Rail Accident Investigation Branch

Rail Accident Report

Derailment and fire involving a tanker train at Llangennech, Carmarthenshire 26 August 2020

Report 01/2022
January 2022

This investigation was carried out in accordance with:

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

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Preface

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. Accordingly, it is inappropriate that RAIB reports should be used to assign fault or blame, or determine liability, since neither the investigation nor the reporting process has been undertaken for that purpose.

RAIB's findings are based on its own evaluation of the evidence that was available at the time of the investigation and are intended to explain what happened, and why, in a fair and unbiased manner.

Where RAIB has described a factor as being linked to cause and the term is unqualified, this means that RAIB has satisfied itself that the evidence supports both the presence of the factor and its direct relevance to the causation of the accident or incident that is being investigated. However, where RAIB is less confident about the existence of a factor, or its role in the causation of the accident or incident, RAIB will qualify its findings by use of words such as 'probable' or 'possible', as appropriate. Where there is more than one potential explanation RAIB may describe one factor as being 'more' or 'less' likely than the other.

In some cases factors are described as 'underlying'. Such factors are also relevant to the causation of the accident or incident but are associated with the underlying management arrangements or organisational issues (such as working culture). Where necessary, words such as 'probable' or 'possible' can also be used to qualify 'underlying factor'.

Use of the word 'probable' means that, although it is considered highly likely that the factor applied, some small element of uncertainty remains. Use of the word 'possible' means that, although there is some evidence that supports this factor, there remains a more significant degree of uncertainty.

An 'observation' is a safety issue discovered as part of the investigation that is not considered to be causal or underlying to the accident or incident being investigated, but does deserve scrutiny because of a perceived potential for safety learning.

The above terms are intended to assist readers' interpretation of the report, and to provide suitable explanations where uncertainty remains. The report should therefore be interpreted as the view of RAIB, expressed with the sole purpose of improving railway safety.

Any information about casualties is based on figures provided to RAIB from various sources. Considerations of personal privacy may mean that not all of the actual effects of the event are recorded in the report. RAIB recognises that sudden unexpected events can have both short- and long-term consequences for the physical and/or mental health of people who were involved, both directly and indirectly, in what happened.

RAIB's investigation (including its scope, methods, conclusions and recommendations) is independent of any inquest or fatal accident inquiry, and all other investigations, including those carried out by the safety authority, police or railway industry.

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Derailment and fire involving a tanker train at Llangennech, Carmarthenshire, 26 August 2020

Contents

Summary

At about 23:04 hrs on 26 August 2020, train 6A11, the 21:52 hrs service from Robeston (Milford Haven) to Theale, conveying 25 laden tank wagons, derailed near Llangennech, in Carmarthenshire. The derailment and the consequent damage to the wagons resulted in a significant spillage of fuel and a major fire. The driver, who was unhurt, reported the accident to the signaller. Subsequent examination of the site found that ten wagons (positioned third to twelfth in the train) had derailed, and that around 446,000 litres of fuel had escaped.

The spilled fuel caused major damage to the environment in an area which is both a site of special scientific interest (SSSI) and a special area of conservation (SAC), including cockle beds, natural tidal mud flats and wetlands.

The derailment occurred because one set of wheels on the third wagon in the train stopped rotating during the journey. The wheelset had become locked, probably because of a defect in the braking system on the third wagon, arising from deficiencies in the design and maintenance of components. The sliding of the locked wheel along the railhead caused damage to the profile of the wheel treads. This meant that the wheels were unable to safely negotiate Morlais Junction, near Llangennech, damaging the pointwork and causing the third wagon to become derailed. The following wagons derailed on the damaged track. Some of the derailed tank wagons were ruptured in the accident, and the spilling fuel ignited.

RAIB has made nine recommendations. These cover a review of the actions taken by the owner of the wagons following this and previous accidents, and improvements to the maintenance processes at the locations where the wagons involved in the accident are maintained and overhauled. The probable failure mode of the braking system and the lessons learned from reconstruction tests have led to a recommendation to the manufacturer of some of the braking system components to undertake a review of their design. A recommendation has been made to the organisations who carry out surveillance and certification of entities in charge of maintenance of rail freight vehicles to review their processes. A further two recommendations have been made to improve the management of wagon maintenance on the railways in Great Britain, and to review the technology and systems used to alert traincrew, signallers and railway control offices to wagon defects that may lead to derailment. The final recommendation is for a review of the arrangements for regulatory oversight of entities in charge of maintenance and certification bodies that are not based in the UK.

Introduction

Definitions

1 Metric units are used in this report, except when it is normal railway practice to give speeds and locations in imperial units. Where appropriate the equivalent metric value is also given.

2 The terms ‘up’ and ‘down’ refer to the lines heading towards and away from London respectively. Distances on the South Wales Main Line are normally measured from London Paddington station. For ease of reference, distances in this report are quoted from the start of the journey of train 6A11 at Robeston oil terminal, approximately 285.5 miles (459.4 km) from Paddington.

3 The report contains abbreviations which are explained at appendix A. Sources of evidence used in the investigation are listed at appendix B. Urgent Safety Advice (USA) issued by RAIB appears in appendix C. Details of fastener tests and analysis are in appendix D. Other factors considered are described in appendix E, and a description of safety management requirements relating to wagon maintenance is in appendix F.

The accident

Summary of the accident

4 At about 23:04 hrs on 26 August 2020, train 6A11, the 21:52 hrs service from Robeston (Milford Haven), Pembrokeshire, to Theale, Berkshire, conveying 25 laden tank wagons, derailed on the up Swansea District line at Morlais Junction, near Llangennech, Carmarthenshire (figure 1). The train was travelling at around 38 mph (61 km/h) when it derailed. Each wagon was carrying up to 75.5 tonnes of diesel fuel or gas oil.

5 Ten wagons (positioned third to twelfth in the train) derailed, and three of these, wagons 3, 4 and 5, caught fire. Around 446,000 litres of petroleum products were spilled. The fire consumed about 116,000 litres of this, with the remaining 330,000 litres draining into the surrounding wetlands.

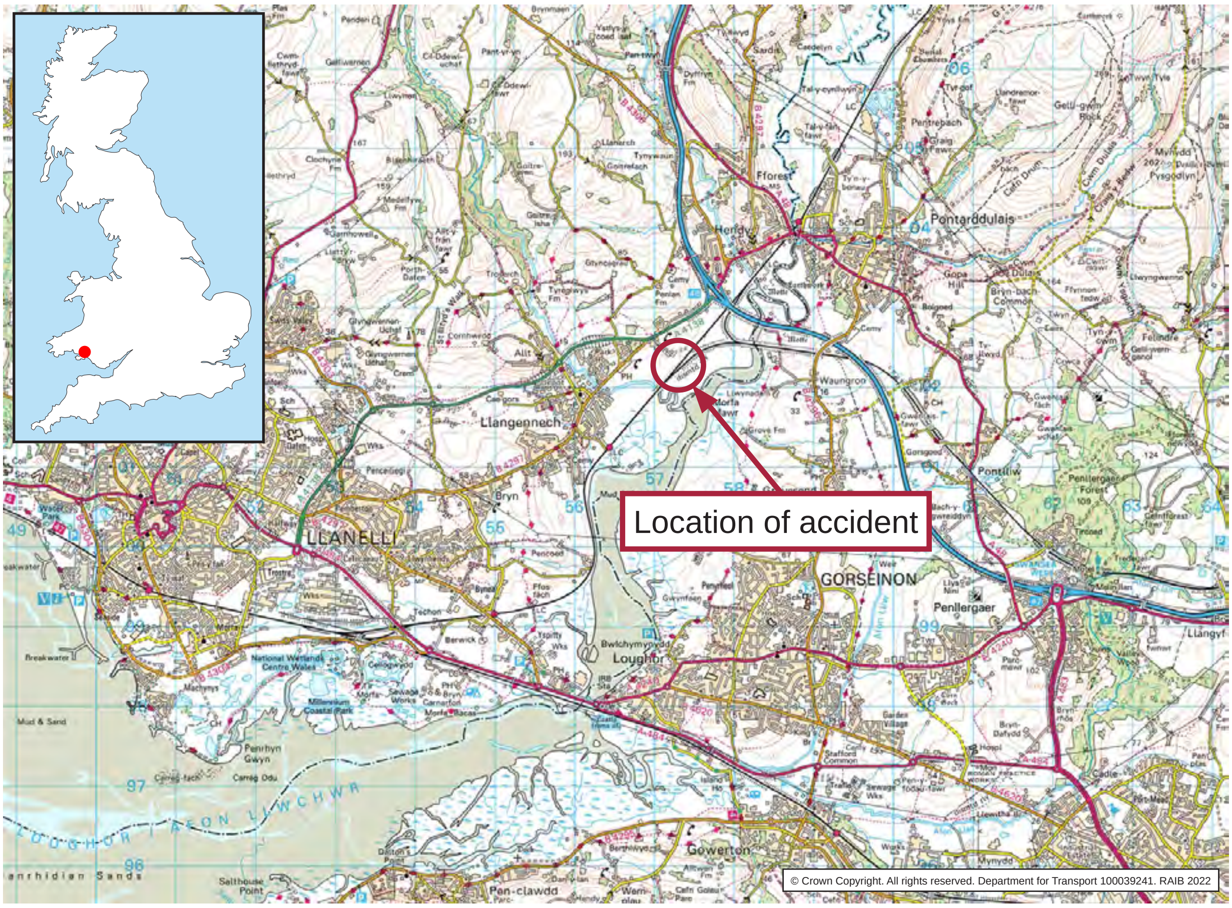

Figure 1: Extract from Ordnance Survey map showing location of accident

6 The train driver moved the locomotive and the first two wagons away from the scene of the accident. The emergency services declared a major incident, and on arrival at the scene, they acted to extinguish the fire and attempted to limit the spread of the spilled products.

7 No one was hurt in the accident, but there was major environmental damage to the ecosystem of the nearby estuary.

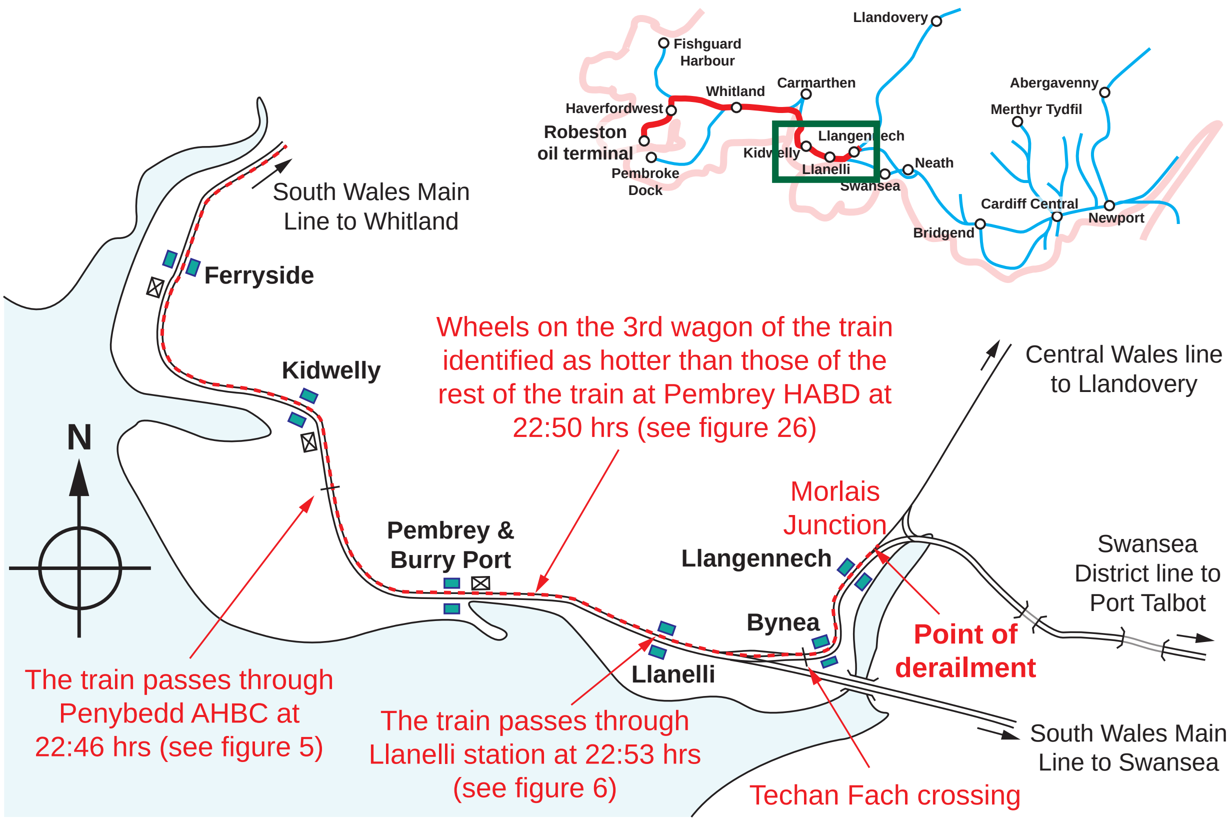

Figure 2: Map showing locations on the route from Robeston oil terminal to Morlais Junction

Context

Location

8 Train 6A11 started its journey at Robeston and travelled through Haverfordwest, before continuing eastwards along the South Wales Main Line via Whitland and Carmarthen Junction, as far as Llandeilo Junction. It was then routed towards Morlais Junction, where the Central Wales line diverges (towards Pantyffynnon) from the Swansea District line (which provides a means for trains travelling between Llanelli and Neath to avoid Swansea). The route is signalled using track circuit block[1] principles for the first 14.3 miles (23 km) from Robeston, and then by absolute block[2] to the start of the Port Talbot signalling area, approximately 57.6 miles (95.4 km) from Robeston, 1.8 miles (2.8 km) east of Pembrey signal box (figure 2), where it becomes track circuit block. The signals are operated from signal boxes at Clarbeston Road, Whitland, Carmarthen Junction, Ferryside, Kidwelly, Pembrey, and Port Talbot. The train passed the first six of these on its journey. At Ferryside, Kidwelly and Pembrey the relevant regulations for train signalling[3] require the signaller to observe the train as it passes the signal box.

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[1] A method of signalling which relies on the continuous detection of the presence of trains by electrical means, described in Rule Book module TS2 ‘Track circuit block regulations’.

[2] A method of signalling which aims to prevent more than one train being in a section on the same line at the same time, and requires manual confirmation of the passage of complete trains. It is described in Rule Book module TS3 ‘Absolute block regulations’.

[3] Rule Book module TS3, section 3.2.

9 The derailment occurred at Morlais Junction on the up Swansea District line, 3.6 miles (5.8 km) from Llandeilo Junction and 62.1 miles (100 km) from the start of the train's journey at Robeston (figure 2).

Organisations involved

10 Network Rail is the owner of the railway infrastructure. It employs the signalling and control staff who managed the emerging situation.

11 Puma Energy operates Robeston oil terminal. It employs the staff who loaded the fuel into the wagons and the driver of the shunting engine that formed the wagons to make up the train.

12 Touax Rail purchased General Electric Rail Services (referred to as GERS for the remainder of this report) in December 2015 and is the owner of wagon GERS 89005, the first to derail, and 13 of the other wagons in the train. It is also the entity in charge of maintenance (ECM)[4] for wagon 89005. Touax contracts maintenance delivery to DB Cargo Maintenance Ltd and Arlington Fleet Services Ltd (figure 3). Touax contracted the overhaul and repair of brake system components to Wabtec (UK), located in Birkenhead, and CFL and DB Fulda, located in Luxembourg and Germany respectively.

13 Belgorail is owned by the Certifer group and is based in Belgium. Belgorail is the certification body that assessed and certified Touax as an entity in charge of maintenance between 2015 and 2019. Belgorail was accredited to act in this capacity by BELAC, the Belgian national accreditation body.

14 DB Cargo (UK) Ltd was the operator of the train (on behalf of Puma Energy) and employed the driver and the member of ground staff who carried out the train preparation at Robeston oil terminal.

15 DB Cargo Maintenance Ltd (formerly Axiom Rail Maintenance and referred to as DBCM for the remainder of this report) carries out the day-to-day maintenance of wagon GERS 89005. It employs the wagon maintenance staff based at Robeston.

16 Arlington Fleet Services Ltd (referred to as AFSL for the remainder of this report) was contracted by Touax to carry out a seven-yearly 'General Repair' (GR) on each of its wagons.

17 Wabtec Faiveley (and its predecessor companies) designed and manufactured the braking system (including the C3W distributor and relay valve) that was installed on wagon GERS 89005.

18 VTG owned the other eleven wagons in the train. The VTG wagons were manufactured by Marcroft Engineering Limited in 2002 and Greenbrier in 2012.

19 All the companies listed freely co-operated with the investigation.

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[4] The role of the ECM is defined in regulation 18A of 'The Railways and Other Guided Transport Systems (Safety) Regulations 2006' (ROGS), as amended by 'The Railways and Other Guided Transport System (Safety) (Amendment) Regulations 2011' and 'The Railways and Other Guided Transport Systems (Miscellaneous Amendments) Regulations 2013'. These regulations state that no person may place in service or use a vehicle on the mainline railway unless that vehicle has an entity in charge of maintenance (ECM) assigned to it, and that entity in charge of maintenance is registered as such in the National Vehicle Register.

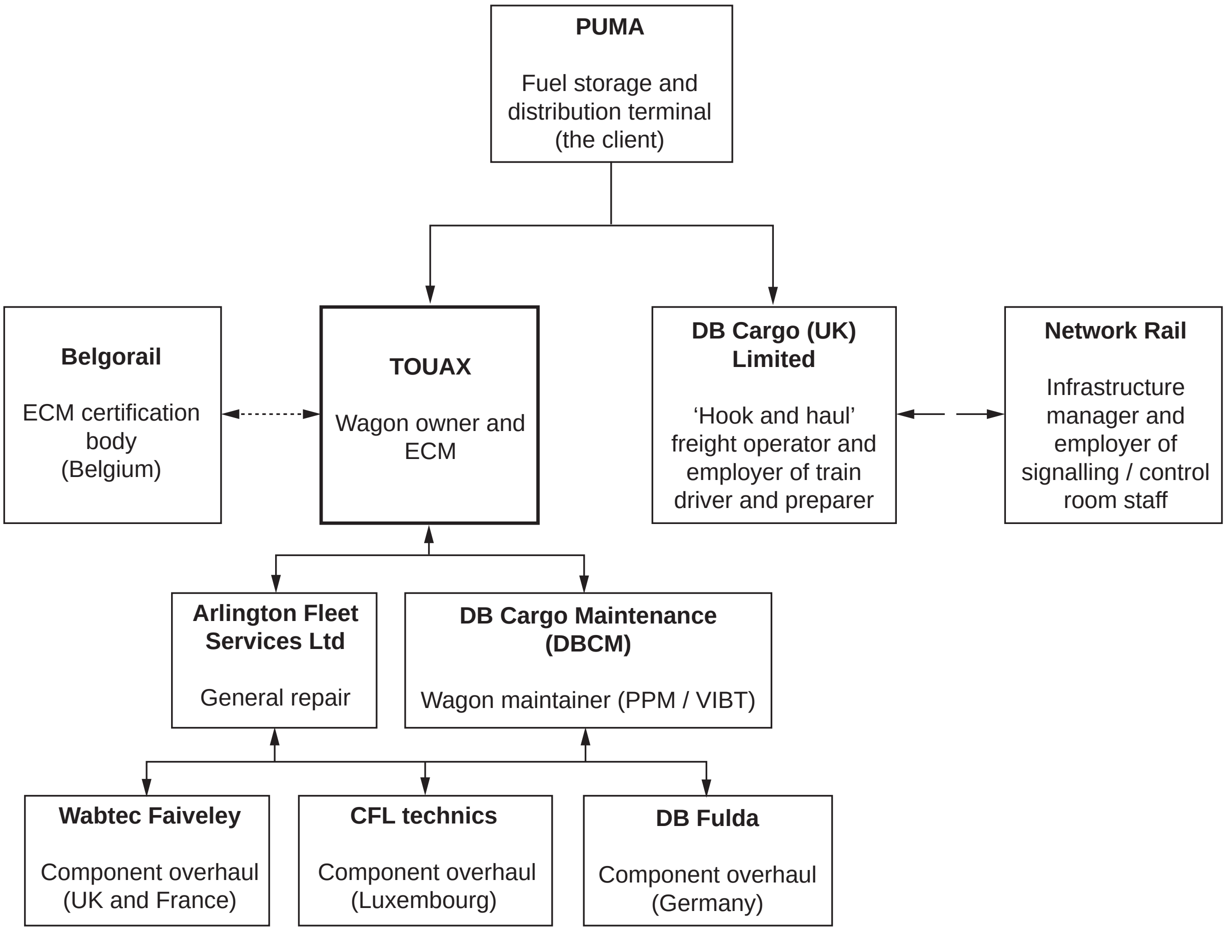

Figure 3: Diagram showing the organisations involved in the investigation

Train involved

20 Train 6A11 consisted of a class 60 locomotive, number 60062, and 25 bogie tank wagons with a combined weight of about 2672 tonnes. The wagons were of types TDA, TEA, and TIA and were carrying class 3 dangerous goods. The front portion of the train was carrying diesel fuel, and the rear portion gas oil. The maximum permitted speed of these wagons is 60 mph (96 km/h).

21 The first vehicle to derail was the third wagon behind the locomotive, numbered GERS 89005 (figure 4). This was a TEA wagon, loaded with 90,889 litres of diesel fuel (gross weight 101.2 tonnes).[5] The Touax-owned TEA wagons were built in 2001 by AFR in Douai, France.

Staff involved

22 The train driver was employed by DB Cargo and was based at Margam depot. The driver had 37 years' experience. The actions and role of the train driver are described further in appendix E. At the time of the accident, a fitter was travelling in the rear cab of the locomotive, but he played no part in the operation of the train.

[5] TDA and TIA wagons have a maximum gross laden of weight of 90 tonnes and TEA wagons have a maximum gross laden weight of 102 tonnes. None of the wagons were overloaded.

23 The member of ground staff undertaking train preparation at Robeston was employed by DB Cargo. He was certificated as competent to the required standards.

