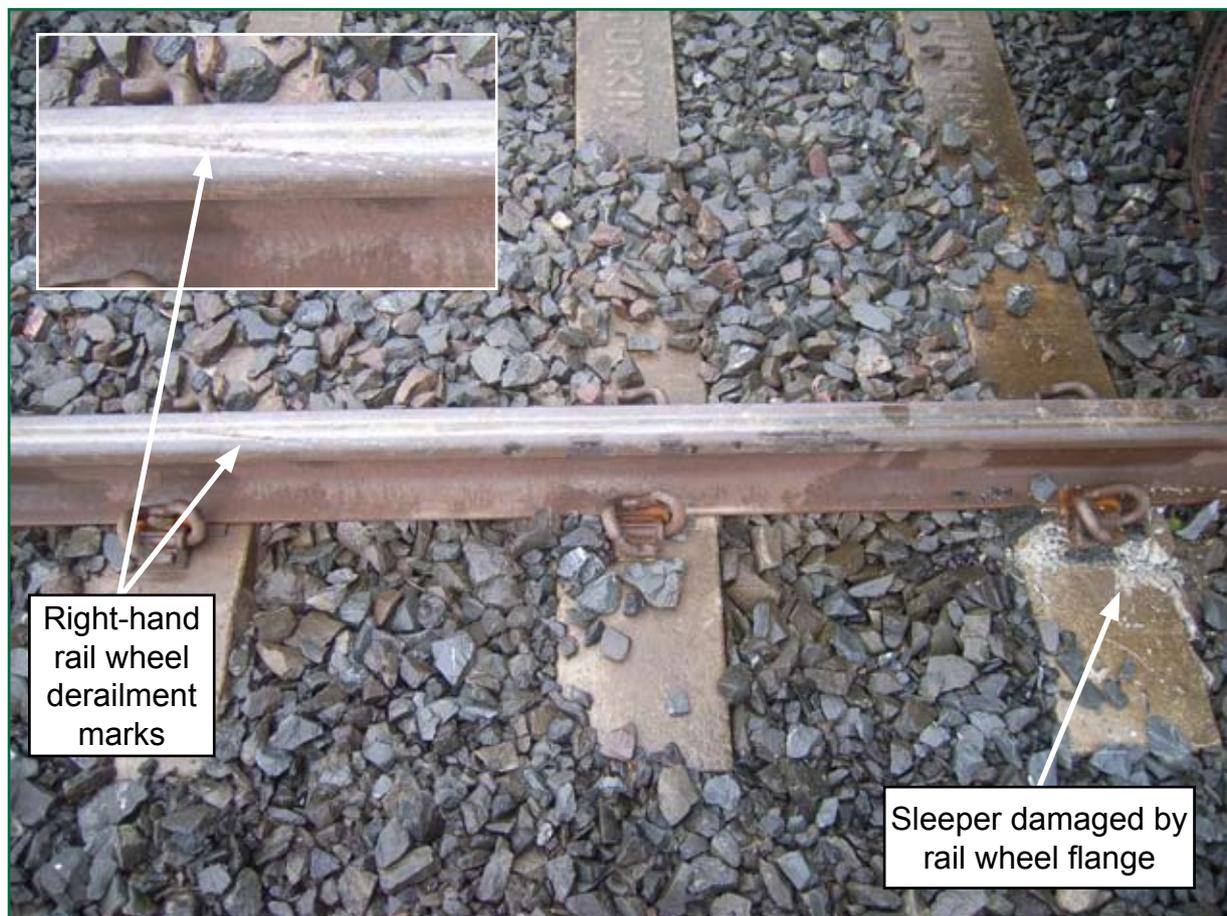


Figure 9: The point of derailment

- 33 By calculation, it was determined that the excavator overturned and stopped within 3 seconds of derailing. It came to rest 6.5 metres from the point of derailment; here, it was completely off the track and on its side, supported in this position on the embankment by a tree. Its descent derailed its wagons and pulled them part way over the embankment edge (Figures 2 and 11).

