



Rail Accident Investigation Branch

Rail Accident Report



**Derailment at Trooperslane near Carrickfergus,
Northern Ireland
23 April 2006**

This investigation was carried out in accordance with:

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

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Derailment at Trooperslane near Carrickfergus, Northern Ireland 23 April 2006

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Introduction

- 1 The sole purpose of a Rail Accident Investigation Branch (RAIB) investigation is to prevent future accidents and incidents and improve railway safety.
- 2 The RAIB does not establish blame, liability or carry out prosecutions.
- 3 Access was freely given by Plasser & Theurers and Northern Ireland Railways to their staff, data and records.
- 4 Appendices at the rear of this report contain glossaries:
 - acronyms and abbreviations are explained in Appendix A; and
 - certain technical terms (shown in *italics* the first time they appear in the report) are explained in Appendix B.
- 5 The RAIB found slight discrepancies between the time recording systems in the *track circuit* records and the mobile phones. All times have been reconciled and are given in British Summer Time (BST).
- 6 Distances are quoted in miles and metres as is the convention on Northern Ireland Railways.

Summary of the report

Key facts about the incident

- 7 On Sunday 23 April 2006, a Northern Ireland Railways (NIR) engineering train, head code 1C93 departed York Road depot in Belfast on the *down* Larne line en route to a planned possession at Whitehead (see Figure 1).
- 8 The train consisted of a Plasser & Theurer 08 series *tamper* towing a Plasser & Theurer USP Type 3000 *ballast regulator*.
- 9 At approximately 09:17 hrs whilst travelling at 33 mph (54 km/h), the train travelled over Trooperslane Manually Controlled Barrier (MCB) crossing located immediately prior to Trooperslane Station (Figure 1). The torque arm of the ballast regulator, which had become partially detached, hit the road surface panels of the crossing, causing the derailment of the ballast regulator.
- 10 The tamper did not derail but suffered major damage during the incident.



Figure 1: Extract from map showing location of incident at Trooperslane

- 11 The ballast regulator had just emerged from a 3-month maintenance program which also included some refurbishment at York Road depot (Figure 2). The incident journey was its first operational use since that work had been completed.



Figure 2: Belfast to Larne harbour showing York Road depot

Immediate cause, causal and contributory factors

Immediate cause

- 12 The immediate cause of the derailment was the torque arm lifting the ballast regulator off the track after it hit Trooperslane level crossing deck.

Causal and contributory factors

- 13 The omission of the split pin from the upper torque arm securing pin is the sole causal factor in the derailment.
- 14 The lack of a check process on the torque arm security is a contributory factor to the derailment.
- 15 The lack of a cross reference to the Plasser & Theurer Operations manual within the *Vehicle Maintenance Inspection (VMI)* process and the lack of a specific VMI document relating to ballast regulator 315, and particularly the lack of reference to the torque arm, is a contributory factor to the derailment.
- 16 The installation of two bolts, where the torque arm meets the headstock, where a single failure could cause catastrophic result, is the underlying cause of the derailment.

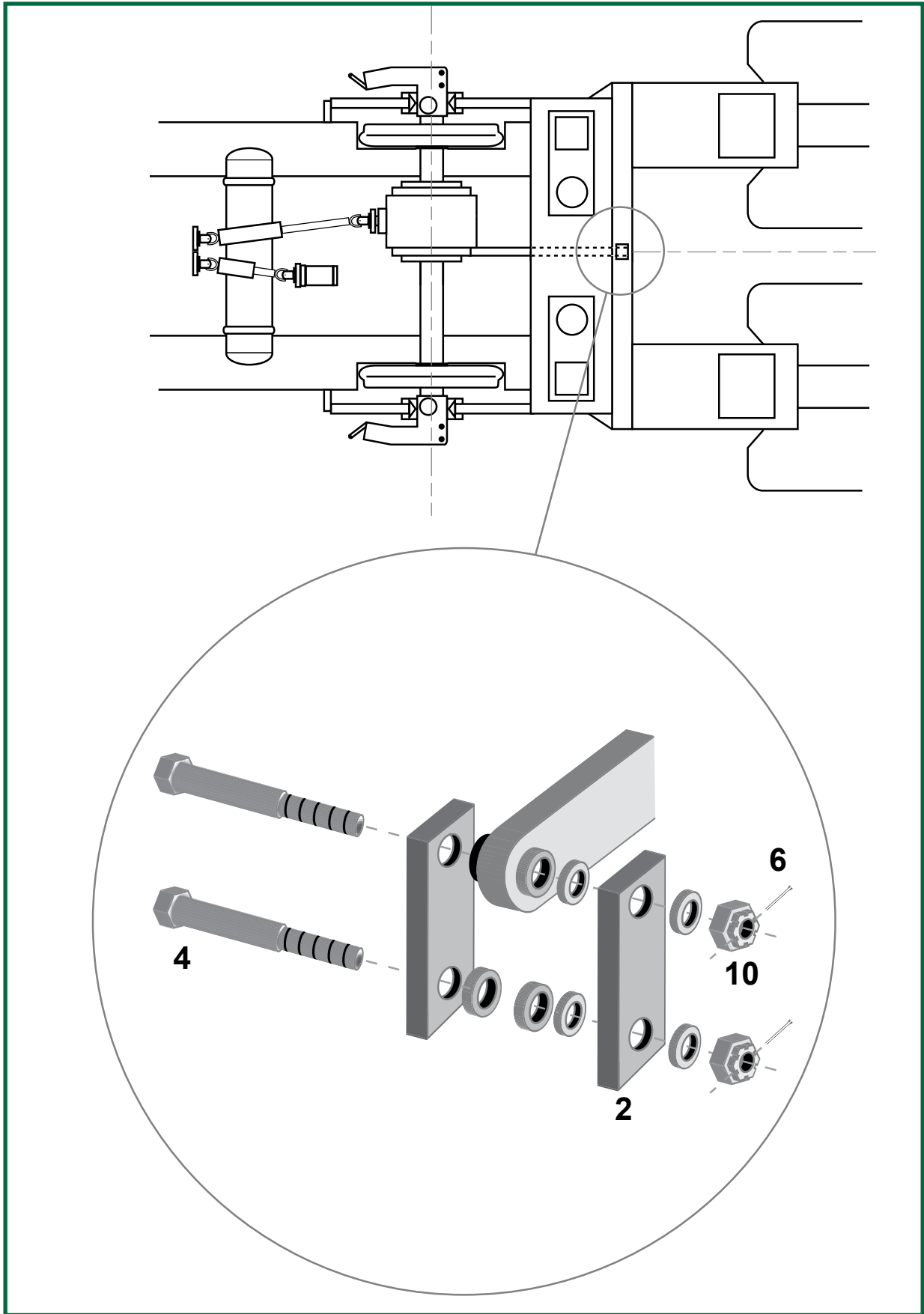


Figure 3a (above): plan view of underside of ballast regulator showing the torque reaction arm assembly attached to the front axle and headstock bracket

Figure 3b (below): Assembly diagram of torque reaction arm anchor fixings. The pin (4), castellated nut (10) and split pin (6) arrangement is duplicated at the top and bottom of the fishplates (2)



Figure 4: Trooperslane crossing with rear aspect of ballast regulator 7003



Figure 4a: Point of Derailment (POD) showing sleeper zero

Severity of consequences

- 17 There were no serious injuries but the guard suffered shock and bruising and bruising to his body.
- 18 The tamper, ballast regulator, track and sleepers leading to the crossing and the level crossing itself were damaged.
- 19 The Environmental Agency attended the site as a result of diesel spillage which had leaked due to the puncture of the tamper and ballast regulator fuel systems by material from the crossing.
- 20 Train services were disrupted on the day of the incident; single line working was introduced the following morning.

Recommendations

- 21 Recommendations can be found in paragraph 229. They relate to:
 - NIR maintenance procedures;
 - fitting restraining systems to all operational vehicles with a torque reaction arm of the incident type;
 - issue of operational documents;
 - the training and development of NIR engineering and infrastructure staff, in particular on methods of communication;
 - towing on track plant;
 - fitting of on train monitoring and recording systems to on track machines;
 - issues relating to NIR relations with the RAIB after an incident; and
 - access rights for Plasser & Theurer to the National Incident Reporting database to ensure safety information is briefed efficiently.

NIR have already begun to address and completed many of the above points (paragraph 227).

The Incident

Summary of the Incident

- 22 On Sunday 23 April 2006, a Northern Ireland Railways (NIR) engineering train, head code 1C93 departed York Road depot in Belfast on the *down* Larne line en route to a planned possession at Whitehead (see Figure 2).
- 23 The train comprised of an 08 series tamper number 2673 towing a USP Type 3000 ballast regulator, number 315 (Figure 5). The train was crewed by a driver in the tamping machine and a guard in the ballast regulator.
- 24 At approximately 09:17 hrs whilst travelling at 33 mph (54 km/h) the train travelled over Trooperslane MCB crossing located immediately prior to Trooperslane station. The torque arm of the ballast regulator, which had come partially detached, hit the road surface panels of the crossing causing the ballast regulator to derail.



Figure 5: Ballast regulator 315 at Trooperslane station following derailment. The headstock on which both the towing brackets and anchor bracket are mounted is painted black (insert). A displaced road crossing block originating from the level crossing is shown in the background wedged beneath the vehicle

The parties involved

Northern Ireland Railways

- 25 NIR was formed in 1968. It is a subsidiary of Northern Ireland Transport Holding Company (NITHC) and the owner, maintainer and operator of the ballast regulator and tamper. The *driver*, shunter and guard are employed by NIR.