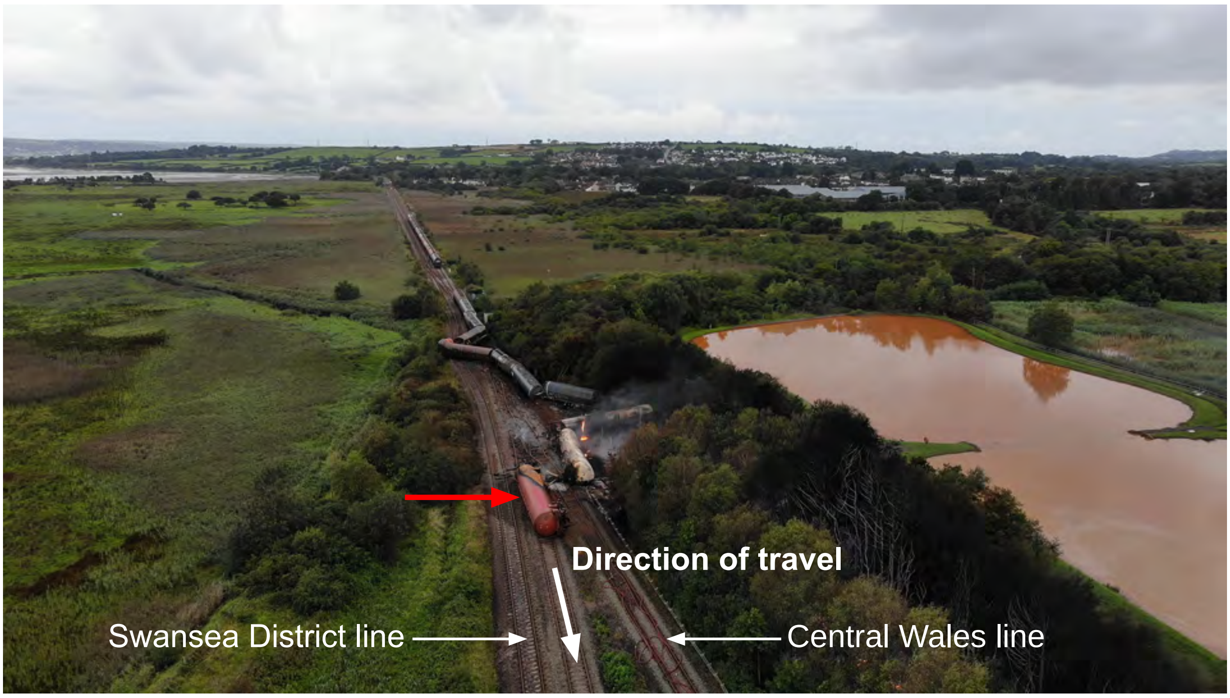

Figure 4: Image of the scene at Llangennech showing wagon GERS 89005 (red arrow). Please note the colour of the nearby water is not connected to the accident.

24 The signallers at Ferryside, Kidwelly and Pembrey signal boxes were all certificated as competent in accordance with Network Rail's competence management system.

External circumstances

25 Records from Hywels weather station, near Llanelli, show that the air temperature in the area around Llangennech at the time of the accident was 11 °C. The weather was dry with patchy cloud and no wind. Weather conditions can affect levels of wheel/rail adhesion. However, there was nothing exceptional about the conditions on the day of the accident that would suggest that the weather led to particularly low levels of wheel/rail adhesion.

The sequence of events

Events preceding the accident

26 Locomotive 60062, hauling another rake of empty wagons, arrived at Robeston terminal at 19:56 hrs on the day of the accident, and was uncoupled from its train. While there was still daylight, the train preparer made his initial walk-round of the rake of loaded wagons which had been prepared for train 6A11, making sure all the handbrakes except one were released.

27 The train preparer did not find anything out of the ordinary on his walk-round. He then coupled the locomotive onto the train. While the driver was waiting for the air pressure in the train's braking system to build up, the train preparer drove slowly in his van to the other end of the train, doing a visual inspection and listening for any air leaks. He then received confirmation (via radio) that the train driver was ready to carry out a static brake test, and released the final handbrake. The train preparer opened the brake pipe isolating cock on the rear wagon, thereby venting the brake pipe, and checked that the brake blocks on the rear three wagons were in contact with the wheels.

28 The train preparer closed the isolating cock to build the air pressure in the brake pipe. He then asked the driver to overcharge the brakes (see appendix E), while he waited at the rear wagon to ensure all the brake blocks had moved clear of the wheels once the brake pipe air pressure had built back up. The train preparer then walked around both sides of the rear three wagons. He found no problems, and concluded that the brake system on train 6A11 was working properly.

29 The train preparer then radioed the train driver to confirm the brake test was complete, and made his way back to the driver's cab. The train preparer told the driver that the train could proceed to the terminal gate, and he subsequently drove his van to the front of the train. As it was now dusk, he positioned his van with the headlights facing the side of the locomotive to illuminate the area (figure 5). The train preparer then authorised the train driver to proceed beyond the terminal gate to signal CR30, and, as the train moved off, the train preparer performed an inspection of the train's running gear as it rolled by. He has stated that he saw and heard nothing unusual. Closed circuit television (CCTV) footage reviewed by RAIB shows that all the wheels of the train were turning at this time. Signal CR30 subsequently cleared, and the train departed from Robeston, on time, at 21:52 hrs.

Events during the accident

30 The train's journey was initially uneventful. The signallers at Clarbeston Road, Whitland, Carmarthen Junction, Ferryside and Kidwelly signal boxes did not report anything untoward as the train passed them.[6]

[6] Rule Book Module TS1, 'General signalling regulations', section 19, requires a signaller to take action to stop and examine the train if they become aware of anything unusual or wrong.

31 The train passed over Pen-y-bedd level crossing at 22:46 hrs. This crossing is approximately 11.5 miles (18 km) from Morlais Junction, 15 to 16 minutes running time at the speeds the train travelled at. CCTV footage from this level crossing shows that the front wheelset of wagon GERS 89005 was generating sparks when the train passed (figure 6). This can be an indication of a wheelset that is not rotating freely, or is completely locked.

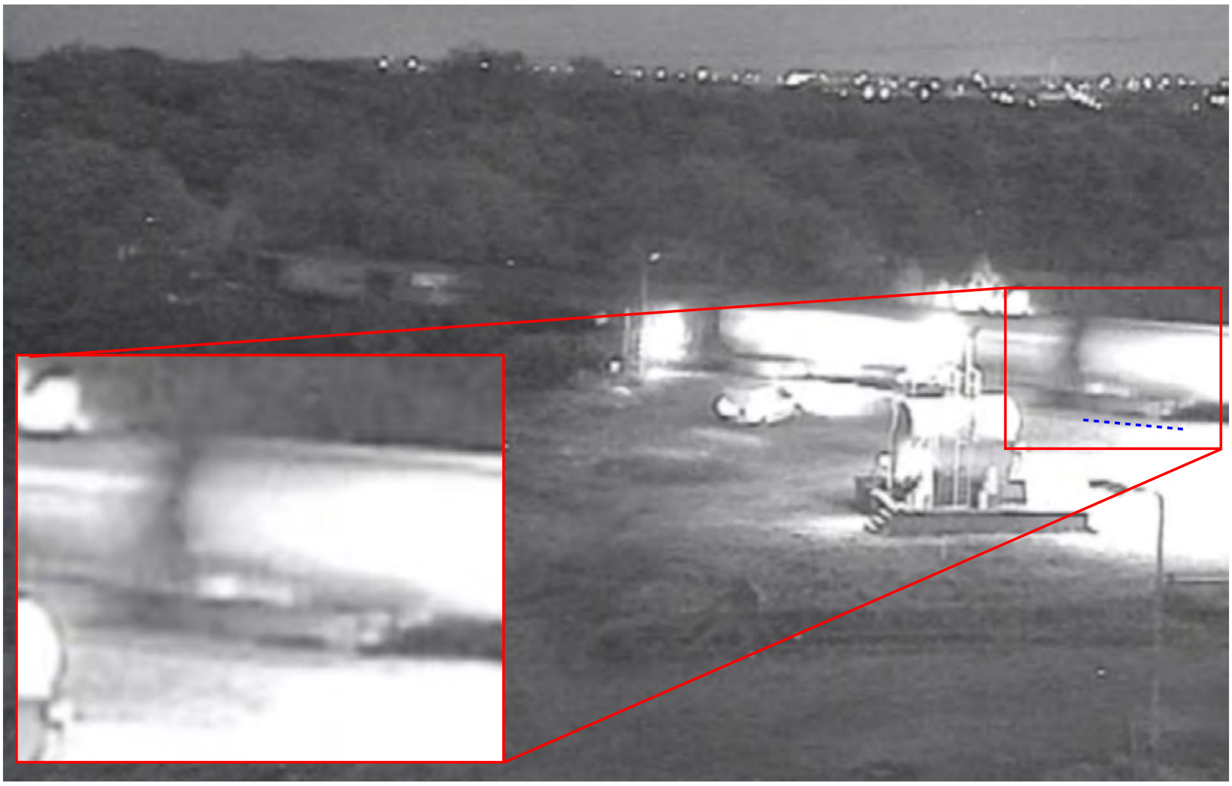

Figure 5: CCTV image of train 6A11 and (inset image) wagon GERS 89005 leaving Robeston depot

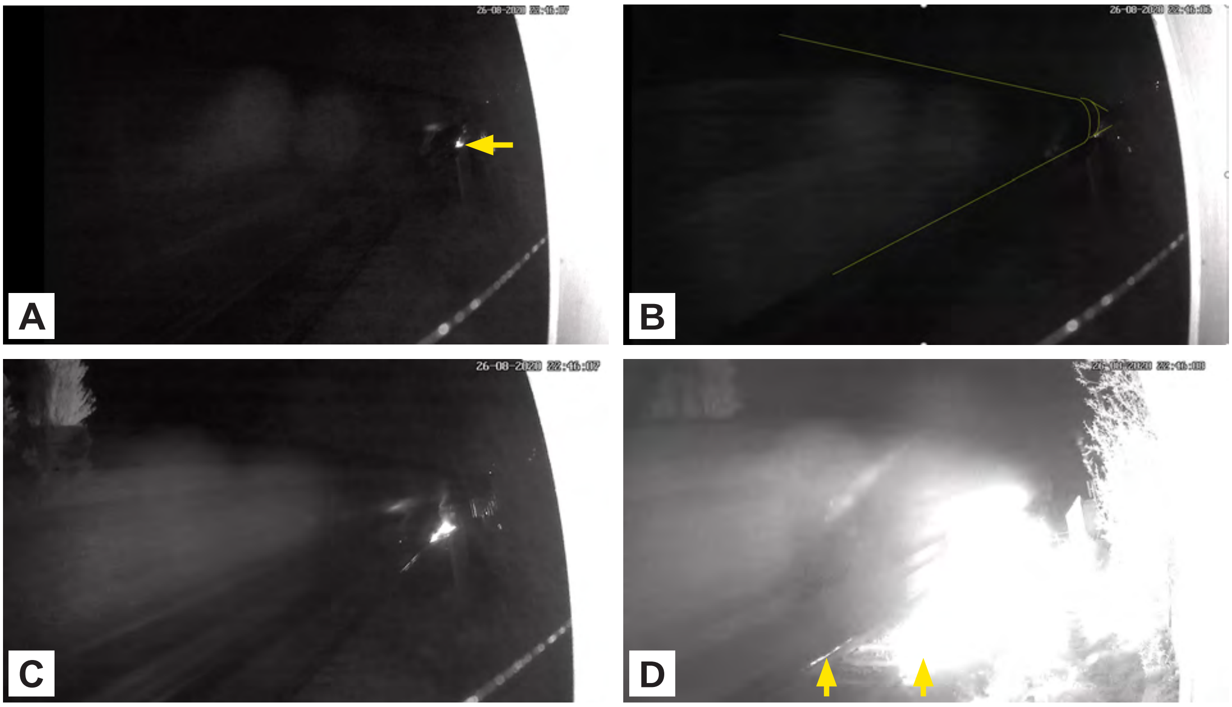

Figure 6: CCTV images ((a) to (d)) showing train 6A11 and wagon GERS 89005 passing Pen-y-bedd AHBC showing sparks emanating from the left and right wheels on the front wheelset

32 Members of the public reported hearing an unusual 'metal on metal' sound as the train passed through Pembrey station. However, the signaller at Pembrey did not report anything unusual about the train. The train then passed over the hot axle box detector system (HABD) at Pembrey at 22:50 hrs. Subsequent examination of data from this equipment indicated that the front wheelset was not rotating (see paragraphs 135 to 143). The HABD is approximately 8.5 miles (14 km) from Morlais Junction, approximately 13 minutes running time at the speeds the train travelled at.

33 The train passed through Llanelli station, where CCTV evidence indicates that the leading wheels of wagon GERS 89005 were still generating heavy sparking (figure 7).

Figure 7: Station CCTV image showing train 6A11 passing through Llanelli station with sparks emanating from the front axle of wagon GERS 89005

34 The train left marks on the railhead, of the type associated with locked wheels, as it passed through Llangennech station, about 0.5 miles (0.8 km) from Morlais Junction, and these marks continued to the point of derailment. When the third wagon reached the trailing points (figure 15) of a crossover at Morlais Junction, at around 23:04 hrs, the leading wheelset, on which a 'false flange' had by now developed because it had been sliding on the rail, derailed to the left (see paragraphs 56 to 58). At this point the train was travelling at approximately 38 mph (61 km/h). When the partly derailed wagon reached the facing points of the junction, a short distance further on, it was diverted to the left, and the resulting damage to the points caused derailment of the following nine wagons. The coupling between the second and third wagons broke, and the train's brakes applied automatically (figure 8) when the brake pipe separated.

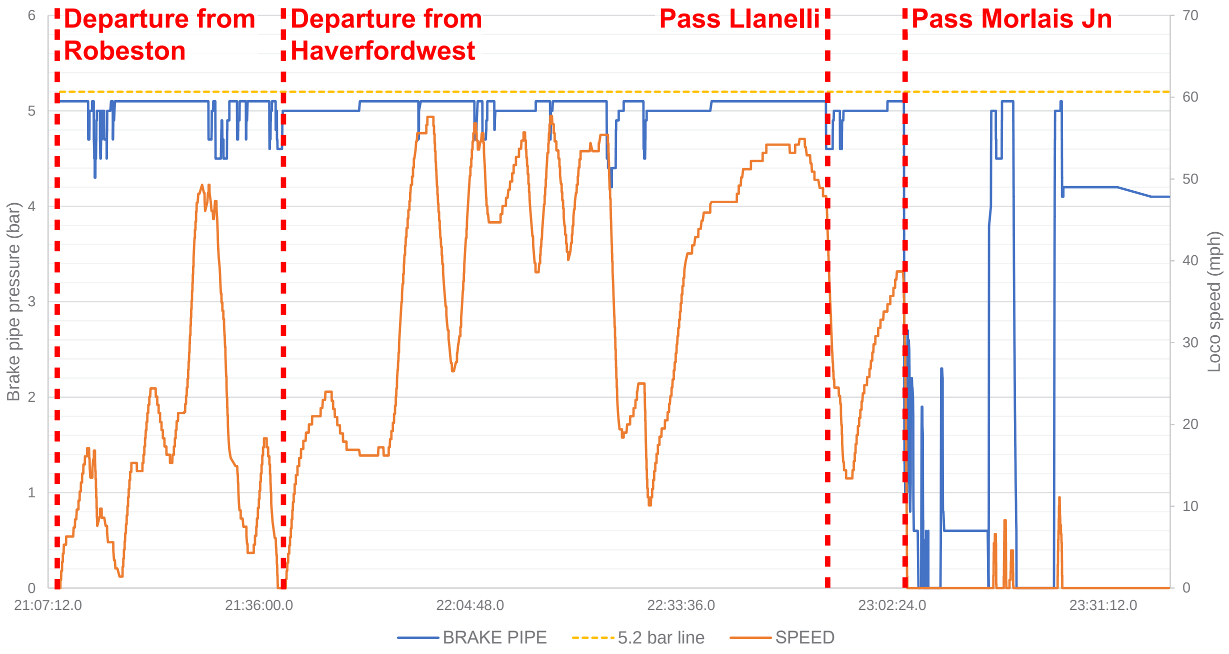

Figure 8: Data recorded by the on-train data recorder (OTDR) fitted to the locomotive of train 6A11 for the journey from Robeston to Morlais Junction, including the brake pipe pressure (blue solid line), 5.2 bar pressure line (yellow dotted line), speed (orange solid line) and locations en route

35 The train driver reported that he was unaware of any problem with his train until an un-commanded brake application occurred in the vicinity of Morlais Junction.

Events following the accident

36 The train driver, on looking back at his train after the locomotive came to a stop, could see a wagon on fire. He made an emergency radio call to the signaller at Port Talbot. The locomotive and the first two wagons had come to a stand around 180 metres from the derailed third vehicle (wagon GERS 89005). After closing the brake pipe valve at the rear of the second wagon, the driver then moved the locomotive and the first two wagons about 400 metres away from the rest of the train.

37 All the emergency services were called, and a major incident was declared. On arrival the fire and rescue service reported that three wagons (the third, fourth and fifth in the train) were on fire and that ten wagons (third to twelfth in the train) had derailed, five of which had overturned. Because of the seriousness of the accident and the materials involved, the fire and rescue service asked a small number of residents in nearby properties to evacuate to a designated safe area.

38 Six of the derailed wagons were punctured, resulting in the contents leaking out, and three of them had caught fire (figure 15). The probable ignition source of the fire was sparks generated by wagons colliding with track components or other wagons during the derailment. Sparks ignited the fuel leaking from wagons three, four and five (see paragraph 191). The fire and rescue service took an early decision to allow the leaking fuel to burn, despite the air pollution this would cause, to prevent further ground contamination and pollution of the local area. Approximately 116,000 litres of the 446,000 litres of diesel which leaked from the damaged wagons were burnt. The remaining 330,000 litres spilled into the environment within Llangennech marsh, which is part of Burry Inlet and Loughor Estuary site of special scientific interest (SSSI), and the adjoining intertidal waters which form Carmarthen Bay and Estuaries special area of conservation (SAC, as defined by the European Union Habitats Directive (92/43/EEC)).

39 At around 06:00 hrs on 27 August, the rear wagons (14 to 25) were uncoupled from the front portion of the train, and were then hauled back a short distance towards Llangennech station. The fire was extinguished at around 19:00 hrs on 27 August and the site was allowed to cool until 08:20 hrs on the following day, when it was declared safe for investigators to begin examining the scene and the derailed vehicles.

40 The emergency response, and the recovery of the scene, was carried out in a collaboration between Natural Resources Wales, the local authority and the rail industry. After the construction of access routes and working areas for heavy lifting equipment on the site, recovery of the damaged tank wagons began on 3 September and was completed the following week. The extensive damage to the track and the underlying formation, and the need to remove contaminated soil, meant that the route was not fully reopened until 5 March 2021.

Consequences of the accident

41 A debrief undertaken by Dyfed Powys Local Resilience Forum (DPLRF) found that there had been an effective response and recovery which limited the ecological damage. The recovery co-ordination group, under the auspices of the DPLRF and working to agreed protocols, were responsible for co-ordinating the recovery stages, including both economic and environmental interests. However, the area directly adjacent to the railway and the accident site was contaminated by oil, with unknown longer-term impacts on the wider area. This resulted in approximately 30,800 tonnes of contaminated ground material being excavated to a depth of two metres and removed from site for treatment at a specialist waste treatment facility. The ground was replaced by clean quarried material, resulting in over 30 heavy goods vehicle movements per day in each direction during November and December 2020.

42 Natural Resources Wales reports that approximately 2.6 million litres of oily water and oil were contained and removed. The contaminated mixture was transferred to a waste treatment facility. Fuel was removed from the damaged wagons using pumps and returned to the oil terminal at Robeston. Further containment and removal was carried out using oil absorbent materials. However, around 65,000 to 100,000 litres of fuel were estimated to have spilled into shallow soil. Dealing with this will require long-term treatment of local water.

43 The Gower Saltmarsh along the southern fringe of the estuary is the largest saltmarsh in Wales, and supports many licensed shellfish gatherers. On the advice of the Food Standards Agency (FSA), the risk of contaminated shellfish entering the human food chain resulted in the temporary closure of all shellfisheries in the area as a precaution, including the main cockle fishery, which meant that a large number of licensed gatherers were unable to work for seven weeks. The marsh is also extensively grazed, primarily for saltmarsh lamb. The accident resulted in the grazing being disrupted. The wider local community were also affected, as the marsh around Llangennech is used by the general public and wildfowlers who were unable to undertake recreational activities following the accident. Arrangements were put in place for ongoing monitoring of the site and wider environment.

44 It should also be noted that had this accident occurred close to centres of population, involved more volatile fuel, or if more of the train's contents had been involved in the fire, the direct human consequences could have been considerably worse.

Background information

The train braking system

45 The train was fitted with a single-pipe air brake system, operating on all wheels of all the wagons. A single pipe along the train both supplies air to the wagons, and controls braking. Air pressure in the pipe is generated by a compressor on the locomotive, and the train driver controls the pressure in the pipe. Each wagon carries one control and one auxiliary air reservoir. To hold the brakes off when running, air pressure is created in the train brake pipe which connects all the wagons. The pressure in the pipe is normally 5 bar (this pressure can be higher if the brakes are 'overcharged', for details see appendix E). Reduction in the pressure in the train brake pipe causes the distributor valve (see paragraph 47) to operate to admit air from the auxiliary reservoir on each wagon to the two brake actuators (often called brake cylinders), on each bogie of the wagon. Air pressure in the actuators moves a piston which, in turn, acts through a system of rods and beams, known as the BFCB system, to apply the brake blocks to the wheel treads. The BFCB systems on both bogies are controlled from a single 'brake group' fitted under the centre of the wagon body (figure 9).

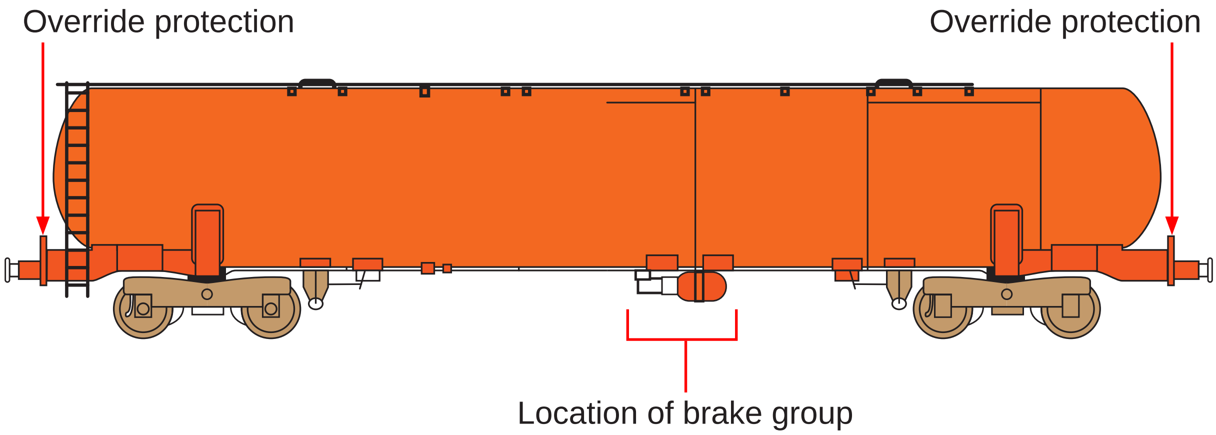

Figure 9: Diagram of a GF4-SS1 brake group on a GERS TEA type wagon

The brake group

46 The brake group on a TEA wagon is a design known as GF4-SS1, and consists of a pipe bracket, distributor, control reservoir and relay valve, which together detect changes in the train brake pipe air pressure, and command the BFCB system on each bogie to apply or release (figures 9 to 12). The auxiliary reservoir (paragraph 45) is mounted on the vehicle underframe, but is not part of the brake group.