Events following the accident

- 34 The operator climbed out of the cab, onto the track, and telephoned the person in charge of the possession to report the accident. The engineering supervisor, who was walking along the track at this time, heard the derailment as it occurred and made his way to the excavator to investigate.
- 35 As part of their normal procedure, NI Railways tested the vehicle operator and the worksite staff for the presence of drugs and alcohol; all test results were negative.
- 36 NI Railways preserved the accident site for the RAIB to conduct their investigation on 10 March 2008.



Figure 10: The path of the excavator's rail wheels immediately after derailment



Figure 11: The excavator and the leading wagon

- 37 After the accident, Northern Excavators planned to scrap the excavator. However, it was subsequently acquired by the Downpatrick and County Down Railway in Northern Ireland for use on their heritage railway that operates between Inch Abbey and Downpatrick.

Consequences of the accident

- 38 No-one was injured as a consequence of the derailment. The excavator and the wagons sustained damage to their running gear and bodywork, and there was minor damage to the infrastructure. Train services between Dublin and Belfast ran at reduced speed on the up line until NI Railways cleared and repaired the down line on 11 March 2008; normal services resumed on the morning of 12 March 2008.

Previous occurrences of a similar character

- 39 The RAIB has received a number of reports of incidents and accidents involving road rail vehicles on Network Rail infrastructure, for example at Glen Garry on 5 December 2007, Brentwood on 4 November 2007 and Snow Hill on 31 October 2007, and has commenced specific and general investigations into their use.
- 40 The incidents and accidents identified in paragraph 39 fall into two categories: those where the road rail vehicle ran away during the on or off-tracking process and those where they failed to stop during normal movement along the track. The RAIB did not consider the excavator accident at Terryhoogan to be in either of these two categories as it derailed rather than ran away; it was therefore the subject of its own, separate investigation.

Analysis

Identification of the immediate cause

- 41 The immediate cause of the derailment was flange climb; the lateral contact force at the excavator's trailing right-hand rail wheel resulted in a vertical force that exceeded the weight applied through it, forcing the wheel up, onto and then off the rail (paragraph 32).

Identification of causal factors

- 42 The following factors were causal to the derailment:
- a. the operator transferring the excavator's weight from its rail to its road wheels (paragraph 28); and
 - b. the canted track that brought the excavator's right-hand rail wheel flanges into contact with the right-hand rail (paragraph 14).

Identification of contributory factors

The following factors, when combined, required the operator to transfer the excavator's weight from the rail to the road wheels to increase traction and continue operation. They are therefore contributory factors.

Uncompensated tyre wear and weight distribution

- 43 In Great Britain, the Rail Safety and Standards Board publish the voluntary rail industry standard RIS-1530-PLT, 'the Engineering Acceptance of Possession Only Rail Vehicles and Associated Equipment'. Issue 1 is dated April 2006.
- 44 The standard states that a 'low ride' vehicle should share its weight to ensure adequate guidance from its rail wheels and traction and braking from its road wheels. It states that vehicles in low ride mode should bear 25 to 31% of their weight through their rail wheels and the remaining weight through their road wheels.
- 45 Chieftain Trailers designed and manufactured the excavator to have rail wheels that deployed to a pre-set position (paragraph 18). However, their operating and maintenance manual did not consider the effect of tyre wear on weight distribution (paragraph 19) and so did not require the maintainer to adjust the excavator to compensate for wear or maintain weight distribution within acceptable limits.
- 46 Consequently, Northern Excavators did not maintain the excavator to compensate for tyres that became progressively worn from contact with the railhead (Figure 12), transferring more weight from the excavator's road wheels to its rail wheels.
- 47 After the accident, the RAIB measured the excavator's weight distribution in its pre-set low ride mode and found that it applied 95% of its weight through its rail wheels and 5% through its road wheels (Figures 13 and 14).

