



Rail Accident Investigation Branch

Rail Accident Report



Collision of a road-rail vehicle with a buffer stop at Bradford Interchange station 25 March 2012

Report 09/2013
July 2013

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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Collision of a road-rail vehicle with a buffer stop at Bradford Interchange station, 25 March 2012

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Summary

At around 06:50 hrs on 25 March 2012, a machine operator was in the process of removing a road-rail dumper from the railway close to Bradford Interchange station. As it was being lowered onto its road wheels, it ran away for 380 metres down a gradient towards the station.

The operator, who was on the dumper, was unable to stop it and jumped clear before it collided with the buffer stops in platform 1. The operator received minor injuries, and the dumper and buffer stop sustained some damage.

The RAIB's investigation identified that the dumper was not in a fully braked state when being removed from the track. This was due to a combination of operator error, a wiring irregularity within a control circuit, and the underlying design of the same control circuit which prevented the operator from recovering the situation once the runaway had begun.

The RAIB has made five recommendations. Two recommendations have been made to Quattro Plant Limited, the owner and maintainer of the dumper. It was also responsible for the design and installation of the braking control circuit and provided the machine operator. One of these recommendations relates to improving the level of safety assurance when undertaking modifications to road-rail vehicles (RRVs). The other relates to better management of the competence of its staff.

Three recommendations have been made to Network Rail. One is in relation to minimising the risk of runaways on certain types of RRVs on which the design restricts the ability to regain control of an RRV once it has begun to runaway. Another relates to reviewing and improving compliance monitoring and assurance activities, which both Network Rail and its rail plant suppliers undertake, in order to provide better focus on matters relating to the safe maintenance and operation of RRVs. The third recommendation is to review two aspects of the engineering acceptance process, to give clarity to rail plant suppliers and those assessing modifications to RRVs.

The RAIB has also identified a learning point for RRV owners regarding possible improvements to the layout of RRV controls to minimise unintentional operation.

Introduction

Preface

- 1 The purpose of a Rail Accident Investigation Branch (RAIB) investigation is to improve railway safety by preventing future railway accidents or by mitigating their consequences. It is not the purpose of such an investigation to establish blame or liability.
- 2 Accordingly, it is inappropriate that RAIB reports are used to assign fault or blame, or determine liability, since neither the investigation nor the reporting process has been undertaken for that purpose.

Key definitions

- 3 All dimensions in this report are given in metric units, except speeds and locations which are given in imperial units, in accordance with normal railway practice. Where appropriate the equivalent metric value is also given. The report contains abbreviations and technical terms (shown in *italics* the first time they appear in the report). These are explained in appendices A and B.

The accident

Summary of the accident

- 4 At around 06:50 hrs on 25 March 2012, while in the process of *off-tracking*, a *road-rail dumper* ran away down a gradient for a distance of 380 metres and collided with buffer stops in platform 1 of Bradford Interchange station.

Severity of consequences

- 5 The machine operator sustained minor injuries when jumping from the moving dumper.
- 6 The collision caused the friction sliding buffer stop at the end of platform 1 to move 3.3 metres. Damage was caused to the rear of the dumper including its lights and fixtures.

Context

Location

- 7 Bradford Interchange station is located on Network Rail's London North Eastern route, 40 miles 27 chains from a zero datum at Manchester Victoria station (figure 1).

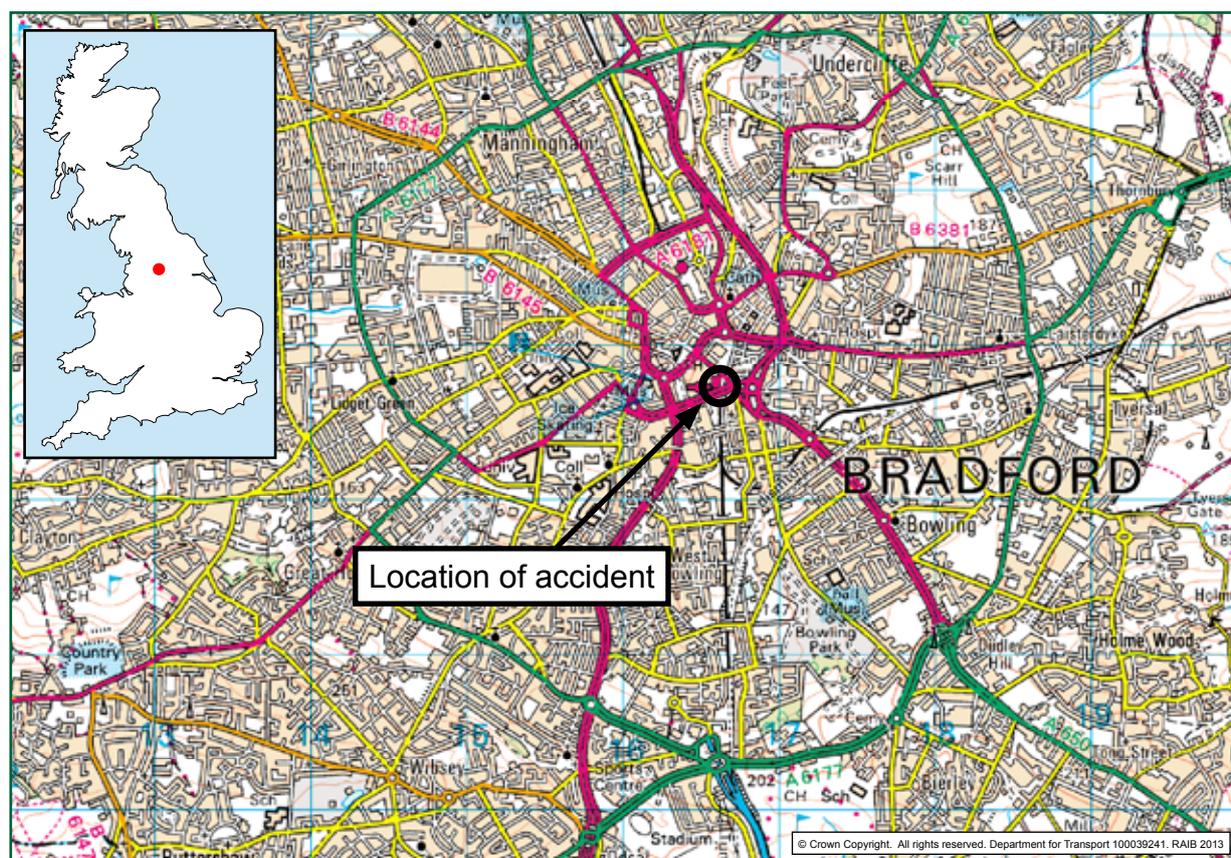


Figure 1: Extract from Ordnance Survey map showing location of accident

Organisations involved

- 8 Network Rail owns and maintains the railway infrastructure where the accident occurred.
- 9 Keltbray Rail Limited (Keltbray) was the main contractor to Network Rail and was responsible for the provision of the *machine controller* and a security officer involved in the accident.
- 10 Quattro Plant Limited (Quattro) was the owner of the dumper and responsible for the provision of the machine operator.
- 11 Interfleet Technology Limited (Interfleet VAB) was the *Vehicle Acceptance Body* (VAB) responsible for assessing the compliance of a modification to the dumper with the relevant railway standards and issuing approval certificates. They were accredited by *RSSB*.
- 12 Network Rail, Quattro, Keltbray, Interfleet VAB and *RSSB* freely co-operated with the investigation.

The dumper involved

- 13 The vehicle involved in the accident was a 'Barford' dumper, number 216 (Network Rail No. 99709 943048-7), owned by Quattro Plant Limited (figure 2). This was a road-rail vehicle (RRV) capable of operating on both ordinary terrain and railway track.

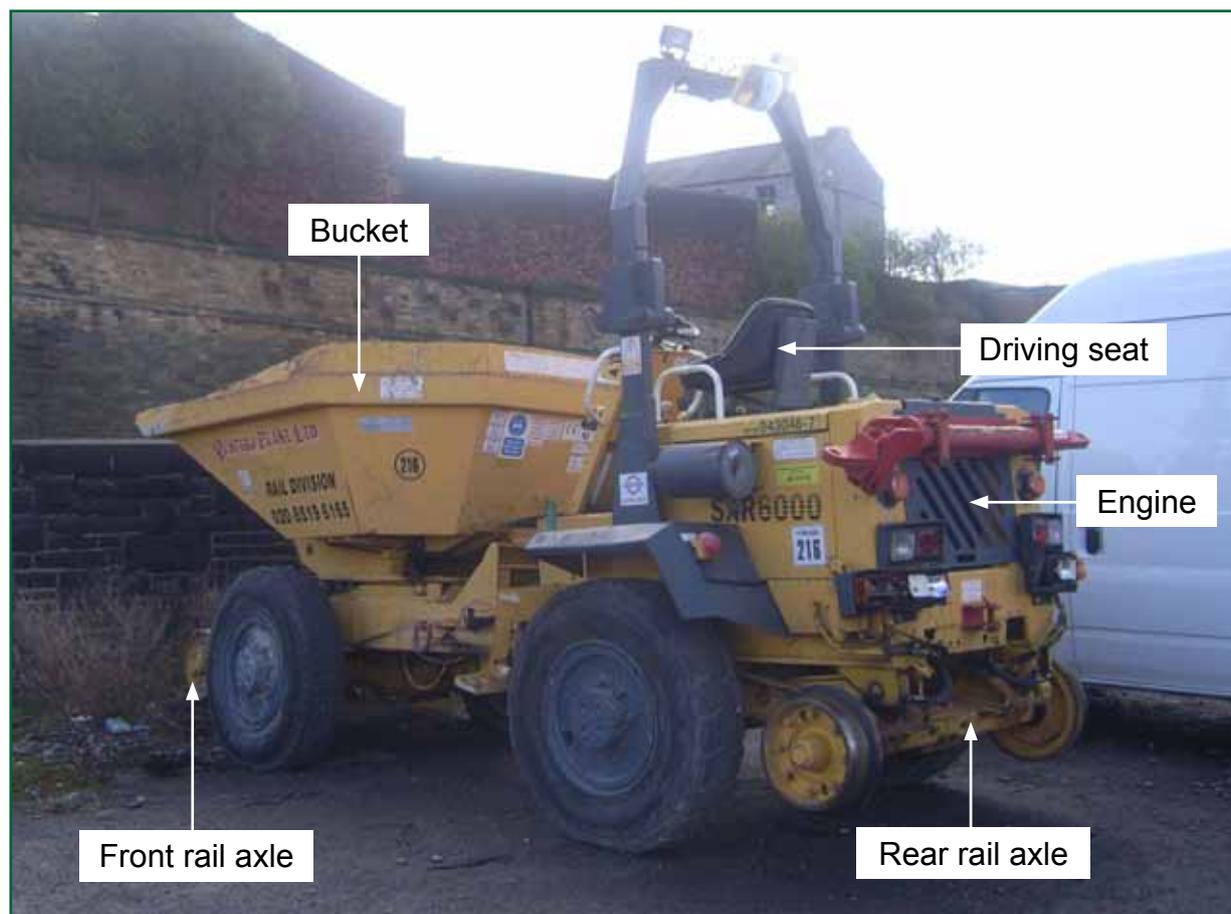


Figure 2: Dumper 216

- 14 Dumper 216 (and its sister machine 217) were acquired by Quattro in April 2005. These were the only two Barford dumpers that Quattro owned that, at the time of the accident, were certified for use on both Network Rail and London Underground infrastructures. Before they were acquired by Quattro they had both been converted for use on rail and were known as 'Type 9B high ride' RRVs. The rail modification consisted of the addition of two rail wheels at each end mounted on moveable axles which were pivoted on the chassis, and raised and lowered by hydraulic actuators (figure 3).



Figure 3: Rear rail axle in fully lowered position

- 15 For non-railway use, the rail wheels are positioned away from the road wheels. When used on the railway the rail wheels are lowered to make contact with the rails, lifting the road wheels clear of the rails. The rail wheels did not have their own brakes (known as direct rail wheel braking); when mounted on the rails, braking and traction was achieved through contact between the road wheel tyres and the rail wheels.

Staff involved

Dumper operator

- 16 The operator had driven dumpers and other types of RRVs for around 10 years. He had first been assessed under Network Rail's *Sentinel* scheme as competent to operate RRV dumpers in December 2010. He had been self-employed since December 2011 and since then had undertaken work for Quattro and another rail plant supplier.

Machine controller

- 17 The machine controller was self-employed and was under contract to Keltbray at the time of the accident. He had held the competency of 'machine controller / crane controller' under Network Rail's Sentinel scheme for seven years. The responsibilities of a machine controller include giving vehicle movement instructions to RRV operators and ensuring that machines and people on the site are kept clear of one another.
- 18 The accident occurred on the fifth consecutive weekend that he had worked on this site. That night was the first time that the work had required the use of a dumper.

Security officer

- 19 The security officer was self-employed and was under contract to Keltbray on the weekend concerned. He was responsible for the security of Keltbray's own machines at the site and ensuring that they had sufficient fuel for the shift. He had previously been an RRV operator and a fitter, but at the time of the accident he was no longer qualified to perform these roles.

External circumstances

- 20 It had been foggy throughout the work shift. At the time of the accident some fog patches remained, but visibility was not significantly impaired. Surfaces, including rails and RRV wheels were likely to have been moist. Although not a primary cause, this moisture is likely to have contributed to a loss of braking effectiveness during the incident.

Events preceding the accident

- 21 On the afternoon of Friday 23 March, Keltbray requested a dumper and an operator from the Quattro depot in Manchester. These were to be available at Bradford Interchange station on the evening of Saturday 24 March. Ordering plant at short notice is not unusual in the rail industry. The dumper was required to assist in maintenance work with the track in that area. Staff at Quattro's Manchester depot contacted the company's depot in Doncaster whose staff confirmed to them that dumper 216 was available for hire.
- 22 The Manchester depot made arrangements directly with an operator who was listed on Quattro's personnel competence database as being competent in operating dumpers.
- 23 Before dumper 216 was sent to site it underwent a pre-dispatch inspection, known as a PDI. This was carried out by a Quattro fitter at the Doncaster depot and it involved working through a machine specific service checklist. Once the fitter had completed the checks, the dumper was dispatched to a Network Rail compound close to Bradford Interchange station.
- 24 The dumper operator arrived at the site compound at around 22:00 hrs on Saturday 24 March. He started the dumper, moved it closer to the road-rail access point (RRAP) (figure 4), and checked the operation of the rail axles. This check was one of the functional checks prescribed by Quattro that an operator should undertake at the beginning of a work shift. While doing this he encountered a problem with raising and lowering the rail axles.