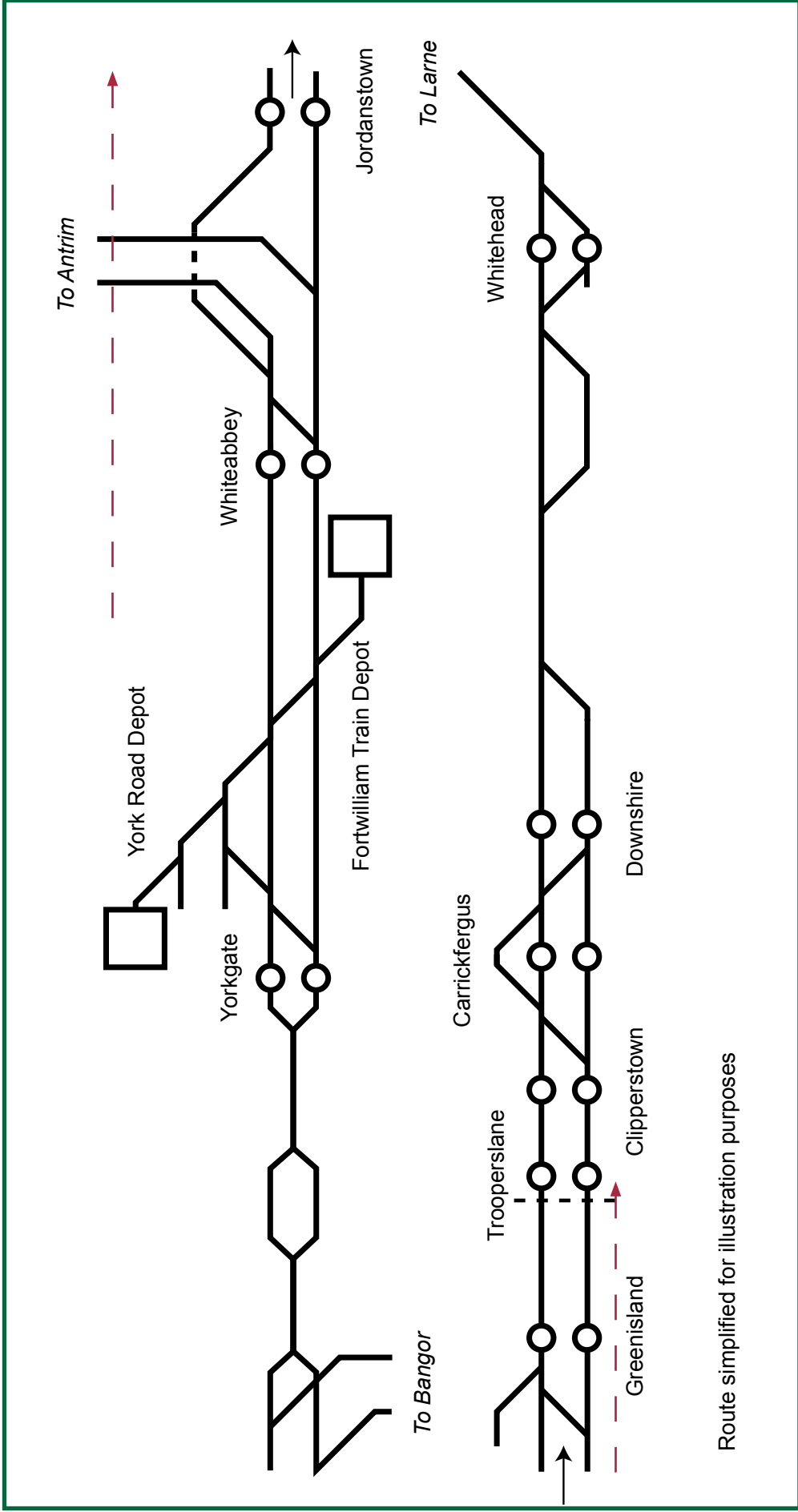
- 26 NIR is made up of a number of sub divisions, two of which are:
- rail operations;
 - infrastructure and property (maintenance and renewals, including infrastructure staff).

Plasser & Theurer

- 27 Plasser & Theurer Export von Bahnbaummaschinen Gesellschaft mbH is an international company specialising in supplying on track plant (OTP) and machinery. They manufactured and supplied the tamper and regulator involved in this incident.
- 28 Plasser Machinery Parts and Services Ltd supply parts and offer a maintenance service to track and civil engineering companies. They archive records relating to OTP at their branch in West Ealing, London and also with the parent company in Austria. They provided these services to NIR for the tamper and regulator involved in this incident.

Location

- 29 The current NIR network is 210 track miles (342 km) long. The locations on the railway are measured in miles and metres from Belfast Great Victoria Street Station.
- 30 The Belfast Great Victoria Street to Larne line passes through Belfast Central Station and heads towards Larne. Small but frequently used stations are located along the route (Figure 6).
- 31 Greenisland Station is 6 miles 1004 metres, Trooperslane Station 7 miles, 1370 metres and Trooperslane level crossing 7 miles, 1362 metres from Belfast Central station, all on the Larne line.
- 32 The alignment east of Greenisland station is straight, transitioning into a large radius right hand curve as the line heads towards Trooperslane. There are three UWC crossings on the approach to Trooperslane Station. These are:
- UWC crossing X301 (7 miles 163 metres) also referred to by witnesses as Wilson's or 'Sammy Steel's crossing.
 - UWC crossing X304 (7 miles 799 metres) also referred to by staff as 'Barrs 1' crossing.
 - UWC crossing X305 (7 miles 1078 metres) also referred to as 'Barrs 2' crossing (refer to Figure 7).
- 33 Trooperslane level crossing is an MCB crossing controlled remotely by a signaller at Belfast Central Station.
- 34 The crossing is interlocked with the crossing signals. It is not possible to clear the protecting signals unless the barriers have been lowered or to clear the signals until the barriers have been raised. The barriers extend across the full width of the road. The crossing is monitored by CCTV cameras from Belfast Central Signalling Centre to allow the signaller to check that the crossing is clear prior to the passage of trains. The CCTV does not record images.
- 35 The crossing is constructed of rubber road surface panels inset between the rails with galvanised steel restraining frames at each end. Outside of the restraining frames and in common with other level crossings in this area, longitudinal triangular section timbers are provided to act as a cattle grid to prevent animals and discourage trespassers from entering onto the line from the crossing.



Route simplified for illustration purposes

Figure 6: Track diagram showing York Road depot and route taken by Tamper and regulator

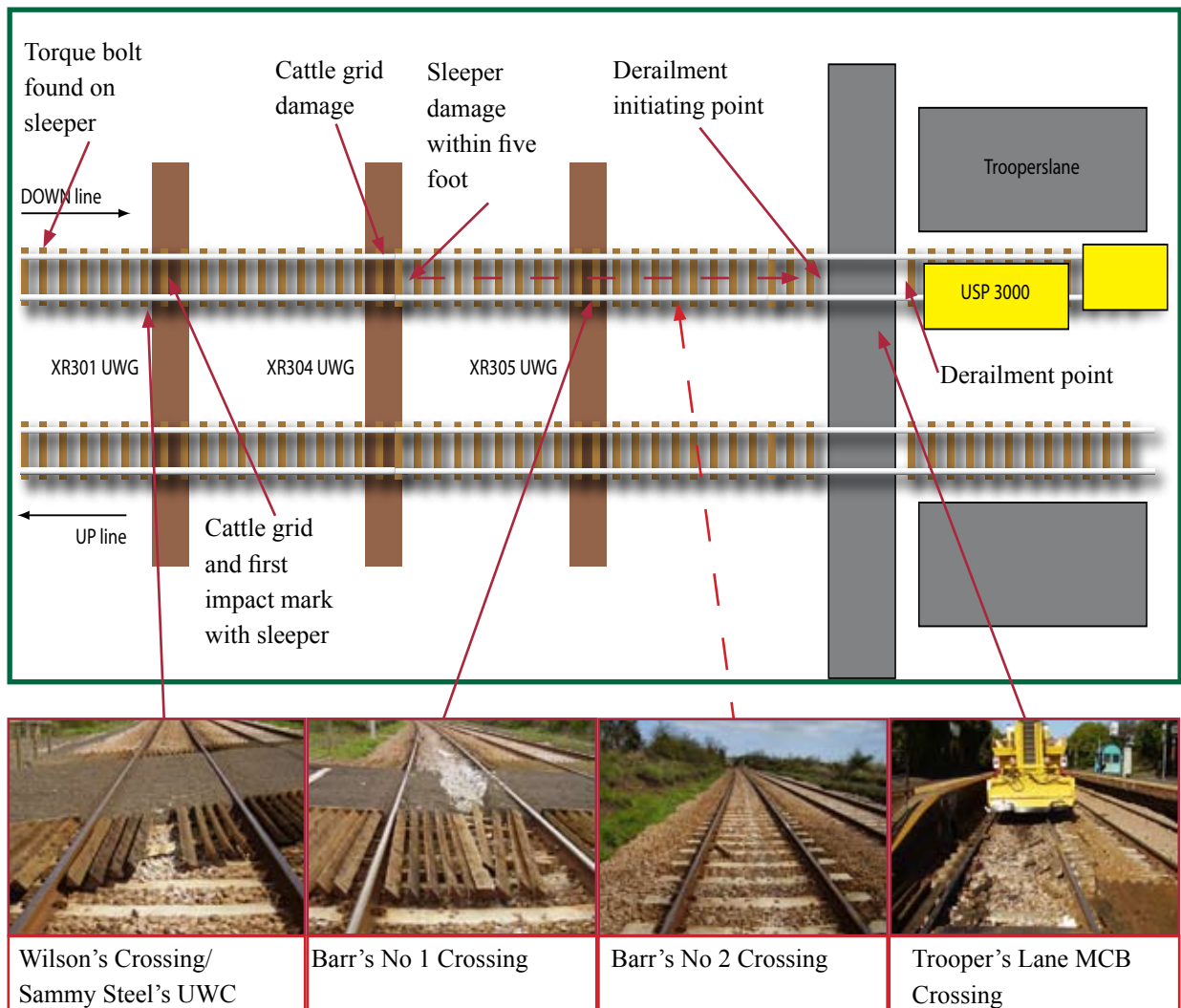


Figure 7 Detailed diagram showing immediate incident route prior to derailment

Solid State Interlocking (SSI)

36 The line has *three aspect signalling* and is controlled by *solid state interlocking (SSI)* operated under *track circuit block* rules. The signallers and line controllers are located at Belfast Central Station (see paragraph 162 - Track circuit data analysis).

Track

- 37 The double track is constructed of British Standard 113A flat bottom rail on concrete sleepers in the vicinity of the derailment.
- 38 The track between Bleach Green Junction (4 miles 1250 metres) and Greenisland was renewed during 2005 with new sleepers and ballast.
- 39 There is no evidence that the condition of the track contributed to the derailment.

External circumstances

40 There were no geographical or environmental factors which had any effect on the incident. The weather at the time of the incident was clear, warm (65 degrees Fahrenheit / 18 degrees Celsius), dry and bright with patchy cloud.

Events preceding the incident

- 41 Prior to the incident the ballast regulator had not been in operational use for approximately 12 months, having been laid up at Larne Harbour following a clutch and gearbox failure. Following initial gearbox and attempted clutch repairs, it was transferred to York Road depot in Belfast on the 12 January 2006. Maintenance work commenced on 20 January 2006 which included the renewal of the clutch and repainting of the unit.
- 42 Maintenance work on the ballast regulator was completed on the 20 April 2006.
- 43 On 21 April 2006 the tamper and ballast regulator were coupled together on 5 road in the diesel shed. Other types of rolling stock were later stabled within the depot effectively blocking the tamper and regulator's exit from the depot. This blockage caused a delay on the day of the incident.
- 44 The tamper and ballast regulator were due to be used on a planned *possession* at Whitehead on the 23 April 2006. Ballast regulator no. 315 was to be used because of its small size and manoeuvrability on the *permanent way*.