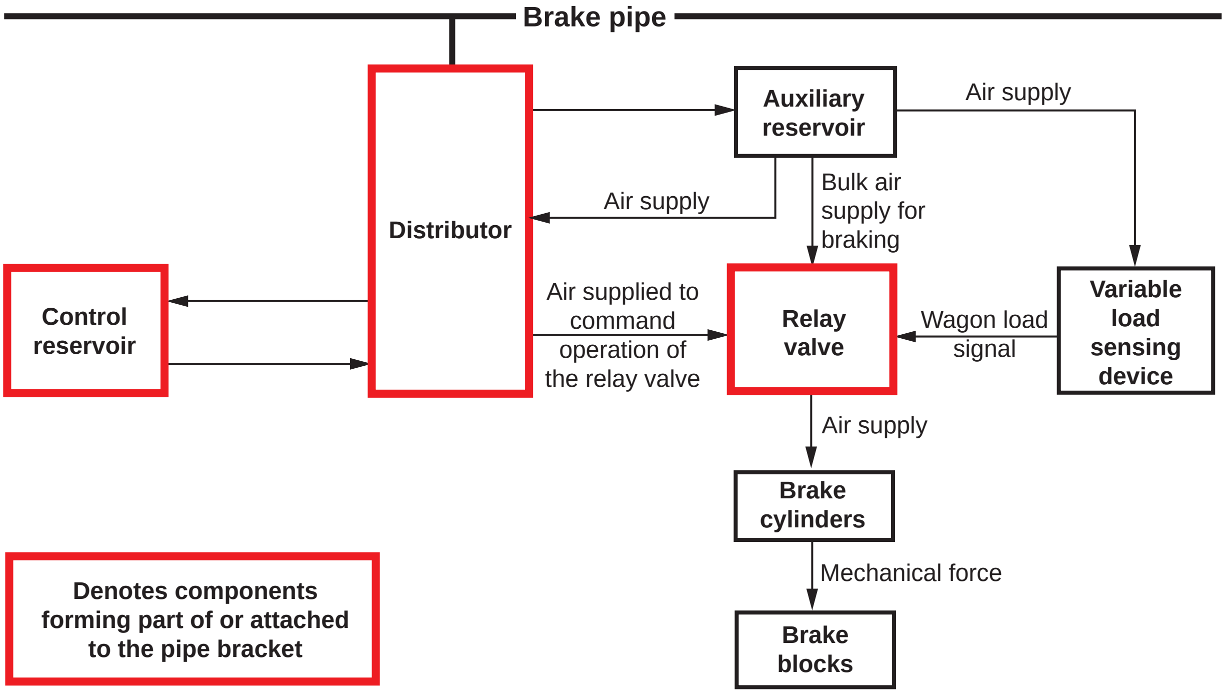

Figure 10: Schematic diagram of the wagon braking system showing the relationship between the various components including the distributor, control reservoir, auxiliary reservoir, relay valve, variable load sensing device, brake cylinders and brake blocks

47 The core of the brake group is a machined cast block, known as the 'pipe bracket'. It is drilled with channels which provide pneumatic connections between the components which are fixed to it. These components are:

a. A Sab Wabco type C3W brake distributor which detects the variations in pressure in the train pipe and causes the vehicle brakes to be applied or released.

b. Associated reservoirs:

   i. 7.5 litre control reservoir, which is mounted onto the pipe bracket as part of the brake group and under normal operating circumstances is maintained at a pressure of 5 bar. This provides a reference pressure which causes the distributor to operate whenever the pressure in the brake pipe is decreased (for a brake application) or increased (to release the brakes) by the train driver's control actions.

   ii. 2.5 litre reservoir (not shown in figure 10), fitted between the distributor and the relay valve, used to provide a finite volume for filling and releasing the pilot pressure from the distributor in a prescribed time. The timing is controlled by chokes in the distributor. The reservoir also acts as a buffer to prevent undesirable pressure surges from taking place whenever air passes from the distributor to the relay valve and brake actuators during brake applications.

c. A Sab Wabco type 1P-1E relay valve which detects braking demands from the distributor and controls the supply of air from the auxiliary reservoir to the brake cylinders, in response to input from the load sensing device (figure 11). The air connections at the interface between the relay valve and the pipe bracket are sealed by means of four 'O' rings. The relay valve is mounted on two studs (threaded pillars) protruding from the pipe bracket, and secured by two nuts with CS type washers.

d. A load weigh valve (also referred to as a load sensing device) is a two-stage valve which senses that the vehicle is either laden or empty. The changeover point is adjusted by the vertical positioning of the plate below the valve. The valve is connected to the wagon suspension, and sends an air pressure signal to the relay valve. The relay valve combines the output from the distributor with the output from the load sensing device. The relay valve produces a variable output, so that as the vehicle weight increases, the air pressure in the brake cylinders increases proportionally when the driver applies the brakes.

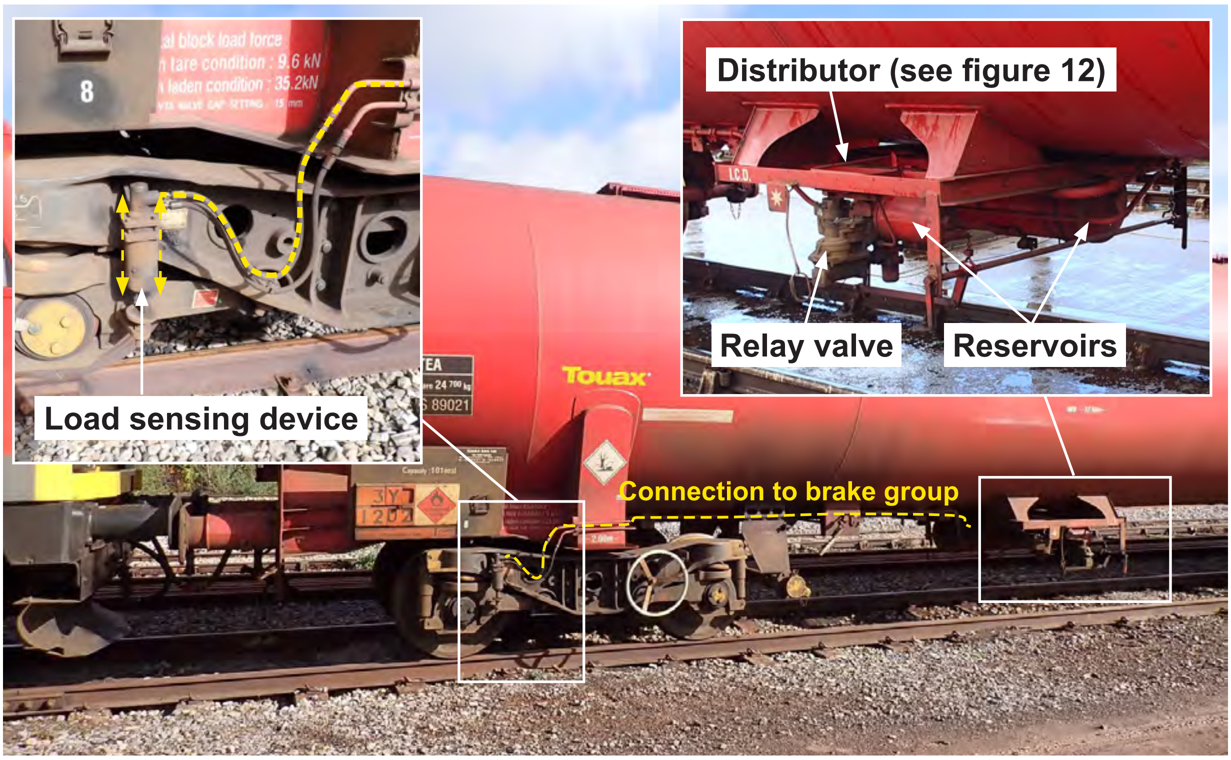

Figure 11: GF4-SS1 brake group on a TEA type wagon

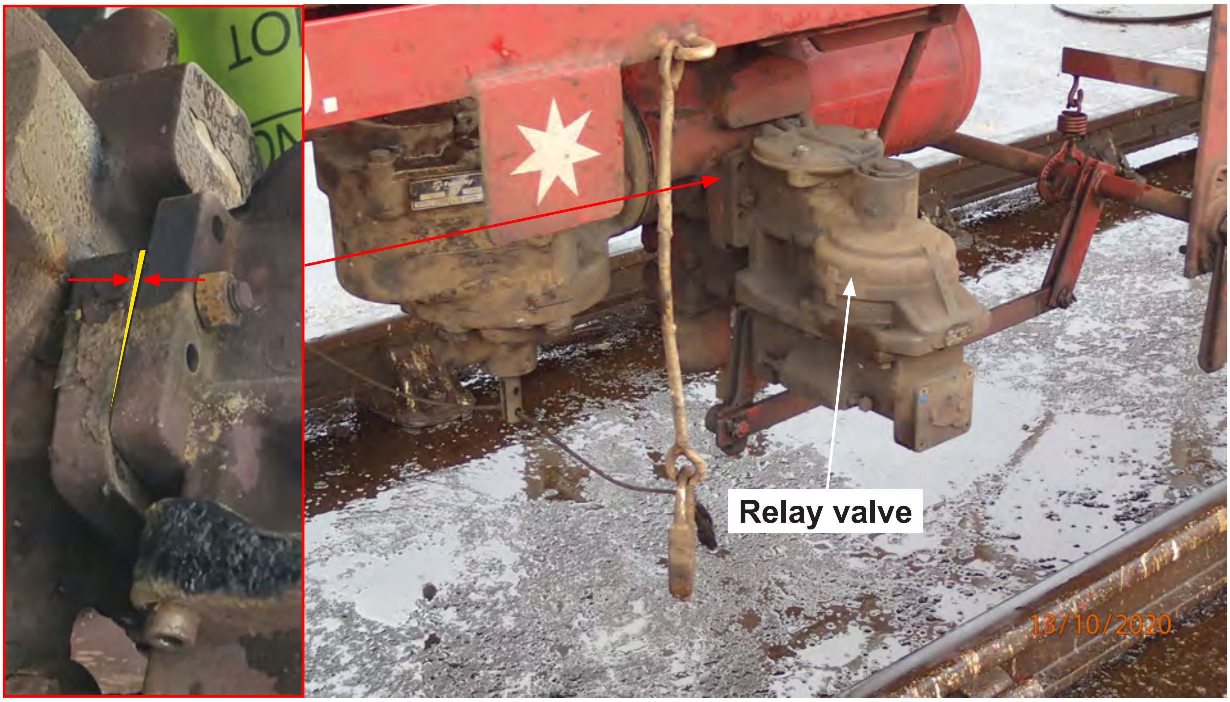

Figure 12: Image (main) showing the connection between the pipe bracket and the relay on a GF4-SS1 brake group with inset image showing the 1-2 mm gap (yellow segment) found between the pipe bracket and the relay valve on wagon GERS 89005

Requirements for wagon maintenance

48 The concept of the entity in charge of maintenance (ECM) was introduced by EU Directive 2008/110/EC, amending the Railway Safety Directive 2004/49/EC. In the UK these requirements were implemented by an amendment to the Railways and Other Guided Transport Systems (Safety) Regulations 2006 (commonly known as the ROGS regulations).[7] Regulation 18A of the amended ROGS regulations requires anyone placing a vehicle in service or using it on the mainline railway to ensure that:

- an ECM has been assigned to the vehicle;
- the details of the ECM are registered on the national vehicle register (NVR); and
- for freight wagons, the ECM holds an ECM certificate.

49 The ECM certificate specifies four functions that must be performed:

a) management function

b) maintenance development function

c) fleet maintenance management function

d) maintenance delivery function

Function a) must be performed by the ECM itself. However, the regulations permitted functions b) to d) to be outsourced, subject to the ECM implementing suitable management controls, such as auditing.

50 More detail of the regulations relating to ECMs is provided at appendix F.

[7] The amendment to ROGS was enacted by the 'Railways and Other Guided Transport Systems (Miscellaneous Amendments) Regulations, 2013'

51 Although originally considered as part of the EU wagon maintenance regime, there is no legal requirement for the certification of workshops. For this reason, it is the responsibility of ECMs themselves to audit the adequacy of workshop processes and facilities (as part of function d)).

The maintenance records for wagon GERS 89005

52 The maintenance records for wagon GERS 89005 indicate that a seven-yearly ‘general repair’ overhaul had been completed between April and August 2017 (see paragraph 87). Since then, it had received routine planned preventative maintenance (PPM) examinations every four months. A yearly vehicle inspection and brake test (VIBT) examination was also completed at Robeston, most recently on 18 June 2020, two months before the accident. These intervals were in line with the wagon maintenance schedule defined by Touax in its maintenance specification manual DT 432 (see paragraph 86). This manual permits a tolerance on the defined intervals of 14 days for PPM and 28 days for VIBT, and the examinations of the wagon since 2017 had been carried out within these tolerances.

Analysis

Identification of the immediate cause

53 The leading wheelset of the third wagon in the train developed a false flange, which was not detected before the train reached Morlais Junction, where the damaged wheelset was unable to negotiate pointwork and became derailed.

54 After the accident, the leading wheelset of wagon GERS 89005 was found to have developed a substantial flat area on the wheel treads and, as a consequence, there was a 'false flange' on the outside of the tread of each wheel, approximately 230 mm long and up to 15 mm deep (figures 13 and 14). The evidence from CCTV from Pen-y-bedd crossing and Llanelli station and the data from Pembrey HABD (see paragraphs 135 to 143) indicates that the leading wheelset was not rotating, and the other three wheelsets on this wagon were dragging (not rotating freely) when the train passed those recording devices. Score and burn marks were found on the railhead between Llangennech station and Morlais Junction. Railhead marks were also visible over the three miles (4.8 km) from Llandeilo Junction through to Llangennech level crossing where the marks appeared to change in shape, suggesting that wheels may have also been intermittently sliding and releasing.

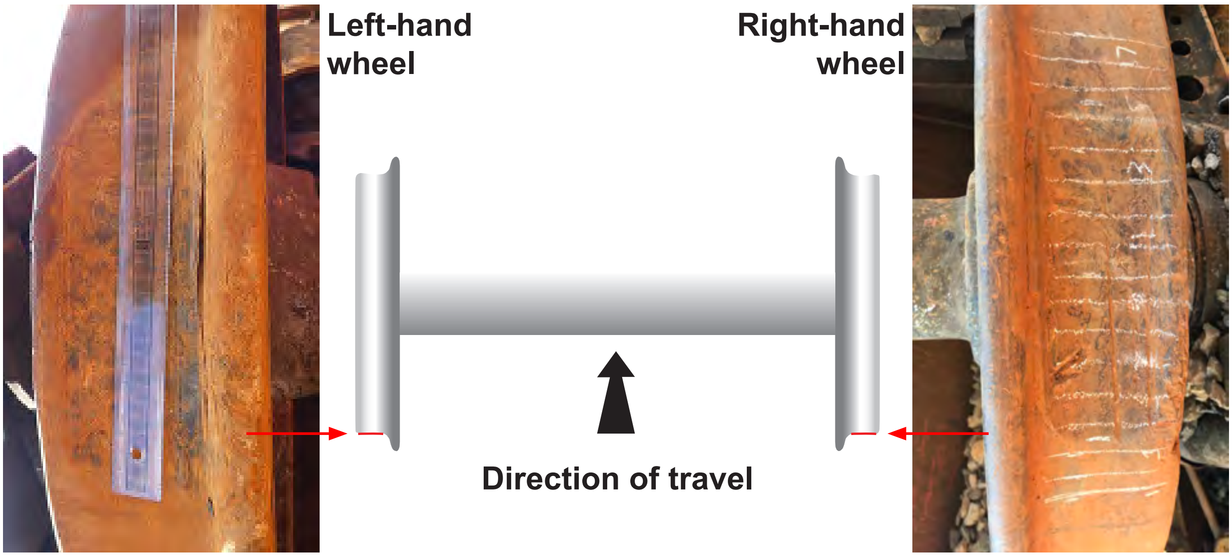

Figure 13: Images showing the profile of the wheel and the damage (red line) that occurred to the left and right wheels on the leading axle of wagon GERS 89005

55 RAIB cannot precisely determine the rate at which the damage to the wheels developed to confirm how far the train travelled with the leading wheelset of the third wagon locked. However, the CCTV footage and HABD data suggest that it is likely to have been of the order of 13 miles (21 km).

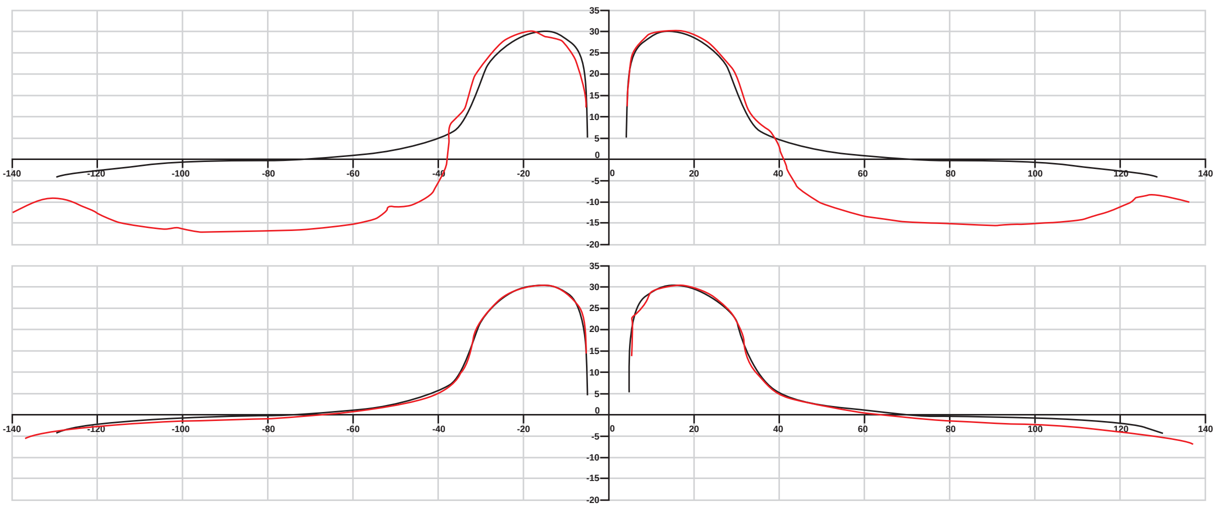

Figure 14: Diagrams showing the left (LHS) and right (RHS) wheel profiles (shown as black line) on the front axle (top) and rear axles (bottom) of wagon GERS 89005. The front axle (also shown as axle 15 on the HABD data on figure 29) also shows the depth (shown as a red line) of wear on the tread of the locked wheels. The treads on the rear axles (also shown as axles 16 to 18 on figure 29) show a lower depth of wear as these wheels were not locked although the brakes were dragging

56 The point of derailment was identified from track marks and damage as being near the open end (the toe) of the switch rails of points 997A, which form part of a trailing crossover at Morlais Junction. As the third wagon traversed the trailing points, the false flange on the right-hand leading wheel rode along the inner face of the stock rail and caused the rail to rotate outwards towards the six-foot. The right-hand wheel then travelled along the web of the rail until it reached a fishplate, at which point the left-hand wheel climbed over the left-hand rail (figures 15 to 17).

57 The wagon then ran with its leading wheelset derailed to the left for around 175 metres until it met the facing turnout, where it was guided to the left along the Central Wales line.

58 Marks on the track showed that the derailed wheelset travelled approximately 8 metres along the Central Wales line until the third wagon began to tip over, and the coupling between the second and third wagons broke. This caused the train brakes to apply, resulting in the train driver becoming aware of the derailment. Damage to the track caused by the derailed third wagon caused the derailment of the following wagons (figures 18 and 19).