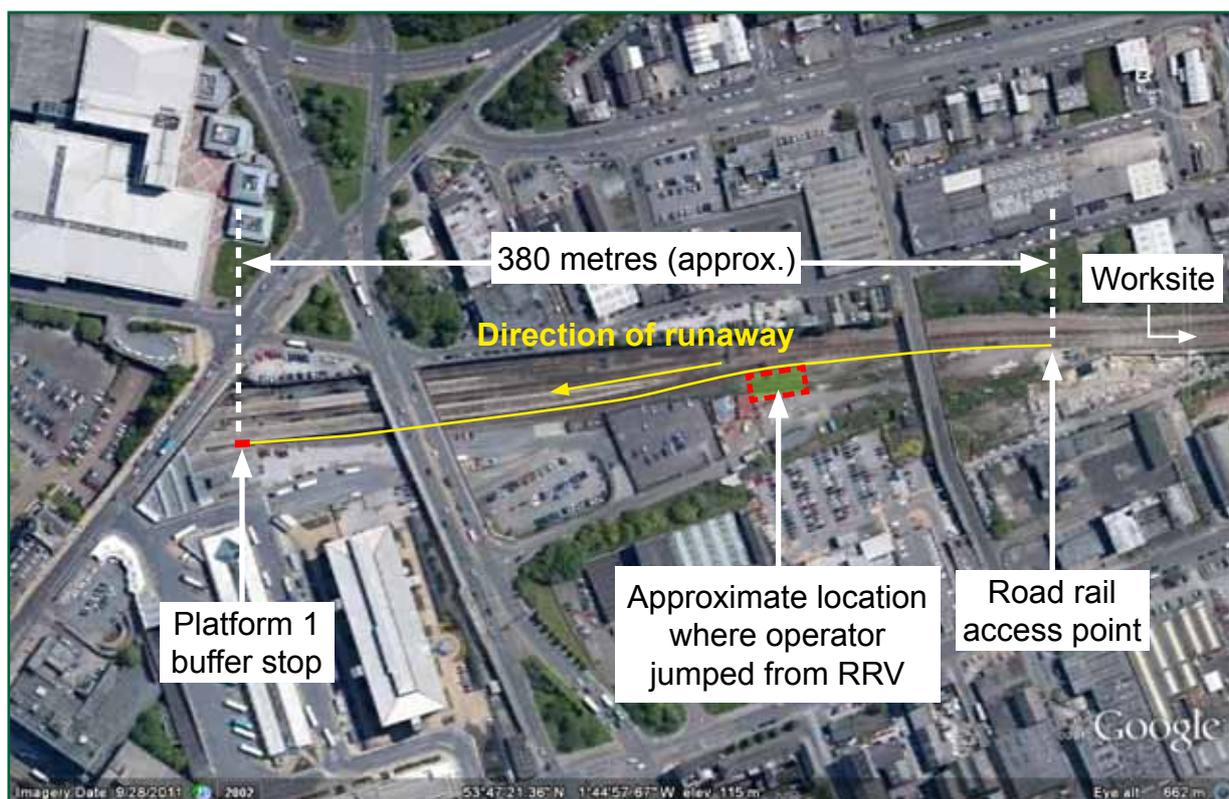


Figure 4: Location of accident at Bradford Interchange station

- 25 At this time there were no other people present. He opened the toolbox on the side of the dumper and, using a coin and an adjustable spanner, wedged a button depressed. This overrode a safety system which had been added some years earlier, and was intended to ensure one end of the dumper was always restrained in a braked condition. This is explained further in paragraphs 51 to 60. With the override button held in this position, the operator was able to raise and lower the rail axles.
- 26 At around 23:30 hrs, the machine controller briefed the operator about the job and checked documents related to the operator's competency and other documents present on the dumper. This was in accordance with the industry code of practice¹. As part of the briefing the operator was made aware that there was a gradient present both at the RRAP and on the journey to the worksite. The gradient at the RRAP was 1 in 46 (2.17%).
- 27 Some tools were put in the dumper's bucket to be taken to the worksite and at around 23:45 hrs, after experiencing a problem restarting the machine, the operator drove the dumper to the RRAP. At this time the security officer had offered the operator assistance in starting the dumper with jump leads, but it restarted without the leads being necessary.

¹ Code of Practice for RRV & RMMM Machine / Crane Controller Checklists, COP0016, issue 3. Produced by the M&EE Networking Group and available at www.rgsonline.co.uk.

- 28 At the RRAP, the machine controller was ensuring that other people were clear of the dumper as it moved onto the rails with the front of the dumper pointing uphill. While on-tracking the operator experienced difficulties lining up the rail wheels with the rails. During this operation the operator again had problems lowering and raising the rail axles and he requested assistance from the security officer and asked him to open the toolbox containing the override button. The security officer found that the coin and the adjustable spanner had fallen from the position that the operator had put them in. He handed them back to the operator and, at the operator's request, pressed and held the override button until the dumper had fully lowered its rail wheels, and was sitting correctly on the rails.
- 29 The dumper then travelled up the gradient to the worksite. Other than the work lights flickering, there were no problems with the dumper's operation on the journeys to and from the worksite and during the work itself.
- 30 At the end of the shift, on the following morning (Sunday 25 March), the operator drove the dumper towards the RRAP, and was asked to travel further down the gradient towards the station to allow another machine to off-track before him.

Events during the accident

- 31 At around 06:45 hrs the operator, under instruction from the machine controller, drove the dumper uphill to the RRAP with its front end leading. The operator applied the handbrake and then, at the start of his off-tracking movement, inadvertently partially raised the front rail axle. He was unaware that the front rail axle had partially moved (paragraph 120).
- 32 The operator then attempted to raise the rear rail axle. At this stage he was unable to move either rail axle, and so he told the machine controller that it was necessary to press the override button inside the toolbox. The machine controller tried to open the toolbox door, but although unlocked, it was stuck. He prised open the door using the blade of a shovel.
- 33 The security officer who was nearby came over to offer his assistance. At the operator's request the security officer pressed the override button. The operator again selected the switch to raise the rear rail wheels.
- 34 The dumper began to roll backwards downhill towards the terminus station. The security officer remained alongside for the first few metres of its travel, still pressing the override button, while the operator continued to raise the rear rail wheels.
- 35 The security officer was forced to release the button when he approached some bags of ballast alongside the track that blocked his path. The release of the button prevented the operator from making any further movements of the rail axles and the dumper continued downhill at increasing speed.
- 36 The operator remained on the machine for a distance of approximately 150 metres before jumping from it. This was before the dumper had reached the ramp at the end of platform 1 (figure 4). He landed on the ballast between the line on which the dumper was travelling and an adjacent line. The estimated speed when the operator jumped from the dumper was 18 mph (29 km/h) (paragraph 74).

- 37 Witnesses then reported hearing a loud bang as the dumper collided with the buffer stop at the far end of platform 1. The estimated speed of collision was 11 mph (18 km/h).

Events following the accident

- 38 The operator, who had received minor injuries, stood up and made his way towards the buffer stop, as did the other people who had witnessed the collision.
- 39 The dumper's engine was still running and the operator switched it off. The tools in the bucket were unloaded.
- 40 The machine controller contacted Keltbray control to report the accident which was then reported to Network Rail. The operator reported the accident to Quattro's on-call manager.

The investigation

Sources of evidence

41 The following sources of evidence were used:

- RAIB site inspection photographs;
- closed circuit television footage from platform 1 at Bradford Interchange station;
- documents in the toolboxes of dumpers 216 and 217;
- RAIB tests and examinations of dumpers 216 and 217;
- witness statements;
- Quattro documentation (for details see paragraph 61);
- documentation from the Vehicle Acceptance Body;
- Network Rail company standards; and
- Railway Group standards and Rail Industry standards².

² Railway Group and Rail Industry Standards are managed by RSSB (available at www.rgsonline.co.uk).

Key facts and analysis

Background information

The operator

- 42 The operator had experience of working with Quattro's Barford dumper number 217 which was the same type of machine as dumper 216. Quattro's records indicate that he had operated dumper 217 on three occasions in the previous 12 months, but that this was the first time he had operated dumper 216.
- 43 He had first been assessed as competent to operate certain RRVs under Network Rail's Sentinel scheme in December 2010 (although he had around 10 years previous experience of operating RRV dumpers and similar RRVs under other road/rail competency schemes). This assessment was in accordance with Network Rail company standard NR/L2/CTM/025, issue 01, 'Competence and Training In On-Track Plant Operation'. Since this time his logbook (containing his work experience) had been reviewed on 14 March 2012.
- 44 This standard contained a list of safety and pre-work checks which formed a part of a candidate's training and assessment. Two items on this list are particularly pertinent to this investigation; firstly, to check whether there were any previous entries within the machine's logbook that may affect its operation, and secondly to record any faults found during the specified pre-start checks that may affect the operation of the machine. The standard required the operator to sign the machine's logbook to confirm that pre-start checks had been completed.

Rail industry standards

- 45 RRVs have to meet certain standards before they can operate on Network Rail's infrastructure. The dumpers were new in 2001, and at that time they were approved against Railway Group Standard GM/RT1300 issue 2. They were re-approved in 2006 against Railway Group Standard GM/RT1300 issue 4, following an earlier modification, which included the fitting of an emergency stop system. One requirement of this standard was that when on- and off-tracking there should be no inadvertent movement of the vehicle. The standard required the creation of an assessed and documented procedure for on- and off-tracking. This was intended to minimise the risk of a runaway³.
- 46 Following the runaway of a high-ride mobile elevated work platform (MEWP) near Copenhagen Tunnel in October 2006, the Office of Rail Regulation (ORR), served an improvement notice requiring additional measures to ensure that MEWPs were continuously braked when on- and off-tracking. The solution to address this was a modification known as 'rail axle interlocking'. The intention of this modification was to prevent simultaneous loss of contact between the rail wheels and the road tyres at both ends of a machine. RRV owners were allowed to provide their own design solutions for this, subject to them gaining engineering acceptance by a VAB.

³ At this time the majority of RRVs did not have direct rail wheel braking ie brakes fitted to their rail wheels. Braking when on- and off-tracking relied on the correct operating procedure to ensure that there was contact directly between the road tyres and the rails, or the road tyres and the rails indirectly via the rail wheels.

- 47 There were two further runaways involving MEWPs in 2007, at Brentwood and Birmingham Snow Hill, which were investigated by the RAIB (RAIB report 11/2009). All MEWPs were provided with rail axle interlocking by January 2008. In addition, the ORR required Network Rail to assess the runaway risk of other types of RRV. This led to 90 further machines being identified as a priority for the fitting of rail axle interlocking. Most of these machines were modified by the end of December 2009. By this time Railway Group Standard GM/RT1300 issue 4 had been withdrawn and replaced by Rail Industry Standard⁴ RIS-1530-PLT issue 1. The remaining RRVs were to be provided with rail axle interlocking in time for their reassessment under their seven-year recertification cycle specified within RIS-1530-PLT issue 1.
- 48 When the dumper was originally converted for use on rail, its design, construction and maintenance plan was checked by the VAB for compliance with standard GM/RT1300 (a process known as engineering acceptance). Once they had checked that the dumper was compliant, the VAB issued an engineering acceptance certificate and a certificate of conformance for the vehicle maintenance arrangements. GM/RT1300 required that this assessment was carried out whenever an engineering change to a RRV was made. The rail axle interlocking modification was regarded as such a change by RSSB, so assessment of the modification by the VAB was necessary.
- 49 RSSB issued guidance to the VABs on 16 October 2008 via Technical Note TN-039. This stated the scope of engineering acceptance for the interlocking modification to RRVs (at this time the standard applicable was RIS-1530-PLT issue 1). It clarified the requirement for RRVs to remain in a braked condition at all times when on- and off-tracking. The guidance suggested that this was best achieved by the use of rail axle interlocks.
- 50 Dumpers 216 and 217 were within the group of 90 machines to be fitted with rail axle interlocking. Network Rail required that they were modified by the end of December 2009 in order for them to continue to be used on its infrastructure.

Dumper 216 rail axle interlocking

- 51 In 2009 Quattro began to modify its RRVs to incorporate rail axle interlocking. The principle behind the design was to only allow a rail axle at one end to change position if the vehicle was fully braked at the other ('holding') end. This holding end was considered to be fully braked if either the road tyres were in direct contact with the rails (with the rail wheels fully raised) or if the rail wheels were fully lowered to the rails (figure 3). In this latter condition, the road tyres also need to be in contact with the rail wheels by a set amount defined by the degree of tyre compression, known as 'squash'.
- 52 Quattro brought in a technical consultant to work with its own fitters to convert their high ride RRVs. The majority of the machines converted in 2009 were road-rail excavators, one of which was examined by Interfleet VAB as a '*first-of-class*' in July 2009.

⁴ Rail Industry standards are managed by RSSB (www.rgsonline.co.uk).

- 53 On dumper 216 the rail axles were operated by two rocker switches, one for each end. Each switch had three positions corresponding to:
- raise;
 - no movement (centre-off position); and
 - lower.
- 54 Before the modification it had been possible to move either rail axle in any sequence, either partially or fully, and it was therefore possible for the dumper to be placed in an unbraked state.
- 55 The rail axle interlocking previously designed for the Quattro excavators used both electrical and hydraulic components within its logic control circuit. This could not be used on dumpers 216 or 217 as these machines were almost entirely electrically controlled. Therefore a solely electrical logic control circuit was designed by Quattro for the dumpers.
- 56 The dumpers' rail axle interlocking circuit forced the axles to move in a set sequence. When on-tracking (lowering the rail wheels into contact with the rails) the front rail axle was prevented from moving until the rear rail axle was detected to be fully lowered (figure 5). The rear end then became the holding end and the front rail axle could be lowered. When off-tracking, the front rail axle had to be detected as fully raised, before the rear axle could be raised (figure 6).
- 57 Until one end was fully braked, the interlocking prevented any movement of the other end if, for example, an incorrect switch selection was made.
- 58 If there was a rail axle movement which was not in the correct sequence the logic control circuit caused the dumper to lock out. A lockout prevented any further movement of either rail axle. An out-of-sequence rail axle movement could occur while in service on track, if there was a loss of hydraulic pressure within the rail axle hydraulic circuit during transportation, or after long periods of non-use. It may also be necessary to move the axles to any position during maintenance activities. To restore the dumper to full operation following lockout, a reset, or override feature was provided. This allowed the rail axles to be moved in any sequence (as had been possible before the interlocking modification was added).
- 59 The override was operated by a spring-return push button. To keep the override function active during repositioning of either or both rail axles, it was necessary to keep the button depressed. If the button was released before a rail axle had been restored to its correct position within the sequence, the dumper's axles would return to a locked-out condition and any further movement of either axle would be prevented.
- 60 The override button on dumper 216 was positioned on the side of the interlocking circuit box which was located in the toolbox (figure 7). This was out of reach of the driver and therefore required that another person be present to operate it. This was intended to prevent inadvertent or improper use by the operator which could compromise the safe use of the machine. The button was intended to be used by fitters for recovery purposes.