Events during the incident

- 45 The tamper driver had previously been on a period of annual leave followed by a rest day on Saturday 22 April 2006.
- 46 On Sunday 23 April 2006 the tamper driver was scheduled to work a 12 hour duty. At 07:00 hrs he allegedly met the guard at Larne and travelled by road vehicle to Coleraine. He picked up his copy of the *Weekly Operating Notice* (WON) and together they made their way to the depot at York Road to prepare the train.
- 47 The guard had been on night duty the previous week followed by a rest period prior to working his rest day on the 23 April 2006. He was scheduled to work a 10 hour duty and was in possession of the WON.
- 48 The guard and the tamper driver are alleged to have arrived at York Road depot at approximately 07:30 hrs. The train was due to leave the depot at 08:00 hrs for the possession to commence at 08:30 hrs. The tamper driver found the train's exit route out of the depot blocked by three other units.
- 49 Prior to the tamper driver's arrival at the depot, a *shunter* coupled the tamper and ballast regulator together, using a draw bar, to form engineering train 1C93.
- 50 The guard and tamper driver were joined by the driver of the ballast regulator and together they checked the oil, water, fuel, brake system, tamper clearance indicators and handbrake on both units. Although this was carried out there was no documented process to show these checks were completed.
- 51 The three units stabled in front of the tamping machine and ballast regulator were shunted from number 5 road to enable the train to leave the depot. The crew then removed the wheel *scotch* from the rails and the train was then taken to the fuel point within in the depot.
- 52 The brakes on the ballast regulator were operational but there was no *through air brake* from the brake system of the tamper. The ballast regulator was effectively being towed without continuous brakes to the possession, using the draw bar.
- 53 The ballast regulator driver then left the tamper driver and guard at the depot and travelled by road vehicle to the possession location at Whitehead.

- 54 The obstruction of the train caused by the presence of the other units and the time taken for train preparation delayed the train from leaving the depot by approximately 50 - 55 minutes. It was therefore late for the planned start time of the possession.
- 55 NIR rule book, instruction 104a, mandated a radio test message to the signaller to be completed by the driver prior to the use of any rolling stock on the network. The tamper driver maintains he made a test call from the tamper whilst en route to Whitehead with no response. There was no record of a radio communication test call on the systems that record all telephone and radio conversations to the signaller and controller. The radio communication centre equipment was investigated and tested after the incident and found to be working correctly.
- 56 The tamper and ballast regulator both had cab radio systems to contact the signaller, controller and other train units. However, there was no process that required the radios between the units to be tested. The cab radio in the regulator was not working, but this was not discovered as there was no test.
- 57 No formal arrangement for communication for the journey was agreed between the driver and the guard. This arrangement is not specified in the NIR rule book.
- 58 The tamper driver was in possession of a mobile telephone supplied to him by NIR. The guard was in possession of his personal mobile telephone.
- 59 The tamper driver telephoned the signaller at 08:58 hrs to request permission to leave the depot and enter the down Larne line. After receiving permission and the proceed aspect on the exit signal, the train departed York Road depot at approximately 09:00 hrs. On exit, it proceeded onto the down Larne line en route to Whitehead.
- 60 The tamper driver was in the leading cab of the tamper and the guard was riding in the ballast regulator cab. The guard's duties, as specified in his job description, included the operation of the hand brake of the ballast regulator as required.
- 61 The train passed through Greenisland station travelling at an estimated speed of 25 mph (40 km/h). The tamper driver observed a single yellow aspect at signal CL 455 on the approach to X 301 UWC and received a single yellow aspect, which changed to a green aspect, as he approached signal CL 457 on the approach to Trooperslane Station.
- 62 As the train passed over crossing X301 (7 miles 163 metres) (Figure 7) the guard became aware of bad riding of the regulator. Ballast and chippings from the crossing sprayed out and upwards from around the front axle towards the ballast regulator cab. He initially thought this had been caused by person(s) unknown throwing stones at the cab.
- 63 The train passed over UWC crossing X304 (7 miles 799 metres). The guard and tamper driver were not aware of any bad ride taking place here.
- 64 As the ballast regulator passed over UWC crossing X305 (7 miles, 1073 metres) the guard was thrown out of his seat onto the cab floor. At 09:14 hrs he attempted to contact the tamper driver using his personal mobile telephone. The call lasted 9 seconds as the call request was registered but the connection was unsuccessful. This was due to the poor signal strength in the area when the mobile telephone call was made.
- 65 The driver continued towards Whitehead unaware of the above incident taking place. The guard did not use the horn to alert the tamper driver or apply the handbrake on the ballast regulator because he did not feel confident, and because he felt that the application of the handbrake may cause a *risk* of derailment (see paragraph 172).

- 66 At Trooperslane crossing the regulator once more was subject to a violent impact, and derailed towards the *six foot*. At this point the tamper driver recognised that something was amiss because of the very bad ride and applied the emergency brakes. The tamper travelled a further 9 metres. The rigid towing bar between the tamper and the ballast regulator was wrenched free distorting the link pin and bracket (see Figure 5).
- 67 The guard made a successful mobile telephone call at 09:17 hrs to the tamper driver advising him that the train had derailed.
- 68 The tamper, ballast regulator, track and sleepers leading to the crossing and the level crossing itself were damaged.

Events following the Incident

- 69 Following the incident at 09:17 hrs the tamper driver implemented emergency procedures and took charge of protecting the down line. He instructed the guard to protect the line using *detonators*. The tamper and derailed ballast regulator did not obstruct the *up line*.
- 70 The tamper driver used his mobile telephone at 09:17 hrs to speak to the on-call Permanent Way Inspector. No radio or telephone communication to protect the line was made or recorded between the driver and signaller at this time.
- 71 The signaller, who had no knowledge of the incident, raised the crossing barriers for road vehicle access. No motor vehicles were present when the barriers were raised.
- 72 At 09:19 hrs the tamper driver used his mobile telephone to contact the duty controller in the control office at Belfast Central station. The tamper driver was unable to contact the duty controller. A message was left with a person acting as a second line 'controller' who at the time of the call did not introduce or identify himself. The tamper driver did not state it was an emergency call and safety critical communication methods were not adopted.
- 73 At 09:19 hrs the tamper driver telephoned the signaller at Belfast and advised him of the incident and location of the vehicles. The incident was recorded on the signalman's register at 09:22 hrs. All lines were blocked. Safety critical communication methods were not followed.
- 74 No emergency services were called or responded. NIR appointed a Rail Incident Officer (RIO) and investigation team to manage the incident.
- 75 On call duty staff were appointed to introduce single line working by the use of a *pilotman* on 23 April 2006. The Larne line was fully reopened on the 24 April 2006 at 14:20 hrs
- 76 The tamper and ballast regulator were recovered to York Road depot on 24 April 2006. The torque arm was removed from the front axle for detailed examination and analysis by the RAIB.

The Investigation

Investigation process

- 77 The investigation process examined the following issues;
- operational issues during and after the incident;
 - maintenance and refurbishment of the ballast regulator prior to its operational use; and
 - the design of the ballast regulator gear box torque arm.

Sources of evidence

- 78 Evidence was gathered from a number of sources:
- examination of the site, rolling stock, the point of derailment and damage preceding the point of derailment from Greenisland Station to Trooperslane;
 - interviews with NIR and Plasser and Theurer staff;
 - examination of the rolling stock and review of maintenance and refurbishment works of the ballast regulator at York Road depot;
 - image data from the last passenger train preceding the incident;
 - signalling data;
 - voice recordings;
 - NIR's operational and incident management procedures;
 - examination of the damaged torque arm and the securing pin found on site;
 - chemical analysis of the oil, grease and debris recovered between Greenisland and Trooperslane MCB, the torque arm, the *headstock* bracket and the securing pin; and
 - examination of the Plasser & Theurer Machinery and Parts Ltd design processes and documentation relating to the torque arm on the USP 3000 ballast regulator.

Key facts

Rolling stock

Tamper 08-164SH no. 2673

- 79 The leading vehicle was tamper 08-164SH number 2673, manufactured by Plasser & Theurer.
- 80 The *train-radio* on the Tamper was working correctly.
- 81 The tamper suffered consequential damage from the incident. Several parts of the road surface panels became embedded in the tamper under frame. Wooden cattle grid stakes that had lifted and spilt and were also found within the tamper under frame and hanging beneath the vehicle bodywork.
- 82 The tamper had its torque support arm bent, its hydraulic tank, hydraulic pipes and fuel pipes ruptured and its alternator and pneumatic pipe work damaged as a result of this incident.

Ballast Regulator 7003 USP 3000 C. number 315

- 83 The derailed vehicle was ballast regulator 7003 type USP 3000C machine number 315 manufactured in 1978 by Deutsche Plasser, Freilassing, now Plasser & Theurer of Linz, Austria. The machine was purchased by NIR from the manufacturers in 1978.
- 84 The USP 3000 regulating machine was the first ballast regulator designed and manufactured by Plasser & Theurer. The machine was designed to pick up or 'sweep' excess ballast from the track, which is stored in a hopper for distribution in areas where it is required.
- 85 The machine is self propelled, running on two axles with a welded steel body. The driver's cab is mounted on the chassis. The driver's chair is fixed so that it faces to the left as viewed facing the direction of travel. The machine can be towed with the clutch and gearbox disengaged.
- 86 A mechanical drive with six speed gear box allows for speeds of 47 mph (75 km/h) to be attained. A hydrostatic drive powers the machine whilst working. The machine has air activated disc brakes on all wheels. There is a handbrake which acts upon two wheels, and this is also used as a parking brake.
- 87 The regulator's radio was found to be faulty after the incident. No record relating to a fault report for the radio had been submitted whilst the machine was being maintained and overhauled at York Road Depot.
- 88 There is no visual contact between the ballast regulator and tamping machine cabins when coupled as on the 23 April 2006.
- 89 The ballast regulator was found to have suffered substantial damage after the incident. The torque arm was severely bent, the hydraulic tank and pipe work were ruptured, and several other components were bent by the derailment.

History of Approval and records

- 90 Plasser & Theurer retain records of machines that they have built, in accordance with the Product Liability Directive (EEC 374/85 as amended by EEC 34/1999 issued on 4 June 1999). Records are retained for ten years after manufacture of a product has ceased. Archived records after this 10 year period are only retained by Plasser & Theurer if a machine type is known to be operational. This additional process is dependant on details published within recognised on track plant almanacs, published by independent bodies, and company records relating to clients' order requirements for spare parts and maintenance.
- 91 Plasser & Theurer machinery is sold and resold by other companies in the UK and worldwide.
- 92 USP 3000 regulators were designed and manufactured in the 1970s and Plasser and Theurers considered that they had an operational lifespan of 10 years, although no published documentation to support this has been forthcoming. Current plant has a much longer lifespan if manufacturer's recommendations for maintenance is followed.
- 93 It is not clear if any other USP 3000 regulators have operated in the rest of the UK, but there have been none in service there for at least twenty years.
- 94 At the time that NIR acquired the regulator in 1978 there were no vehicle approval processes equivalent to the *Vehicle Acceptance Board* (VAB) approval process, introduced into the UK from 1994 onwards. Although NIR have now introduced such processes, in common with other UK Railways, they were not applied to stock already in service and the ballast regulator was being operated on NIR under *Grandfather Rights*.