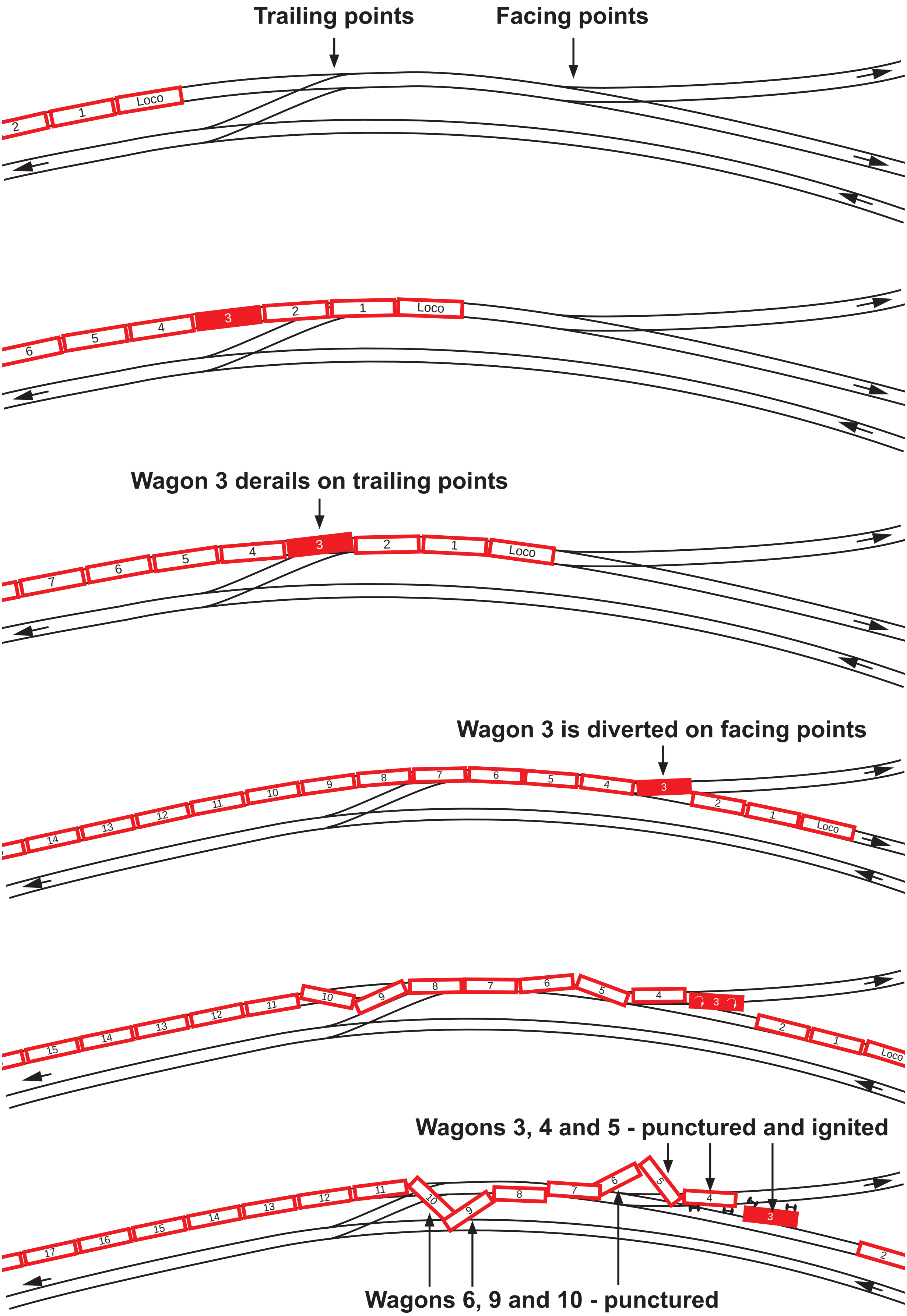

Figure 15: Diagram (from top to bottom) showing the likely sequence of the train derailment

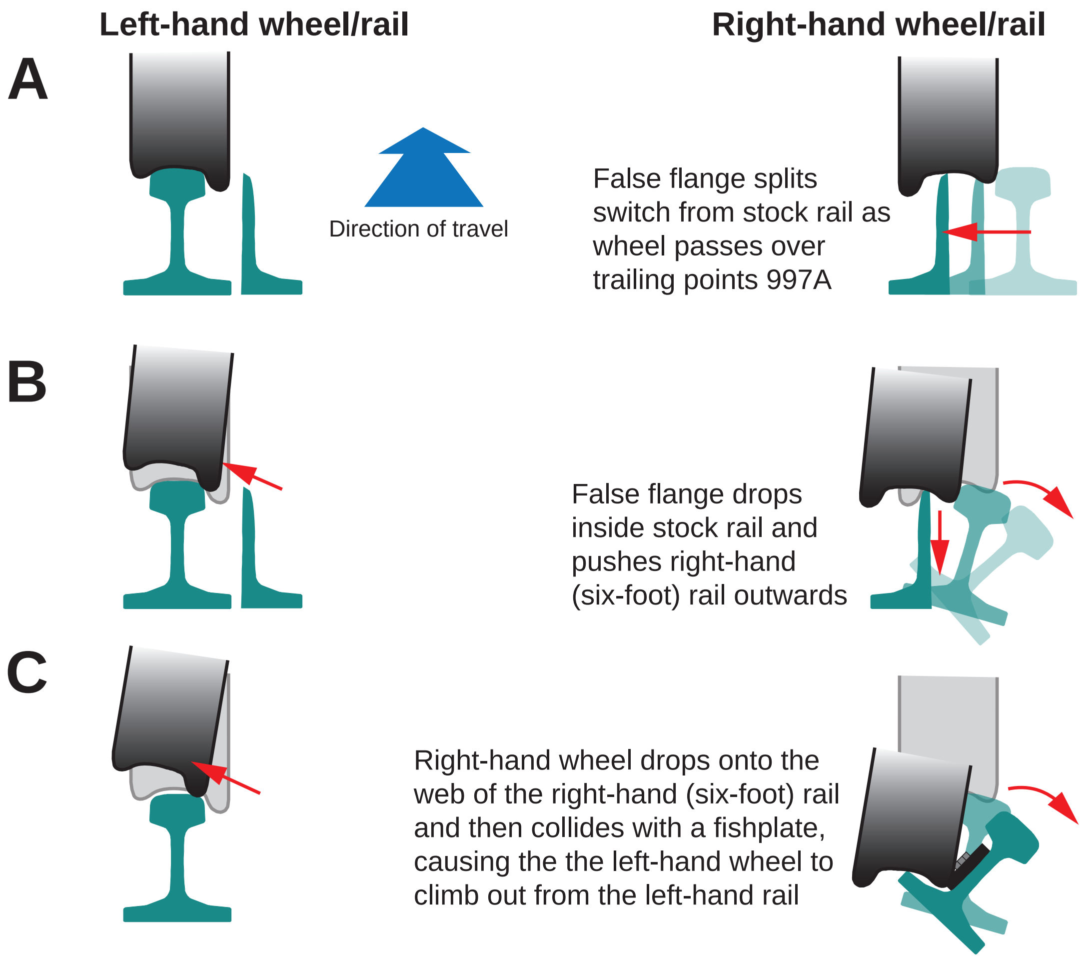

Figure 16: Diagram showing the sequence of the derailment of wagon GERS 89005

Figure 17: Damage to the switch tip of points 997A

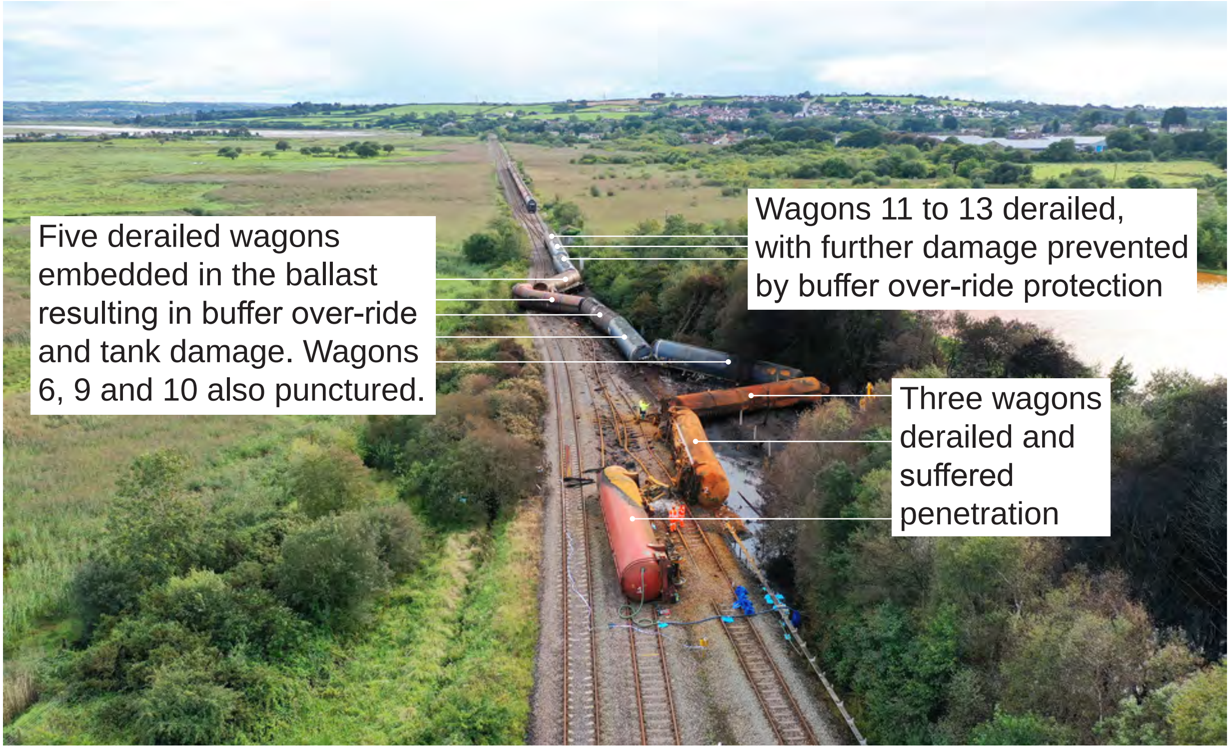

Figure 18: Aerial image of the accident site looking towards the rear of train 6A11(image courtesy of South Wales Fire and Rescue)

Figure 19: Aerial image of the accident site looking towards the front of train 6A11(image courtesy of South Wales Fire and Rescue)

Identification of causal factors

59 The causal factors were:

a) The false flange was caused by the leading wheelset of wagon GERS 89005 ceasing to rotate. This lack of rotation was probably caused by a malfunction of the braking system of the wagon, that resulted in uncommanded brake applications, commonly known as 'dragging brakes' (paragraphs 62 to 70). The malfunction of the braking system was the result of a combination of the following sub-factors:

i. A historical change to the design of the Sab Wabco relay valve increased the chance of a dragging brake event occurring (paragraphs 71 to 82).

ii. The relay valve on wagon GERS 89005 was further susceptible to becoming loose because it was not being maintained as specified by the brake equipment manufacturer. This was able to happen because Touax's management of its ECM requirements was inadequate (paragraphs 83 to 107).

Two sub-factors were also identified that were possibly linked to the cause of the brake malfunction. These were:

iii. The opportunity to learn from previous experience was missed (paragraphs 108 to 127).

iv. The ECM certification process applied to Touax by Belgorail was below a standard that was effective (paragraphs 128 to 134).

b) The wheelset detection software within the infrastructure technology was not installed to alert the signaller to the dragging brakes on the wagon. This is a probable factor (paragraphs 135 to 147).

60 The investigation also considered the following potential factors:

- the geometry of the track
- the preparation and driving of the train and overcharge of the brake system
- other components failing within the relay valve or distributor.

While these cannot completely be discounted as possible contributors to the accident, RAIB has found no evidence that they were. Details of these potential factors are discussed in appendix E.

61 Each of the causal factors is now considered in turn.

Malfunction of the braking system on wagon 89005

62 The false flange was caused by the leading wheelset of wagon GERS 89005 ceasing to rotate. This lack of rotation was probably caused by a malfunction of the braking system on the wagon, that resulted in uncommanded brake applications (commonly known as 'dragging brakes').

63 The derailment resulted in the brake group becoming detached from the wagon underframe, and it was also affected by the heat from the fire. On examination, the relay valve was observed to be loose on the pipe bracket. The nuts holding the relay valve in place were loose, and no washers were present. The mating faces of the relay valve and the pipe bracket had become separated by 1 to 2 mm. The mounting studs, which are screwed into threaded holes in the pipe bracket, were only 'finger tight' (figure 12).

Figure 20: The brake group from Wagon GERS 89005 as found after the accident

64 RAIB's examination of the relay valve and pipe bracket mating faces found that one of the four 'O' rings which seal the air passages between the relay valve and the pipe bracket was missing (figures 21 to 23). The missing 'O' ring, one of the two smaller 'O' rings, was from the passage carrying the distributor output to the relay valve. It is not possible to be certain when this 'O' ring was lost. RAIB carried out reconstruction tests on the brake group (see paragraph 70), which suggested two possible scenarios. These are:

- The loose relay valve and consequent air leakage between the two mating faces resulted in air circulating between the two faces and entering the recessed ports in which the 'O' rings sit. This resulted in air pressure under the distributor 'O' ring which caused it to be ejected (as observed during several of the RAIB reconstruction tests - figures 25 and 26)
- The distributor output 'O' ring may have been dislodged during the derailment, and fell out.

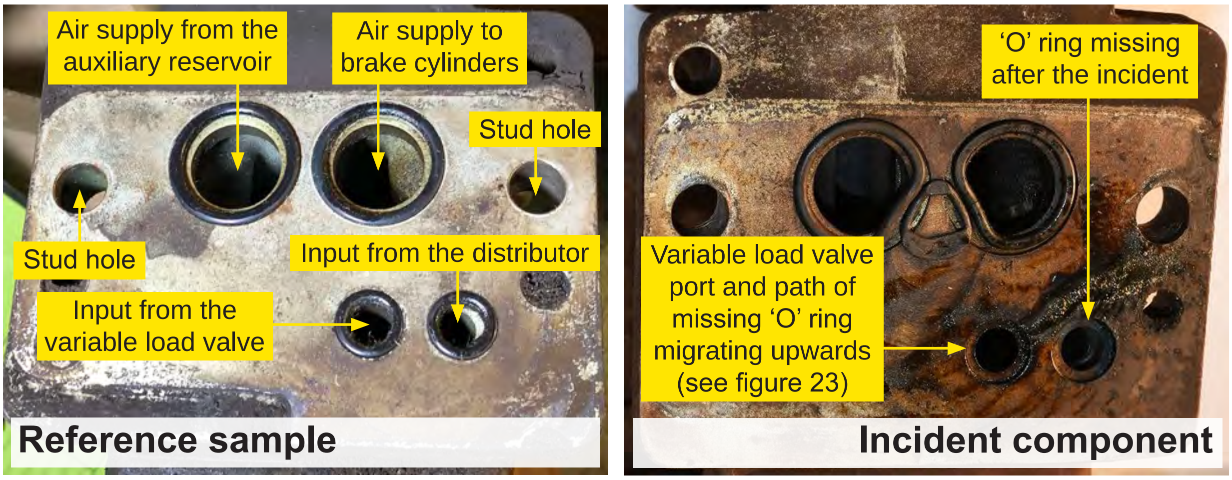

Figure 21: Image showing the correct 'O' ring locations of a refence sample (GERS 89014) in comparison to the incident wagon (GERS 89005)

65 The other smaller 'O' ring, which seals the connection between the load sensing device and the relay valve, had migrated out of its recessed port (figures 22 and 23). Such migration would only have been possible if the relay valve was loose on the pipe bracket. The design of the two-stud mounting on the side of the pipe bracket is such that, if the relay valve becomes loose, a wedge-shaped gap develops between the mating faces, with a larger gap at the top than at the bottom. Contact trace marks found on the mating surfaces show the path the 'O' ring had taken as it migrated out of its recess. The 'O' ring had then become effectively 'sandwiched' between the two mating faces (figures 22 to 26).

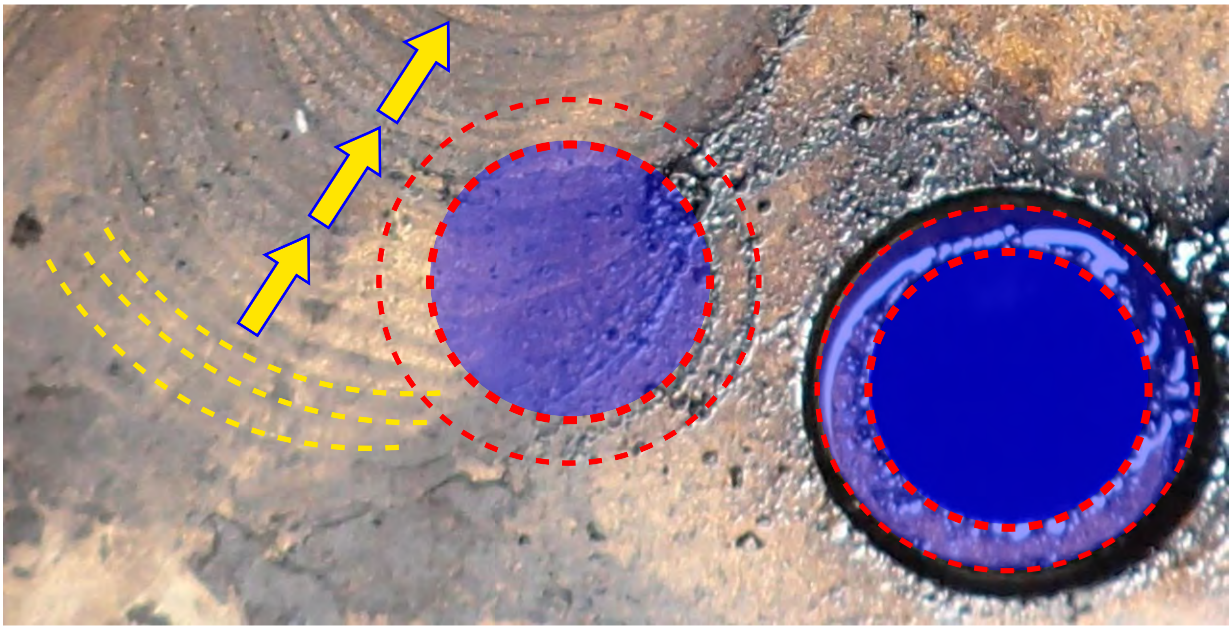

Figure 22: Microscopic image showing the original location and a surface imprint on the mating face of the relay valve (red dotted lines) of what is believed to be an undamaged load sensing device 'O' ring. Also shown to the left (yellow dotted lines and arrows) are surface imprints of the same 'O' ring as it migrated up towards the auxiliary reservoir and brake cylinder ports (see figure 23)

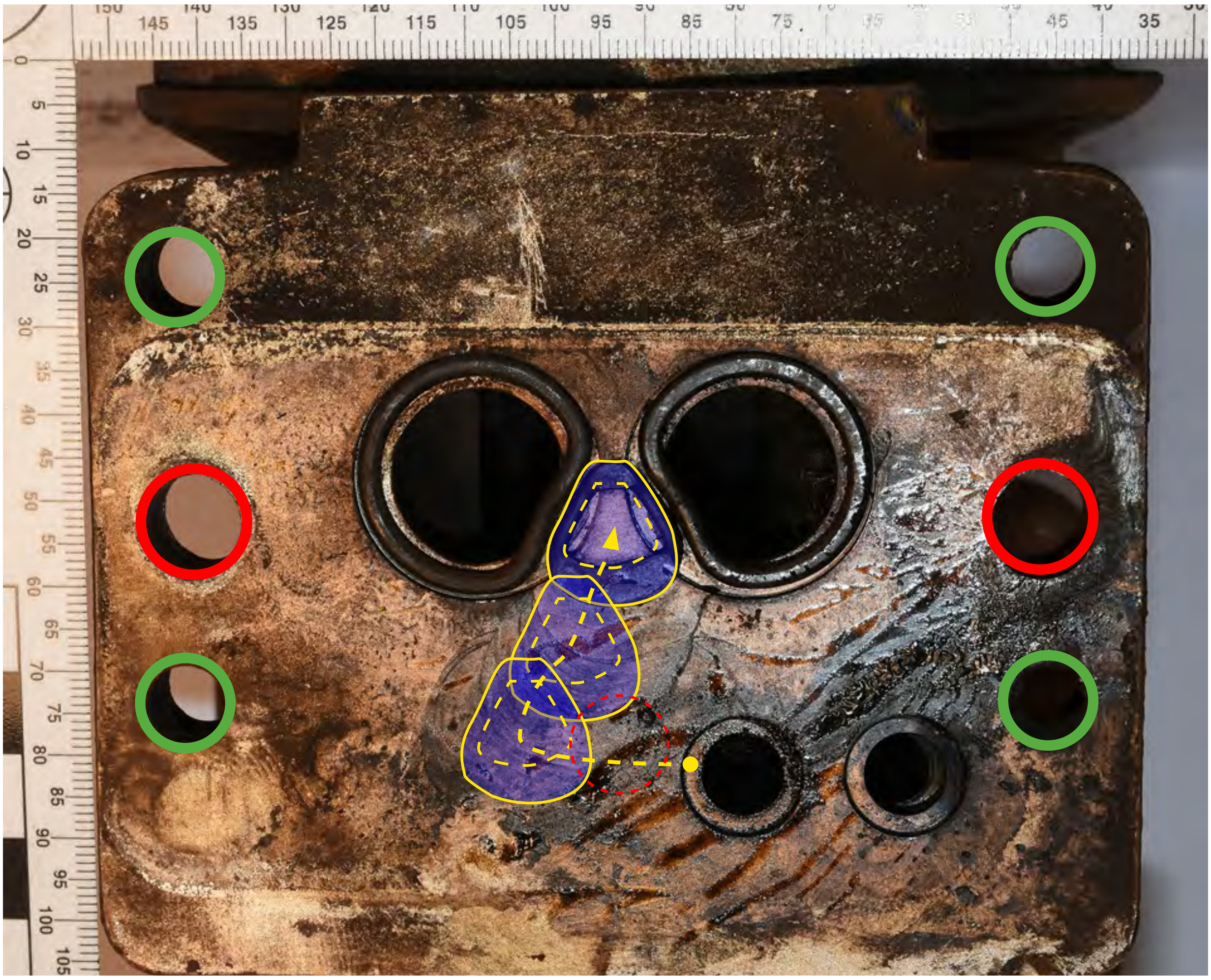

Figure 23: The relay valve mating face and what is believed to be the path taken by the variable load sensing device 'O' ring (yellow dashed line). Pre-1994 design incorporated four fixing points (green circles) and later design change to two fixing points (red circles)

66 As the wagon travelled, its motion led to movement of the mating faces relative to each other which caused the 'O' ring to migrate upwards. As the 'O' ring moved, it became flattened and deformed (figures 21 to 23), and came to rest wedged between the two larger 'O' rings which seal, respectively, the input from the auxiliary reservoir to the relay valve, and the output from the relay valve to the brake cylinders.

67 The three 'O' rings were found in the position shown in figure 23 when the assembly was dismantled after the accident. It was apparent that after the migrated small 'O' ring made contact with the two larger 'O' rings, all three became distorted. This resulted in the creation of a route for air to flow directly between the input and output ports of the relay valve, leading to uncommanded air pressure developing in the brake actuators.

68 This air pressure was sufficient to produce a partial brake application at some point on the journey to all the wheels on the third wagon, GERS 89005 (paragraph 70). This application may not have been capable of immediately locking wheels, but it is clear from the evidence that the front wheelset ultimately became locked. It is not possible to say exactly why the front wheelset alone behaved in this way, and the relationship between dragging brakes and locked wheels is uncertain. The likelihood that a wheel will become locked in these circumstances depends upon the friction between the wheel and the rail, as well as the brake cylinder pressure (given a fixed level of friction between the brake block and the wheel, and a fixed axle load). The levels of wheel/rail friction during the train's journey are unknown, but RAIB has no reason to believe they were in any way exceptional, given the time of year and the weather conditions (paragraph 25). The route had been well used in the hours before the accident and there were no reported problems with adhesion. Although wheel/rail adhesion would have had some effect once the brakes started to drag, RAIB has found no evidence that it was unusually low, and believes the evidence indicates that the locked wheel was primarily associated with the brake system fault.