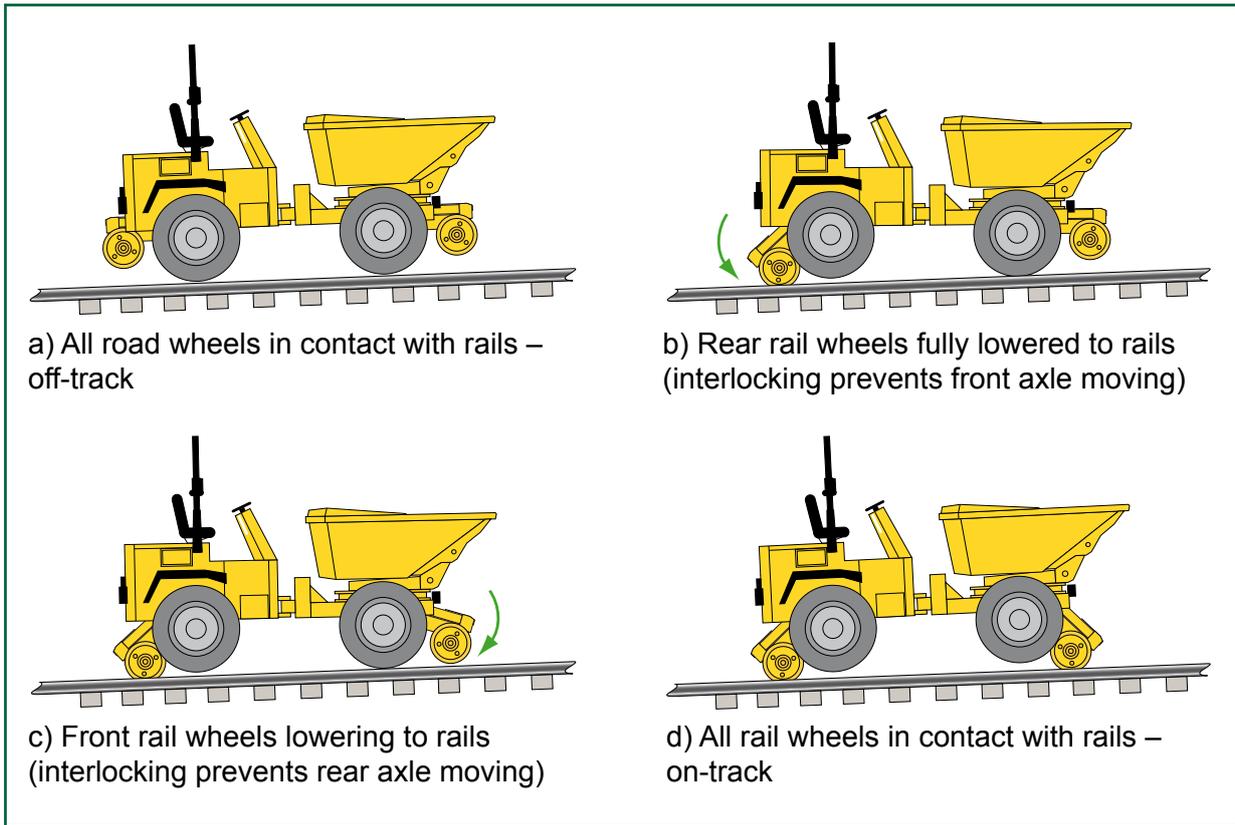


Figure 5: Rail axle movement sequence when on-tracking

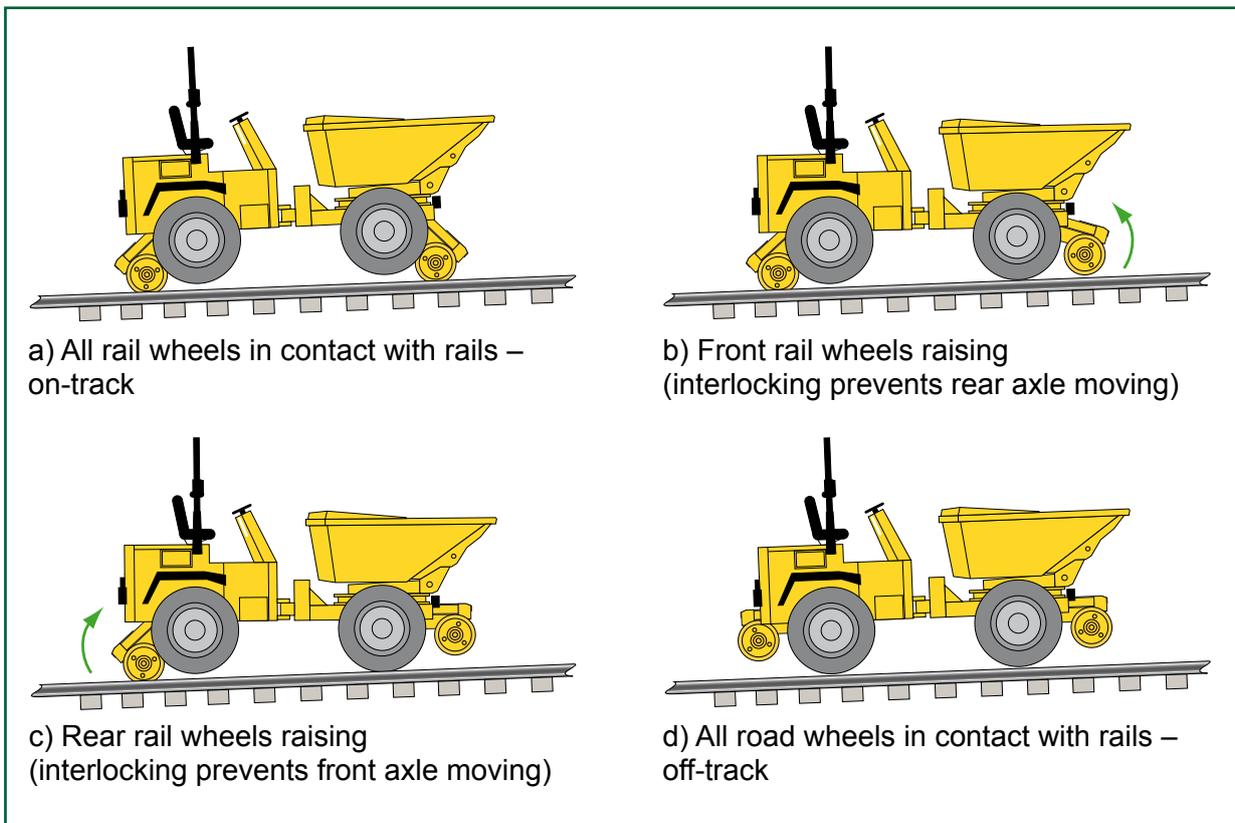


Figure 6: Rail axle movement sequence when off-tracking



Figure 7: Location of interlock circuit box and override button

Dumper 216 documentation

- 61 Quattro provided the following documentation to the RAIB relating to the dumper:
- a. **The original manufacturer's manual.** This was for the base Barford dumper before the rail axles were added.
 - b. **A maintenance plan.** This was created by its previous owner following its conversion for rail use.
 - c. **Service and maintenance instructions.** This document contained tasks, referenced by a job number, for the maintenance and service activities for all of Quattro's RRVs. It was available on the company's intranet system and it referenced other machine specific documents such as items (a) and (b) above.
 - d. **Interlocking installation and test procedure.** This was a workshop-type procedure to instruct Quattro's personnel on fitting the interlocking modification to its other RRVs, but was not applicable to the dumpers.
 - e. **Dumper specific service checklist.** This was a list of the service and maintenance activities to be undertaken on a Barford dumper. Included on this checklist were the checks to be done as part of the pre-dispatch inspection, known as the PDI (paragraph 23). It consisted of one-line descriptions of the activities, each one identified by a job number. The details of the specific jobs were within the service and maintenance manual, ((c) above). Examples of PDI activities included checking the function of the dumper's brakes, horn, lights etc, as well as checking the engine oil, coolant and hydraulic oil levels.

- f. **Dumper logbook.** Its purpose was to provide a book in which fitters and operators should record that checks had been done and to report any faults. At the front of the book was the telephone number to contact Quattro's on-call manager (known as Quattro Control) and a pre-start check procedure with a list of job numbers. Some of these job numbers did not correspond to those on the PDI checklist or the service and maintenance instructions.
 - g. **Quattro's engineering briefing 002.** This gave instructions to operators and fitters using RRVs fitted with rail axle interlocking. It contained guidance on pre-hire/pre-shift checks, the order in which to operate the rail axles, and how to operate the axle interlocking override.
 - h. **Electrical circuit diagram.** Quattro provided the RAIB with a hand-drawn circuit diagram (reproduced at figure 11). Although unreferenced and undated, Quattro confirmed that this was the interlocking circuit diagram for the dumpers.
- 62 Rail Industry Standard RIS-1700-PLT required that certain documents accompany the dumper so that they could be checked by the machine controller at the site of work (paragraph 26). The file containing these was kept inside the toolbox and included the logbook, the certificates of engineering acceptance and conformance to vehicle maintenance (paragraph 48). There were also other documents within the file, including a brake test inspection certificate and a copy of engineering briefing 002.

RAIB examination and testing

- 63 Following the accident the RAIB examined and tested the operation of dumpers 216 and 217. The tests included operating the rail axle control switches and observing the movements of the rail axles.
- 64 Testing on dumper 216 indicated that if the incorrect rail axle switch was selected (ie an attempt was made to move the holding end) the selected rail axle moved slightly (figure 8). This movement occurred in the following two cases:
- operating the front rail axle lower switch with the rear axle not in its fully lowered position, and
 - operating the rear rail axle raise switch with the front axle not in its fully raised position.
- 65 Following this slight movement, further movement of both axles was prevented by the lockout (paragraph 58). To recover from this condition, it was necessary to press and hold the override button within the toolbox. If the override button was held pressed during any out-of-sequence movement of the rail axles, and then released, the lockout was restored and further rail axle movement was again prevented (ie the machine could lock out when neither rail axle was fully braked).
- 66 An examination of the dumper's interlocking electrical circuit found that there was a wire connected between terminals of the two electrical relays controlling the movement of the front and rear rail axles (figure 9). This wire was not shown on the electrical circuit diagram (paragraph 61h and figures 11 and 12).
- 67 The wire provided a parallel electrical feed to the coils of both relays controlling rail axle movements and was responsible for the performance of the rail axles as described in paragraph 64.

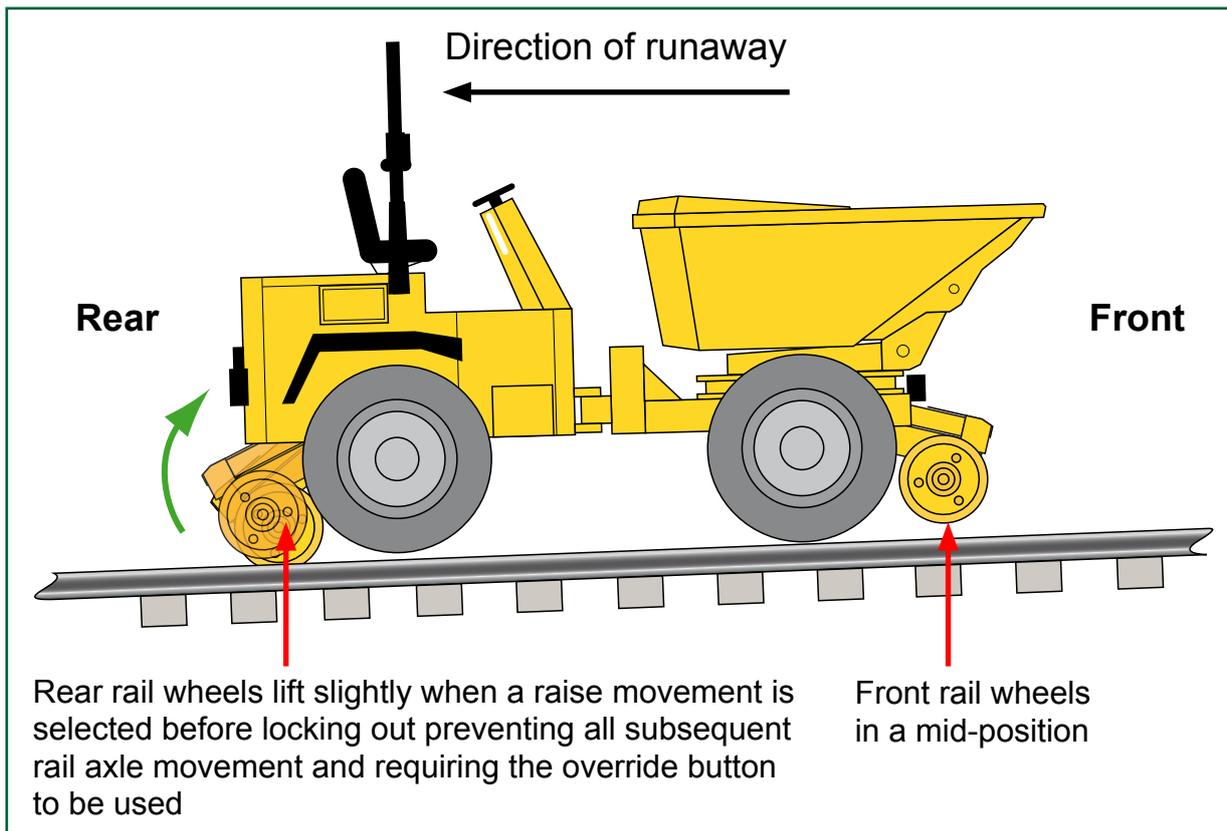


Figure 8: Effect of selecting an out-of-sequence movement of the rail axles when off-tracking dumper 216