- 95 Plasser & Theurer stated that they did not know that any USP 3000 regulators remained in operational use; they thought them to be extinct.
- 96 During 2004 NIR ordered parts specifically relating to the USP 3000 ballast regulator from Plasser & Theurer, and Plasser & Theurer responded to the orders in writing.

Torque arm design

- 97 The gearbox drives the rotation of the regulator’s wheels. This creates an opposing torque, and this is resisted by a torque arm that prevents the gearbox from rotating (Figure 8).
- 98 The torque arm is attached to the axle of the ballast regulator which was leading in the direction of travel on 23 April 2006. The torque arm extends forward from the axle to the front of the machine where it is held by the headstock (Figure 9).

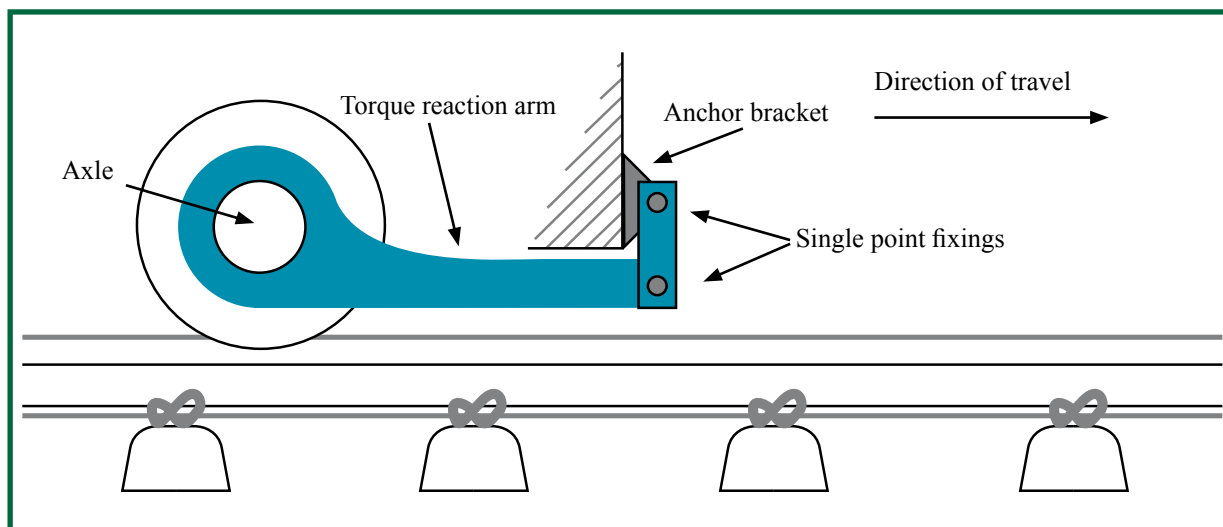


Figure 8: Schematic cross-section through regulator viewed from right in direction of travel. The torque reaction arm is shown in position linking powered axle to anchor bracket mounted on headstock

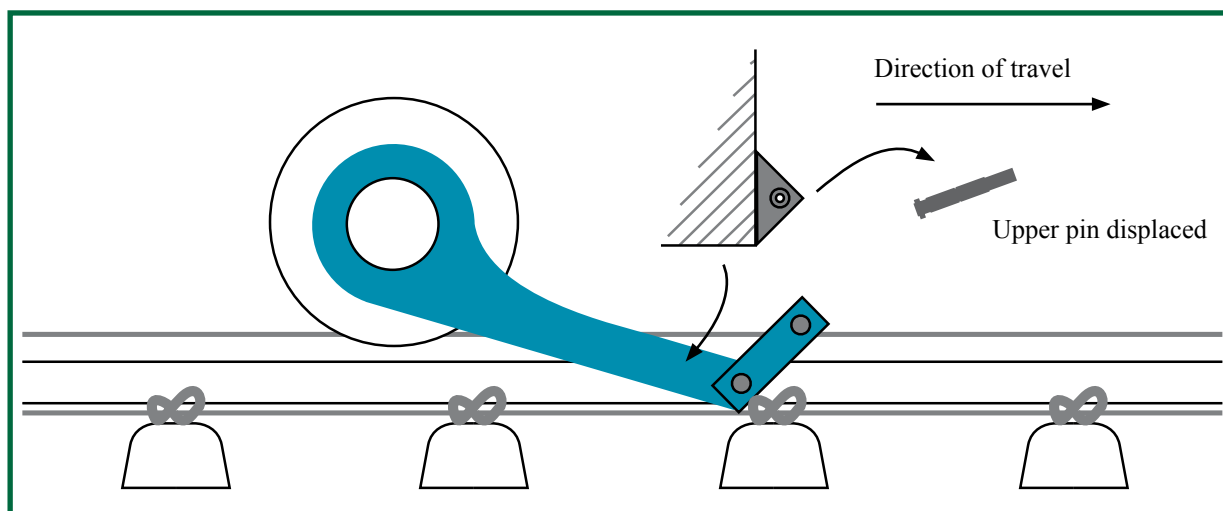


Figure 9: Schematic cross-section through regulator viewed from right in direction of travel showing torque reaction arm impacting on a sleeper following loss of the upper pin.

- 99 The headstock end of the arm is retained by two securing pins which pass through the torque arm and the headstock bracket. Each securing pin is secured by a *castellated nut*. The nut is in turn prevented from working loose by a split pin through the castellations of the nut and the securing pin (see Figures 12, 15 & 16).

100 Later designs of machine either have a 'wishbone' type end to the torque arm, the sides of which are on either side of a fixed stop on the chassis; or the torque arm is designed to be much shorter in length. Should either type become detached, its movement is restricted by the bogie or the underframe, so the torque arm cannot drop and cause a derailment.

Torque arm examination

101 When the ballast regulator was examined after the derailment on 3 April 2006, the upper securing pin and associated castellated nut and split pin were missing.

102 Failure of the securing pin, headstock bracket, fixings or torque arm will lead to the partial detachment of the arm, thus posing a derailment risk. There is no secondary restraint for this arm to mitigate this risk.

103 The headstock of the machine, on which the anchor bracket is mounted, was originally painted yellow in colour and was repainted black one week before the end of the maintenance work on the 20 April 2006. NIR have no record or knowledge of the presence or loss of the upper split pin and castellated nut at this time.

104 Samples of paint and grease were taken from the damaged area of the torque arm and headstock bracket to enable positive identification of the relationship between components. The previous yellow coloured paint was still visible on the headstock and the head of the lost pin recovered from site.

105 A pin similar to the securing pin was found in the track at 7 miles 46 metres on the approach to UWC crossing X 301, where the poor riding commenced (see paragraph 124).

106 The recovered pin was to specification and identified as the correct type for the torque arm assembly. Forensic examination of the site debris, the pin and the evidence recovered from the damaged torque arm found similar materials in all three, and indicated that this was the missing upper securing pin (see Figure 10).

107 Neither the castellated nut nor the split pin were found despite an extensive search between Trooperslane and York Road.

108 The torque arm and the lower securing pin were heavily damaged, with ballast, wood, grease and concrete debris visible on the end of the arm. The lower securing pin and castellated nut were damaged but secure and were to the correct specification. The split pin was in place and visible; it had been spilt in the correct fashion around the castellated nut.

109 Wood debris from the cattle grid stakes was visible in the crown of the lower castle nut. Fresh marks were visible around the mating surface of the holes of the upper bracket. The securing pin is slotted through the bracket and the headstock to secure the torque arm. The marks (Figure 10) indicated that the mating surfaces of the pin and castle nut had been in position for sometime before the incident and corroborate the pin being released just prior to UWC crossing X 301.

110 The recovered upper securing pin has a thread diameter of 20 mm and was to specification. Visible 'chatter and rocking' witness marks in grease were present in the 'as found' condition. The varying frequency of the witness marks on the shaft of the bolt indicate an initial slow release and 'rocking' motion between the torque arm and the headstock. This is likely to have occurred at low speed as the train left the depot.



Figure 10: Image of securing pin found on site

- 111 There is evidence of rotation as well as wider ‘chatter / rocking’ marks along the shaft of the pin indicating a quicker release as the train increased its speed en route to Whitehead. Vibration between the arm and the headstock bracket caused greater movement to take place and the dimensions between the pin and the headstock bracket increased. The top pin eventually came apart from the bracket and the torque arm dropped hitting the track.
- 112 The thread of the securing pin had been contaminated from ballast. This was caused as the pin collided with the ballast and sleepers after its release. This contamination was ‘fresh’ in appearance and still attached to the tips of the thread indicating it had been recently connected to the pin. There was slight damage to the thread, which was probably caused at the same time; any damage to the tip or root of the thread of the pin prior to the incident would have prevented the nut being fitted or released.
- 113 The tips and root of the thread were also contaminated with uncontaminated grease residue and free of any significant geological debris. The lack of significant amounts of dirt at the thread root also indicates that the castle nut (20 mm diameter) would have been in good order and in place shortly before the incident.
- 114 The castellated nut is designed to be held tight by a 4 mm diameter split pin. There is no torque specified in the Plasser & Theurer manual to secure the castle nut. It is presumed by fitters that installation is ‘spanner tight’.

- 115 A microscopic examination of the securing pin was undertaken. The area surrounding the drilled 5 mm diameter hole for the split pin to be located was examined. Traces of layered yellow paint from previous applications were visible around the orifice. There were also traces of oxidation which had formed in and around the drilled hole. Ballast, micro-vegetation (pollen), paint and oxidation debris was undisturbed and had not been cross contaminated by the presence of a split pin, which would have 'wiped' the inner surface clean if it had come into contact with the hole (Figure 17).
- 116 The dry weather and environment on the day of the incident would not have created the oxidation around the hole.
- 117 There was no damage to the pin or threads around the drilled hole. There were no traces of any debris from a split pin or evidence supporting the possibility that the drilled hole had suffered any impact damage caused by a split pin shearing or fracturing.

Trooperslane area

- 118 The impact from the forward motion of the ballast regulator caused the Belfast end cattle grid and the level crossing to compress against the panel frame.
- 119 The remaining cattle grid frame adjacent to the down line platform at Trooperslane Station compressed and became detached from its fixings. It then splintered and pierced the underside of the tamper and the ballast regulator. This resulted in damage to the hydraulic components and fuel pipes of both vehicles.
- 120 A total of four road surface panels were lifted as the ballast regulator travelled over the crossing, and the remainder of the crossing deck located in the *five foot* was shifted sideways and forward by 500 mm towards Larne.
- 121 The point of derailment was taken as a mark when the wheel dropped into the five foot. This was defined as sleeper '0'. This was preceded by a climb mark on the six foot rail at sleeper 2, followed by grooves on the sleeper caused by the derailed wheel flanges from sleeper -2 onwards (Figure 4a). Damage to the *Pandrol clips*, *rail pads* and sleeper damage into the six foot was also visible.
- 122 The ballast regulator remained upright coming to rest within the six foot, clear of the up line, 14 metres beyond the crossing and supported on the displaced road surface panels from the level crossing.