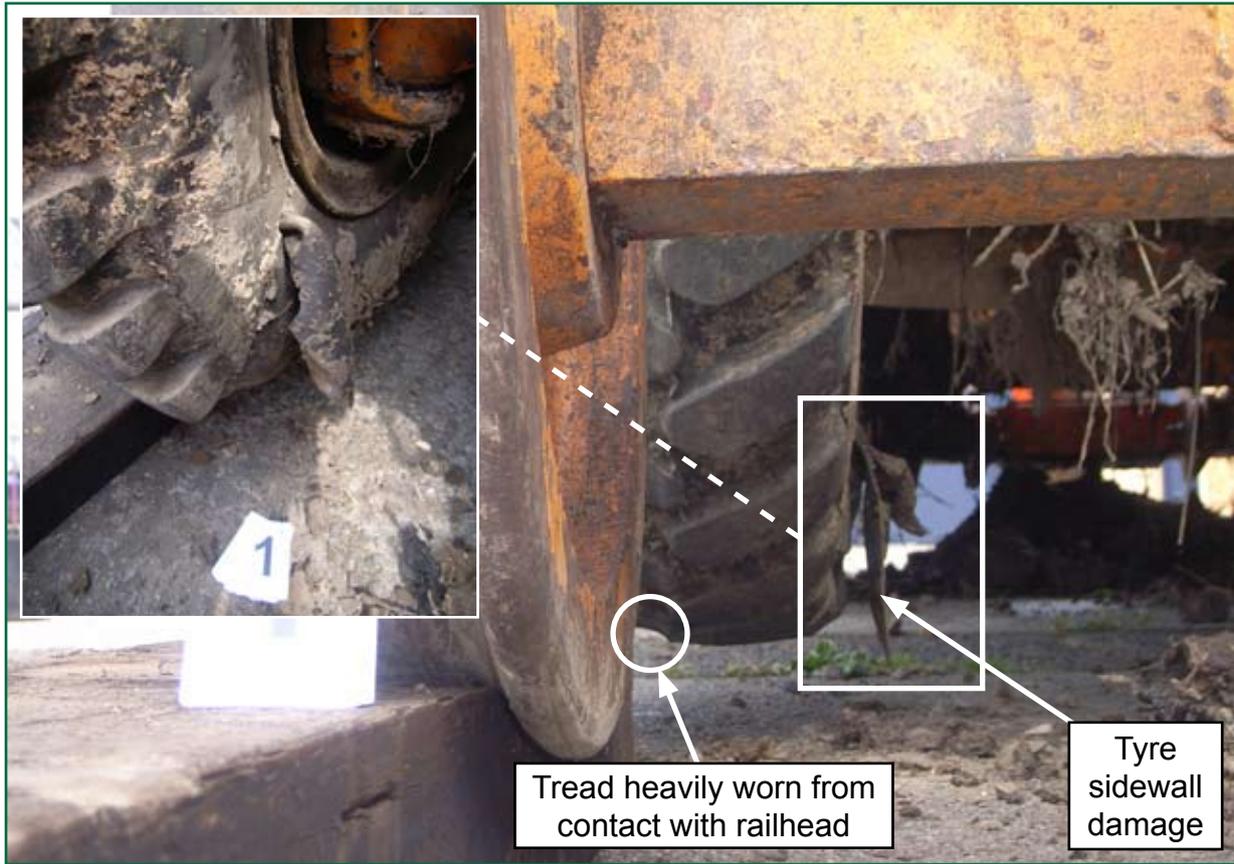


Figure 12: A rail wheel and its adjacent treaded tyre

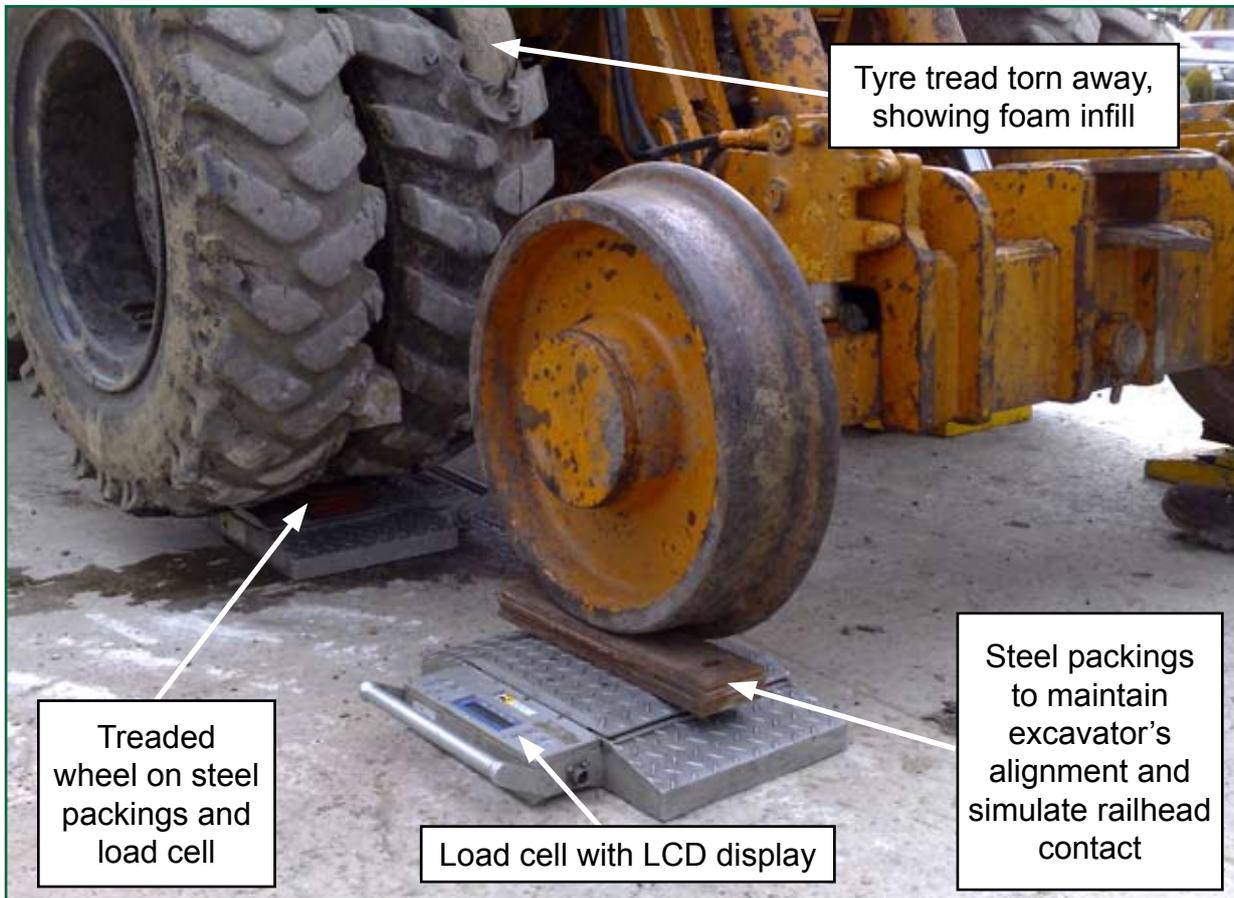


Figure 13: Measurement of the excavator's weight distribution in low ride mode

- 48 Due to uncompensated tyre wear, the 5% of weight the excavator applied through its road wheels would not give enough traction to drive itself and haul its loaded wagons in dry conditions on level track.