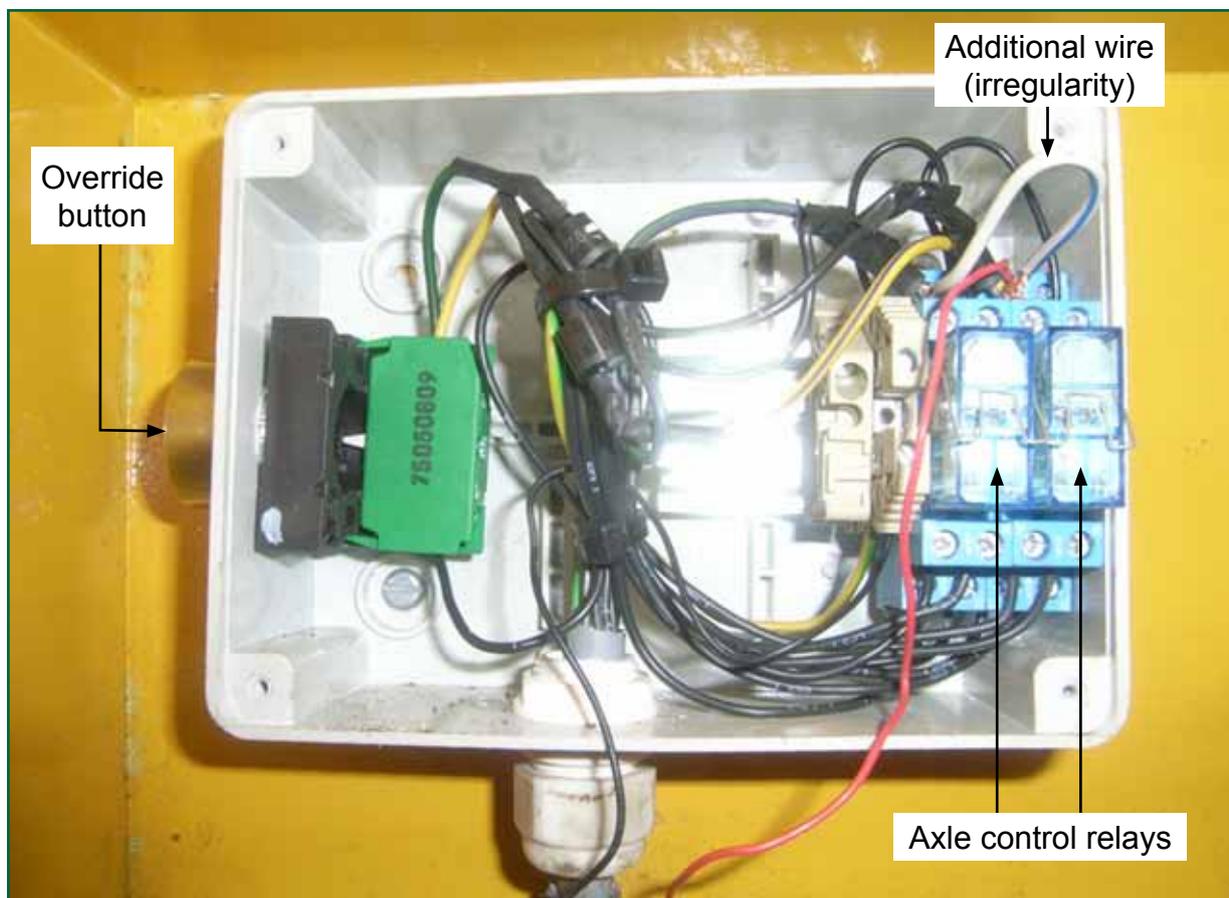


Figure 9: A view inside the axle interlocking circuit box on dumper 216

- 68 The RAIB carried out tests with the wire present and dumper 216 on rails set at a gradient of 1 in 46 (2.17%), which was the gradient of the line at the RRAP at Bradford Interchange. When the switch for the holding end was selected, and with the other end in a fully unbraked condition, there was sufficient movement of the holding end rail axle to allow the dumper to roll away. In all the tests, although there was contact between the road tyres and the rail wheels at the holding end, this was less than the correct tyre squash required for effective braking. At this point, the rail axles locked out, ie further movement of the rail axles was prevented.
- 69 With the wire removed the rail axle interlocking performed in accordance with the requirement to always maintain one end in a braked condition, even when the raise or lower switch for the out-of-sequence end was selected, ie there was no movement of the rail axle at the holding end.
- 70 Dumper 217, the sister machine not involved in the accident but of the same general interlocking circuit design, performed correctly. Its interlocking circuit did not have a wire present providing a parallel electrical feed to both relay coils as in the case of dumper 216 at the time of the accident.
- 71 Dumper 216 had different types of tyres fitted to its front road wheels. Both rear tyres and the front left-hand tyre, as viewed from the operator's position, were foam filled tyres, but the front right-hand tyre was pneumatic. The service and maintenance instructions required the same type of tyre on an axle. Incorrect tyres were identified by a Quattro fitter during a PDI inspection in June 2009 and there is no evidence to indicate that the issue was subsequently rectified (paragraph 157).

Identification of the immediate cause⁵

72 Dumper 216 ran away and hit the buffer stop because it was on a gradient in an insufficiently braked state and with no other means of restraint.

- 73 The dumper was examined on site after the accident and before it was moved. All the road wheel tyres were found to be lifted clear of the rails. At the rear end of the dumper there was no contact between the road wheel tyres and the rail wheels (figure 10). Therefore the rear rail wheels were not braked during the runaway. Contact between the front tyres and the front rail wheels was less than the full squash condition that occurs when the rail axle is in its fully lowered position. There were scrubbing marks on the front tyres indicating that there had been slipping contact with the rail wheels. This suggested that there had been partial braking of the front rail wheels.
- 74 Analysis of the station platform closed circuit television images indicates that the speed of the dumper when it collided with the buffer stop was about 11 mph (18 km/h). This also indicates that there was some braking effect from contact between the front road tyres and the rail wheels because the RAIB has calculated that, if the dumper had been fully unbraked, the collision speed would have been about 28 mph (46 km/h). The estimated maximum speed was 18 mph (29 km/h), and the dumper subsequently slowed as the gradient decreased as it ran towards the buffer stop.

⁵ The condition, event or behaviour that directly resulted in the occurrence.

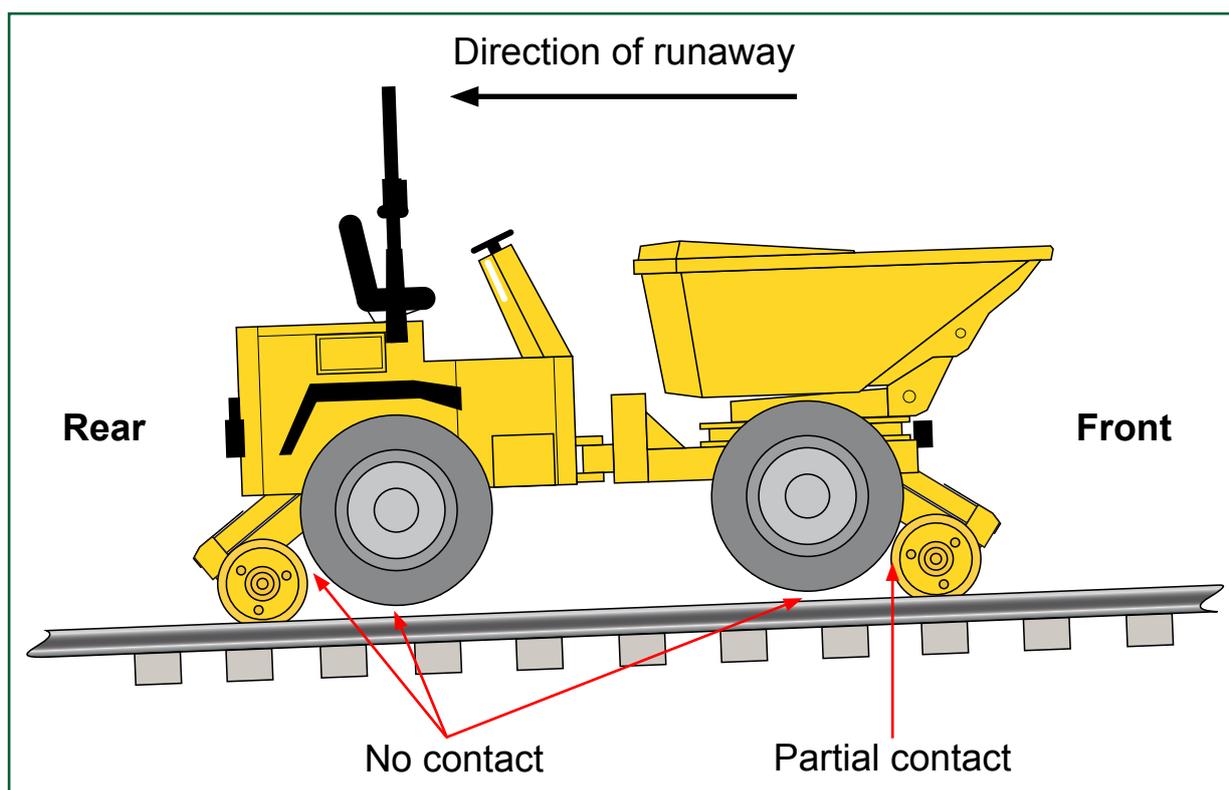


Figure 10: Positions of the road and rail wheels following the accident

Identification of causal factors

75 The accident was caused by a combination of the following factors:

- The dumper was in operation with a wiring irregularity in its rail axle interlocking circuit. This allowed reduced contact between the wheels on a rail axle and the tyres of the road wheels.
- The operator moved the dumper's rail axles in the wrong sequence.
- The operator neither requested assistance from a fitter, nor took action to reduce the risk of running away before he requested the operation of the interlocking override button.
- The design of the axle interlocking fitted to the dumper did not allow recovery from a runaway once it had started.

The interlocking circuit and the pre-dispatch inspection

76 **The dumper was in operation with a wiring irregularity within its rail wheel interlocking circuit that had not been detected by previous inspections and testing. This allowed reduced contact between the road wheel tyres and the rail wheels.**

77 The operator's initial problems with the rail axles (paragraph 24) indicate that the wiring irregularity (paragraph 66) was present in the interlocking circuit when the operator began his shift on the Saturday evening. The problem the operator encountered was the same as described in paragraphs 64 and 65. It is likely that it was present at the time the dumper had its pre-dispatch inspection (PDI) at Doncaster the day before (paragraph 23). The RAIB has found no evidence that the wire was introduced between this inspection and the accident.

- 78 The fitter undertaking the PDI checked the dumper, and subsequently completed the service checklist that was specific to that type of machine (paragraph 61e).
- 79 One particular activity on the checklist was job number U01: 'Check operation of railgear'. The PDI checklist gave no detail about how this should be carried out.
- 80 The service and maintenance instructions (paragraph 61c) contained two requirements against job number U01. The first was to ensure that the rail axles fully lowered and raised; this check was carried out by the fitter. The second instruction was to ensure that the rail axle interlocking was fully operational. However, there was no further instruction as to how this check should be done.
- 81 The fitter, his manager and the Doncaster depot manager have stated that they were not aware that the job numbers on the service checklist referred to the explanatory details in the service and maintenance instructions.
- 82 The fitter was aware that the dumper had rail axle interlocking, but in the absence of further instruction on how to test this safety system, he relied on observing the operation of the rail axles when moved only in the correct sequence. He did not attempt to operate them out of sequence. Had he done so, he would have found that the dumper locked out, preventing further rail axle movements. This would have given him an opportunity to report the fault. Had he done so, it is possible that the dumper would not have been dispatched to site with the wiring irregularity.
- 83 Quattro maintenance records did not indicate that this fault had been reported prior to the accident. The old dumper logbooks had not been kept. If faults had been recorded, they might have given an indication of when the wire had been fitted. None of the documentation seen by the RAIB explains when and why the wire was fitted.
- 84 Whether the wire was present when the interlocking was first added to the dumper, or, as is more likely, was added subsequently, it indicates that there was inadequate control over the access to a *safety critical system*.

Actions of the operator and machine controller

85 The operator moved the dumper's rail axles in the wrong sequence.

- 86 When on-tracking, the correct sequence for deploying the rail axles was to fully lower the rear rail axle first followed by the front (figure 5). When off-tracking, the interlocking was designed to prevent the operator from raising the rear axle until the front rail axle had been fully raised (figure 6). This ensured that the rear road wheel tyres were in full contact with the rear rail wheels and therefore fully braked.
- 87 The operator reported that when he was off-tracking at the end of the shift he wanted to raise the rear axle before raising the front axle. He had a preference for first moving the rail axle which was more easily visible to him (the dumper's bucket obscured the view of the front wheels). This was the incorrect order of raising the rail axles. The selection of the raise switch for the rear rail axle, with the irregular wire present, caused the dumper to lock out.

- 88 There is no evidence that he had read engineering briefing 002 within the file in the toolbox (paragraph 61g) which, although it was not comprehensive and did not accurately reflect the operation of the interlocking on the dumper, did prescribe the correct order for deploying the rail axles. Evidence also indicates that he had not received a briefing on the specific operation of the dumper (paragraph 128).
- 89 When off-tracking it was less important which end was lowered first. When on-tracking the operator has to steer the dumper to line up each set of rail wheels with the rails before lowering them. This operation is not required when off-tracking as the action is solely one of raising the rail axles to lower the dumper before driving off the track. Witness evidence, together with the position of the rail axles after the runaway, suggests that the operator's first action of slightly raising the front rail axle, was not intentional.
- 90 Although this is the correct axle to raise first, this unintended operation was probably due to the operator's unfamiliarity with the control switches, as this was the first time he had driven this dumper (paragraph 42). The type of switches (which were different to those on dumper 217 which he had recently driven) and their position, may also have contributed to his unintentional action (paragraph 120). Once the security officer was holding the override button depressed, the operator then continued to raise the rear rail axle, as was his original intention.

Requesting assistance

91 The operator neither requested assistance from a fitter, nor took action to reduce the risk of the dumper running away before he requested the operation of the interlocking override button.

- 92 Quattro had recognised that rail axle interlocking was a safety critical feature of the converted RRVs, and amended the service and maintenance instructions (paragraph 61c) accordingly at the end of December 2009. Within the 'work arising on site' section, under the job number U01 'Check operation of railgear', there were instructions to inform a fitter if the axles did not fully move and agree a safe system of recovery with the machine controller.
- 93 These instructions were not in any of the documents in the dumper's toolbox file.
- 94 The operator neither worked through the pre-start checklist in the dumper's logbook (paragraph 61f), nor recorded any checks in the logbook. Rather he relied on his experience and training on RRVs in general. The checklist contained specific checks to undertake before using the dumper. He recorded the defective operation of the rail axles in the logbook after the accident. His general RRV training (paragraph 43) had, however, included the instructions to record that the pre-checks were complete by signing the logbook, and to report any defects to the on-call manager.
- 95 Inside the logbook was the telephone number of Quattro's fault control. Had Quattro's on-call manager been informed of the defective operation of the rail axles, an on-call fitter could have attended site within 40 minutes, or could have given advice over the telephone. However, the operator reported that he did not do this because he was unsure when the work was due to start and how long it would take for a fitter to attend site. Rather than requesting assistance, he wedged the override button with a coin and a spanner (paragraph 25).