69 Sliding in this locked condition caused a single large flat spot and false flange to be created on the treads of both wheels of the leading wheelset. There is no evidence of any other flat spots on the leading wheelset. Although the wheelset was able to traverse pointwork at Llanelli (5.25 miles (8.4 km), from Morlais Junction) and Llandeilo Junction (3.75 miles (6 km) from Morlais Junction), by the time the train reached Morlais Junction the false flange was sufficiently deep that the wheelset was not able to negotiate the junction without derailing.

70 As there was very little information on any previous similar faults which had resulted in incidents of dragging brakes and locked wheels, RAIB, in consultation with the rail industry and parties involved in the accident, undertook reconstruction tests on 23 and 24 March 2021 at the Eastleigh, Hampshire, premises of AFSL, using a similar GERS wagon. A relay valve and a TEA wagon that had been recently overhauled were used. The tests were witnessed by representatives of the wagon's owners, and the companies involved in their maintenance and operation, as well the Office of Rail and Road (ORR). Before the testing the individual brake system components and the system as a whole were pressurised and tested with a maintenance test rig to ensure the components and wagon brake system were working correctly, and to the required settings as shown in the Touax maintenance manual. The tests used both the 'O' rings damaged in the accident, and new 'O' rings supplied by Wabtec Faiveley. The 'O' rings were placed in the respective ports and the relay valve was secured (with and without washers being present) to the required 29 Nm torque. The relay valve securing nuts were then systematically loosened by a quarter of a turn at a time each side, to record and observe the effect at the interface between the relay valve and the pipe bracket, and the effect on the brakes on each axle, with brake cylinder pressures recorded on the test rig. Each test was repeated, and the relay and 'O' rings were examined and photographed after each test. In parallel with the reconstruction tests at Eastleigh, additional forensic analysis (figures 24 and 25) of the components was carried out during the RAIB investigation. These tests and examinations identified the following:

- If the two securing nuts are loose, the relay valve body can pivot on the studs, because of the clearance between the studs and the holes in the relay valve body. The tests confirmed that a loose relay valve can move with sufficient vigour to initiate a partial brake application, and to damage the internal surface of the mounting holes as found after the accident, thus providing an indication that the relay valve had pivoted on the studs (figure 24).
- The movement of the load sensing device port ‘O’ ring was the result of the pivoting action of the loose relay valve (figure 24). Reconstruction tests, in which the loose relay valve was manually moved to simulate the movement of the wagon, found that in this situation the smaller ‘O’ rings migrated out of their ports and also suffered distortion and damage.
- The brake cylinder port ‘O’ ring had been deformed and had fractured. Analysis of the fracture surface showed this was not a deliberate cut, but was a fracture which may have been caused before or during the accident (figure 26).
- Irrespective of ‘O’ ring movement, manually pivoting a loose relay valve on the studs can result in air pressure circulating between the mating faces of the pipe bracket and relay valve, resulting in a rise in air pressure in the brake actuators, causing an uncommanded application of the brakes. RAIB believes that a similar movement of the valve would have occurred during the train’s journey from Robeston to Morlais Junction.
- After an uncommanded brake application took place, the brakes would sometimes remain applied. If the relay is loose, its weight means that when the wagon is at rest, the close proximity of the two flanges will still allow an air path between the auxiliary reservoir port and the brake cylinder port which was sufficient to keep the brakes applied.
- If a relay valve is loose such that the mating faces are about 0.5 mm apart, surface contamination, if present, can sometimes prevent the air pressure (4.3 to 5.0 bar) from exhausting to atmosphere, with no sound of escaping air being heard. During the tests, as the relay valve pivoted, brake pipe pressures were seen to fluctuate between 4.96 and 4.73 bar, and brake cylinder pressures fluctuated between 0.17 and 0.83 bar (figure 26).

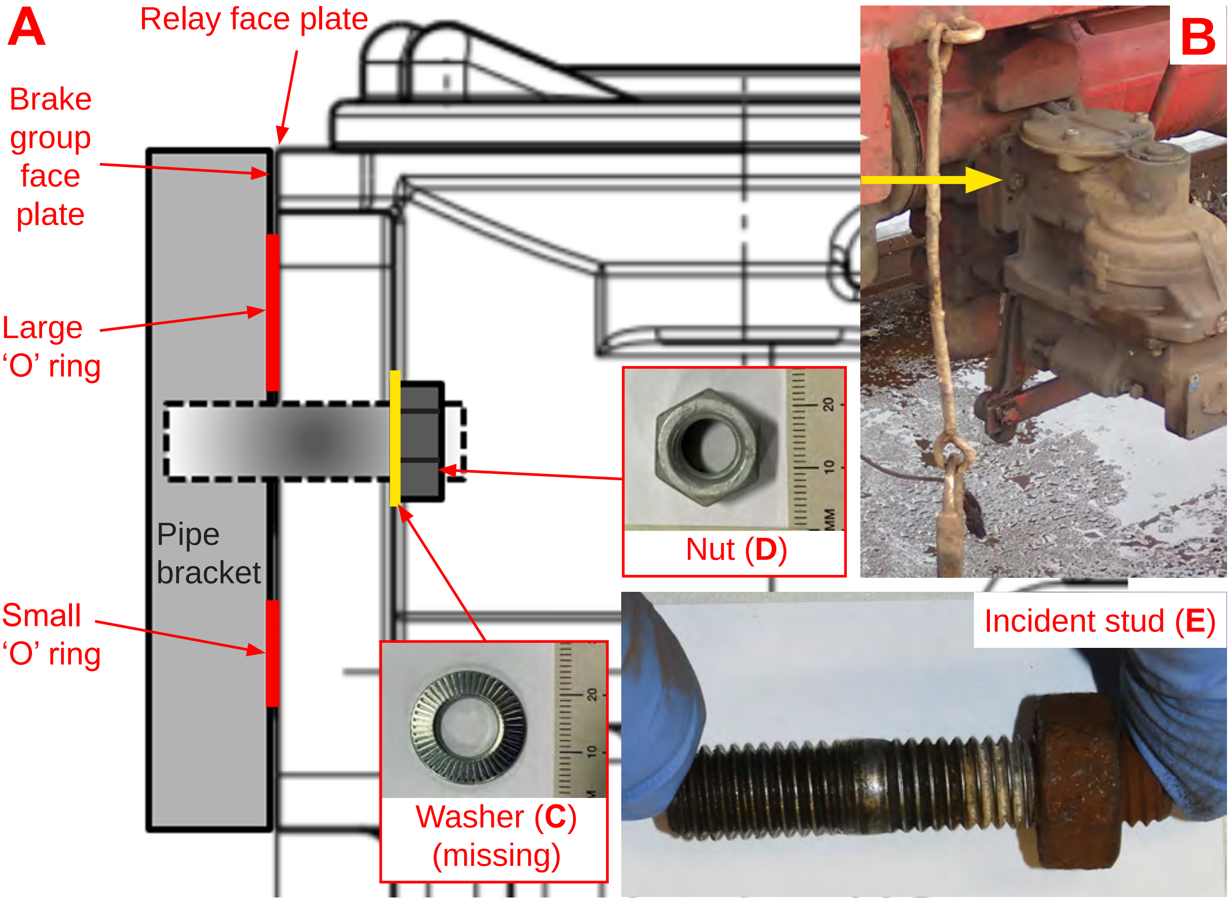

Figure 24: Diagram (A) showing the position of the stud, nut and missing washer with inset image (B) showing the location of the mating faceplates. A washer (C), and nut (D) compared to one of two incident studs (E) attached (through corrosion) to the nut.

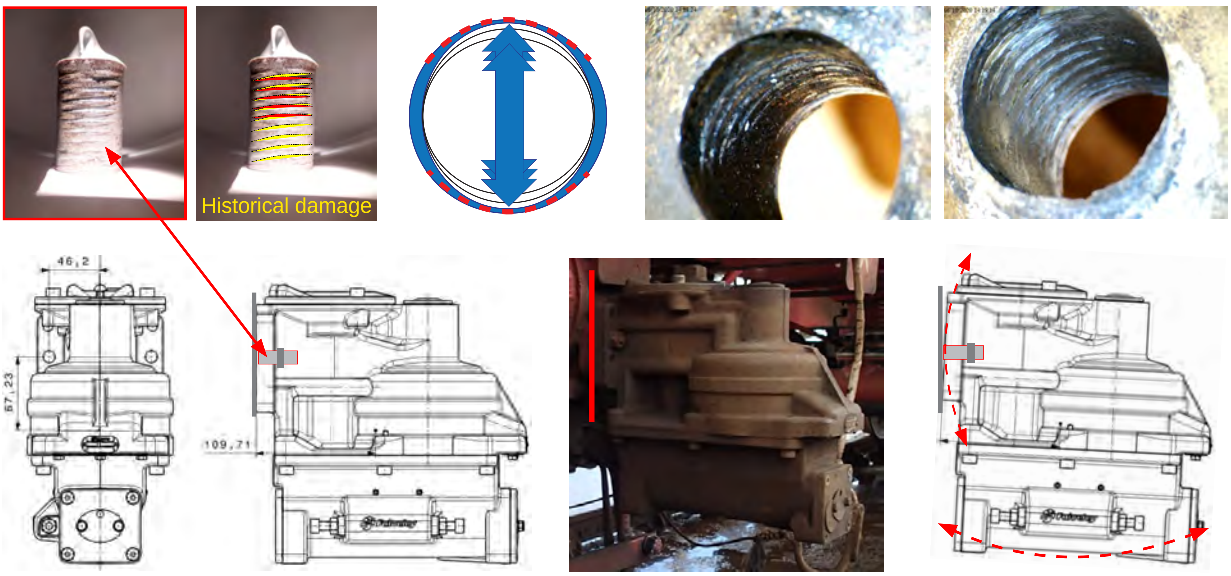

Figure 25: Images (top right and middle) showing the damaged surfaces of the internal bores of the mounting holes of the relay valve (bottom image and diagrams) as a result of the relay valve being loose and pivoting on the studs of the brake group. The inset image (top left) shows the castings taken from the bores for analysis of the marks which confirm that the relay was loose.

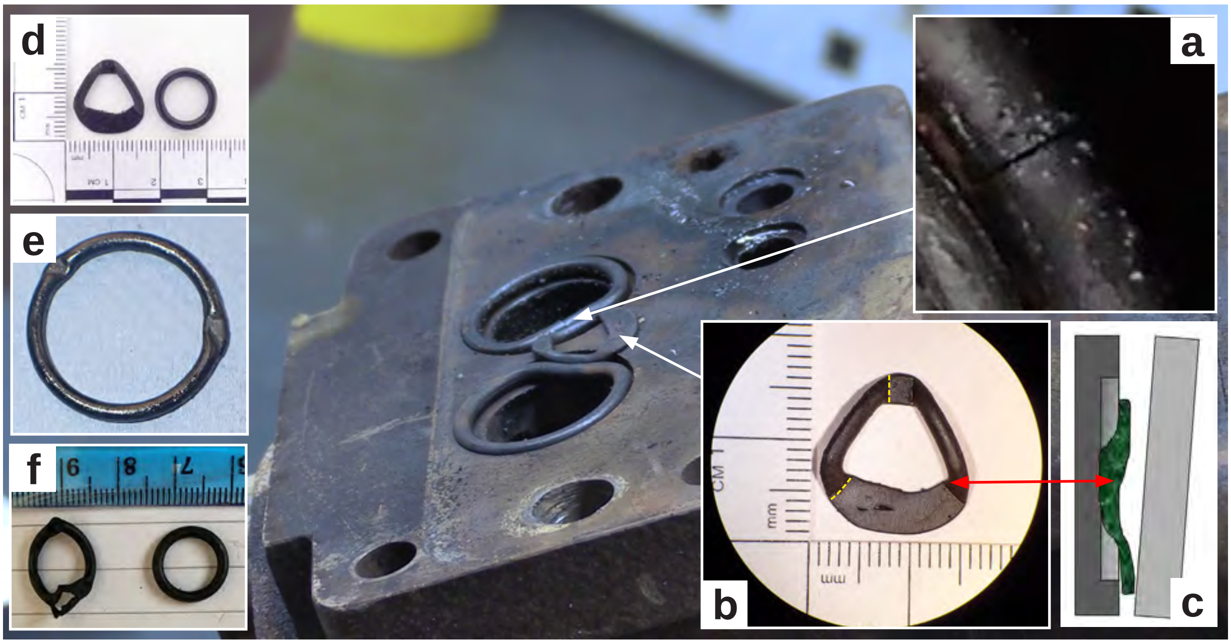

Figure 26: Central image shows the as found location of the small load sensing device 'O' ring lodged between the auxiliary reservoir port and brake cylinder port with top right inset image (a) showing the fracture to the brake cylinder 'O' ring and bottom right images showing the damage and side view of the small 'O' ring (b) and (c). The top left-hand image (d) shows the damaged 'O' ring compared to a new reference sample. Images (e) and (f) show new reference sample 'O' rings used in reconstruction tests which showed similar damage after the mating faces of the relay valve and brake group became loose.

Design of the braking system on wagon 89005

71 A historical change to the design of the Sab Wabco relay valve increased the chance of a dragging brake event occurring.

72 The first version of the design of the VCAV relay valve was produced by Sab Wabco in 1973. The design of the mating surface was based on the need for the valve to be compatible with equipment of earlier design, and included four holes for M8 (8 mm diameter) studs. The upper and lower bodies were manufactured in cast iron. Around 1975, the upper body was modernised and manufactured in aluminium with four holes in the flange (figure 23). The lower body remained in cast iron.

73 Around 1985, the current design (as in operation today) was first produced, with the lower casing manufactured in aluminium to reduce weight. Due to the reduced weight, and to reduce the number of components and the cost, the number of fixings was reduced from four to two studs, nuts and washers. The size of the studs and nuts was increased in size from M8 to M10 in combination with the use of two cupped spring (CS) type washers (figure 24). The four holes for M8 studs were retained to ensure some contingency and compatibility existed for older style brackets on other rail vehicles.

74 In 2004, Wabtec Faiveley (formerly Faiveley Transport) acquired Sab Wabco. Wabtec Faiveley advised RAIB that no documents were available relating to any historical risk assessments of this design change, and that it was likely that the change of design from four M8 studs and nuts to two M10 studs and nuts (figure 23) would not have involved a detailed risk assessment. However, it was likely that the design with two studs and the associated nuts and washers would have been considered to be adequate, if assembled and tightened correctly. Wabtec Faiveley and its predecessors have specified CS washers on brake system components since 1994.

75 Wabtec Faiveley reported that the torque value of 29 Nm which it specified for the relay valve nuts was derived from French standard NF E25-030-1 (August 2014) covering design rules for tensile loaded bolted joints. Studs and plain nuts are not required to be routinely replaced during overhauls unless the components are damaged.

76 Wabtec Faiveley's manual 3079 (see paragraph 105(ii)) states that CS type washers must be replaced at each overhaul. A washer is typically used to evenly distribute the force between the nut face and the object being clamped. Because of their flexibility, CS washers act like a spring washer that is intended to prevent a nut loosening or coming undone, and are considered suitable for applications where a component or environment is subject to shock and vibration. The manual did not specify that new nuts should be used.

77 Wabtec Faiveley stated that locking nuts (for example, castellated, Philidas and nyloc (Nylstop) type nuts) should not be used on a relay valve or distributor because CS washers combined with a plain nut are considered to be reliable, if the right torque of 29 Nm is applied.

78 In 2015, Wabtec Faiveley's technical department based in Amiens, France commissioned vibration and frequency testing of the brake group in accordance with CEI standard 61373 'Railway applications on rolling stock equipment-shock and vibrations tests' (2000). The test report concluded that there was slight movement of the relay valve after the shock and vibration tests, but no loss of torque was observed. As Wabtec Faiveley was not aware of any loosening incidents in service, it considered the design to be sound.

79 From the documents and photographs of the 2015 tests, RAIB has concluded that the tests used new studs, washers and nuts. However, at the time of the tests the manufacturer's instructions did not require new nuts and the risks with using old nuts (see paragraphs 80 and 81 and appendix D) had not been identified. Because Wabtec Faiveley did not consider possible elements of human error, it did not consider that the joint clamping forces might be reduced if old washers were reused, if plain rather than CS washers were used, or if a fitter did not fit any washers. Wabtec Faiveley did not share the test results with Touax or other users of its products.

Fastener testing and analysis

80 RAIB commissioned forensic testing and analysis of the damage to the components from wagon GERS 89005. Reference samples were taken from another wagon brake group together with samples of new studs, nuts and washers supplied by the manufacturer (figures 24 and 26). The objective of the tests was to determine if the relay valve had started to become loose before or during the journey from Robeston on 26 August 2020. The details of this work are in appendix D.

81 The conclusions from the test and analysis work were:

- The design change from four to two fasteners on a critical joint produced an inherently higher risk. If one of the two fasteners is not tightened, or not adequately tightened, the moment loading acting on the joint would tend to rotate the joint around the remaining tightened stud. Even if fully tightened, this fastener would tend to loosen and cause the integrity of the joint to be at risk (figures 23 to 26).
- A new nut as well as a new CS washer should always be used during any maintenance work requiring the detachment and reattachment of the relay valve.
- Instructions should be provided to maintainers that the joint faces must be free from grease or other contaminants. This is so that the slip resistance of the joint is not compromised. Joint slip is a cause of self-loosening as well as being detrimental to the ‘O’ rings in the joint interface.
- The tests showed that the tightening torque specified by the manufacturer could be increased to reduce the overall risk of the nuts loosening. Calculations indicate that a mean tightening torque value of 34 Nm is feasible with a +/- 15% torque variation. If the allowable torque scatter is reduced to +/- 10%, the torque could be increased to 36 Nm.

Previous experience of loose fastenings of valves on pipe brackets

82 Witness evidence suggests that in each year from 2015 to 2020 there were at least two occasions when engineering staff working on a wagon of this type that had arrived at a depot for maintenance or overhaul found fastenings of valves on a pipe bracket to be loose. Although these incidents are alleged to have been reported, no records of this have been found.

Maintenance of the braking system on wagon 89005

83 The relay valve on wagon GERS 89005 was further susceptible to loosening because it was not being maintained as specified by the brake equipment manufacturer. This was able to happen because Touax’s management of its ECM requirements was inadequate.

84 Evidence indicates that, at some point, the nuts on the relay valve lost their preload and began to loosen, causing the mating faces of the relay valve and pipe bracket to part. This enabled the loose relay valve to move up and down on the brake group (paragraph 70). As a result of movement of the wagon, the internal bores of the aluminium body of the relay valve were damaged by impact with the threads of the two steel studs (figure 25).

85 Since 2015, the ECM, Touax, had contracted out the maintenance delivery function for its wagons (figure 3). The ECM regulations (see paragraph 48 and appendix F) permit this function to be carried out by the ECM or outsourced to a third party, but there is still a requirement for the ECM to define the maintenance requirements and technical specifications, and to ensure that this work is undertaken correctly. An ECM must therefore have procedures in place to ensure that contracted work is properly controlled, and carried out to the required standards.

86 Wagon GERS 89005 had been maintained by DBCM (for the PPM and VIBT) and AFSL (for general repairs) since 2016. At the start of their contracts, Touax provided DBCM and AFSL with the Touax maintenance specification manual DT 432 version A, dated October 2016. This manual provided the maintainer with a specification for wagon inspection and maintenance. The investigation identified that the contractors had not always complied with the requirements specified in the manual. These non-compliances are noted in the description of the maintenance history (since 2017) of the brake system of wagon GERS 89005 which follows in paragraphs 87 to 99.

87 Between April and August 2017, AFSL completed a general repair on wagon 89005. As part of this overhaul, a functional brake test and a pre-inspection report was completed before the wagon was disassembled and repaired. The wagon passed the brake test.

88 Documentary evidence[8] showed that the distributor (serial number 514335) and relay valve (serial number 13/000005)[9] from wagon GERS 89005 were removed in April 2017 and sent to Luxembourg and Germany to be overhauled. When they arrived back at AFSL in May 2017, they were tested on wagon GERS 89016, and then reattached to wagon GERS 89005.

89 Touax was not in possession of the manufacturer's maintenance manuals, and the Touax maintenance manual DT432 supplied to AFSL did not state the manufacturer's required torque setting for nuts securing the relay valve and the requirement to use new CS washers. It is therefore likely that the AFSL fitters simply applied judgment when tightening the relay valve nuts to the brake group faceplate and reused the original nuts and washers (see appendix D). Witness evidence indicates that AFSL did not routinely stock new washers, nuts and studs for the relay valve or distributor. It is also possible that when the relay valve was reattached, no washers were used under the nuts.

90 The general repair and a functional brake test were completed before the wagon's release onto the rail network in August 2017. Wagon GERS 89005 continued to run in service without fault, until May 2019.[10]

[8] Maintenance documents showed the brake group was installed in 2001 and the distributor was overhauled in Amiens in France in 2011. No records could be identified for the relay valve.

[9] Relay valve 13/000005 was also recorded using references numbers 781106508 and 08/2001.

[10] PPM and VIBT documents showed no mechanical intervention or fault with wagon GERS 89005 between August 2017 and May 2019.

91 In May 2019, wagon GERS 89005 was returned to the DBCM maintenance depot at Robeston for a PPM examination. During this examination the wagon failed a brake test (possibly following the changing of a wheelset). Witness evidence indicates that when a wagon failed a brake test, DBCM staff would routinely use a process of elimination to identify which component was the source of the fault. This methodology involved the swapping of potentially faulty components (such as the relay valve and distributor) onto another wagon that was known to be working correctly, to confirm which component was faulty. DT 432 states that brake valves must not be swapped from wagon to wagon without authority from Touax, but DBCM staff did not contact Touax before carrying out this process. The PPM documentation shows that the fault was identified as a faulty distributor (serial number 514335), which was replaced on wagon GERS 89005 with a functioning distributor (514330 - as found on the accident site) taken from wagon GERS 89002.

92 Although maintenance manual DT 432 required DBCM staff to check the security of the components, the PPM documents for the examination did not record whether washers were present or missing. It is unlikely that new nuts were used when the relay valve was reattached, as DBCM did not hold stocks of new fasteners. As Touax had not identified that the manufacturer's manuals were missing from its technical library (see paragraph 107), there was no documented requirement for DBCM to undertake a torque test or to record the procedure.

93 RAIB has been unable to identify if the washers found missing on the incident relay were as a result of the general repair at AFSL in 2017, or if the relay valve was detached and reattached without washers being reapplied by DBCM at Robeston in May 2019. Although DT 432 required maintainers to check the security of fixings, witness evidence shows DBCM staff only visually checked a relay valve or distributor if the wagon failed its functional brake test.

94 In October 2019, the Touax operations manager identified a concern with the rate of brake block wear on wagon GERS 89005 compared to the rest of the Touax fleet. The Touax manager expressed his concern to DBCM, describing the wagon as 'eating brake blocks'. Documentary evidence shows that an instruction was given for the DBCM supervisor to monitor the situation.