Trooperslane - York Road area

- 123 The cattle grids either side of the UWC X301, 304 and 305 had fractured and splintered, which corroborated witness testimony about the chippings and ballast hitting the underside of the regulator at UWC crossing X301 and the bad ride encountered from there to Trooperslane (See Figures 7 and 11).
- 124 The securing pin was found at 7 miles 45 metres (see paragraph 105) in the *cess* side of the running rail of the down line on a concrete sleeper.
- 125 There was no damage to the track between the immediate area of UWC X301 and 6 miles 1700, nor between that point and York Road depot
- 126 A track walk and visual search for the missing castellated nut and split pin was undertaken between York Road depot and 7 miles 46 metres but they were not located.

Image and signal data

Rolling stock image data

127 Digital image data from a camera fitted to the front of the previous service train from Belfast to Larne confirmed that at that time no obstructions were visible on the line which may have caused a collision or impact with the underside of the tamper or regulator headstock.

Signal centre data

128 The signaller within the Belfast Signal Box did not observe the incident on the monitors for the MCB at Trooperslane. There is no requirement for the signaller to observe the CCTV other than when lowering the barriers. The system is for 'live' use only and does not record onto tape or disc.

129 The signalling aspect data was not investigated as it played no part in the incident. The track circuit data was analysed (see paragraph 161).



Figure 11: Torque arm damage seen when regulator lifted on site

Communication

130 Voice recordings of communication between the tamper driver and signaller were analysed (see paragraphs 69 - 73).

NIR Instruction 104 A Train radio test procedure

131 NIR Operating instruction 104A, (paragraph 55), was issued on 21 June 2004. This information was included in the WON for the planned possession on 23 April 2006.

132 The driver stated that he was not aware of document 104A relating to the NIR radio test procedure even though he also stated that he made such a call.

General safety critical communication

133 The Rule Book is a joint *Iarnrod Eireann* and Northern Ireland Railways document.

134 Rule Book *Section's 'A' and 'M'* procedure mandate that the signalman must be contacted immediately after an incident or accident and *safety critical communication* must be carried out.

135 Analysis of the recordings of telephone and radio communication showed that the method of communication of safety critical information was not completed in accordance with NIR Rule book standard Section M, when the driver spoke to the Permanent Way Inspector, Controller and the Signaller (paragraphs 69 - 73).

136 Section M 3.1.2 states:

‘(h) The signalman must be contacted immediately or within 30 seconds by train radio if possible.

Otherwise use a telephone or mobile phone which is immediately available.’

137 The remaining parts of Section M relates to other types of incident and the requirement to contact the signalman immediately.

138 The guard and driver had not received any refresher training in the recognised emergency call procedures in accordance with the NIR rule book section ‘A’ and ‘M’. Paragraphs 167 to 177 give more details of training issues.

Weekly operating notice (WON)

139 The WON information is compiled by the NIR Operations department and disseminated to all staff by the NIR Policy and Standards department. It includes the details of possessions.

140 The WON is issued to all passenger train drivers who sign for it at their booking on points.

141 Infrastructure staff, including engineering train drivers and guards did not have recognised booking on points. They did not sign for the WON or view *engineering notice boards*.

142 However, the guard and tamper driver were in possession of their WON relating to the planned possession for 23 April 2006 which they had collected from Coleraine whilst on route to York Road.

143 The train was en-route to a planned possession for ballast regulating documented in the WON issued on the 12 March 2006, from Whitehead to Larne Harbour and from Larne to Whitehead.

144 The possession was due to come under the control of the tamper driver involved in the incident.

145 No aspects of the planned possession or its associated paperwork contributed to the incident.

Maintenance and Condition of On Track Plant

Maintenance Processes

146 The NIR On Track Machine maintenance regime is split into two categories.

- Reactive: Machines which are reported as having broken down on the network or where a fault is reported on the defect repair sheet by the driver or guard.
- Planned: Inspection regimes that are triggered by the number of hours in service.

147 The defect reporting process is identified in the NIR Engineering ISO9001 Quality Management System. NIR's Maintenance and Overhaul Policy for rolling stock identifies the maintenance instructions and checklists to be completed for planned maintenance.

148 Drivers report fault and repair requests on the 'NI Railways' Translink defect repair sheet form. This form is submitted to the Engineering Department and the fault is either repaired on site or in the depot. The report form is chronologically numbered, dated and signed by the fitters completing the work for archive and audit purposes.

Ballast Regulator Maintenance Manual

149 The Deutsche Plasser Bahnbaummaschinen USP 3000 operators' manual was supplied to NIR on purchase of the plant. Several members of staff including the incident driver attended a course on the regulator but did not receive a personal copy of the manual.

150 A copy of the manual was kept at the depot. Engineering staff working in the depot, including the current Infrastructure Engineer (Track) and Plant Engineer, were under the impression that this was an operating manual, so it had not been referred to by them for maintenance purposes. The latter part of the manual specified various maintenance activities.

151 The operating section of the manual mandates the maintenance of the machine and offers guidance and instruction for trouble shooting problems.

152 The maintenance section of the manual incorporates a section on grease, fuel, oil and check points to be maintained. Item 23 of the checklist relates to the 'torque arm checkpoint'. The section does not explain what action is required in relation to the security or specify the frequency for a visual inspection.

Ballast Regulator 315

153 The NIR VMI record sheet requires details of the vehicle, its hours in service, Inspection signatures, check numbers and details of the repairs completed to be entered.

154 The NIR VMI requires under frame checks on the frames, springs and mountings, wheels and bearings, buffers and couplings. It also requires checks on all elements of the transmission. It does not mention the torque arm.

155 Relevant maintenance defect repair sheets and VMI forms relating to the ballast regulator were inspected by the RAIB and found to be all up to date.

156 The fault rectification reports for ballast regulator 315 from 2004 showed that no items of the work were scheduled or recorded which would have necessitated the torque arm or the headstock bracket being removed or worked upon.

157 On 20 April 2006 the maintenance and refurbishment work on the ballast regulator that had been specified had been completed. The NIR engineers completed the VMI checklist for the ballast regulator. All job sheets relating to the work were filed at York Road depot offices.

- 158 There were no cross references to any Plasser & Theurer manual in the VMI process. There were no details recorded on the VMI documentation relating to this manual being referenced whilst the ballast regulator was at York Road.
- 159 The security of the torque arm and testing of radio equipment was not incorporated into the VMI checklist.
- 160 Paperwork relating to the preparation of engineering trains was not available as NIR do not use a written process to record train preparation for engineering trains (paragraph 50).

Train Speed

- 161 There was no *on train monitoring recorder* (OTMR) installed on either On Track Machine therefore no record of the train speed was available. There is no requirement in the Railway Safety Regulations 2006 (NI) for On Track Machines to be fitted with an OTMR in Northern Ireland. A risk assessment by NIR concluded such fitment was not reasonably practicable.
- 162 Track circuit data established that the engineering train was travelling at an average speed of 33.88 mph (54 km/h) between Greenisland and Trooperslane Station.
- 163 Appendix 8.1.1 of the NIR rule book mandates the maximum speeds at which the OTM, on the system operate. In particular it mandates a maximum speed of 30 mph (48.3 km/h) for the tamper and 20 mph (32.2 km/h) for the ballast regulator. There is no speed limit specified for plant being towed as this operational process has evolved over time and is not documented in the NIR rule book. The maximum speed permissible for towing cannot be greater than the operational speed of the slowest vehicle, ie the limit of 20 mph (32.2 km/h) for the ballast regulator.
- 164 The tamper driver was driving 3 mph (5 km/h) over the speed limit for the tamper and 13 mph (20 km/h) over the speed limit for the ballast regulator.
- 165 The driver of the tamper believed there was a 25 mph (40 km/h) temporary speed restriction (TSR) in place on the down Larne line. He alleged he was not aware of his train's speed as he approached Trooperslane. There was no TSR in place and no information relating to a TSR had been published in the WON.
- 166 The speed of the train did not directly contribute to the incident but may have contributed to an increase in vibration on the headstock.

Training & Competence

Role and job descriptions

- 167 The written roles and job descriptions of a tamper driver and a guard are not based upon a task analysis, and they define the performance of safety critical tasks without having been based upon risk assessments of the tasks.
- 168 The Infrastructure staff involved in the incident, including the driver and guard, come under the management responsibility of the Infrastructure Engineer in the Infrastructure (Track) department. At the time of the incident the infrastructure train drivers were considered to have 'grandfather' rights in relation to training, thus they had not been included in previous training and development programmes.
- 169 The lack of training was shown during the incident by:
- The guard and driver alleged they were not aware of the requirement to test the ballast regulator and tamper radio systems.
 - The tamper driver drove the train at 33 mph (54 km/h) although the mandated maximum speed of the train was 20 mph (32 km/h)
 - Safety critical information (Rule book section M) was not passed to the signaller immediately after the incident occurred to ensure the route was protected. The driver, signaller and NIR incident room staff did not come to a clear understanding relating to post incident management, incident details and locations involved.
- 170 During 2006, NIR had started to introduce competence training for all Infrastructure drivers and control room staff but this had not been completed prior to the incident.
- 171 Both the driver and the guard had requested refresher training relating to the NIR rule book and ballast guard duties prior to the incident.

Staff competence

Ballast guard

- 172 The guard had current and valid Personal Track Safety (PTS), *Lookout* and medical certificates. He had received initial ballast guard training in 1992 and was qualified to act as a Person In Charge of a Possession (PICOP). The guard was confident in his role although he felt his job description was vague as it did not accurately reflect the role he was expected to do. He had learned most of his duties through practice on the job rather than through formal training in the NIR rule book and operational procedures.
- 173 The guard did not frequently perform ballast guard duties and was concerned that he needed refresher training to keep up his competence. His last refresher training was in 2002.
- 174 During the incident the guard was concerned about the rough ride of vehicles but he did not feel confident or competent in using the controls on the regulator to sound the audible horn or use the radio. He felt that the application of ballast regulator hand brake might have caused a greater risk of derailment to the train, and thus tried to use his mobile telephone to warn the tamper driver after the first rough ride incident.

Tamper driver

- 175 The tamper driver had valid competency and medical records. He was scheduled to undertake refresher training on the NIR rule book in May 2006.

- 176 The tamper driver received rule book training in 1992. He had also received training from Plasser & Theurer relating to the ballast regulator in 1993. The driver had not received refresher training in the 13 years between the initial course and the incident. He was an experienced tamper driver who took charge of the tamper each week.
- 177 The tamper driver protected the *running lines* in a manner that ensured the safety of the down line. The process of notifying the signaller and controller was prolonged because the driver telephoned the on call permanent way inspector and control cabin assistant before calling the signaller. This may have posed a safety risk on the up line. This highlighted a training gap in relation to NIR Rule book Section M relating to post incident notification to the signaller.