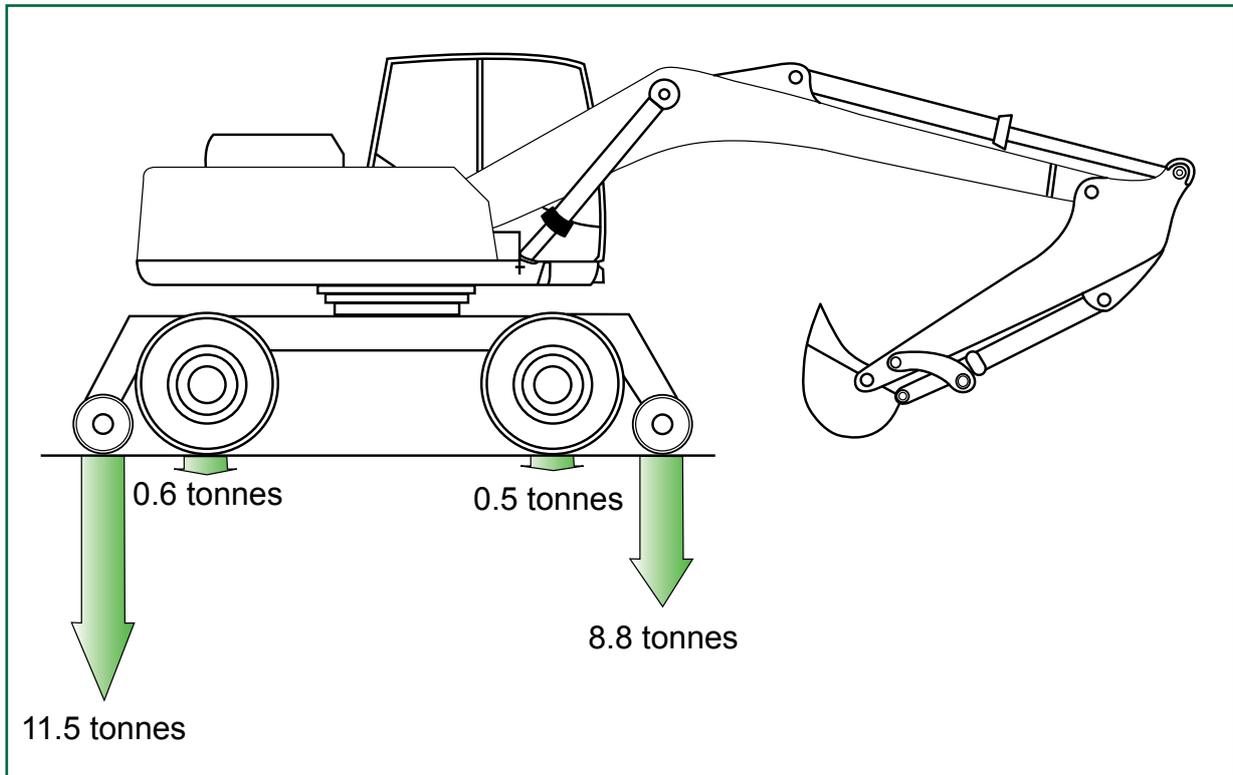


Figure 14: The excavator's weight distribution in low ride mode - 95% through rail wheels and 5% through road wheels

The track gradient

- 49 Track gradient (paragraph 14) increased the amount of traction the excavator needed to overcome the effect of gravity acting on itself and its wagons.

Rainwater lubrication of the rubber road tyre/rail interface

- 50 The RAIB carried out track tests, and found that rainwater lubrication of the rubber road tyre/rail interface reduced friction and traction to 6% of that available to an excavator's tyres operating on a clean, dry road.

Wagon overloading

- 51 The voluntary rail industry standard RIS-1530-PLT paragraph 5.18.2.5 states that unless a service brake is provided, the towed or propelled weight of trailer vehicles shall not exceed the weight of the towing vehicle.
- 52 The RAIB calculated that at the time of the accident, the gross laden weight of each wagon was 20 tonnes, so the combined weight of two wagons, 40 tonnes, exceeded the 21.4 tonnes weight of the excavator (paragraph 20) by 87%.
- 53 The wagons had also been loaded above their design gross laden weight of 18 tonnes (paragraph 24) by 11%.