95 RAIB reviewed the maintenance documents for wagon GERS 89005 from 2018 to 2020, which confirmed that the increased rate of brake block wear continued up to April 2020. However, there is no evidence this issue was monitored or followed up by the DBCM supervisor or Touax manager after the brake blocks were renewed on wagon GERS 89005 in January 2020 and then again in April 2020.

96 The investigation and reconstruction tests completed by RAIB show that a loose relay valve can potentially produce many small brake applications in service. Although this may have contributed to the excessive brake wear rate on wagon GERS 89005 compared to the rest of the Touax GERS fleet, the wagon passed its PPM and VIBT examination/tests during this period which should have included a visual check of the relay valve fastenings. For this reason, RAIB cannot be certain that the unusual wear rate was a precursor to the accident in August 2020. However, this possibility cannot be discounted.

97 On 18 June 2020, wagon GERS 89005 underwent a VIBT examination at Robeston. The wagon passed its brake test, with no faults being identified. DBCM staff did not identify that the washers were missing on the relay valve. They made a visual check of the fastenings, but did not check the tightness of the nuts.

98 DBCM reported that a torque wrench for the specific task of tightening the relay valve and distributors was available, although there was no equipment to calibrate it. When RAIB visited the Robeston depot after the accident, the torque wrench was found to be broken. The fault with the torque wrench had been reported two months earlier but no action had been taken to repair it.

99 Witness and documentary evidence indicates that the maintenance system prescribed by Touax for its contractors, and the contractors' subsequent application of the process, were inadequate. Had the process and level of supervision been more effective it is possible that Touax, or its contractors, might have identified that no washers were fitted to the relay valve, that contractors were frequently reusing old nuts and washers, and that the nuts were not being adequately tightened.

Management of maintenance

100 The investigation found deficiencies in several areas of management of the maintenance and monitoring of the wagons owned by Touax, and processes that were being undertaken by DBCM and AFSL staff. These deficiencies are discussed in the paragraphs referenced at the end of each bullet:

- the supervision and audit of subcontracted activities were not effective (paragraphs 101 to 103).
- the development and implementation of the Touax maintenance system had not been effective, as omissions within the Touax maintenance manual DT 432 had not been identified since December 2015 (paragraphs 104 to 107).
- the analysis of information gathered through accidents and incidents, to learn and adopt preventive or corrective measures to maintain or improve the level of safety, had been unstructured and inadequate, as evidenced by the actions taken in response to recommendations made following the Ferryside investigation, and a dragging brake incident at Whitland (see paragraphs 108 to 125).

Supervision and audit of maintenance activities

101 Touax acquired the GERS fleet of wagons in December 2015 (paragraph 12). Witness evidence indicates that following this acquisition, the company was restructured, and operational requirements and responsibilities within the United Kingdom changed. This resulted in several staff leaving or retiring. Witness evidence also shows that, although the managers in the UK reported to the technical and operations directors based in Hamburg and Paris, the restructuring had affected the level of engagement, direction, communication, leadership and support offered to the UK managers.

102 At the time of the accident three Touax UK managers were responsible for the supervision, liaison and audit of 15 depots, maintaining around 1161 wagons. Witness evidence indicates that this resulted in a lower level of liaison and assessment of contractors than was the case before 2017.

103 Witness evidence indicates that the workload of two of the three managers, and the restructuring of the company and responsibilities, had resulted in limited contact between colleagues responsible for the supervision and management of the UK fleet operations. Consequently, the activities of Touax's sub-contractors were not subject to levels of monitoring and review commensurate with the role of ECM. It was also evident during the investigation that there was a lack of strategic leadership and direction provided by the technical and operational directors to the company's UK managers.

Maintenance instructions and documentation

104 The maintenance development function (function b) of the management system (paragraph 48 and appendix F) requires the ECM to manage the maintenance documentation, including operational data on performance. This requires the ECM to have procedures to:

- identify and manage maintenance activities affecting safety and safety critical components
- design and install appropriate maintenance facilities, tools and equipment
- provide a maintenance file containing records of safety critical components and maintenance instructions
- as part of change management, ensure that maintenance files are updated with information on types of operation, incidents and maintenance undertaken
- ensure a competence management process for activities affecting safety
- ensure traceability of specific documentation.

Although Touax had revised its maintenance processes in anticipation of the requirements of EU regulation 2019/779 coming into force in the UK (see appendix F), in the event the terms of the UK's departure from the EU meant that Article 4 of this regulation, relating to safety critical components, which came into effect in June 2021 (one year later than the rest of the regulation), was never applicable in the UK (see paragraph 202).

105 The manufacturer of the brake system components, Wabtec Faiveley, had issued the following English versions of documents covering requirements for maintenance:

i. Document 3380 'Maintenance pamphlet of relay' (Faiveley Transport, dated 17 May 2006). Section 4.2, which is concerned with preventative maintenance states:

> '*install the relay pressure with its O rings on the two studs, put in place the washers and nuts and tighten. Carry out a tightness and brake test after installation'.*

The torque requirements for tightening fastenings each time components are reattached are repeated in section 5 (tests -reference document 3397) and section 9 (Torque- reference document 3079).

ii. Document 3079 'Assembly instructions tightening torque for the relay' (VCAV type 1 P-1 ECM - dated November 2018), which shows the torques as 29 Nm (+/- 15%).

iii. Document 3624 'Explanatory and maintenance pamphlet stage brake unit type GF4-SS1' (Sab Wabco dated May 1995 and amended June 1998). The document states that general servicing is recommended at intervals of five years or 800 000 Km, when the unit must be removed for disassembly, cleaning, verification, and replacement of worn parts. Section 5.2.2. (B) says:

'Using a 16-mm socket wrench, loosen and remove the nuts (part 1/25), recover the washers (part 1/26), remove the variable load relay (type differential) VCAV and recover the O rings (for maintenance refer to pamphlet No. 3380). After general servicing, the relay (type differential) must comply to tightness and operating test defined in the routine test (SR 3397). When the relay (type differential) is mounted on the stage brake unit (GF4-SS1) comply with tightening torque of the nuts as shown in section 9.'

iv. Document N-e3092 'C3W Distributor tech file' (Sab Wabco dated April 1991). This is also shown as document E 3120 (Faiveley Transport dated July 1995).

106 Wabtec Faiveley reported that it had supplied the documents to previous owners of the wagons, but it had no record of the documents being supplied to or requested by Touax, when the wagons changed hands in 2015.

107 Touax (or Belgorail during its certification activities (see paragraphs 128 to 134)) had not identified that the Wabtec Faiveley maintenance pamphlets were missing from its technical library. Under ECM management function part 1, Touax should have had a structured approach for ensuring the traceability of all relevant information. However, when RAIB asked Touax for copies of these documents the company stated that it did not have any knowledge of these documents, and had only become aware of them after the accident. The Touax maintenance manual DT432 supplied to DBCM and AFSL was therefore deficient in detail and did not provide the contractors with a detailed process for the maintenance and monitoring of important components of the braking system. The investigation also identified deficiencies in the manufacturer's instructions (paragraph 76).

Corporate learning

108 The opportunity to learn from previous experience was missed. This is possibly causal.

109 Witness evidence shows that the liaison between Touax, its sub-contractors and suppliers was not effective. Consequently, the practice of maintainers applying grease to the 'O' rings to prevent them falling out during maintenance processes was not discussed. This meant that the opportunity was missed to identify that this practice created a risk of contamination which would reduce the face plate to face plate friction, making the joint more prone to slip for a given clamping force (see appendix D), or affecting the security of the nuts. Alternative types of seal, such as the use of a gasket, were not considered and there was no sharing of good practice, such as witness marking the nuts between maintenance examinations to highlight any movement.

110 Witness evidence also suggests that some wagons arriving at depots for maintenance (PPM/VIBT and general repair) had passed a brake test but were later found to have loose relay valves or distributors with nuts and studs being 'finger tight'. Witness evidence also indicates that relay valve 'O' rings had been found, on dismantling, to have been lost or to have migrated out of their respective ports. This information had allegedly been reported to managers within the respective maintenance contractors, but no action had been taken to share this information with Touax or with other contractors. Had the level of liaison between Touax and its contractors been effective (paragraphs 101 to 103) it may have led to this information being discussed and the risk of relay valves becoming loose while in operation being identified.

111 As part of its ECM responsibilities, Touax had a management process to identify activities affecting safety. This included a process for learning from accidents, incidents and staff reports, and implementing associated safety learning. The Touax incident report procedure (TECH-15 – Incident reports and follow-up) describes the procedure for managing incident investigations involving its wagons. However, it is clear from Touax's response to the Ferryside and Whitland incidents (see paragraphs 112 and 123) that this procedure was not effectively applied.

Learning from previous accidents and incidents

The Ferryside incident

112 On 30 October 2017, a Touax wagon in a train carrying oil-based products from Robeston to Westerleigh oil terminal suffered a catastrophic failure of its braking system, having developed severe wheel flats. The train did not derail and there were no injuries, although extensive damage was caused to the track between Ferryside and Llangennech. The RAIB investigation (RAIB report 17/2018) identified that maintenance work at Robeston was carried out in all weathers and sometimes during the hours of darkness when, in some circumstances, errors are more likely to occur (although DB Cargo reported that there was no previous history of defect issues for wagons maintained at Robeston).

113 RAIB made an observation that the facilities at Robeston were 'suboptimal' for carrying out safety critical wagon maintenance tasks such as replacing brake blocks. This observation led to Recommendation 1 (shown below), the intent of which was for Touax, in conjunction with the other parties, to improve the working environment for safety critical wagon maintenance activities at Robeston, by completing a risk assessment of the facilities and processes used for maintenance of wagons operating out of the terminal, and developing a time-bound plan for any necessary improvements that were identified.

> *Touax Rail, in conjunction with DB Cargo Maintenance and Puma Energy, together with the owners of other wagons based at Milford Haven, should carry out a risk assessment of the facilities and processes that are used for maintenance of tank wagons operating out of Robeston terminal, taking account of the dangerous goods that are carried and the working environment at the site. A time-bound plan should be developed for any necessary improvements that are identified. This recommendation may also apply to other organisations which are responsible for the maintenance of wagons that carry dangerous goods, where such maintenance is carried out in outside environments.*

114 Documentary evidence shows that the response to this recommendation was focused on the maintenance of brake components, and the requirement to review other areas of maintenance was not addressed. Had Touax's risk assessment of all maintenance processes undertaken at DBCM and AFSL included specific observations on staff undertaking maintenance, including the removal and refitting of the components that form part of the brake group, it might have identified the areas which are considered to be linked to the cause of the derailment at Llangennech. These include:

- Touax was not in possession of the manufacturer's technical pamphlets for the brake system components.
- The manufacturer's requirements for the relay valve components were missing from the Touax maintenance manual, DT 432.
- There was no requirement for DB and AFSL staff to ensure or check that critical brake group fastenings remained tight during maintenance examinations, and the depots did not hold stocks of new washers and nuts.
- DBCM and AFSL used grease to retain 'O' rings in their respective ports when refitting relay valves. Contamination from this grease could result in nuts being over-tightened or affect the torque/stiffness characteristics of the joint.

115 A comprehensive response to the recommendation would also have provided an opportunity to identify areas of good practice, such as the use of soap and water to test for air leaks and the adding of painted witness marks to assist in identifying nuts that may have loosened during the interval between PPM examinations.

116 In April 2019, DB Cargo, Puma Energy, Touax and VTG Rail provided a joint response to the recommendation to ORR. The response was based upon the joint review of the facilities and processes for maintenance of tank wagons operating out of Robeston. The response included the following post-incident actions:

- DB had implemented a complete fleet check of all wagons, with no examples of split pins missing from brake blocks being found.
- DBCM had completed a 'Tool Box Talk' on the correct methods of fitting brake components, with a requirement for a supervisor to check brake block fitment.
- The sharing of independent audit reports between DBCM, Touax and VTG.

117 The joint review concluded that most work at Robeston was completed in the designated maintenance area and was controlled by the safe system of work and associated risk assessments. The review also concluded that the maintenance facilities and the maintenance processes at Robeston were adequate.

118 The response also reported that all parties would continue to incorporate the recommendations of incident investigations and reports of high-risk defects into their processes, procedures and monitoring of the maintenance of the vehicles. Investigations into safety-related incidents would be reviewed, and where necessary hazard identification and monitoring processes would be amended within their respective safety management systems.

119 Witness evidence indicates that in responding to the recommendation DBCM, in consultation with Touax, had focused solely on the risks and processes associated with the replacement of brake blocks (which was the immediate cause of the incident at Ferryside), and had not identified that the RAIB recommendation related to the risk assessment of all processes that are used for maintenance of tank wagons operating out of Robeston terminal, taking account of the dangerous goods that are carried and the working environment at the site.

120 Although a generic risk assessment and time-bound plan was developed and the process for the replacement of brake blocks was amended, no other risk assessment incorporating observation or task analysis was undertaken on any other maintenance process. Witness evidence also shows that Touax staff were not trained in how to conduct, or were not aware of how to complete, a risk assessment process incorporating task analysis, or to identify and understand the risks associated with the practical application of the maintenance process on important components of the braking system.

121 On 12 June 2019, ORR inspectors visited and inspected the facilities at Robeston. They reported that in their opinion the organisation and processes in place were capable of providing suitable maintenance arrangements in line with the relevant health and safety legislation, and there were no matters of evident concern identified (see paragraph 178).

122 In December 2019, ORR informed RAIB that Touax Rail, in conjunction with DBCM and Puma Energy, had reported that all parties had completed the specified actions in response to the RAIB recommendation.

The Whitland incident

123 In November 2020, RAIB was contacted by a member of the public about an incident that occurred on 13 June 2019 at Whitland, involving brakes dragging on a tank train from Robeston. A signaller had reported smoke from the wheels of wagon GERS 89026. The train was stopped, and a fitter attended and reported that all the wheels and brake blocks on the wagon were hot because the brakes had been dragging. The brakes would not release, and the train driver was asked to overcharge the brake system. As the brakes would still not release, the fitter isolated the brakes and the wagon was taken out of the train at Margam. The problem was later identified as being a faulty relay valve on the wagon.

124 RAIB established that the wagon had been given a general repair which was completed in 2019, and the relay valve and distributor had been removed from the wagon during this process and refitted on 23 April 2019. The wagon returned from the general repair on 28 May 2019, and the incident had occurred on its first operational journey. RAIB identified that, after the incident, the wagon was stabled in Margam sidings and was moved to either Margam or Robeston depot by 3 July 2019.

125 Touax was asked for details of any investigation or actions that it had taken as a result of this incident. Touax stated that it was not aware of the incident and could find no documentation or actions relating to the incident, the movement of the wagon, or examination or repair of the faulty component. The faulty relay valve was later found at AFSL in March 2021.

The Carpenters Road Junction incident

126 In June 2019, an empty wagon in a freight train derailed near Carpenters Road North Junction, in east London. The wagon derailed because it ran over a substantial part of its own brake equipment which had fallen onto the track beneath it (RAIB safety digest 07/2019). Touax's UK managers reported that they had no knowledge of this incident and any safety lessons that might have been applicable to their company, as they had not been briefed or made aware of the incident.

Touax's follow up of incidents – summary and conclusion

127 The response to the incidents described in the previous paragraphs, combined with witness evidence, shows that Touax's processes to follow up incidents and for the sharing of safety learning were often ineffective. Had Touax investigated dragging brake events more thoroughly, and had the liaison between Touax and its contractors been more effective, it is possible that at least some of the weaknesses in the management of the critical components of the braking system would have been identified and addressed by Touax and its contractors.

The ECM certification process

128 The ECM certification process applied to Touax by Belgorail was below a standard that was effective. This is possibly causal.

129 The ECM certification process (see figure 3 and appendix F) required Touax to be assessed by a body accredited to undertake such assessments and issue an ECM certificate, in accordance with Regulation EU 445/2011, and latterly Regulation EU 2019/779.[11] After certification, the process also required an annual surveillance visit to be completed, which should have included focused inspections and liaison with Touax and its staff.

130 When Touax Rail Limited acquired GERS in December 2015 the company immediately integrated the activities of GERS, and its ECM certificates were transferred to Touax Rail. Touax contracted Belgorail, a commercial company based in Belgium, to inspect, assess and certify its processes, systems and staff using the procedures for the evaluation of systems as defined by the European Rail Agency certification scheme (ERA/GUI/09-2011/SAF) for the implementation of all maintenance functions. Unlike many UK freight operators, Touax has a pan-European ECM certificate to oversee maintenance delivery (function d)) in both continental Europe and the United Kingdom.

131 BELAC, the Belgian accreditation body, which operates according to international requirements for such bodies (in a similar way to the UK's accreditation service, UKAS) accredited Belgorail as competent to assess and certify entities in charge of maintenance, in this case Touax, under EU Regulation 445/2011 and later 2019/779.

132 Touax had opted to subcontract the maintenance delivery function (function d)), which it was legally allowed to do provided that it undertook supervision and assessment of its maintenance delivery contractors to ensure they were working to the required standard. Because of this, Belgorail was only contracted by Touax to assess and inspect functions a) to c) (management function, maintenance development and fleet maintenance management) during Belgorail's annual surveillance visits or recertification process.

[11] The numbering of EU legal acts was harmonised from 1 January 2015. Instruments published before 2015 may have numbers in a different format.

133 From December 2015, Belgorail[12] undertook annual surveillance and assessments of Touax and later (from April 2016) took over the ECM certification of both Touax Rail in Paris and Dublin and the former GERS in Hamburg. The surveillance programme was then undertaken in Paris and alternately in Dublin and Hamburg, until Touax stopped its operational activities in Dublin. Witness evidence shows that Belgorail accepted that to complete an effective assessment of functions a) to c), engagement with Touax on elements of function d) (maintenance delivery) had to be reviewed or discussed. However, witness evidence shows that when meetings and visits took place in continental Europe and the Republic of Ireland, there was very little engagement between Belgorail and Touax managers in the United Kingdom, which led to a lack of discussion of function d). Had there been closer scrutiny of Touax's activities in the UK before the Ferryside incident in 2017, or as part of Belgorail's annual audit of Touax's processes, it is possible that the factors related to the malfunction of the braking system on 26 August 2020 would have been identified.

134 Belgorail completed a recertification audit of the Touax maintenance management system in December 2020 for the 2019 calendar year (see paragraph 226). However, witness evidence shows that Belgorail was unaware of the investigation into the Ferryside incident in 2017 (referred to in the Touax annual safety reports), the safety recommendations from the investigation and the actions that had been taken. It was also unaware of the more recent accident at Llangennech, some four months earlier. Belgorail explained that its lead auditor had only reviewed the 2019 yearly maintenance report presented to him by Touax, which did not incorporate accidents and incidents occurring during 2020. To address this lag in information reaching it, Belgorail has reported that in future the scope of its audits will include the period of time between the end of the year in question and the date that the audit takes place.

Detection and management of incidents involving dragging brakes

135 The wheelset detection software within the infrastructure technology was not installed to alert the signaller to the dragging brakes on the wagon. This is a probable factor.

136 Hot axle box detectors (HABDs) are located at various points on the national network and are intended to detect failing axle bearings. HABDs send a message to a monitoring point, usually a nearby signal box, to alert the signaller that a temperature above a defined value has been detected as a train passed. The signaller should then identify the train concerned and arrange to stop it in a convenient place of safety for examination.

137 Sensors are mounted on the outside of the rails to detect the increased radiated heat emitted by a defective axle bearing. There is also a sensor mounted in the four-foot (between the running rails) to detect the temperature of wheels. The system uses infrared beams to measure the temperature of the targeted area.

[12] Belgorail undertook surveillance audits on Touax in:
i. March 2016 followed by a visit to Hamburg (November 2016)
ii. Paris and Dublin (November 2017)
iii. Paris and Hamburg (November 2018)
iv. Hamburg and Paris (renewal audit in November, 2019) with follow up surveillance audits after the renewal audit undertaken remotely from Belgorail offices (December 2020).

138 The type of HABD systems deployed on the rail network in the 1980s generated multiple spurious alarms, and trains were frequently stopped. The HABD system incorporates sensors and software to detect the heating of the wheel treads in case of dragging brakes. However, because of the number of spurious alarms generated, there was little appetite for this feature among freight operators and it was disabled in 2001. The prevailing view was that 'hot wheel detectors' did not provide a benefit, were unreliable (for example, by detecting hot wheels in zones where trains normally brake) and caused unwarranted delays. Since the hot wheel detection feature was intentionally disabled, the detection software was not considered when the HABD equipment was replaced or became defective.

139 The Pembrey HABD is the only example of equipment for detecting heated axleboxes on the route of train 6A11 between Robeston and Morlais Junction. The HABD equipment located at Pembrey was connected to Port Talbot signal box (rather than the signal box at Pembrey). When train 6A11 passed over it the temperature threshold for the hot axle was not met and so no alarm was sent in real time to the signaller. High temperatures at the wheel and rail were recorded for wagon GERS 89005 (see figures 27 to 30) but because there had been no business case to support the provision of the wheelset detection software and the necessary data link within the HABD system these temperatures did not trigger any alarms to the signaller, and the data was only identified after the accident. Consequently, if an incident involving high wheel temperatures occurred, showing a dragging brake or locked wheel event, the equipment did not transmit an alarm but captured and stored the data, which could be accessed remotely and downloaded after an event.

140 Temperature sensors are located near the head of the rail, to detect hot wheel treads, and also higher up, nearer to the axle, to detect hot axle boxes. As a wheel passes, the two types of sensor record the wheel for different lengths of time. The sensor near the rail only 'sees' the wheel for a short time, whereas the sensors nearer the axle see the wheel rim at the leading edge of the wheel, the wheel disc and then the wheel rim at the trailing edge of the wheel.

141 The data from the Pembrey HABD site shows temperatures that were measured as each wheel passed (figures 27 and 28). The contact point between the rail and leading wheelset recorded 334 ºC, the second wheelset recorded 326 ºC, and the wheelsets on the rear bogie recorded 248 ºC and 270 ºC. The data shows that, although all wheels registered a high temperature, there is a different temperature pattern for the leading wheel as compared to the other wheels on wagon GERS 89005 (figures 29 and 30).

142 For the leading wheelset (figure 30(a)), the sensor near the rail records the highest wheel temperature, whereas the sensor near the axle records a much lower temperature. This indicates that the heat is emanating from one part of the wheel, where it contacts the railhead. This indicates that this wheel was not rotating and was sliding along the railhead as it passed the Pembrey sensors.