Shift worked

- 178 The tamper driver had returned from leave and a rest day on the day of the accident, and was adequately rested. The guard had had a rest day period of 24 hours following five twelve hour night shifts prior to the incident. There is no evidence that either was fatigued.
- 179 Examination of the NIR Working Times Directive records established that the tamper driver had worked an average of 71.31 hours per week over the previous seventeen weeks period.
- 180 The NIR management were responsible for checking the timesheets of the tamper driver and guards to ensure excessive hours were not worked. The hours worked by the tamper driver and guard were not identified by NIR management staff prior to the incident. NIR stated that the overtime records did not accurately reflect the actual working time as staff were paid for a full duty even if the full hours were not physically worked.

Previous occurrences of a similar character

- 181 NIR have a fleet of seven on track machines. Four of the engineering vehicles (7008, 7005, 7003, 7015) were inspected at York Road depot but these vehicles did not have the same torque arm design as the USP 3000 regulator.
- 182 There have been no previous incidents on NIR or elsewhere in the UK which relate to the loss of the torque arm securing pins through maintenance activities, fracture, collision or headstock failure.
- 183 Since 1996 there have been five incidents in the UK and no incidents in Northern Ireland which relate to the torque arm mechanism and assembly. These incidents were recorded on the Network Rail National Incident Room database and notification was made to Northern Ireland Railways and Plasser & Theurer. The incidents relating to the torque arm attachment have involved:
- the torque arm bearing bush;
 - a fractured torque arm and suspension point; and
 - a loose or sheared bolt on the flange for retaining the torque arm to the gearbox.
- 184 The other incidents did not result in the torque arm dropping to a position that could cause a derailment.

Analysis

Identification of the immediate cause

Site examination

- 185 There was no evidence of any mechanical fault or equipment failure on the tamper immediately prior to the incident and this did not contribute in any way to the derailment.
- 186 Impact marks from the regulator torque arm hitting the first cattle grid on the down line at Trooperslane were visible. This damage indicated that the torque arm dug itself into the sleeper and caused the regulator to lift. A similar mechanism occurred at the following three other level crossings. However at the fourth crossing, that at Trooperslane, the construction of the crossing deck was of a more substantial nature, and trapped the hanging torque arm, which had previously ploughed through the crossing. The height of the torque arm and speed of the train forced the ballast regulator up and over the crossing before hitting the running rails again and derailing into the six foot.
- 187 The immediate cause of the derailment was the torque arm lifting the ballast regulator off the track after it hit Trooperslane level crossing deck.

Identification of causal factors

- 188 Although it cannot be firmly established whether the castellated nut was tight on leaving York Road depot, the evidence indicates that the split pin was not present but the castellated nut was. Marks examined on the brackets still attached to the torque arm indicate the nut and the securing pins had been in recent contact with the mating surface of the bracket (Figures 12, 14 and 15).
- 189 The lack of thread wear and deformity to the pin indicate the pre-incident state of the nut and pin would have allowed the rapid release of the nut through vibration. There is no visual evidence on the thread or shaft of the securing pin recovered from the scene which supports a hypothesis that the bolt spent any significant period of time in one position prior to its release. This would indicate the securing pin and castellated nut vibrated loose over a short period of time and distance (Figures 13, 16 and 18).
- 190 The drilled hole for the split pin on the securing pin had visible contamination inside the drilled hole and oxidation in and around the thread areas of the hole. This indicates that the split pin had not been in place for sometime (Figure 17). The lack of a split pin would have assisted in the nut and pin vibrating loose. The omission of the split pin from the upper torque arm securing pin is the sole causal factor in the derailment.

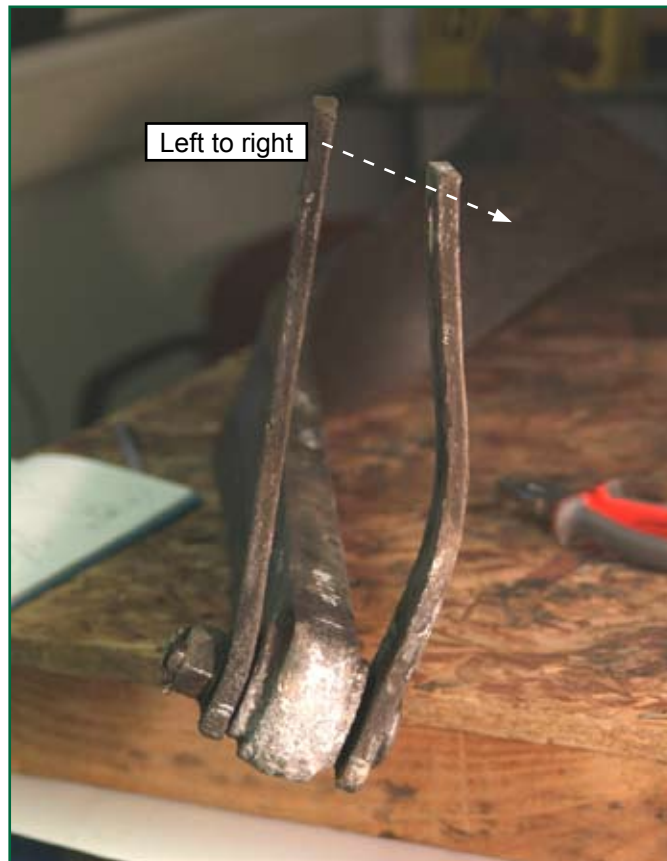


Figure 12: Incident torque bracket



Figure 13: Lower torque arm fixing bolt with post incident damaged castle nut and split pin. Wooden debris from a cattle grid stake is also visible



Figure 14: Damaged lower torque arm

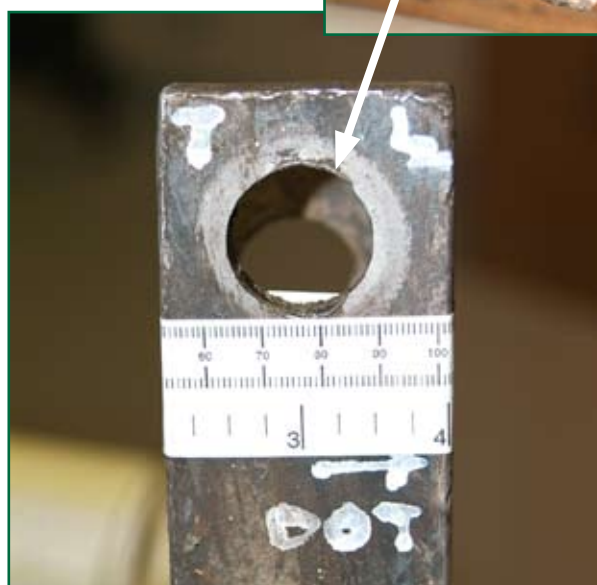
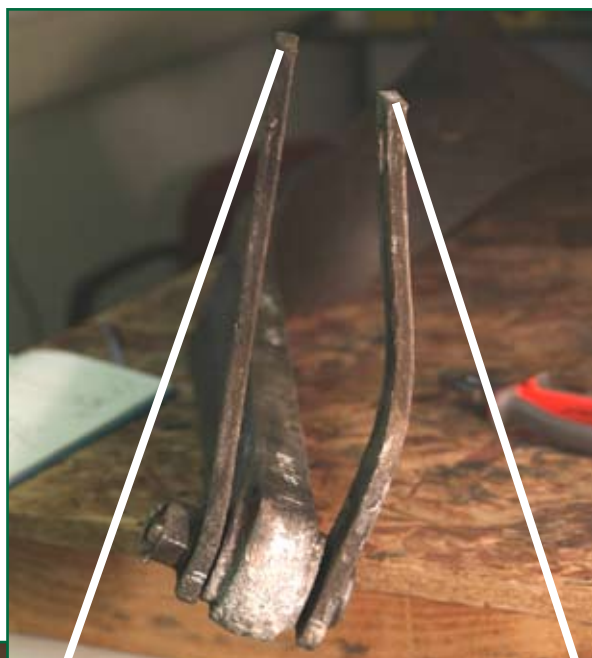


Figure 15: Torque support left side arm bracket (castle nut side)

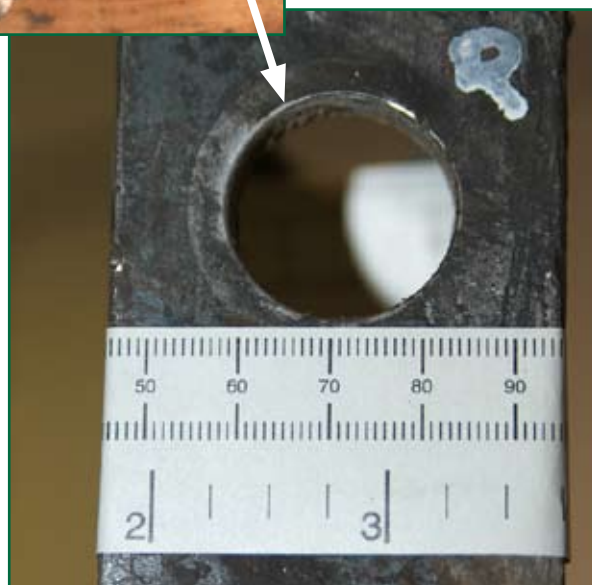


Figure 16: Torque support left side arm bracket (securing pin side)



Figure 17: Microscopic image (100x magnification) of split pin hole. Residual geological debris inside the hole and oxidisation indicate split pin has not been in place for some time prior to the incident

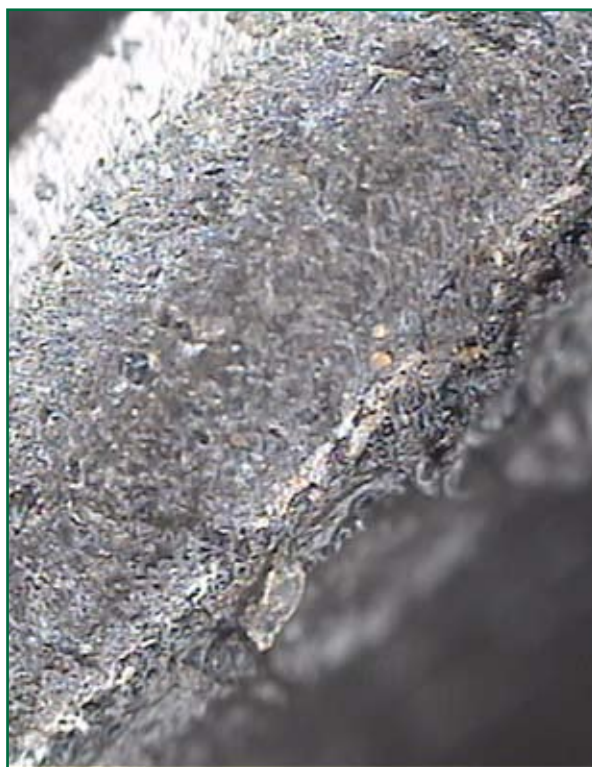


Figure 18: Image of clean tip and root of incident thread indicating contact with tip and root of internal threads of a nut

Identification of contributory factors

Maintenance

- 191 There was no visual check on the presence or security of the torque arm assembly prior to the Regulator leaving York Road depot after its 13-week maintenance program. The lack of a check on the torque arm security is a contributory factor to the derailment.
- 192 There is no cross reference to the Plasser & Theurer Operations manual within the VMI process. There is no specific VMI documentation relating to ballast regulator 315. It is evident that the NIR engineers completed the VMI checklist but the Plasser & Theurer ballast regulator manual was not referred to.
- 193 A section of the Plasser & Theurer manual specifically mandated that the torque arm assembly should be checked. The lack of a specific VMI for the ballast regulator, with a cross reference to the Plasser & Theurer manual is a contributory factor to the derailment.