The machine controller

- 96 The machine controller reported that at the beginning of the shift he was unaware that the interlocking had been overridden by the coin and the spanner. He recalled that when off-tracking at the end of the shift the front axle had partially risen before the operator had informed him that he needed assistance. However, he was neither trained in, nor aware of, the specific operation of the dumper. He was not aware that the operator was going to raise the rear rail axle next, rather than continuing to raise the front axle.
- 97 The machine controller has stated that he thought that the security officer was a fitter because, in his experience, it was common for an RRV to be provided with both an operator and a fitter. He had also seen the security officer assist the operator at the start of the shift. Even if the machine controller had fully understood what was happening in this instance it would still not have been part of his role to question the actions of the operator and security officer.

The design of the railgear interlocking

98 The design of the rail axle interlocking fitted to the dumper did not allow recovery from a runaway once it had started.

- 99 In normal operation, as designed and without the extra wire (paragraph 66), the interlocking circuit would have operated to maintain one end of the dumper in a braked condition (paragraph 69).
- 100 The design of the override feature relied on the correct operating procedure being applied. The override button was a spring-return type which had to be held depressed to operate it (paragraph 59). If, as in this case, it was released before the rail axles were in their correct positions, the interlocking circuit would not allow any further rail axle movement. This prevented any further control of the rail axles by the operator, and, if they were then in an unbraked state, they would remain so.
- 101 Had the security officer been able to hold the override button for about five seconds longer, the operator could have raised or lowered either axle sufficiently to regain braking of the dumper and prevent it rolling further down the gradient.
- 102 From his time as a depot manager, the operator was aware that some RRVs were fitted with rail axle interlocking. He also knew that they had a facility which a fitter could use to override this (paragraph 118). However both he, and the security officer, did not fully appreciate the risks of releasing the override button part-way through a movement of the rail axles when on a gradient and without any other means of restraint.
- 103 The positioning of the override button remote from the operator was to ensure that it was out of reach to prevent misuse (paragraph 60). Quattro intended it to be operated by a fitter for recovery purposes. However, it is evident, from its misuse at the start of the shift, that access to it by others was possible as the toolbox was not locked. Its remote positioning meant that once the dumper was running away, the operator could not depress the button and recover the situation.

Identification of underlying factors⁶

Quattro's engineering safety management system

104 Quattro did not adequately control the design, installation, inspection and related documentation of the interlocking modification to ensure its safe use.

Lack of engineering risk controls

- 105 The risks to safe operation introduced with the design and fitting of the axle interlocking were not adequately controlled.
- 106 In normal use the interlocking achieved the general principle of maintaining one rail axle in a braked condition while moving the other rail axle, and thereby reduced the risk of a runaway. However, even if the interlocking had been correctly wired, it would still have been possible (if the override was used on an unsecured vehicle) for both dumper 216 and 217 to have become unbraked, and then to remain locked out as occurred in this accident (paragraph 98).
- 107 Quattro provided no documentation to demonstrate the safety of the design of the rail axle interlocking. There was no document explaining the design of the system, its function, and the risks it sought to address and those which remained. The RAIB has found no evidence that the potential failure modes of the system and the risks associated with possible errors/mistakes of operators had been assessed. No evidence has been found of any systematic review of the risks associated with the design and potential mitigation measures.

Design and installation

- 108 The hand-drawn circuit diagram (paragraph 61h) did not reflect the circuits fitted on either dumper 216 or 217 because some electrical components were not shown and others were shown incorrectly (figure 11). The RAIB has produced circuit diagrams representing the actual wiring on each dumper (figures 12 and 13).
- 109 During the examination of the dumpers, the RAIB observed that the wiring of the interlocking circuit on dumper 216 was substandard (figure 14). Many of the connections between components were insulated by tape rather than heat-shrink insulation and the legs of components were connected directly to screw terminals. Even though the dumpers were of the same type, with a common design of interlocking circuit, the layout of the control relays was different, as were the rail axle control switches (paragraph 122). These differences are very unlikely to be as a result of tampering and are further indications that the installation of a safety critical system was not adequately controlled.
- 110 When the interlocking was fitted to the dumpers, Quattro submitted documentation to the VAB for engineering acceptance. Because Interfleet VAB had previously assessed a first-of-class test (paragraph 52), albeit on another type of RRV fitted with a different design of axle interlocking, it was agreed that Quattro would submit a modification declaration form to Interfleet VAB.

⁶ Any factors associated with the overall management systems, organisational arrangements or the regulatory structure.

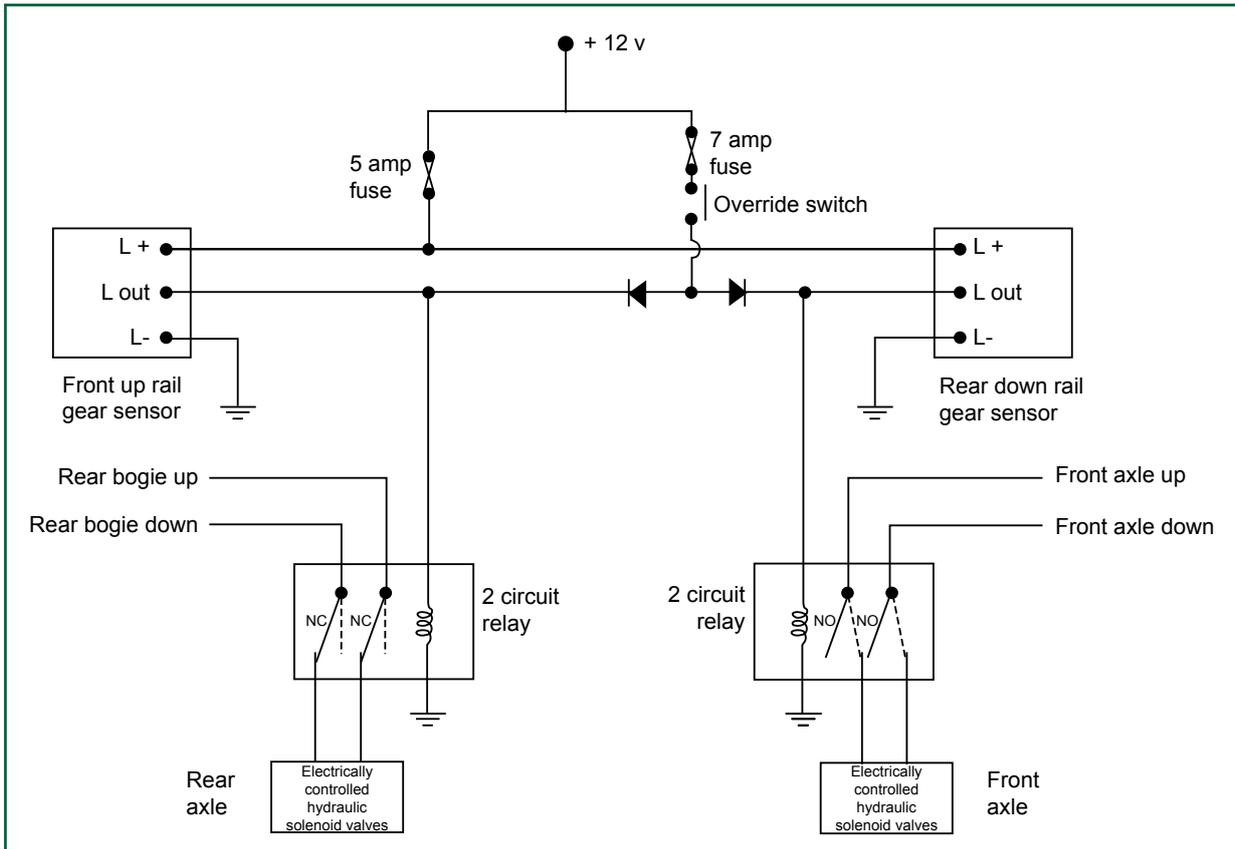


Figure 11: Axle interlocking circuit diagram for dumpers 216 and 217, as designed (information from hand-drawn diagram supplied by Quattro)