The following factors allowed the operator to transfer weight from the excavator's rail wheels to its road wheels to increase traction and continue operation. They are therefore contributory factors.

The excavator design

- 54 The excavator's design did not prevent the operator from retracting the rail wheels to increase the load on the road wheels and thus increase traction, adjusting weight distribution by 'feel' before continuing to operate the excavator.

The excavator operating and maintenance manual

- 55 The excavator operating and maintenance manual describes how to change from road to low ride mode. However, it neither requires that an operator deploys the rail wheels until the left and right-hand indicator lights illuminate (paragraph 18), nor does it prohibit an operator adjusting weight distribution by feel.

Identification of underlying factors

- 56 Neither NI Railways nor McLaughlin and Harvey had a process for planning the work carried out by the excavator that considered the relationship between track gradient, rainwater lubrication of the road tyre/rail interface and wagon loading. For this reason, neither NI Railways nor McLaughlin and Harvey placed a limit on the gross laden weight that the excavator could safely haul.
- 57 On site, the engineering supervisor and the track safety co-ordinator were unaware of the need to limit wagon loading when operating on a gradient. The excavator operators were therefore allowed to load the wagons as fully as possible before each trip to the worksite.

Additional observations

- 58 Neither NI Railways nor McLaughlin and Harvey had a process that determined whether Northern Excavators had maintained the excavator and wagons to a standard acceptable for use on NI Railways infrastructure. For this reason they did not know that:
- the excavator had not been adjusted to compensate for road tyres that became progressively worn from contact with the railhead, transferring more weight from its road to its rail wheels (paragraph 46);
 - the excavator's road tyres were damaged (Figures 12 and 13) and continued to function only because they had been foam and not air filled;
 - the wagons' service brakes had been disabled; and
 - the wagons were in a dangerous state because their parking brakes were either missing or inoperable (Figures 15 and 16).
- 59 As the wagons were neither causal nor contributory to the derailment, the RAIB handed responsibility for them to the Health and Safety Executive Northern Ireland (paragraph 72).



Figure 15: The wagons involved in the derailment, on hard standing at Tandragee station



Figure 16: Defective brake on the leading wagon

Conclusions

Immediate cause

- 60 The immediate cause of the derailment was flange climb; the lateral contact force at the excavator's trailing right-hand rail wheel resulted in a vertical force that exceeded the weight applied through it, forcing the wheel up, onto and then off the rail (paragraph 41).

Causal factors

- 61 The following factors were causal to the derailment:
- a. the operator transferring the excavator's weight from its rail to its road wheels (paragraph 42a and Recommendation 1); and
 - b. the canted track that brought the excavator's right-hand rail wheel flanges into contact with the right-hand rail (paragraph 42b).

Contributory factors

The following factors, when combined, required the operator to transfer the excavator's weight from the rail to the road wheels to increase traction and continue operation. They are therefore contributory factors.

- 62 Uncompensated tyre wear reduced the weight the excavator applied through its road wheels to a level that would not give enough traction to drive itself and haul its loaded wagons in dry conditions on level track (paragraph 48, Recommendation 1).
- 63 Track gradient increased the amount of traction the excavator needed (paragraph 49).
- 64 Rainwater significantly reduced friction and traction available at the rubber road tyre/rail interface (paragraph 50).
- 65 The excavator was hauling wagons that were overloaded with stone ballast (paragraph 53).

The following factors allowed the operator to transfer weight from the excavator's rail wheels to its road wheels to increase traction and continue operation. They are therefore contributory factors.

- 66 The excavator's design did not prevent the operator from retracting the rail wheels to increase the load on the road wheels and thus increase traction, adjusting weight distribution by feel before continuing to operate the excavator (paragraph 54).
- 67 The excavator operating and maintenance manual neither requires that an operator deploy the rail wheels until the left and right-hand indicator lights illuminate, nor does it prohibit an operator adjusting weight distribution by feel (paragraph 55 and Recommendation 1).