Design

- 194 When the torque arm is not restrained by the securing pins it is sufficiently long to make contact with the top of sleepers within the five foot. Such contact clearly initiated the derailment, at a point where the torque arm became trapped at the Trooperslane level crossing.
- 195 The torque arm material briefly took the weight of the vehicle and caused the leading wheels to lift off the rails, thus causing the derailment.
- 196 The risk of detachment stems from the presence of two single bolt fixings to the front headstock of the Regulator, the failure of either of which will lead to the partial detachment of the Arm and a significant derailment risk. The installation of two such single points of failure is the underlying cause of the derailment

Response of others

- 197 There was a slight delay in notifying the RAIB of the incident. There was also confusion by control room staff regarding the notification of the incident to the RAIB and a lack of awareness of Rail Accident Investigation Reporting Regulations in relation to notification, site access and preservation of evidence.
- 198 An *accredited agent* (AA) was appointed by the RAIB and NIR three hours after the incident; he was asked to record and preserve evidence. On his arrival on scene there were some issues regarding identification of evidence. This was due to lack of resources and the large geographical area involved. Overall the AA's work was effective.
- 199 Several members of NIR staff were allowed in the sites for examination of potential evidence without the permission of the RAIB. This is contrary to the Railways (Accident Investigation and Reporting) Regulations 2005 (RAIR). NIR staff were also allowed free access to the incident vehicle cabs. No visible control to protect the potential evidence was established.
- 200 RAIB requested a download of the data evidence relating to signals and track circuits data at Belfast Central Signal cabin. The immediate download could not be completed as the on call staff did not have the knowledge or competence in the current system. The member of staff who was competent in the system was on leave and no contingency plans were in place to recover voice and signal data evidence when required.

Other factors for consideration

Human factors

- 201 The tamper driver was unable to recall all the rules that affected his work on 23 April 2006, although he could quote the speed limits for the tamper. The RAIB considers the lack of refresher training of the tamper driver may explain this lack of recall.
- 202 The tamper was driven above its speed limit as set out in the NIR rule book and above what the tamper driver believed to be the TSR. No TSR was in place at the time and this belief may have been due to a lack of awareness of information held within the WON and the tamper driver's recent return from a period of leave; the delay in leaving the depot may have exacerbated this issue.
- 203 Not carrying out the radio test procedure did not contribute to the incident but did prevent the radio fault being identified.

Vehicle Acceptance and risk assessment (VAB)

- 204 The design of the vehicle and derailment risks associated with the USP 3000 design torque arm were not recognised by Plasser & Theurer or by NIR.
- 205 Neither the owner nor the manufacturer of the vehicle had made any assessment that resulted in a modification since the machine was supplied in 1978. There is no reference to any similar incident having occurred with this design of regulator.

National Incident reporting

- 206 National Incident Reports were introduced by British Rail in 1994 to disseminate safety critical issues to the UK railway group members only¹. They are now sent out by the Rail Safety and Standards Board (RSSB) to the following:
- *Safety case holders*: These companies have to acknowledge and respond to the National Incident Reports within 24 hrs.
 - *Stakeholders*: These companies will acknowledge and add comments but cannot raise a National Incident Report. They have 72 hours to respond to the notification of reports.
 - *Second tier suppliers*: Companies who can view the current log, search but will not receive the alerts as they cannot respond within the specified time limit set by the National Incident Reports criteria.
- 207 Northern Ireland Railways (NIR) are in the 'stakeholder' category.
- 208 Plasser & Theurer Machinery Parts and Services Limited do not have access to the National Incident Room alerts, and obtain safety information and alerts through clients who do have access. Plasser & Theurer raised the issue of safety critical information being missed by the company under the current process with RSSB in November 2005.
- 209 A National Incident Report relating to the derailment could not be sent out by NIR or Plasser & Theurer. On the 26 May 2006 a UK contractor, at the request of the RAIB sent out an National Incident Report to ensure the rail industry was made aware of the risk. (National Incident Report 2155, Appendix E). The report related to the safety of other plant machinery with a similar torque arm design and assembly.
- 210 Subsequently it was established that no other on track machines with a similar torque arm design were operating in the UK.

¹ UK Railway Group Standards are not applicable to Iarnrod Eireann/Northern Ireland Railways

Conclusions

Immediate cause

211 The immediate cause of the derailment was the torque arm lifting the ballast regulator off the track after it hit Trooperslane level crossing deck (paragraph 187, **Recommendation 2**, paragraph 229).

Causal and contributory factors

212 The omission of the split pin from the upper torque arm securing pin is the sole causal factor in the derailment (paragraph 190, **Recommendation 1 & 2** paragraph 229).

213 The lack of a check process on the torque arm security is a contributory factor to the derailment (paragraph 190, **Recommendation 1**, paragraph 229).

214 The lack of a cross reference to the Plasser & Theurer Operations manual within the VMI process and the lack of a specific VMI document relating to ballast regulator 315, and particularly the lack of reference to the torque arm, is a contributory factor to the derailment (paragraph 193, **Recommendation 1**, paragraph 229).

215 The installation of two bolts, where the torque arm meets the headstock, where a single failure could cause catastrophic result, is the underlying cause of the derailment (paragraph 196, **Recommendation 1 & 2**, paragraph 229).

Other factors affecting the consequences

216 The lack of clear communication protocols between the driver and guard led to the guard not being able to contact the driver at the earliest opportunity (paragraph 203, **Recommendation 4**, paragraph 229).

217 The omission to test the radio equipment led to the guard not being able to contact the driver (paragraph 203, **Recommendation 4**, paragraph 229).

218 The lack of initial training and refresher training for infrastructure staff performing safety critical roles contributed to the lack of awareness of NIR rule book procedures. This led to poor communication which, if avoided, may have prevented the derailment, and which made its notification to the signaller less effective than it could have been (paragraphs 167 - 177 and **Recommendation 4**, paragraph 229).

Additional observations

219 The ballast regulator engine was running with the clutch disengaged. It could therefore have been coupled to the tamper at York Road depot so that its brake was controlled by the tamper driver. There is no instruction documented within the rule book or infrastructure manuals relating to the requirement to connect the 'through' brake between the engineering units prior to operational use (paragraph 52, **Recommendation 5**, paragraph 229).

- 220 The hand brake was also available but was not used as been guard had not been trained in how to brake the vehicle. The handbrake would not have been sufficient to stop the train effectively but may have given warning to prevent the train striking the level crossing deck.
- 221 Although not required in the NIR rule book had the guard could have sounded the regulator horn to warn the driver.
- 222 The draw bar was originally intended to be used for recovery purposes but the practice had evolved of towing to site which was not mentioned in the NIR rule book (paragraph 49, **Recommendation 5**, paragraph 229).
- 223 Excessive overtime was not identified by NIR management who reviewed staff timesheets. The excessive overtime was caused by the current lack of qualified infrastructure guards and drivers (paragraph 180).
- 224 There is no scheduled maintenance dates for the machines other than the accumulated hours in service. Machines could therefore have long periods of time between inspection and maintenance if the machine was not in frequent use (paragraph 146, **Recommendation 1**, paragraph 229).
- 225 The lack of an OTMR on the machines made it more difficult to analyse the performance of the train. On Track Plant on NIR is now the only type of train operating on the main line networks in the UK that does not either have an OTMR fitted, or does not have a programme for such fitment (paragraph 163, **Recommendation 6**, paragraph 229).
- 226 Not all NIR staff were aware of the requirements of the Railways (Accident Investigation and Reporting) Regulations 2005 (paragraphs 197 to 200).

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

227 During the investigation RAIB has kept NIR aware of their progress, and briefed them on the likely recommendations. NIR have reported the following actions:

- (a) special Fleet Check No 113 carried out covering a detailed inspection of all track maintenance machinery to ensure there is no risk of torque arm collapse (completed).
- (b) update of VMI documentation to include inspection of safety critical securing pins, safety restraints and radio tests (completed).
- (c) safety slings / loops fitted to all NIR On Track Plant equipment where a component falling could have a catastrophic effect (completed).
- (d) safety slings fitted to Ballast Regulator 315 torque support arm before return to traffic (completed).
- (e) revised the basis of planned maintenance of OTP so that all plant receives an inspection every three months even if it has not accrued the required mileage (completed).
- (f) appointed Delta Rail Engineering to conduct an annual programme of independent vehicle inspections and audit maintenance documentation for all powered On Track Plant equipment. First audit completed in July 2006.
- (g) Introduced a program for all NIR on track machine drivers, guards and Operations Department controllers to attend training courses relevant to the training gaps identified from the incident, specifically:
 - controllers briefed in reporting to the RAIB;
 - track machine drivers have scheduled rule book and refresher training;
 - operations staff trained in incident management training;
 - all operations staff re-briefed in communication protocols;(on going programme. All staff involved in the incident have been communications trained).
- (h) Ceased the towing of one OTP by another (completed).
- (i) Reviewed the process of dissemination of the WON and other safety information to ensure all operational and infrastructure staff obtain such document. All infrastructure and operational staff now sign for WON and all infrastructure staff now commence duty at recognised booking on points (completed).
- (j) NIR tamper drivers and infrastructure staff are now restricted to 48 hrs per week (completed).



Figure 19: USP 3000 ballast regulator torque arm with recommended safety keep. Similar safety keeps have been fitted to all NIR OTP

Plasser & Theurer

228 Plasser & Theurer have confirmed there are no safety risks involving long torque arms within any other rolling stock of their manufacture in the UK and Europe.

Recommendations

229 The following recommendations are made:²

Recommendations arising from the conclusions

1. NIR should review its maintenance procedures for OTP to identify the specific risks for each type of plant, and ensure that such risks are addressed in the relevant VMI (see paragraph 227 (a) and paragraph 214).
2. Northern Ireland Railways should ensure restraining keeps are retrofitted to any operational vehicles where a single point failure could result in a piece of equipment falling and causing a derailment (see paragraph 227 (c) and paragraph 213).
3. NIR should ensure that all operational and infrastructure staff receive a controlled copy of the WON and other relevant operating documents (see paragraph 227 (i) and paragraph 142).
4. NIR should review their process for staff training in incident, communications and post incident management and should ensure that all relevant staff involved in the incident and post incident management are appropriately trained (see paragraph 227 (g) and paragraph 216).