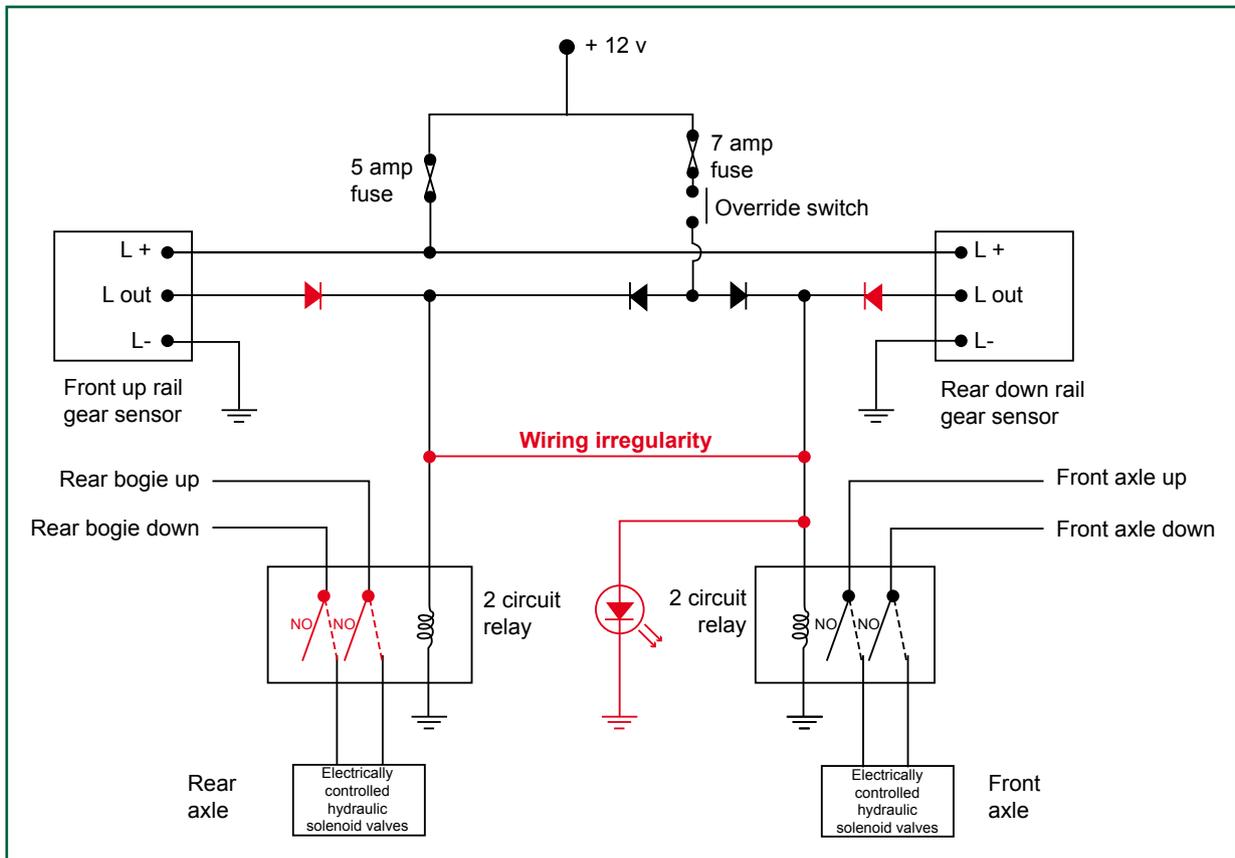


Figure 12: Actual axle interlocking circuit diagram for dumper 216

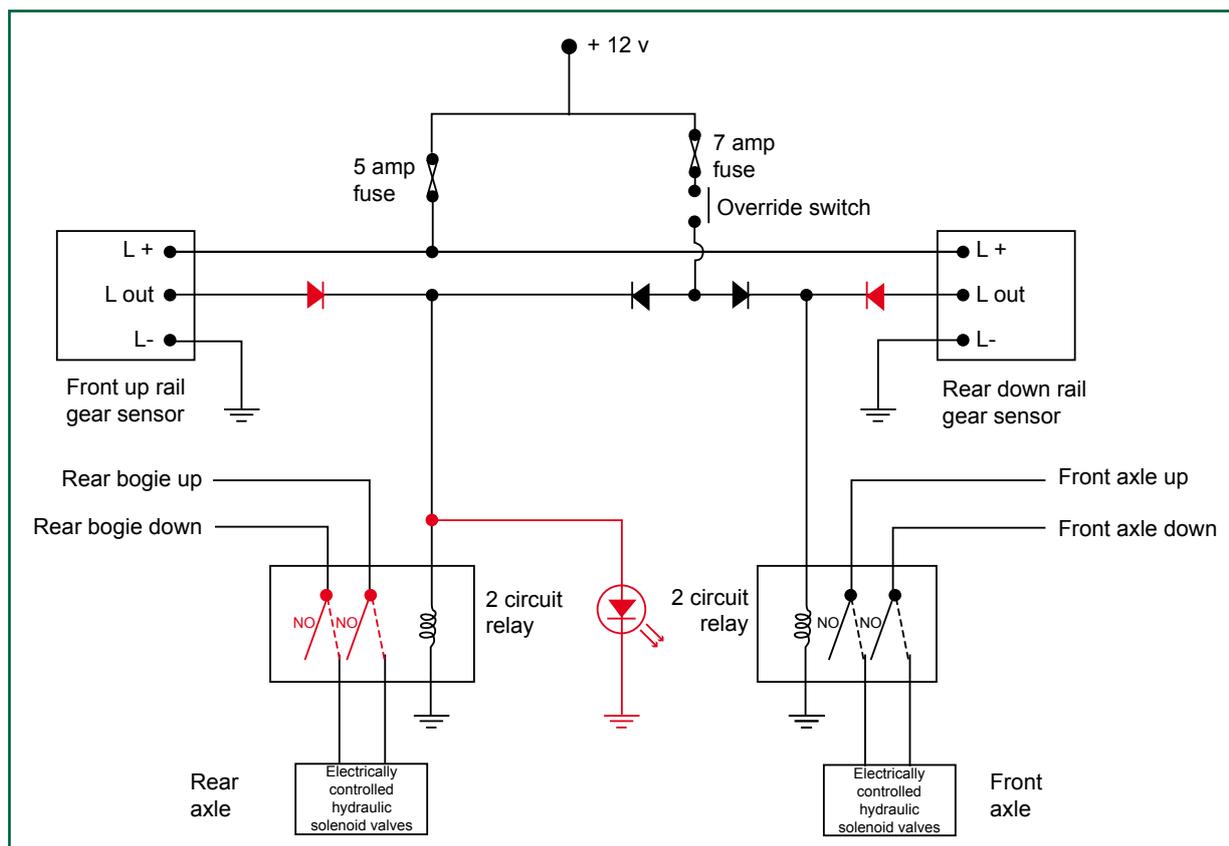


Figure 13: Actual axle interlocking circuit diagram for dumper 217

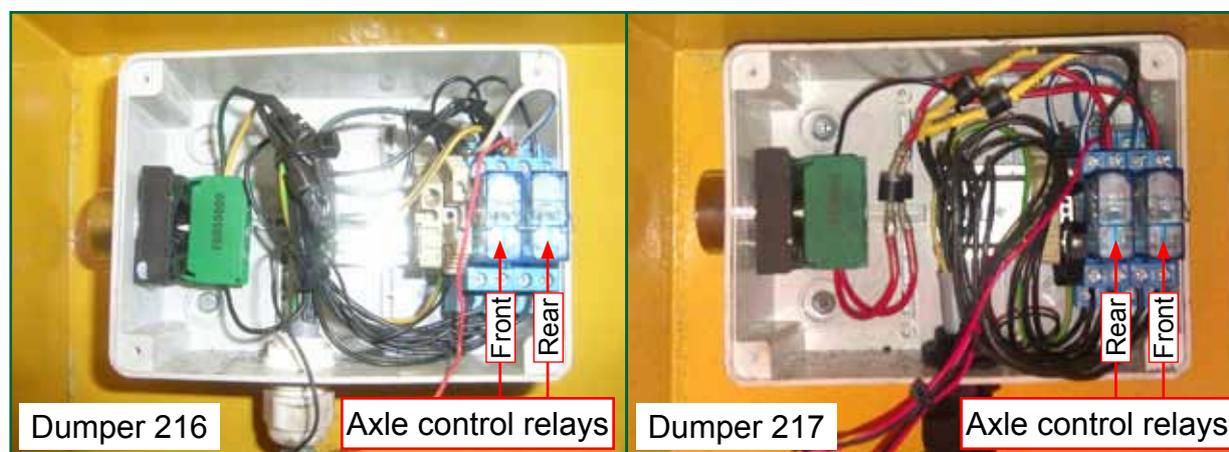


Figure 14: Views inside dumper 216 and 217 interlocking electrical circuit boxes

111 This form had a reference to the interlocking installation and test procedure document (paragraph 61d) which included a list of the RRVs to which it applied. This list did not include the dumpers and there was no other document specifically relating to the dumpers. The document contained an interlocking circuit diagram which did not represent those fitted to either dumper (figure 15), but was for other Quattro RRVs (paragraph 55). These discrepancies were not identified by the VAB. This is discussed further in the Observations section of this report (paragraph 150).

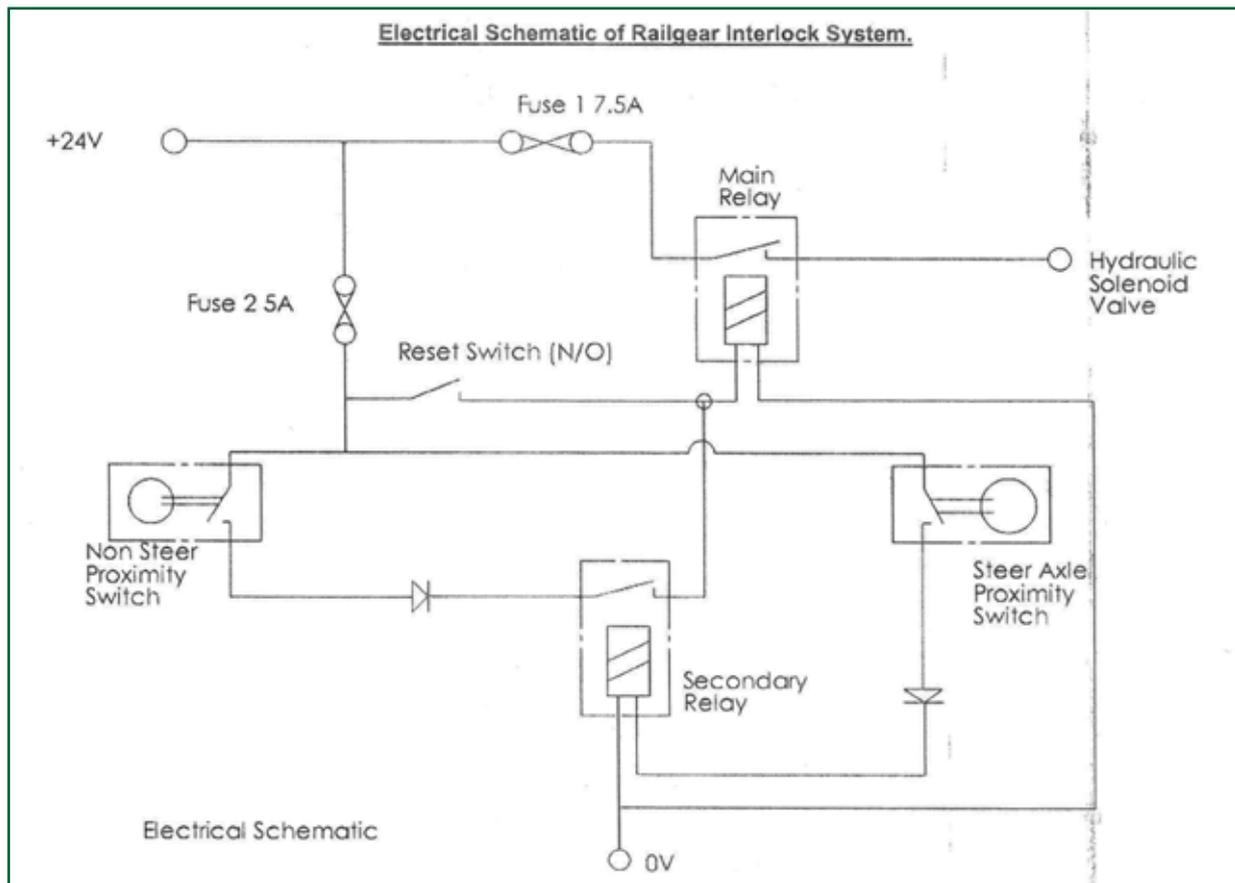


Figure 15: Interlocking circuit diagram referenced from modification declaration and submitted to the VAB by Quattro

Testing and operation

- 112 Rail axle interlocking formed part of the braking system on RRVs and therefore was safety critical. This was stated in Quattro's service and maintenance instructions. However, there was no ongoing test regime defined in any of the documents to prove that the axle interlocking was operating correctly. The sequential operation of the switches to raise and lower the rail axles, as undertaken by the fitter at Doncaster (paragraph 82), did not actually prove that the protection provided by the interlocking was working; ie preventing the holding end axle from moving.
- 113 A valid test would have been to operate the rail axle switch for the holding end (ie select the switch to move the braked axle) while the other axle was unbraked (with the dumper adequately restrained). The success criteria for such a test would be that there is no movement of the holding end rail axle, and that lockout does not occur. Such a test would have detected the effect of the wiring irregularity, or other fault which may have caused a similar condition, and alerted Quattro to the defect.
- 114 The need for a test of this type should have been identified during risk assessment at the design stage. The test method and frequency should have been prescribed in the service and maintenance instructions, and staff suitably briefed.

Control of access to a safety critical system

- 115 There was inadequate control of access to the interlocking override button and the interlocking circuitry.
- 116 The dumper's interlocking override button was mounted on the outside of the interlocking circuit box and was easily accessible. Interfleet VAB has informed the RAIB that when its staff saw the first Quattro RRV that was fitted with the axle interlocking conversion (paragraph 52), they verbally informed them that the override button should be inside the circuit box. The Interfleet VAB staff further recall that subsequently, during first-of-class testing on that machine, they observed that the override button was inside the circuit box. However there is conflicting witness evidence on this issue and Quattro staff have stated that they have no recollection of this advice, and the two companies have no written records relating to this issue.
- 117 Although the circuit box was inside a lockable toolbox on the side of the dumper, the toolbox was not normally locked and the override button was readily accessible to the operator. In any case the locks on RRV toolboxes had a common lock key, because access to the machines' document files kept in them was required by operators, fitters and machine controllers.
- 118 Interfleet VAB understood that the override facility was to be used for recovery situations with a safe system of work in place and with assistance from a fitter. This was also stated in Quattro's service and maintenance instructions (paragraph 61c).
- 119 Had the override button on dumper 216 been inside the interlocking circuit box, or only accessible to a competent fitter by other means, this would have restricted access by the operator.

Positioning of machine controls

- 120 When off-tracking the operator pressed the front rail axle 'raise' rocker switch in error (paragraph 31) although this was the correct end to operate first when off-tracking. The design and positioning of the switches are considered likely to have contributed to his error in selecting the 'wrong' switch, particularly as he was wearing gloves. The switches were situated low down on the vertical panel beneath the steering wheel making them difficult to see (figure 16).
- 121 The switches were not labelled, except for faded markings hand written in black marker pen, nor were they illuminated. The revision of Rail Industry Standard RIS-1530-PLT, issue 2 (December 2009) required the provision of a visual indication to the operator when the axles were in the fully raised or lowered positions. There were no indications fitted to the dumpers to inform operators of the positions of the rail axles. However dumper 216 was converted before this standard was mandatory and the standard only applied to new RRVs or those undergoing their seven-year reassessment.
- 122 There were two rail axle switches on dumper 216 and these were three-position rocker types. Dumper 217, which the operator had recent experience of driving (paragraph 42), had four separate coloured push buttons (figure 16).
- 123 It is possible that the poor positioning and labelling of the control switches contributed to the accident.

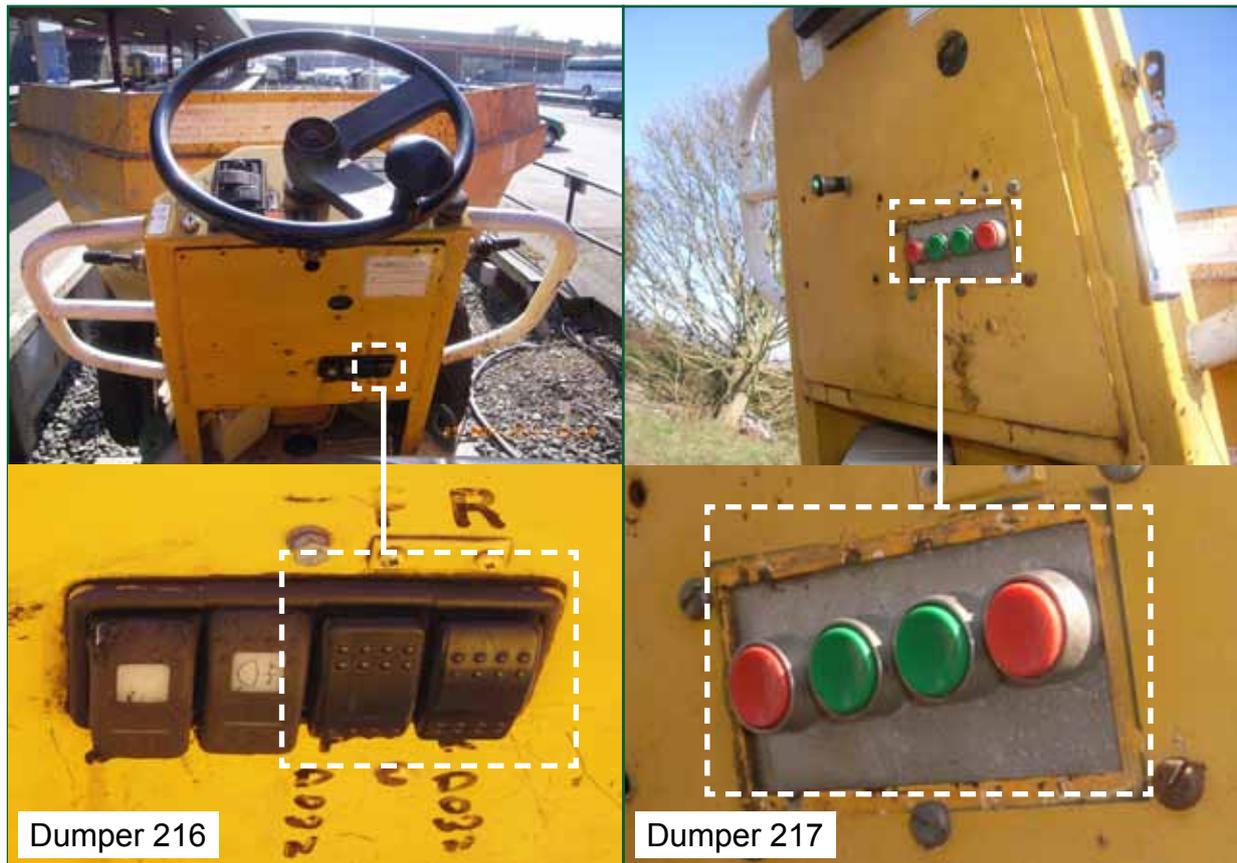


Figure 16: Rail axle control switches on dumpers 216 and 217

Availability of industry guidance on the management of engineering change

124 The rail industry has developed detailed guidance on applying the principles of engineering safety management. This guidance was contained in a document known as the Yellow Book⁷, originally issued in 1996. Although originally focused on new works, the guidance had been expanded in 2005 to cover ongoing maintenance.

125 The Yellow Book guidance was superseded in September 2012. However, since the modification to the dumpers was made, large elements of this guidance are now reflected in three documents published by RSSB on behalf of the Industry Standards Coordination Committee. These are:

1. The Principles of the Safe Management of Engineering Change (Issue 1, May 2012).
2. GE/GN8642; Guidance on Identifying Hazards and Assessing Risk (Issue 1, September 2012).
3. GE/GN8643; Guidance on Reducing Risk (Issue 1, September 2012).

126 Quattro has provided no evidence that it used any guidance or principles within the Yellow Book during the design, installation and subsequent inspection and maintenance of the dumpers' rail axle interlocking.

⁷ Withdrawn document section of RSSB's website: www.rgsonline.co.uk.