Axle	Waggon	Axle (Waggon)	HOAL	HOAR	FBOA1
1	?	1	26	24	34
2	?	2	25	21	30
3	?	3	31	27	38
4	?	4	29	26	40
5	?	5	33	29	34
6	?	6	29	31	38
7	?	7	35	32	40
8	?	8	26	29	36
9	?	9	27	21	32
10	?	10	26	23	36
11	?	11	18	16	32
12	?	12	18	16	34
13	?	13	20	18	42
14	?	14	17	15	30
15	?	15	32	29	334
16	?	16	42	53	326
17	?	17	37	34	248
18	?	18	45	42	270
19	?	19	35	[illegible]	[illegible]
20	?	20	44	41	38
21	?	21	34	43	32
22	?	22	42	44	34

Figure 27: Diagram of the HABD data provided for train 6A11 on 26 August showing axles numbers 1 (front) to 4 (rear) for wagon GERS 89005 (labelled 15 to 18), with corresponding temperatures shown in degrees Celsius

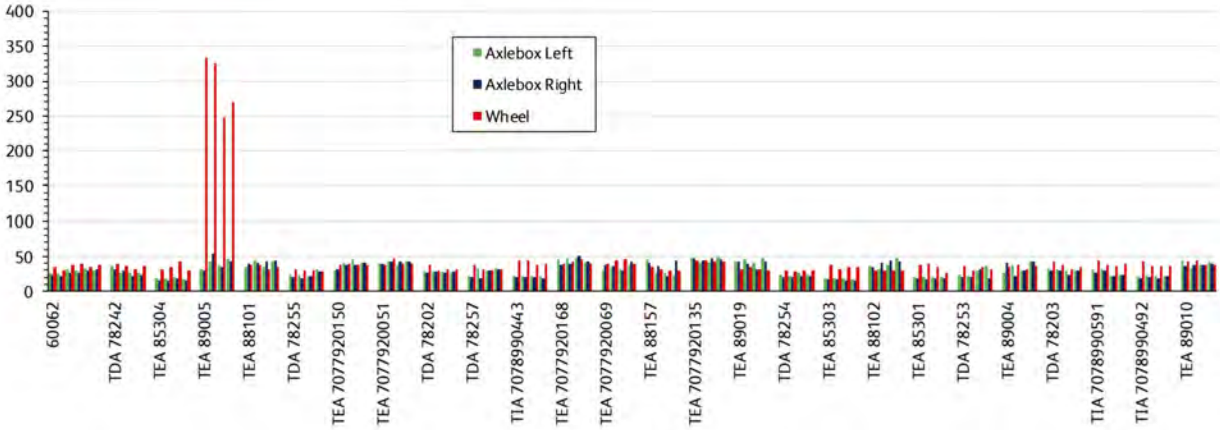

Figure 28: HABD data for train 6A11 showing temperatures recorded for all wagons

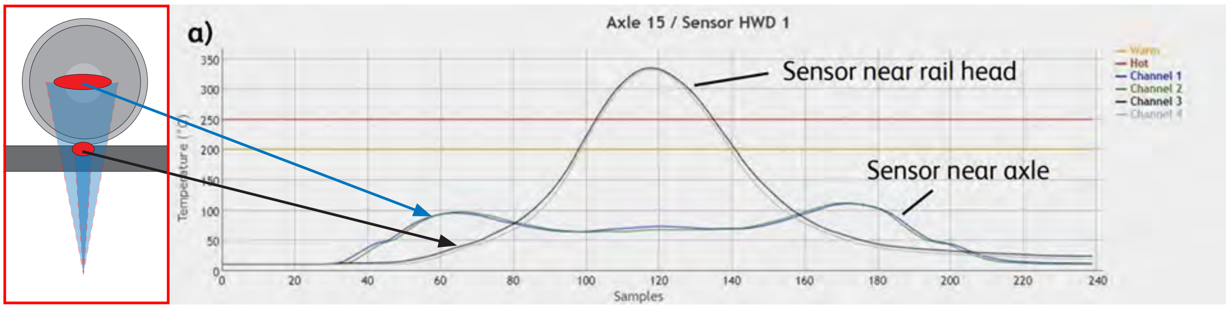

Figure 29: Diagram (left) showing the locations of the HABD sensors in relation to measurements taken from the axle box area of a wagon (shown as channels 1 and 2) and contact point between a wheel and the rail (channels 3 and 4). The graph (right) shows the temperature curves for the locked wheel of train 6A11 (Diagrams courtesy of Network Rail)

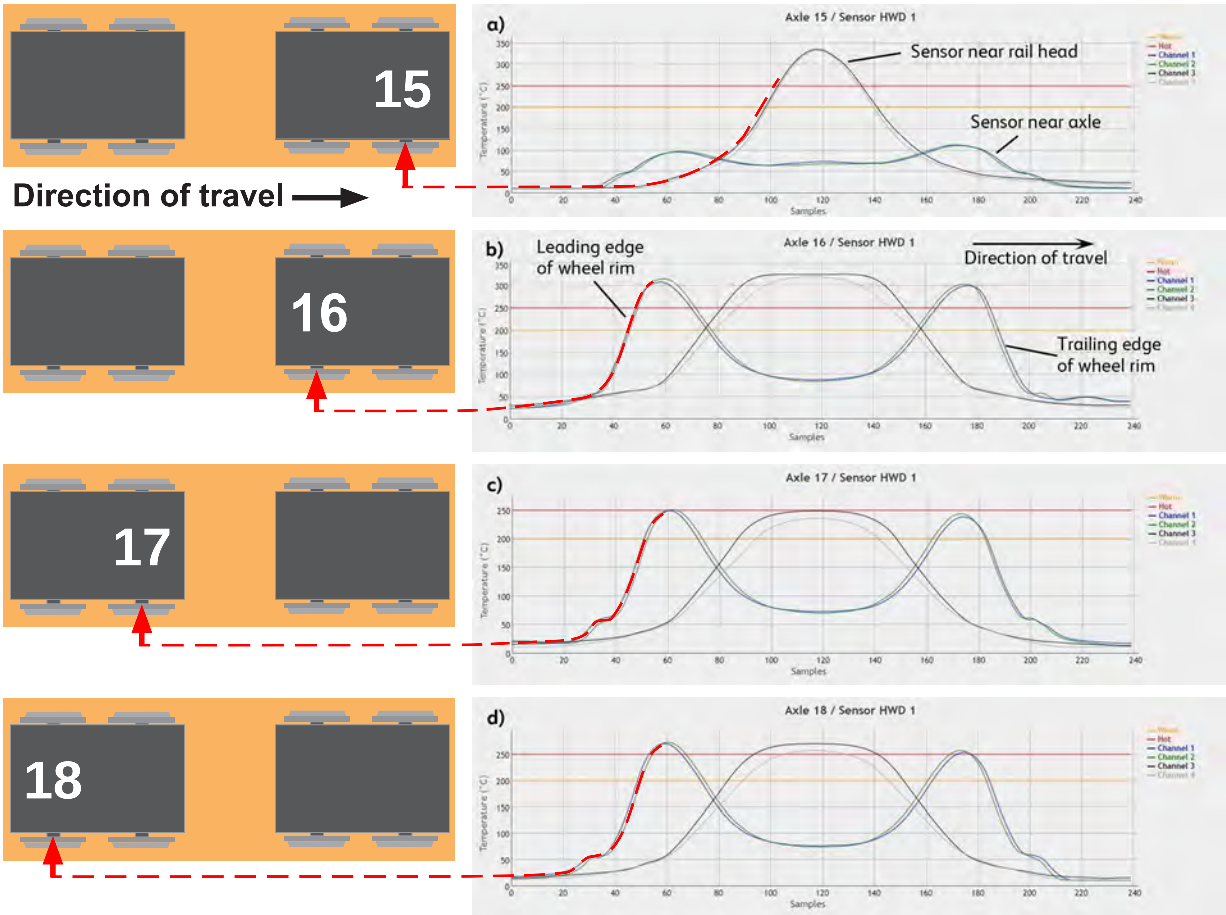

Figure 30: Recorded temperature curves from Pembrey HABD for train 6A11 on 26 August 2020, for the third wagon (axles 15 to 18). The curves for axle 15 (leading) are characteristic of a locked axle, while the curves for the other axles (16 to 18) show evidence of dragging brakes, in that high temperatures are recorded for the whole wheel, not just the tread (graphs courtesy of Network Rail)

143 The other three wheels (figure 30(b)) show very similar heat patterns to each other. The sensors near the axle have recorded peaks in temperature when the leading and trailing edges of the wheel rim pass, and these are the same temperature as recorded by the sensor looking at the wheel rim in contact with the rail. In graphical format, this shows an 'evenly balanced' hot wheel temperature curve for the wheel rims and indicates that these three wheelsets (2, 3 and 4) are rotating, but the brakes are dragging causing the tread to get hot. All other wheels and axle boxes on the train had temperatures below the 50º C threshold, and can therefore be assumed to have been rotating normally.

144 Had the wheelset detection technology within the Pembrey HABD system been connected and capable of identifying and discriminating between the two conditions, it would have been capable of triggering an alarm. The distance to the next junction, and the speed of the train involved in the accident, means that there would have been time, after the train passed Pembrey HABD, for the signaller or control room to have been alerted and the train stopped before the damaged wheelset was able to cause a derailment. Since this is likely to have prevented the accident from occurring it is considered to be a probable causal factor.

145 There have been three derailments in the Netherlands since 2008 where the subsequent investigations identified that, had the hot axle / wheel detection system provided real time warnings, it might have prevented the accident. In Switzerland hot axle and hot wheel detection systems are used to stop the train in a safe place where the driver can inspect it. If a fault is found an assessment is undertaken to see if it can be fixed on site, or if the train can be moved at a low speed, or if alternative action is required.

146 Network Rail is currently working with the rail industry reviewing the use of thermal radiometry equipment located trackside to monitor passing trains, using network technology to remotely access the thermal recordings and surface temperatures. A review and risk assessment of the current locations and positioning of lineside hot axle box detection equipment is currently being undertaken to assess and, if necessary, increase, upgrade or decommission the equipment in conjunction with the introduction of radio frequency identification (RFID) tags on rail vehicles that can be used in conjunction with lineside technology (see paragraph 230).

Onboard monitoring equipment

147 Some passenger trains are fitted with onboard systems to monitor the condition of axle bearing. Although such technology is allowed for in point 4.2.3.4 of the EU technical specification for interoperability (TSI) relating to the freight rolling stock sub-system, the TSI states no requirements relating to its design or conformity assessment. No provision is made for the detection of hot wheels using onboard equipment.

Identification of underlying factors

The rail freight sector's approach to managing the condition of wagons

148 The approach to the maintenance and monitoring of the condition of wagons and safety critical components within the rail freight sector was not based upon best practice.

149 RAIB has highlighted issues regarding the condition of freight trains on the network in its annual reports for 2015 and 2020, and this is one of the areas of concern highlighted in RAIB's summary of learning 5, published in 2020 and updated in March 2021. The freight section of the RSSB's Annual Health and Safety Performance report 2019 to 2020 indicated a worsening trend in respect of potentially high-risk freight train accidents.

150 The National Freight Safety Group (NFSG), which is an industry group hosted by RSSB,[13] aims to facilitate the improvement of health and safety in the rail freight industry by managing system risk. Although the cross-industry freight derailment working group work has taken actions with regard to uneven loading of wagons and rail/wheel dynamics, the condition of vehicles had not yet been addressed by NFSG. However, the NFSG considered the condition of wagons on the network as being the highest risk to the freight sector. Because of this, NFSG has developed a programme and integrated plan for safety which was published in May 2020, and is intended to:

[13] A not-for-profit body whose members are the companies making up the railway industry. The company is registered as Rail Safety and Standards Board Ltd, but trades as RSSB.

- quantify the risk and identify emerging trends of vehicles entering the network in an unsafe condition, and develop a risk management plan that identifies immediate risk reduction initiatives and long-term mitigation objectives
- standardise and embed best practices and suitable control measures within the safety management systems of all freight operators, to mitigate the emerging trends identified and prevent future recurrences
- improve the sharing of information on incidents and accidents which is pivotal to identifying areas that would lead to the condition of freight vehicles being improved.

151 The safety management information system (SMIS) is an industry-supported system that was designed by and for rail companies, and is managed by RSSB. SMIS is used to record events (accidents and incidents) which are reported and investigated, with the information from the investigations identifying the immediate and underlying causes, to underpin a risk-based approach to safety management as well as forming the basis for national safety performance reporting within the industry's safety risk model.

152 The aim of SMIS is to bring consistency to the management of safety reporting. However, the system is dependent on the quality of the information supplied, and the information being entered in a timely manner onto the database. Witness evidence has highlighted several deficiencies within the current system and process for capturing and sharing data. These areas are as follows:

- Rail Industry Standard RIS-8047-TOM 'Reporting of Safety related information on SMIS' (Issue two March 2018) requires the event owner to update and share its findings if an investigation is commenced. As the event owner, the SMIS member is usually a railway undertaking (RU). In the case of the Llangennech accident the RU was DB, as the train operator. The RU should ensure information is shared or gathered from other parties, such as ECMs (Touax) and ECM contractors (DBCM or AFSL) and their respective component overhaulers (Wabtec Faiveley, CFL or DB Fulda). SMIS data should be entered within twenty days of the event being reported (or at the conclusion of an investigation). Recommendations, whether from industry or RAIB, are added later. However, as ECMs and their respective contractors and component repair companies have neither access to SMIS nor the ability to directly input information onto the database, the various parties do not routinely communicate with each other to identify where a maintenance deficiency, component failure or the use of sub-standard replacement parts has resulted in a safety event such as a dragging brake. If no investigation or follow-up takes place, the entry is closed with no further action being required to identify the cause of the event. This lack of follow-up has restricted the flow of information and may have led to SMIS events being prematurely closed with the loss of critical information.

- When multiple organisations are involved in an event, they are required to share information with the SMIS event owner (the lead party) to ensure the completeness of the record of the event.[14] Although the SMIS data is not intended to be used for the purposes of gaining commercial advantage over market competitors, witnesses have suggested that commercial interests in the freight industry can, and have, prevented or restricted the sharing of information.
- Analysis of SMIS data from 2015 to 2020 shows that only 40% of incidents reported as a 'dragging brake' event (excluding 'handbrake left on') recorded the final outcome or immediate technical cause of the dragging brake incident. This may be because the relevant data was not recorded during the incident, or was not of sufficient quality to enable follow-up by the ECM. This could have resulted in little or no follow-up taking place between the ECM and event owner, and/or a failure to update the original SMIS entry. The lack of clarity as to the cause of dragging brake incidents within SMIS, and the inconsistent reporting of such incidents across the freight train operators, reduces the value of the data, both as a means to identify trends and as an aid to the implementation of a proactive maintenance and monitoring strategy.
- The analysis of the data also showed a disparity between events reported on SMIS as a dragging brake or dangerous goods event, compared to details recorded on Network Rail's Control Centre Incident Log (CCIL). This shows a level of inconsistency in the sharing of the data within the industry and could have affected the perception of the reliability of brake components. Witness evidence has highlighted that dragging brake events are often seen as an 'operational performance' event, rather than a precursor to a 'safety' incident, and this perception may have led to a lack of appreciation within the freight industry of the number of dragging brake events, and that they can result in a high consequence accident.
- ECM certification bodies do not have access to, or make use of, the intelligence that is available on SMIS. Such access might enable them to focus on specific issues within their annual surveillance audits of ECMs, including procedures for condition monitoring of freight wagons or safety critical components.

153 Before the accident at Llangennech, both RSSB and the NFSG had identified some of the factors considered in this report (such as trains entering the network in an unfit condition, inaccuracy of SMIS data, ineffective sharing of information and poor training and development of operational staff) and these areas have been included within the strategy for freight wagon maintenance, which is due to be completed by 2024 (see paragraph 232).

[14] Regulation 22 of the Railways and Other Guided Transport Systems (Safety) Regulations 2006 (ROGS) places a duty on transport operators to cooperate, insofar as is reasonable, with any other transport operator who operates on the same transport system to achieve the safe operation of that transport system.

154 Witness evidence also shows that details of engineering faults, or problems identified by operational staff during inspection or overhaul, such as loose relay valves and distributors, and issues with reattachment of components (paragraph 108), are very rarely shared, or communicated back to the ECM. Witnesses described instances where staff had relayed information regarding loose components found on inspection to their supervisors, but this had not been acted upon. Operational staff are often trained 'in house' and witness evidence in this investigation indicated that the training and development of staff has been poor. RAIB believes that this may have resulted in a perception among maintenance staff that their skills are not valued, and that their role and responsibilities in maintaining wagons on the rail network in a safe condition may not be recognised or appreciated.

155 Witness evidence suggests that there has been a low level of investment by the rail freight sector in developing the workshop environment, as a result of short-term commercial contracts that do not encourage longer term investment in workshop facilities.

The role of the safety regulator

156 When ORR relinquished its responsibilities as an ECM certification body the level of regulatory oversight of wagon maintenance activities significantly reduced, because the certification and surveillance of ECMs was transferred to accredited certification bodies. In some cases the ECM and certification body were based outside the UK. However, the new arrangements for surveillance of freight wagon maintenance were not always effectively applied.

157 Before the privatisation of the railways in the 1990s, British Rail was responsible for the audit of privately owned freight wagons, premises and maintenance regimes.[15]

158 After the privatisation of the railways, Railtrack and later Network Rail had a Private Wagon Registration department which was responsible for the monitoring and administration of permissions for maintenance regimes which were granted to wagon maintainers. Staff within the department liaised with the wagon owners and maintainers, and wagons were inspected, reviewed and assessed to ensure they met the railway group standards before they were authorised to use the rail network.

159 The new legal framework for the certification of ECMs for freight wagons (Commission Regulation (EU) 2011/445) allowed EU Member States to choose whether the certification body function was carried out by a commercial accredited company or a public body.[16] In November 2011, the UK notified the European Commission that ORR would undertake the function of certification body when the legislation took effect in 2012.

[15] The private wagon registration agreement (PWRA) evolved during the late 1980s to encourage use of the rail network and ensure all private wagon operators worked to a common standard. It identified the legal responsibilities and duties of private wagon owners in relation to those of British Rail.

[16] In accordance with the then-current EU Directive 2004/49, now Article 14.4 of EU Directive 2016/798.

160 In 2012, ORR made it clear that in future it would:

- act as the certification body for ECMs for an initial period of two years to ensure that the requirements in the Railway Safety Directive 2004/49/EC (as amended) and the ECM Regulation were met
- review the certification body role in 2013/14 when the position on accredited certification bodies would be clearer.

This reflected the fact that at the time there were no UK accredited bodies to fulfil the role of certification body, and ORR was therefore temporarily stepping into the role to allow the market for accredited bodies to become established. ORR continued to deliver the certification function while there were no alternative accreditation bodies.

161 In October 2014, the Department for Transport provided funding to the United Kingdom Accreditation Service (UKAS) to develop an accreditation scheme for certification bodies which would take over the function of certification of ECMs. UKAS notified ORR at the end of August 2016 that three organisations had been accredited to perform the certification function. In addition, a further eight certification bodies were accredited by other national accreditation bodies,[17] an example being the accreditation of Belgorail by BELAC (paragraphs 128 to 134).

162 Between 2016 and 2017 an ORR review[18] concluded that there were sufficient accredited bodies in the market to allow it to withdraw from performing the ECM certification body function, and in May 2018 ORR ceased to be an ECM certification body. Certificate holders were required to transfer to another certification body for ongoing surveillance. In the UK, this was undertaken by the three commercially run certification companies (see paragraphs 192 to 197).

163 ORR has informed RAIB that its decision to relinquish the certification role was always its intention, and based on two factors: the need to create a fair environment in which the accredited bodies would operate (not possible while ORR was delivering the service for no fee), and to release ORR resource for proactive, targeted inspection of wagon maintenance activities. ORR's view was that the pre-2018 process of ORR being the certification body was not the best use of its limited inspectorate resources, and the commercial certification bodies had now developed to an extent where there was sufficient competence and competition, allowing ORR to focus on its priority areas of safety and enforcement. Although ORR chose to relinquish its responsibilities for ECM certification, it still had powers to regulate the industry in accordance with the Health and Safety at Work etc Act 1974 and associated relevant statutory provisions.

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[17] Details of the accredited or recognised certification bodies are shown on the European Railway Agency Database of Interoperability and Safety.

[18] The certification body function for entities in charge of maintenance of freight wagons - A review of ORR's role - March 2017 (https://www.orr.gov.uk/sites/default/files/om/review-of-ecm-certification-consultation-march-2017.pdf)

164 ORR has provided evidence that it actively considered the implications and risks of withdrawing from the certification role and the shift to a 'supervision only' function. It informed RAIB that its approach to implementing the new ORR role of supervision included the following:

- An ECM workshop for Certification Bodies, ECMs (Touax was not involved), Freight Operating Companies and related trade associations was held to enable ORR to explain the various roles and ORR's expectations, share experience, and discuss methods for strengthening cooperation and information sharing across the industry (including encouraging ongoing engagement between the certification bodies).
- A plan for ORR's supervision work to encompass the analysis of annual reports from ECMs; monitoring of ECM activity via intelligence such as from the Freight Technical Committee and RAIB reports; regular audits and in the longer term to encourage ECMs to adopt ORR's Risk Management Maturity Model (RM3).
- New guidance for ORR inspectors on the requirements in ROGS that relate to ECMs.

165 ORR issued a report following the ECM workshop which explained that:

> *'when supervising the effectiveness of the safety management systems of infrastructure managers and railway undertakings who operate freight wagons, ORR may take into account the safety performance of ECMs. We will establish and maintain effective dialogues with certification bodies in all circumstances in order to avoid any duplication of assessment.'*

166 Internal guidance to ORR inspectors issued in April 2019 outlined the means by which ORR intended to supervise compliance with regulation 18A of ROGs. It stated that:

> *'An ORR inspector can rely on an ECM certificate as confirmation that an ECM responsible for freight wagons complies with regulations18A(2) and 18A(3)of ROGS. It should not be necessary for inspectors to inspect certificate holders to check compliance with the regulations.'* [19]

167 The guidance went on to state:

> *'If an ORR inspector has justified reason to doubt the ability of an ECM to meet the criteria, perhaps through intelligence or because they have inspected the company for compliance with other requirements in ROGS (e.g. safety certificate/authorisation), the inspector should liaise with the certification body that issued the certificate in the first instance. Unless it is an emergency, the inspector should not carry out additional inspections or raise findings against an ECM without liaising with the certification body.'*

168 The April 2019 policy indicated that ORR saw no need for the continued routine inspection of ECMs but recognised that ORR might sometimes wish to intervene if it had reasons to doubt that an ECM was able to comply with the requirements in ROGS.