Recommendations to address other matters observed during the investigation.

5. NIR should either:
 - a. cease the towing of one piece of OTP to site by another; or
 - b. ensure that any such towing moves have a continuous brake operational, and an adequate, purpose designed, coupling (see paragraph 227 (h) and paragraphs 219, 222).
6. NIR to re-review the practicability of fitting data recorders to engineering vehicles in the light of this derailment and other OTP accidents on the UK mainland. If it is considered to be reasonably practicable then OTMR should be fitted to the OTP fleet (see paragraph 225).
7. NIR should ensure all appropriate staff are briefed on the requirements of the RAIR with particular reference to reporting incident promptly to RAIB and the management and access to site and evidence preservation (see paragraph 227 (g) and paragraph 197).
8. RSSB should grant Plasser & Theurer second tier supplier access rights to the National Incident Reporting database to ensure safety information relating to their products reaches them as soon as practicable (paragraph 206 to 210).

² Responsibilities in respect of these recommendations are set out in the Railways (Accident Investigation and Reporting) Regulations 2005 and the accompanying guidance notes, which can be found on RAIB's web site at www.raib.gov.uk

Appendices

Glossary of abbreviations and acronyms

Appendix A

AA	Accredited Agent
BST	British Summer Time
MCB	Manually Controlled Crossing
NIR	Northern Ireland Railways
OTM/OTP	On Track Machines/ On Track Plant
ORR	Office of Rail Regulation
OTMR	On Train Monitoring Recorder
PICOP	Person in Charge of Possession
PPE	Personal Protective Equipment
PTS	Personal Track Safety
RAID	Rail Accident Investigation database
RAIR	Rail Accident Investigation Reporting regulations
RAIB	Rail Accident Investigation Branch
RIO	Rail Incident Officer
RSSB	Rail Safety & Standards Board
RSC	Railway Safety Case
S&C	Switch & Crossing
SB	Signal Box
SC	Signalling Centre
SCC	Safety critical Communications
SSI	Solid State Interlocking
TC	Track circuit
TCB	Track circuit block
TCOD	Track circuit operating device
TSR	Temporary Speed Restriction
UWC	User Worked Crossing
VMI	Vehicle Maintenance Inspection
VAB	Vehicle acceptance Board
WON	Weekly Operating Notice

Glossary of terms

Appendix B

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

Accredited Agent	A member of rail industry staff who has been trained and certificated by RAIB and who acts on behalf of RAIB at an accident site until an Inspector arrives.
Ballast Regulator	The machine was designed to pick up or 'sweep' excess ballast from the track, which is stored in a hopper for distribution in areas where it is required.
Castellated nut	Designed to be used with a split or cotter pin. The bolt or pin onto which the nut is threaded will have a hole drilled through it. The castellations then line up with the hole when tight and the split pin or cotter pin is inserted and locked in place. This prevents the nut from turning.
Cess	The space on either side of the track ballast normally used for drainage.
Derailment	An incident or accident that causes a rail vehicle to lose the guidance and support provided by the Rails.
Detonator	A small disc shaped explosive warning device designed to be placed on the railhead for protection and emergency purposes. It explodes when a train passes over thus alerting the driver. Correctly known as a railway fog signal.
Down	Generally the line taking trains away from Belfast.
Driver	The Driver in charge who may be a Probationer, Driver or Supervisor/ Instructor competent in Driving duties.
Engineering notice board	A notice board usually within a booking office where documents published weekly and issued as required, giving details of Possessions, Temporary Speed Restrictions (TSR) and alterations to the operational infrastructure of the Railway. See also Weekly Operating Notice (WON).
Five foot	The area between the inner running faces of a pair of rails.
Grandfather Rights	Vehicles in operation before 1 April 1994 are considered to have 'grandfather rights' over those routes they regularly operated on, at that date and do not necessarily require the above approvals. However, if such vehicles are required to be operated over new routes or are subject to substantial modifications, then the above requirements will apply. The Network Rail Acceptance Guidance Note For Plant Acceptance AS/A/ACCEPTANCE/009 issue February 2004.
Headstock	The stationary support of a machine or power unit that supports and drives a revolving part.

Iarnrod Eireann	The national statutory authority rule book providing rules of operation for rail transport within the Republic of Ireland and Northern Ireland Railways.
Lookout	A person responsible for observing the approach of trains and warning staff working on the line.
Manually Controlled Barriers	A Manned Level Crossing with Full Barriers operated locally from a Signal Box (SB) or Level Crossing Box.
Notice (the)	Weekly Circular or Weekly Operating Notice.
OTMR	On Train Monitoring Recorder that records the train system data.
Pandrol clips	A Rail Clip that secures Flat Bottom Rail to sleeper fixings.
Permanent way	The track structure which includes rails, sleepers, ballast, blanketing material and drainage.
Permissible speed	The maximum permitted speed as shown as in the Working Timetable.
Pilotman	Person appointed in connection with the passage of trains over a double line, single line or bi-directional line during a failure of equipment.
Possession	A section of the line which is under exclusive occupation of an engineer for maintenance or repairs. The engineer may run his own trains within the limits of the possession but no other trains are allowed to run within it and comprehensive safety arrangements ensure that these conditions are kept.
Rail Pads	A resilient layer of rubber or similar material fitted between a Rail and Bearer or Rail and Baseplate.
Risk	The combination of the severity of a hazard and likelihood of its occurrence.
Running lines	A railway line which is not a siding and is ordinarily used for the passage of trains or tramcars.
(Railway) Safety case holders	Railway Safety Case (RSC). A document by which a potential operator of Trains demonstrates their compliance with mandatory safety standards in support of a system or process and providing evidence that the system complies with the relevant safety objectives.
Safety Critical Communication	Any message given or received which may affect the safe operation of the railway.
Scotch	A lump of wood either placed in an open switch of a set of points to prevent movement or on a rail under a wheel to prevent a vehicle from being moved.
Section A	NIR Rule book section mandating employment rules concerning safety, security, communications and emergencies.
Section M	NIR Rule book section mandating instructions for drivers, guards and signalman relating to trains stopped by accident, failure or obstruction.

Shunter	Any person performing shunting duties.
Six foot	The space between two sets of tracks (which may be wider than six feet).
Solid State Interlocking	A microprocessor based Signalling System using two-out-of-three voting to perform the Train Detection, Interlocking and control functions.
Stakeholders	Collective term for all those with a commercial, engineering, financial or regulatory interest in a project.
Tamper / Tamping Machine	An engineering vehicle that compacts ballast under sleepers which maintains the correct geometry of the track.
Three Aspect signalling	An arrangement of Colour Light Signals which normally provides only Red Aspects, Yellow Aspects and Green Aspects. This can be achieved using only Two Aspect Signals, Three Aspect Signals, or a mixture of both.
Through air brake	In its simplest form, a braking system in which the application of the brakes is made by large springs; in order to move the brake shoes or pads are forced off by the action of air or vacuum in a cylinder. The cylinders are fitted with a small hole, so that the brakes leak back on without further intervention. This arrangement means that should a Train become divided, the brakes will automatically apply themselves. The requirement for continuous Automatic Brakes was made compulsory by Act of Parliament in 1889, after many serious accidents.
Torque arm	The torque arm prevents movement of the cardan shaft and allows generated torque and transmission between the engine and the wheels to take place.
Track Circuit	An electric device installed in running rails which detects the presence of a train.
Track Circuit Block	A method of signalling trains in a section of line where safety is ensured by the use of track circuits or other means of automatic train absence detection and without the use of block instruments.
Track Circuit Operating Device	TCOD - A device (or clip) which can be placed on the line to provide protection by operating track circuits.
Train-Radio	Radio system permanently installed in the cabs of traction units for communicating with signal boxes. Includes portable radio systems where authority is expressly given for use as train-radio.
Up line	The line taking trains towards Belfast.
Vehicle Acceptance Body	Acceptance body now replaced by Notified Bodies (Nobos) under Railway and Other Guided Transport Systems (ROGTS).
Weekly Operating Notice	A document published on a Region basis, providing information about Engineering Work, Speed Restrictions, alterations to The Network and other relevant information to Train drivers.

Key standards current at the time

Appendix C

The Railways Safety Regulations (Northern Ireland) 2006.

The Railways Safety Act 2002 (Northern Ireland)

The Railways Safety Regulations (Northern Ireland) 2006 Guidance

Northern Ireland railways 'Iarnrod Eireann' Rule book Issue 01/02 issued 5 January 2002 with amendments 1-3 included.

EEC Product Liability Directive EEC 34/1999

GREASE- AND CHECKPOINTS , CAPACITIES OF TANKS AND GEARBOXES

1. Axle bearing
2. Gearbox, cap. 13 ltr.
3. Drive shafts and sliding couplings
4. Pump drive bearings
5. Clutch bearing
6. Clutch shaft bearing
7. Brake linkage
8. Plow adjustment + bearing
9. Gear box, auxiliary drive + brush drive, cap. 0,5 ltr.
10. Final drive, cap. 7 ltr.
11. Container for hydraulic fluid-clutch operation,
cap. 0,5 ltr.
12. Clutch operation, cap. 0,5 ltr.
13. Brush box support
14. Rear guide column
15. Lifting arm, cylinder mount
16. Lifting arm mount
17. Chute damper + cylinder mount
18. Box conveyor gear, cap. 4 ltr.
19. Plow share bearings
20. Front guide column
21. Hydraulic tank
22. Front plow bearings
- 23. Torque support**
24. Idler drums - cross conveyors
25. Idler drums - box conveyor
26. Fuel tank, cap. 350 ltr.





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NIR 2155

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NIR 2155 Initial

Title:	Torque Arm Security
Raised by:	Steve Farrant (M&E Standards And Competence Engineer) , Jarvis Rail Ltd
Defect date:	23 April 2006 09:00
Vehicle type:	On-Track Plant
Vehicle number:	315
Vehicle class:	Plasser 3000C
Vehicle hirer:	NI railways
Vehicle sub-hirer:	
Vehicle owner:	NI Railways
Use being made of vehicle:	Hauled by another vehicle
Systems giving rise to defect:	Bogie equipment
Other affected vehicles:	Ballast Cleaner (OTP), Long Welded Rail Train (OTP), Plasser 07-16 Tamper (OTP), Plasser 07-275 Tamper (OTP), Plasser 07-32 Tamper (OTP), Plasser RM74 Ballast Cleaner (OTP), USP 5000 Ballast Regulator (OTP)
Defect description:	Pin retaining torque arm missing caused torque are to fall and derail vehicle
Geographical location:	Northern Ireland
Action taken:	Inspection of other rail vehicles required - may affect other classes (Unknown)
Justification for advice:	Urgent advice entered on request of [REDACTED]
For Information:	Currently open for Jarvis Rail Ltd
Notified:	26/05/2006 15:54
Acknowledged:	26/05/2006 16:19 ([REDACTED])
Last Review:	(Not Reviewed)
Status:	Open

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