Competence of staff to safely use the dumper

127 Quattro did not adequately control the competence of its staff commensurate with the safe use of the dumper.

Updating and briefing of safety instructions

- 128 Quattro produced engineering briefing documents whenever it was necessary to inform its own, or its contracted staff, of changes. This included informing staff of specific changes to its RRVs. In this way Quattro could update its staff and supplement their general core training (paragraphs 43 and 132) with the specific details of its own RRVs. Engineering briefing 002 (paragraph 61g) which informed staff of the modification of the rail axle interlocking, was present in the file in the dumper's toolbox. Examination indicates that it was produced for the other Quattro RRVs which were part-electrically and part-hydraulically controlled (paragraph 55). Although it gives some general instruction relevant to the dumpers, sections of it are not applicable to dumpers 216 and 217.
- 129 It was common for Quattro depot-based staff to be told about the company's engineering briefings face-to-face. The engineering briefings were sent to contracted staff by post. Quattro provided evidence that engineering briefing 002 had been communicated to some Quattro fitters and operators in March 2009, although the date on the document was February 2010. Quattro informed the RAIB that this document was updated in February 2010, but the issue number had not been changed. However, neither the dumper operator involved in the accident, nor the depot fitter conducting the PDI, recalled having received this briefing. Quattro was unable to provide any evidence that the operator and the depot fitter had received this briefing.
- 130 The service and maintenance instructions for all of Quattro's RRVs had been updated in December 2009 to include the requirement that, in the event of a failure of the rail axles, the fitter should be informed and a safe system of recovery should be agreed with the machine controller (paragraph 92). This implies that the fitter is either on-site to mend the fault, or is available to provide advice. This document was not in the file in the toolbox because it was a large, detailed document containing service tasks for all of Quattro's RRVs.
- 131 Engineering briefing 002 did not contain any information reflecting this addition to the service and maintenance instructions; it made no mention of the need to request fitter assistance and to agree a safe system of work if the override was required to be operated. Although it showed how to override the interlocking, it contained no related safety warnings or instructions.

Access to information for safety critical tasks

- 132 The fitter who carried out the PDI was deemed competent in accordance with the rail industry standards in place. He had been assessed in September 2011 against the *Rail Plant Association* (RPA) maintenance and repair competency scheme. To maintain competency the RPA requires an assessment every 2 years. The assessment consisted of written responses to set questions compiled by the RPA together with a suitably qualified Quattro lead fitter performing the assessment and observing the candidate undertaking checks on an RRV. The fitter's last assessment included one question relating to rail axle interlocking which asked why it was needed. For the fitter's observational assessment, the assessor chose an RRV excavator which had rail axle interlocking fitted. This vehicle was used for the whole assessment and the assessment did not consider variations of this safety system on other types of RRVs. There was no assessment, either by questioning or practical observation, that the fitter knew how to check that the interlocking was working correctly.
- 133 Engineering briefings (paragraph 128) and the service checklists, such as the PDI checklist, with their job numbers referenced to the service and maintenance instructions, were the means by which Quattro communicated details of the specific maintenance tasks to be undertaken on its RRVs. The fitter, his manager and the depot manager at Doncaster stated that they did not know what the job numbers referred to, or where to find the details in the service and maintenance instructions.

Reporting defects on safety critical components

- 134 The dumper was dispatched to site with a wiring irregularity in a safety system.
- 135 There was a note on the back cover of the file in the toolbox of dumper 216. This was hand written in marker pen (figure 17). It informed operators and fitters of the correct sequence of operation of the switches to lower and raise the rail axles.

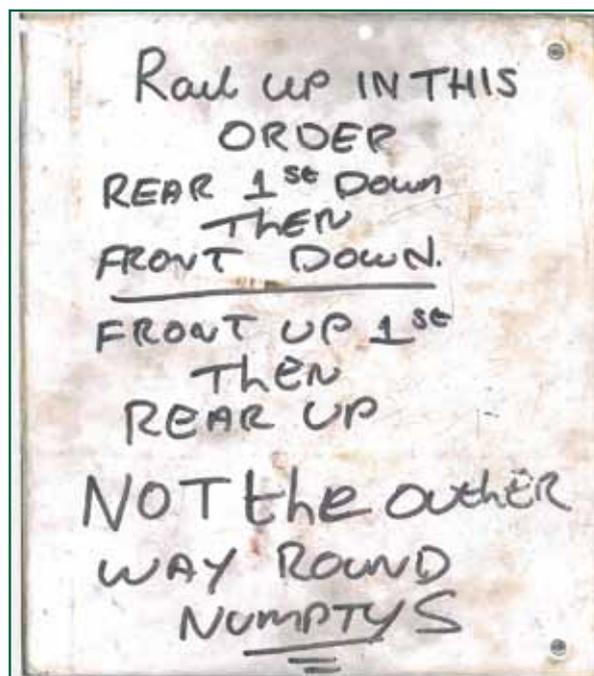


Figure 17: Note written on the back cover of the dumper's file kept within the toolbox

- 136 The presence of this note suggests that the dumper had probably previously locked out due to the wiring irregularity. There was no equivalent note on, or in, the file for dumper 217.
- 137 Rail axles and braking systems are safety critical components defined in road-rail vehicle standards and in Quattro's own management system documents. In the latter, there was an instruction to maintenance staff to report any actual or suspected safety related defects. It is considered likely that the behaviour caused by the wiring irregularity was not investigated because its effect on the dumper's safe operation was not detected by a fitter and/or not fully appreciated. This is due in part to the lack of documentation available to maintenance staff, including the definition, and subsequent briefing, of a check to ensure that the rail axle interlocking was fully operational. This should have included checking that unintended rail axle operation was not possible, rather than just checking the correct operation sequence.

Quattro audits

- 138 Quattro's safety management system included management procedures for conducting both depot audits and site audits.
- 139 The depot audits assessed whether the depot complied with the company's own procedures. These audits were predominantly related to occupational health and safety, and environmental legislation.
- 140 At the time of the accident the Doncaster depot was relatively new, with both its staff and equipment having been relocated from another nearby depot in 2011. There had not been an audit of this new depot before the accident. The last audit of the old depot in May 2011 included a check that service and maintenance documentation, including PDIs, was in place for a variety of road and road-rail plant.
- 141 Although the May 2011 audit included one end-product⁸ check (this was the tightness of bolts on a piece of plant), it did not include a general check on fitter competence. There was no check to verify whether they were able to find information relating to vehicle inspection and maintenance tasks.
- 142 Quattro's site audit procedure, dated February 2011, was intended to verify that systems of work were compliant on sites at which Quattro personnel and/or plant were working. It was a requirement that they were conducted at intervals not exceeding eight weeks. At the time of the accident (March 2012) there had not been any site audits conducted due to the lack of availability of staff.

The rail industry's systems for checking the suitability of contractors and monitoring ongoing performance

- 143 Although Network Rail and others carried out various compliance monitoring and assurance activities in relation to Quattro, no issues were identified in relation to engineering safety management systems or the competence of technical staff.**

⁸ An end-product check on an RRV is an examination of the machine, checking key technical features and the machine's functions. In this way the true effectiveness of the company's management procedures can be assessed.

- 144 There is a system designed to register contractors as approved to tender for work. This is known as the 'Link-up' scheme. The scheme is used by Network Rail, its contractors, London Underground and some train operators to support their procurement and risk management activities. For companies working on railway infrastructure a condition of qualification is an ongoing programme of annual questionnaires and audits to verify that the supplier concerned is compliant with the minimum standards required. Quattro's application was for qualification to supply the rail industry with pre-maintained road-rail plant and competent rail plant operators and maintenance fitters.
- 145 For the most recent annual application to qualify under the 'Link-up' scheme, Quattro completed a questionnaire. The data on the questionnaire was checked and recorded by Achilles Information Limited, who operated the scheme. This was then followed up by a two-day paper-based audit by Achilles auditors visiting the company.
- 146 Although the audit examined Quattro's management systems for its rail plant supply activities, it did not involve end-product checks of RRVs inspected as fit to be dispatched. The audit of Quattro's provision of competent rail plant operators and fitters only involved a check that there was a competence management system in place. It did not involve sample testing of the competence of the staff themselves.
- 147 Network Rail complemented these audits with its own T&RS Technology Assurance audits (TTA). The last TTA audit of Quattro prior to the accident was conducted in May 2009. Although this was primarily a paper-based audit of their management systems, it did include some visual checks on selected RRVs and questioning of maintenance staff on task related issues. Following this accident Network Rail conducted a further TTA audit of Quattro.
- 148 Following other previous RRV runaways (paragraph 170), Network Rail increased the frequency of audits undertaken by its Rail Plant Support Engineers. However, these were only visual checks and did not include end-product checks of either the rail plant or personnel deemed to be safety critical.
- 149 Quattro hired plant and operators to other contractors, as in this case, to Keltbray. Some of these contractors conducted their own audits based upon the voluntary good practice contained in the M&EE Networking Group code of practice, AP0001. This document contains questions within subject areas which can be used during an audit. The questions are similar to those in the 'Link-up' questionnaire and are concerned with a plant supplier's quality management system at a high level, with minimal guidance on how to check the quality of the end product.

Observations⁹

The engineering acceptance process

- 150 Quattro has stated that it expected that the engineering assurance process would provide a greater level of assurance than, in practice, it did.

⁹ An element discovered as part of the investigation that did not have a direct or indirect effect on the outcome of the accident but does deserve scrutiny.

- 151 RIS-1530-PLT issue 1, current at the time of the modifications, defined the role of the VAB in the engineering acceptance process for RRVs. This was to check that the modification conformed to RIS-1530-PLT and relevant Railway Group Standards. RIS-1530-PLT stated that acceptance by a VAB did not imply that the modification was safe in all respects, or that it had been assessed for quality of manufacture. The engineering acceptance process was therefore at a relatively high level and did not involve detailed assessment of the design of RRV modifications.
- 152 Interfleet VAB told the RAIB that it expected the design and installation to have been undertaken in a competent manner and saw no requirement to check that this was the case¹⁰.
- 153 Quattro has provided no evidence to the RAIB to show that the design of the interlocking modification on the dumpers was competently assessed during its design and installation (paragraph 107).
- 154 Interfleet VAB was not informed by Quattro that the interlocking design on the dumpers was different to that of the other RRVs. In addition, the documentation Quattro submitted to Interfleet VAB to support their modification declaration did not directly apply to the interlocking on the dumpers (paragraph 111). Interfleet VAB did not notice that the dumpers were not listed as one of the RRV types covered by the documentation that was submitted to them.
- 155 All versions of RIS-1530-PLT define a 'class' of RRV as a group of identical vehicles of exactly the same design. This standard also states that to be within the same class a group of RRVs must be from the same manufacturer and use the same model type of all sub-components.
- 156 Even if Interfleet VAB had been aware that the interlocking on the dumpers was of a different design to that fitted to the other RRVs, the RAIB considers it unlikely that this would have led to a more robust review of the dumpers' interlocking. Interfleet VAB has informed the RAIB that within the context of its VAB role, it regarded the interlocking modifications to be functionally identical for all the types of RRVs, regardless of their design differences and physical components used. For this reason they only witnessed one 'first-of class' test (paragraph 52) of a modified RRV and then relied upon Quattro to certify that the other RRVs had been modified in accordance with TN-039 (paragraph 49).

Contribution of the tyres

- 157 The right and left-hand tyres fitted to the road wheels of the front axle were of different types (paragraph 71). Braking effectiveness when on rails relies upon the contact conditions between the rail wheels and the road tyres. These conditions were affected by frictional characteristics of the two surfaces, surface contact area and the contact force between the rail wheel and road tyre.
- 158 Although it is possible that differences in the degree of compression (squash) between the solid and air filled tyre may have affected the efficacy of the braking during the runaway, the primary cause was the loss of squash caused by the front rail wheels moving away from the tyres.

¹⁰ Although not applicable at the time, a guidance note within RIS-1530-PLT issue 4, states that the manufacturer should undertake design analysis on control systems. This current issue of the standard also requires that the VAB should check that such analysis has been undertaken.

Summary of conclusions

Immediate cause

159 The dumper ran away and hit the buffer stop because it was on a gradient in an insufficiently braked state and with no other means of restraint (**paragraph 72**).

Causal factors

160 The causal factors were:

- a. The dumper was in operation with a wiring irregularity present within its rail axle interlocking circuit that had not been detected by previous inspections and testing (**paragraph 76, Recommendation 2**).
- b. The operator was unaware of the correct operating sequence of the dumper's rail axles (**paragraph 85, Recommendation 2**).
- c. The operator neither requested assistance from a fitter, nor took action to reduce the risk of the dumper running away before he requested the operation of the interlocking override button (**paragraph 91, Recommendation 2**).
- d. The design of the rail axle interlocking fitted to the dumper did not allow recovery from a runaway once the runaway had started (**paragraph 98, Recommendation 3**).

161 It is possible that the poor positioning and labelling of the rail axle switches contributed to the accident (**paragraph 123, Learning point 1**).

Underlying factors

162 The underlying factors were:

- a. Quattro did not adequately control the design, installation, inspection and related documentation of the interlocking modification to ensure its safe use (**paragraph 104, Recommendation 1**).
- b. Quattro did not adequately control the competence of its staff to ensure safe use of the dumper (**paragraph 127, Recommendation 2**).
- c. Network Rail's audit systems for assessing engineering safety management systems, and the competence management systems for technical staff, were ineffective in respect of the machine and operator supplied from the Quattro depot at Doncaster (**paragraph 143, Recommendation 4**).

Observations

163 Quattro did not understand the level of assurance provided by the engineering process and submitted documentation to the VAB that did not directly apply to the interlocking on the dumpers (**paragraphs 150 and 154, Recommendation 5a**).

- 164 The approach that was taken by Interfleet VAB in deeming functionally similar interlocking arrangements on different RRV types as members of the same class, was inconsistent with the definition of the term 'class' in RIS-1530-PLT (**paragraphs 155 and 156, Recommendation 5b**).
- 165 The dumper was fitted with different tyre types (**paragraph 157, no recommendation**).