Underlying factors

- 68 Neither NI Railways nor McLaughlin and Harvey had a process for planning the work carried out by an excavator that considered the relationship between track gradient, rainwater lubrication of the road tyre/rail interface and wagon loading. For this reason, neither NI Railways nor McLaughlin and Harvey placed a limit on the gross laden weight that the excavator could safely haul (paragraph 56 and Recommendation 2).
- 69 On site, the engineering supervisor and the track safety co-ordinator were unaware of the need to limit wagon loading when operating on a gradient. The excavator operators were therefore allowed to load the wagons as fully as possible before each trip to the worksite (paragraph 57 and Recommendation 3).

Additional observations

- 70 Neither NI Railways nor McLaughlin and Harvey had a process that confirmed that Northern Excavators had maintained the excavator and wagons to an acceptable standard and so they did not know that the wagons were in a dangerous state while on NI Railways infrastructure (paragraph 58 and Recommendation 4).
- 71 The voluntary rail industry standard RIS-1530-PLT (paragraph 43) states that ‘... *the towed or propelled weight of laden trailer vehicle(s) shall not exceed 100% of the gross (fully laden) weight of the towing vehicle...*’; however, the standard does not warn that towing or propelling such loads on gradients may lead to runaways when rainwater lubricates the rubber tyre/rail interface. As the RAIB investigations identified in paragraph 39 will fully consider and address this matter, it is not considered further in this report.

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

- 72 The Health and Safety Executive Northern Ireland issued three prohibition notices that prohibited the use of the two wagons and the excavator until the matters identified (incorrect weight distribution, defective brakes etc) had been remedied.
- 73 NI Railways formally reviewed the maintenance processes of Northern Excavators. This led to the instigation of a maintenance regime for road rail vehicles that comprises daily checks carried out by the machine operator before use, inspection by the manufacturer twice a year and scheduled maintenance. Northern Excavators now store vehicle inspection sheets with the relevant machine and make inspection and maintenance records available to NI Railways via their website. NI Railways audit these records, and are adopting and preparing procedures for road rail vehicle operations.

Recommendations

74 The following safety recommendations are made²:

Recommendations to address causal, contributory and underlying factors

- 1 The Downpatrick and County Down Railway should make arrangements to:
 - a. maintain the excavator so that it distributes its weight appropriately in low ride mode;
 - b. amend the operating and maintenance manual to prohibit an operator adjusting weight distribution by feel; and
 - c. train and assess its staff in the correct method of machine operation. (paragraphs 61a, 62 and 67).
- 2 Northern Ireland Railways and McLaughlin and Harvey should each put in place a process for planning work that:
 - a. considers all the factors that may affect the safe operation of road rail vehicles; and
 - b. identifies the arrangements to eliminate or mitigate those factors as part of a safe system of work (paragraph 68).
- 3 Northern Ireland Railways should:
 - a. clearly identify the members of staff who have a responsibility to ensure the safety of vehicle movements in worksites;
 - b. brief the process identified in Recommendation 2 to those staff members; and
 - c. make the process form part of training and assessment for those staff members. (paragraph 69).

² Those identified in the recommendations, have a general and ongoing obligation to comply with health and safety legislation and need to take these recommendations into account in ensuring the safety of their employees and others.

Additionally, for the purposes of regulation 12(1) of the Railways (Accident Investigation and Reporting) Regulations 2005, these recommendations are addressed to the Department for Regional Development in Northern Ireland to enable it to carry out its duties under regulation 12(2) to:

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

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

Recommendations to address observations

- 4 Northern Ireland Railways should put in place a process for the periodic inspection and assessment of road rail vehicles and their associated wagons that they or their contractors undertake before permitting operation on their infrastructure (paragraph 70).

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