Previous occurrences of a similar character and previous RAIB recommendations relevant to this investigation that are currently being implemented

- 166 The RAIB conducted a class investigation into runaways of RRVs and their trailers in 2009. Appendix E of RAIB report 27/2009 contains a table of 18 reported runaway events from 2001 to March 2009. Some of these occurred prior to the establishment of the RAIB. Appendix F of the same report gives the underlying factors to those events. There are seven runaways relevant to this report.
- 167 Since the publication of the class investigation report, the RAIB has completed an investigation into a further runaway which occurred when on-tracking an RRV excavator, near Raigmore, Inverness in July 2010 (RAIB report 10/2011).
- 168 Factors in the accident at Raigmore that are relevant to this investigation include the actions of the operator, with a possible contribution from confusion relating to the labelling of the rail axle selection buttons specific to that type of RRV.
- 169 The following recommendations, which were made by the RAIB as a result of its previous investigations, address factors identified in this investigation. They are therefore not remade so as to avoid duplication.
- 170 The RAIB completed an investigation into two RRV runaway incidents at Brentwood, Essex on 4 November 2007 and at Birmingham Snow Hill on 31 October 2007 (RAIB report 11/2009). These incidents were also described in the RRV class investigation report.
- 171 Recommendation 2 in RAIB report 11/2009 recommended that Network Rail should require its RRV suppliers to review their procedures for on- and off-tracking RRVs. Recommendation 2 of the class investigation report related to a similar area. This required Network Rail to carry out a structured assessment of the safety of operation of RRVs, including consideration of the adequacy of maintenance documentation in relation to the maintenance of the rubber and steel interface, including tyre condition and pressure and the correct adjustment of the rail gear.
- 172 Network Rail and the ORR began several initiatives in response to these incidents and recommendations, including inspections of road tyres and rail wheels (paragraph 174e). This however did not prevent dumper 216 being in service with different tyre types on the same axle. Network Rail has informed the RAIB that to date it has concentrated on the more regularly used and larger RRVs which are likely to cause more damage in a collision following a runaway than the relatively light RRV dumpers.
- 173 In the RAIB report concerning the runaway at Raigmore, Recommendation 2, albeit specific to the type of RRV involved in the runaway, is relevant to this investigation. It concerns the ergonomics and labelling of the machine's controls and possible confusion to the operator.

- 174 Following the previous RRV runaway incidents Network Rail began a programme of activities to reduce the risk of these events. This is on-going and is being monitored by the Office of Rail Regulation (ORR). The activities include:
- a. The fitting of direct rail wheel braking to high ride RRVs to significantly improve braking performance and remove reliance on the road tyre/rail wheel interface. Following a risk based approach, the first type of machines to be fitted with direct rail wheel brakes were 360° excavator RRVs. Network Rail has funded a direct rail wheel braking retrofit programme that has upgraded around 450 machines. This was completed at the end of April 2013. The ORR has also required Network Rail to risk assess the non-excavator RRV fleet to identify priorities for the fitting of rail wheel braking and identification and implementation of interim controls. The ORR has reported to the RAIB that Network Rail has completed the risk assessment and is considering the control measures.
 - b. Rail Industry Standard RIS-1530-PLT was updated to issue 4 in December 2012 and was mandated by Network Rail from 31 March 2013. This requires the fitting of direct rail wheel braking to all newly supplied and recertified high ride RRVs (except those that are driven and braked by the road tyres being in contact with rail wheels fitted with extended hubs).
 - c. Nationwide restrictions on the use of high ride 360° excavator machines that are not fitted with direct rail wheel braking have been introduced. These machines are prohibited from working on gradients of 1 in 75 or steeper. The prohibition was applied in a phased approach, targeting areas with the steepest gradients first, beginning with six of Network Rail's Infrastructure Maintenance Delivery Units (MDUs) in August and September 2011. Bradford Interchange was not within one of these six MDUs. A further 13 delivery unit areas were brought into scope in June 2012, and from the 22 February 2013 the prohibition had national coverage.
 - d. Discussions with RRV owners, suppliers and convertors to ensure that they are aware of the need to comply with the current issue of RIS-1530-PLT, particularly the requirement of section 5.12.3 that recovery control systems should be provided with secure covers and a visible indication of tampering.
 - e. Audits by Network Rail's Rail Plant Support Engineers. These involve inspections of rail plant suppliers and at the time of writing have included examining the quality of rail wheel/road wheel interfaces.
- 175 Although the actions of the machine controller are not factors in this accident (paragraph 96), in response to Recommendation 4 of the RAIB's investigation report into the Raigmore accident (paragraph 167), Network Rail has reviewed the role of the machine controller and has supplemented one of the relevant training modules. This is to improve the level of the machine controller's competence when supervising on- and off-tracking operations. The core on-track plant training module, previously only a part of the machine operator's training, now forms one of the training modules for newly trained machine controllers.

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

- 176 Following the accident, dumpers 216 and 217 were added to Network Rail's 'Do not use' list. Network Rail has informed the RAIB that they will only be allowed back into service once they have been fully checked and appropriately modified.
- 177 Network Rail conducted an audit of Quattro in April 2012. This included visual checks on some RRVs to ensure that they reflected the maintenance records kept for the particular vehicles.
- 178 The ORR has reported that Quattro corrected the wiring on dumper 216 and amended the wiring diagram and fitted a means to restrict access to the override button. Reviews of Quattro's procedures for the design and installation of safety critical systems and machine inspection, fault reporting and action are in progress.
- 179 The RAIB has informed the ORR of its concern regarding the risk of runaways of existing RRVs that do not have direct rail wheel braking. It is possible that these RRVs may be used on other railway networks, either in the UK or overseas. This includes, for example, the heritage and the light rail sectors. The ORR has advised the RAIB that it is aware of this and has significant on-going work in place covering both Network Rail and the wider rail sector.
- 180 RSSB has informed the RAIB that it is undertaking a project to improve the efficiency and effectiveness of the assurance processes of the supply chain to mainline railways in Great Britain. The details of this are in appendix D.

Learning point¹¹

181 The RAIB has identified the following learning point:

- 1 RRV owners should be mindful of the requirement of RIS-1530-PLT issue 4 (section 5.8.5), to minimise the possibility of unintentional switch or control operation (paragraph 161). They should consider whether RRVs converted before this requirement was mandated need to be improved in this respect.

¹¹ 'Learning points' are intended to disseminate safety learning that is not covered by a recommendation. They are included in a report when RAIB wishes to reinforce the importance of compliance with existing safety arrangements (where the RAIB has not identified management issues that justify a recommendation) and the consequences of failing to do so. They also record good practice and actions already taken by industry bodies that may have a wider application.

Recommendations

182 The following recommendations are made¹²:

- 1 *The intention of this recommendation is for Quattro Plant Limited to better control the design and modification of safety critical equipment by using appropriate measures of engineering safety management.*

Quattro should review, and amend, its procedure for the management of modifications to on-track plant, such that any future modifications which could affect the safety of RRVs follow the principles of engineering change management (paragraph 124), whether the work is done by third parties or in-house (paragraph 162a).

As a minimum the review should identify, and action, the changes required to existing procedures to ensure that:

- a. modifications that have the potential to affect the safety of operation are risk assessed, and any residual risk or newly introduced risk is suitably mitigated by design measures or inclusion within inspection, testing and maintenance procedures;
- b. safety critical design work on RRVs is checked and subject to independent verification;
- c. safety critical design work on RRVs is fully and accurately documented;
- d. systems that are critical to safe operation are formally tested to a documented specification during the initial commissioning, or subsequent modification, to verify that they are operating correctly in all modes of operation, including checking the protection against all credible faults; and
- e. the access to safety critical systems, such as the rail axle interlocking circuit and its override, are reviewed and suitable restrictions are applied.

continued

¹² Those identified in the recommendations, have a general and ongoing obligation to comply with health and safety legislation and need to take these recommendations into account in ensuring the safety of their employees and others.

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

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

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

- 2 *The intention of this recommendation is for Quattro Plant Limited to better manage the competence of its personnel and the provision of information to them.*

Quattro should review and improve its existing systems for the management of staff that are engaged in the maintenance, inspection and operation of road-rail vehicles (paragraphs 160a, 160b, 160c and 162b). As a minimum the review should identify the most effective means of:

- a. creating sufficient working documents for installation, test, inspection, maintenance and operation of safety critical systems on Quattro's RRVs;
- b. providing appropriate warning labels informing staff of the precautions to take when overriding safety critical systems on RRVs;
- c. improving management systems to ensure that:
 - all technical staff and machine operators are fully trained in the specific operations of safety critical systems on each type of RRV that they inspect, maintain and/or operate, and the safety measures to take when it is necessary to override them;
 - controls are in place to ensure that only competent persons are able to override safety critical systems;
 - depot staff and operators have access to information for the installation, test, inspection and maintenance tasks they are undertaking on safety critical systems; and
 - any unexpected behaviour of an RRV is reported and results in an investigation by a person competent to do so to fully discover the cause of the fault and that it is rectified appropriately before use.
- d. establishing monitoring systems to check that staff are correctly applying the inspection and maintenance procedures, and are competent to do so, including:
 - enhanced surveillance and regular audits; and
 - checks that staff are familiar with, and have access to, documentation that is relevant to the safety critical tasks they are undertaking.
- e. checking that the RRVs supplied for use on rail are fully operational and compliant with Quattro's own maintenance documents (these should include physical equipment checks at their depots and on worksites).

continued

- 3 *The intention of this recommendation is that Network Rail and its rail plant suppliers should minimise the risk of runaways of RRVs that rely upon procedures for their safe operation.*

Network Rail should review the adequacy of existing measures to prevent RRV runaways of RRVs that are not yet fitted with direct rail wheel braking and implement necessary improvements. This review should consider reinforcing procedures, briefing and training associated with the safe operation of RRVs. Priority should be the prevention of RRV runaways, but consideration should also be given to the means of regaining control should a runaway occur (paragraph 160d).

- 4 *The intention of this recommendation is that Network Rail should review the scope of the compliance monitoring and assurance activities conducted upon, and by, its rail plant suppliers, and ensure that audits are more comprehensive.*

Network Rail should review the processes for audits of engineering safety management systems and the competence of technical staff that it conducts, or requires others to conduct, on rail plant suppliers. The objective of the review is to identify ways of improving the focus on engineering safety management and the quality of the end products. The findings of this review should be implemented and documented in revised management processes. In addition, Network Rail should take steps to improve the extent to which plant suppliers' own audits are directed in a similar manner (paragraph 162c).

- 5 *The intention of this recommendation is that the vehicle acceptance process applicable to modifications to RRVs should be more widely understood.*

Network Rail should:

- a. brief all suppliers of RRVs on the scope of the engineering acceptance process, and the importance of submitting accurate, vehicle-specific information to VABs when seeking acceptance of modifications to RRVs (paragraph 163); and
- b. clarify with all suppliers of RRVs, and vehicle acceptance bodies, the extent to which reliance on 'first-of-class' approval is appropriate when modifications are made to a number of different vehicles that fulfil the same functional requirement but are significantly different in their design (paragraph 164).

Appendices

Appendix A - Glossary of abbreviations and acronyms

MDU	Maintenance Delivery Unit
ORR	Office of Rail Regulation
PDI	Pre-Dispatch Inspection
RAIB	Rail Accident Investigation Branch
RPA	Rail Plant Association
RRAP	Road-Rail Access Point
RSSB	Rail Safety and Standards Board
T&RS	Traction and Rolling Stock
VAB	Vehicle Acceptance Body

Appendix B - Glossary of terms

First-of-class	The first item in a group which is used to demonstrate compliance with a standard or specification. Following items in the group are then accepted based upon their similarity to the first.
Machine controller	A person trained and authorised to control and supervise an item of on-track plant other than a rail crane.
Off-tracking	The process whereby a road rail vehicle transfers from rail to road, (on-tracking is the reverse of this process).
Rail Plant Association	An organisation representing rail plant suppliers.
RSSB	A not-for-profit company owned and funded by major stakeholders in the railway industry, and which provides support and facilitation for a wide range of cross-industry activities. The company is registered as 'Rail Safety and Standards Board', but trades as 'RSSB'.
Road-rail dumper	A vehicle incorporating a bucket for carrying materials that can operate both on the road and on the rails.
Safety critical system	A system, sub-system or component, the operation of which affects the safety of the machine or system of which it forms part.
Sentinel scheme	The system used by Network Rail for managing the competence of staff, including contractors, working in certain safety critical roles.
Vehicle acceptance body	A body accredited by the RSSB to assess the compliance of vehicles and related maintenance procedures with rail industry standards and issue certificates of engineering acceptance.

Appendix C - Key standards current at the time of the accident

'Competence and Training In On-Track Plant Operation', NR/L2/CTM/025, issue 1, September 2008	Network Rail
'Rail Industry Standard for Engineering Acceptance of On-Track Plant and Associated Equipment', RIS-1530-PLT, issue 3, March 2011	RSSB
'Rail Industry Standard for Safe Use of Plant for Infrastructure Work', RIS-1700-PLT, issue 3, March 2011	RSSB
'Assessment of On and Off Tracking Procedure', TN-038, issue 1, October 2008	RSSB
'Code of Practice for Audit Protocol for Supply of Possession-only Rail Vehicles with and without Operators', AP0001, issue 4, October 2011	M&EE Networking Group (available at www.rgsonline.co.uk)

Appendix D - RSSB's description of its sponsored project on supplier assurance for mainline railways in Great Britain

This project has identified widespread duplication of paper based audits, confusion by clients over the level of assurance offered by Link-up and other interventions and the absence of a coordinated and risk based industry approach to the assurance of its supply chain. In response the RSSB sponsored project is seeking to develop with our members and the wider supply chain, new arrangements to improve the efficiency and effectiveness of industry arrangements as below:

1. Rail Industry Commodity Classification Listing (RICCL) – based on international standards, this will provide a common definition of products and services procured by the GB rail industry using a structure based on rail system and sub-systems.
2. Supplier hazard assessment – designed to be used in conjunction with the above, this tool contains a risk based methodology to consistently assess and record the level of risk imported by the supplier of all products and services to the GB mainline railway.
3. Assurance requirements – designed to be applied following the HAZID assessment, this will specify the minimum assurance requirements to be adopted by GB rail clients.
4. Recognition of existing schemes – this guide for clients and suppliers will identify which of the current third party supplier assessment schemes can efficiently meet the minimum assurance requirements specified above (eg Link-up, RISAS, IRIS, ATOC 1003).
5. Rail Industry Standard – currently being drafted the new RIS will provide clients and suppliers with an understanding of how to adopt the above in to their safety managements systems and thereby deliver a more coordinated and risk based framework towards the assurance of suppliers across the whole rail supply chain.

In support of the above, the Board of RSSB has also recently authorised the establishment of new governance arrangements for the long standing Link-up scheme under the Rail Industry Supplier Qualification Scheme (RISQS) Board and this new governance body has started a programme of work to modernise the long standing Link-up scheme to support the new RIS and arrangements described above.

Item 1, above is complete.

Items 2, 3 and 4 are in progress with the Procurement Risk Management Procedure (PRMP) developed in conjunction with industry and tested on Traction and Rolling Stock (T&RS) brake system products and services defined in the RICCL. Plan developed for PRMP application by RSSB to all remaining T&RS sub-systems, expected completion summer 2014.

Item 5 is in progress, expected completion in summer 2014, subject to Industry consultation.

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