[19] The policy recognises that some ECMs will also be transport undertakings (such as freight train operators), or infrastructure managers, who would be subject to inspection to verify compliance with other requirements in ROGS.

169 Data provided by ORR shows that in the last year that it remained a certification body (2017/18) it carried out 11 inspections of rolling stock maintenance activities. The data also shows that there were no inspections of rolling stock maintenance between May 2018 (when ORR ceased to be a certification body) and March 2021. Those inspections that were carried out at maintenance facilities and yards focused on workplace health and safety, encompassing issues such as trespass, infrastructure maintenance, authorisation of new vehicles and COVID protection measures. RAIB observes that throughout this period ORR had not identified the need to carry out inspections to confirm the correct operation of the new ECM certification and surveillance regime, or to follow up any particular concerns that it had relating to rolling stock maintenance.

170 The new regime that came into force in May 2018 placed high reliance on the effectiveness of the surveillance of ECMs that was undertaken by the new certification bodies. Since ORR did not have any legal powers or authority in respect of certification bodies, it did not supervise their activities but instead had focused on developing a working relationship with UK-based bodies based on mutual co-operation. However, it was unable to establish a similar relationship with non UK-based certification bodies.

171 ORR has confirmed that there has been a lower level of contact between ECMs and ORR since ORR relinquished its certification role in 2018 (as was intended). However, ORR has informed RAIB that it was, and remains, confident that the ECM arrangements work effectively under the surveillance of UK certification bodies. It also points out that ORR continues to engage with UK ECMs and certification bodies via the formal forums it has established and by means of the general monitoring of freight wagon safety and maintenance.

172 In contrast to the above, paragraphs 192 to 197 report a perception among UK-based certification bodies that the extent of their own surveillance of ECMs was sometimes insufficiently detailed to understand how maintenance tasks were actually being undertaken, particularly at the level of yards and workshops (there is no legal requirement for the certification of workshops).

173 ORR has reported that it has now increased its resources dealing with the sector, reviewed the way it undertakes its regulatory monitoring of freight wagon maintenance and issued a new inspection protocol which specifies a number of ECMs that ORR intended to inspect in 2021/22 (see actions already taken at paragraphs 221 to 224). ORR has informed RAIB that the inspections carried out in accordance with this new protocol between April and December 2021 had revealed no significant issues of concern regarding the current operation of the new certification and surveillance regime.

ECMs and certification bodies based outside the UK

174 With regard to ECMs and certification bodies that are based outside the UK, ORR sees that there is still a problem to be solved. Under the current legal framework and working arrangements, ORR is constrained in its ability to monitor the adequacy of the surveillance arrangements established by a certification body that is not based in the UK. This constraint is exacerbated if the ECM is also based outside the UK, and when maintenance activities are undertaken at overseas workshops (as was the case for components of the wagon that derailed at Llangennech).

175 Internal guidance to ORR inspectors issued in April 2019 stated that if an ORR inspector needed to raise a concern or liaise with a certification body outside the UK they should do so directly or via the national safety authority of the Member State the certification body was accredited in. ORR reports that such liaison has become more difficult now that the UK has left the EU.

ORR's follow up of incidents

176 ORR had concluded that the wagon maintenance facilities at Robeston were capable of supporting basic maintenance, following a previous incident involving wheel flats on a loaded oil train.

177 RAIB has reviewed the recommendation and subsequent actions taken as a result of the accident at Ferryside (paragraphs 112 to 122). The review identified that stakeholders directly involved in the Ferryside investigation and freight industry working groups had focused solely upon the procedures relating to the replacement of brake blocks, rather than the risk assessment of all maintenance processes for dangerous goods wagons at Robeston, which was the clearly stated intent of the recommendation. A more comprehensive risk assessment should have led to a much better understanding of the risk associated with all aspects of the maintenance process. It should also have revealed the detail of how maintainers were undertaking their tasks, the information and equipment available to them and the supervision arrangements.

178 ORR visited Robeston in June 2019 and considered that the site was:

> '*capable of facilitating basic maintenance. The staff are more than capable of carrying out basic maintenance, with the facilities and supervisory staff supporting these activities'* and
>
> '*the facilities, working environment and the way the work was undertaken met the required standards and that no matters of evident concern were found'* (paragraphs 121 and 122).

It concluded that the risk assessment that was undertaken in relation to the replacement of brake blocks was sufficient to address the intent of the recommendation.

179 Given the feedback from the ORR visit, the owner of the terminal, Puma Energy, and DBCM, the contractors undertaking maintenance on behalf of Touax (as ECM), believed that the risk assessment that had been carried out was sufficient and that no further investment was required to improve the maintenance arrangements at Robeston.

180 The incident at Carpenters Road in June 2019 and the subsequent investigation (paragraphs 126 and 127) reiterated the safety lessons that had been identified at Robeston depot relating to sub-optimal maintenance facilities increasing the likelihood of maintainer error. However, no further action was taken by ORR or other stakeholders to review the actions taken to implement the recommendation from the Ferryside accident.

Factors affecting the severity of consequences

Ability of the wagon design to prevent tank rupture, fuel spillage and ignition

181 RAIB concludes that it is highly unlikely that there is any reasonably practicable change to the wagon design that could have prevented or mitigated the damage to the wagons near the front of the train, or prevented the fire that occurred. Therefore, RAIB has not made any recommendation relating to the design of the wagons.

182 There have been five accidents since 1980 in which tanks carrying dangerous goods were punctured by other wagons. In 1984, thirteen tank wagons carrying petrol derailed in Summit Tunnel, Yorkshire, resulting in a major fire inside the tunnel. All of the wagons involved were fitted with buffer override protection and the investigation report[20] commented that the buffer override feature incorporated into the design of the wagons had prevented other tank wagons from being punctured, and recommended that the design should be a feature for all tank wagons carrying highly flammable liquids.

183 Railway Group standard GM/RT2101 'Requirements for the Design, Construction, Test & Use of the Tanks of Rail Tank Wagons', which was first issued in 1996, required that all new tank wagons designed to carry dangerous goods must have end protection buffer override beams, if the distance from the tank to the buffer face is less than 920 mm (figure 31).

184 In 2003, RSSB commissioned consultants to review arrangements on dangerous goods tank wagons. The report[21] assessed the potential to improve on existing designs and whether there was justification for retro-fitment or upgrade measures of both buffer override protection and tank shrouding on existing wagons, for the reduction of risk associated with buffer override and the puncture of tank wagons containing dangerous goods. It found that retro-fitment was not justified on purely safety cost-benefit grounds, but the possibility of environmental penalties resulting from spillages might create a commercial justification for certain fleets, which would require further investigation by the operators.

185 The international regulations concerning the International Transport of Dangerous Goods by Rail (RID) defines dangerous goods as those goods which are capable of posing a risk to health, safety, property and the environment during carriage by rail. In the UK, RID superseded GM/RT2101 in 2011, and requires new tank wagons to be protected against damage to ensure the contents remain protected when wagons overturn or derail. There was no requirement to retrospectively provide such protection for existing wagons (other than liquefied gas carriers) unless wagon conversion work was being carried out.

[20] https://www.railwaysarchive.co.uk/docsummary.php?docID=207.

[21] RSSB research report T124 Review of tank wagon end protection, 2004.

186 On 27 January 2009, a dangerous goods train carrying a mixed consignment of gas oil, diesel and kerosene to a fuel depot derailed as the train crossed a bridge south of Stewarton, Ayrshire (RAIB report 02/2010). The bridge, which carried the railway over a road, collapsed and the derailed wagons overturned and caught fire. Although the type of override protection that had been fitted was a plain beam mounted above the buffers, to comply with GM/RT2101, the very high vertical movements that occurred during this accident meant that this protection provided no significant benefit, and around 220,000 litres of fuel were lost as a result of spillage from the derailed wagons and the subsequent fire.

187 The RAIB investigation into the Stewarton accident made twelve recommendations. Recommendation 11 was intended to improve the construction of existing tank wagons to mitigate the risk of leakage resulting from damage to external fittings in accident scenarios. Owners of dangerous goods wagons were again recommended to review the design of tank wagons, and to evaluate end protection measures (including buffer override and end protection using a framework or shroud) that could be taken to protect external equipment, such as pressure and vacuum valves, against damage in the event of overturning and derailment. While some companies decided that no modifications could be justified, ORR informed RAIB that following assessment, one owner had started to modify its fleet because the existing design offered minimal protection. As of 2021, the feature of buffer override protection is still not mandatory for class 3 products (diesel / mineral oil). However, the recommendation was not considered by GERS or VTG, as their fleets had incorporated the design envisaged by the recommendation when they were built in 2001, and did not have external valves. The recommendation was shown as implemented.

188 The site and vehicle inspection carried out by RAIB following the derailment at Llangennech showed that, although there was no end protection incorporated into the design of any of the derailed wagons in the form of a protected framework or shroud, the wagons did have buffer override protection beams. However, a survey of the damage revealed that the large lateral and vertical movements that occurred after the initial derailment caused the wagon buffers to over-ride or by-pass the buffer override protection and collide with the tanks. Other damage was caused by broken rails and components of rolling stock.

189 It was clear that the protective measures designed to reduce the likelihood of the tanks being punctured proved to be ineffective for those wagons subject to the greatest lateral and vertical movements. However, it is considered likely that these measures did provide protection to the tanks towards the middle and rear of the train (figure 31).

Figure 31: (left) VTG wagon (incident wagon 7) with raised buffer override protection beams which mitigated against further damage occurring and (right) wagon (incident wagon 6) that derailed, showing impact damage at high level where override protection could not prevent override and puncturing.

190 In a derailment, once the displacement of the wagons takes them substantially out of alignment with each other, the high forces involved are likely to result in damage which will breach the integrity of the tanks, as was demonstrated in the accident at Stewarton (paragraph 186) and in many other accidents to trains of tank wagons elsewhere in the world in recent years which have resulted in large spillages and fires.[22] In the light of this, RAIB does not believe that there is a reasonably practicable form of protection that could have prevented or mitigated the damage to the wagons near the front of the train, or prevented the fire that occurred. Therefore, RAIB has not made any recommendation relating to the design of the wagons or felt it necessary to repeat recommendations from the Stewarton accident investigation.

[22] Accident at Lac-Megantic, Quebec on 6 July 2013 http://www.tsb.gc.ca/eng/enquetes-investigations/rail/2013/R13D0054/R13D0054.html. RAIB is aware of at least 20 significant oil train derailments in North America, resulting in spillages and/or fires, since 2013. Most recently in Europe, a collision near Rumigny, France on 16 June 2021 resulted in the derailment of seven tank wagons and the puncturing of three of them, resulting in extensive pollution by phosphoric acid: https://www.lardennais.fr/id266114/article/2021-06-16/photos-rumigny-une-fuite-dacide-phosporique-apres-ne-collision-entre-un-train-et.

Ignition source of the fire

191 RAIB commissioned analysis on fuel recovered from the accident site, and ignition tests were also completed on samples provided by Puma Energy. Research indicates the autoignition temperature of diesel fuel (the only fuel type spilled) is between 230 and 260 ºC and hot surface ignition temperature is between 430 and 500 ºC. The characteristics of a given hot surface, for example the composition, geometry, ageing, contamination and catalytic effects, can all have a significant effect on the likelihood of a fuel in contact with that surface igniting, and at what temperature this will happen. It is therefore possible that the condition of the relevant surfaces (such as tanks and wagon frames) at the time of the fire might have favoured or otherwise facilitated hot surface ignition of the fuel. The tests showed it is unlikely that the fuel would have undergone autoignition after coming into contact with a hot metal surface such as the brake blocks, axle or wheels on wagon GERS 89005, and the most likely ignition source of the fire was metal on metal contact causing sparks (a pilot source) during the derailment sequence.

Observations

The role of the ECM certification bodies

192 In general, the level of surveillance undertaken by ECM certification bodies was insufficiently detailed.

193 RAIB issued urgent safety advice (USA) to the industry on 5 November 2020 (appendix C). The USA advised that ECMs should review their system of inspection and maintenance for wagons that primarily carry dangerous goods, to ensure that they have appropriate arrangements in place to manage the safety risk associated with malfunction of the braking system. RAIB's advice stated that the review should include an assessment of the adequacy of facilities, tools and equipment at all maintenance locations and systems for assuring the competence of those involved, combined with management systems and instructions for assuring the quality of work undertaken. Methods for initial and ongoing assurance of the security of fastenings and processes for the identification and tracking of safety critical components were also highlighted.

194 After the USA was published, all three ECM certification bodies within the UK reported to RAIB that they had not previously identified the issues that had been highlighted within the USA, nor had they scrutinised ECM workshops to a sufficient level of detail to fully understand how maintenance tasks were being undertaken. One auditor reported *'we, the industry haven't been kicking the metal to that level of detail'*. ECM certification bodies reported they did not have access to SMIS or use the intelligence that was available there to focus on specific issues within their surveillance arrangements.

195 Two of the three ECM certification bodies expressed concern that in their view the safety issues relating to the condition of freight wagons operating on the rail network were not fully understood within the freight industry. This view was supported by their contacts, since the USA had been published, with other ECMs who reported that the incident had highlighted similar deficiencies within their own ECM maintenance functions. Witness evidence also indicates that during one investigation involving an ECM, the commercial relationship with the company undertaking the certification work had affected the level of scrutiny carried out on a surveillance visit.

196 The investigation has highlighted that the level of surveillance of contractors and workshops by ECM certification bodies could be improved (for example, by using intelligence available on SMIS to formulate strategies for annual visits and certification). It has also highlighted that the communication and liaison between UK ECMs was insufficient to highlight common problems and areas of weakness.

197 Although originally considered as part of the EU wagon maintenance regime, there is no legal requirement for the certification of workshops. For this reason, it is the responsibility of the ECMs themselves to audit the adequacy of workshop processes and facilities which they use.

The role of the ECM

198 The way that Touax carried out its ECM responsibilities for quality assurance of its contractors and in maintaining traceability of safety critical components was inadequate.

199 In 2011, ECM Regulation 2011/445 introduced the system of certification of entities in charge of maintenance for freight wagons. The regulations oblige ECMs to ensure the correct delivery of maintenance (function d)) by establishing procedures to ensure that components and materials are used as specified and components are stored, handled and transported in a manner that prevents wear and damage to ensure compliance with national and international rules.

200 The Touax maintenance manual DT432 section 5.6.1 'Records of all maintenance' requires that:

> '*all activities of scheduled maintenance events, out of course repairs, brake tests, modifications shall record component details in accordance with TOUAX maintenance manual. Records shall be legible, accurate, complete, and held in a secure location that is also accessible for audit purposes. Records shall be held for the life of the vehicle plus seven years.*'

201 The RAIB investigation into the Ferryside accident (paragraph 112) observed that the Touax wagon involved in the incident was fitted with a distributor that had an incorrect choke, which had the effect of slowing the rise in pressure delivered to the actuators when there was a brake demand. The distributor had been supplied by Axiom Rail as a replacement for a missing unit. However, it was found to be configured incorrectly for use on a freight wagon and was sent to CFL (Luxembourg) for conversion. On its return, it was fitted to another wagon before being swapped onto wagon GERS 89009 in April 2017. It is unclear why the presence of the incorrect choke was not identified when the wagon received its annual VIBT in August 2017.

202 After the accident, and in collaboration with the manufacturer, RAIB carried out a controlled disassembly of the brake system components from wagon GERS 89005. This examination identified that parts not made by the original equipment manufacturer (non-OEM parts) were present within the relay valve and distributor, in the form of rubber 'O' rings and diaphragms. It has been difficult to investigate the history and audit of these safety critical assemblies because of a combination of the following:

- Touax began to record serial numbers of valves fitted to its wagons in late 2019 (in line with its interpretation of regulation 445/2011). However, documents that have been examined from 2019 have shown there was inconsistency in the way that fitters were completing this task after PPM and VIBT inspections, and some maintenance documents had been altered or overwritten.
- Touax did not require its contractors to record when parts were swapped or replaced during maintenance, or when replacing defective brake components.
- Labels with misleading component numbers and designations had been attached to the various components during repair or overhaul.
- There were incorrect or no serial numbers recorded on supply chain documents for valves sent to and from Luxembourg and Germany for repair or overhaul.
- The Touax operations manager used an ad-hoc email system to manage the maintenance of wagons and components, rather than using the recognised Touax maintenance 'Kheops' system that recorded maintenance intervals, revisions and maintenance data stored in France.
- The Touax database (due to the factors shown above) had also recorded different identification numbers for the same component.

203 When questioned after the accident, the Touax UK managers stated that they were unaware of the use of non-OEM parts. Furthermore, the operations manager was not aware of the findings of the Ferryside investigation in this respect as he had never had a formal briefing from his supervisors on it. Furthermore, the audit process applied by Touax to identify deficiencies within its maintenance regime, including safety critical brake system components, was deficient.

Previous occurrences of a similar character

204 Accidents involving tank wagons at Summit tunnel in 1984 and at Stewarton in 2009 are described in paragraphs 181 to 187.

Derailment at Washwood Heath West Junction, Birmingham 23 March 2015 (RAIB report 01/2016)

205 On 23 March 2015, one bogie of a wagon in a container train derailed on a set of points as it crossed between lines at Washwood Heath West Junction, in Birmingham. When tested, the wagon which derailed was found not to meet the requirements of the relevant Railway Group Standard for resistance to derailment due to track twist. When examined after the derailment, the liner on the centre pivot of the bogie was found to be worn beyond its maintenance limit.

206 Freightliner, the train operator, had hired the wagon which derailed from Ahaus Alstätter Eisenbahn AG (AAE), a wagon hire company based in Switzerland. The German national vehicle register showed that AAE was the ECM.

207 The wagon was brought to the UK in 2012 and hired to Direct Rail Services, who carried out maintenance on it. In 2014, the wagon was hired to Freightliner, and Davis Wagon Services was contracted to maintain the wagon on behalf of AAE as ECM.

208 The worn centre pivot liner had not been identified during maintenance of the wagon, as the maintenance instructions were unclear about when it should be inspected. AAE had not defined a maintenance strategy that required inspection of the centre pivot liners at a frequency related to the wear rate of the fitted liner material, and AAE was unaware that the UK maintainers acting on its behalf were not lifting the wagons to examine the centre pivot liners. Audits undertaken only checked that the maintenance contractor was following the technical file, and the lack of inspection of the liners continued. An underlying cause of the derailment was that the ECM's processes for management of maintenance were not robust.

209 RAIB also observed that the actions taken by the ECM following discovery of the problem on its UK wagons of the same type did not address the risk posed by wagons with worn liners remaining in service.

Freight train derailment at Ely West Junction,14 August 2017 (RAIB report 09/2018)

210 On 14 August 2017, the rear twelve wagons of a freight train carrying containers derailed at Ely West Junction on the line between Ely and March. The train ran derailed, causing significant damage to the infrastructure. A conclusion of the investigation was the need for ECMs to ensure that the vehicles for which they are responsible are maintained in a safe state by means of an appropriately validated system of maintenance.

Incident resulting in extensive track damage between Ferryside and Llangennech, Carmarthenshire, 30 October 2017 (RAIB report 17/2018)

211 On 30 October 2017 a wagon in a train carrying oil-based products from Robeston oil terminal, Milford Haven, to Westerleigh oil terminal, suffered a catastrophic failure of its braking system, and developed severe wheel flats, which caused extensive damage to the track over a considerable distance. The train did not derail and there were no injuries. The recommendations made following this accident and the way in which the various parties involved implemented them are described in paragraphs 112 to 122.

Summary of conclusions

Immediate cause

212 The leading wheelset of the third wagon in the train developed a false flange, which was not detected before the train reached Morlais Junction, where the damaged wheelset was unable to negotiate pointwork and became derailed (paragraphs 53 to 58).

Causal factors

213 The causal factors were:

a. The false flange was caused by the leading wheelset of wagon GERS 89005 ceasing to rotate. This was probably caused by a malfunction of the braking system on the wagon that resulted in uncommanded brake applications (commonly known as 'dragging brakes'). The malfunction of the braking system was the result of a combination of the following sub-factors:

   i. A historical change to the design of the Sab Wabco relay valve increased the chance of a dragging brake event occurring (paragraphs 71 to 82, **Recommendation 4**).

   ii. The relay valve on wagon GERS 89005 was further susceptible to loosening because it was not being maintained as specified by the brake equipment manufacturer. This was able to happen because Touax's management of its ECM requirements was inadequate (paragraphs 83 to 107, **Recommendations 1, 2 and 3**).

   Two other sub-factors were also identified that were possibly linked to the cause of the brake malfunction. These were:

   iii. The opportunity to learn from previous experience was missed (paragraphs 108 to 127, **Recommendations 1 and 8**).

   iv. The ECM certification process applied to Touax by Belgorail was below a standard that was effective (paragraphs 128 to 134, **Recommendation 5**).

b. The wheelset detection software within the infrastructure technology was not installed to alert the signaller to the dragging brakes on the wagon (paragraphs 135 to 147, **Recommendation 7**).

Underlying factors

214 An underlying factor was that the approach to the maintenance and monitoring of the condition of wagons and safety critical components within the rail freight sector was not based upon best practice (paragraphs 148 to 155, see actions taken paragraphs 223 and 224, **Recommendation 8**).

The role of the safety regulator

215 With regard to the role of the ORR, RAIB found:

a. When ORR relinquished its responsibilities as an ECM certification body the level of regulatory oversight of wagon maintenance activities significantly reduced, because the certification and surveillance of ECMs was transferred to accredited certification bodies. In some cases the ECM and certification body were based outside the UK. However, the new arrangements for surveillance of freight wagon maintenance were not always effectively applied (paragraph 156, see actions taken paragraph 221, **Recommendation 9**).

b. ORR had concluded that the wagon maintenance facilities at Robeston were capable of supporting basic maintenance, following a previous incident involving wheel flats on a loaded oil train (paragraph 176, no recommendation).

Factors affecting the severity of consequences

216 RAIB concludes that it is highly unlikely that there is any reasonably practicable change to the wagon design that could have prevented or mitigated the damage to the wagons near the front of the train, or prevented the fire that occurred. Therefore, RAIB has not made any recommendation relating to the design of the wagons (paragraph 181, no recommendation).

Factors associated with the emergency response

217 The emergency response, and the recovery of the scene was carried out with collaboration between Natural Resources Wales, the local authority and the rail industry. The debrief undertaken by Dyfed Powys local resilience forum found that there had been an effective response and recovery which prevented further ecological damage (see paragraph 229, no recommendation).

Additional observations

218 In general, the level of surveillance undertaken by ECM certification bodies was insufficiently detailed (paragraphs 192 to 197; see also paragraph 232, **Recommendation 6**).

219 The way that Touax carried out its ECM responsibilities for quality assurance of its contractors and in maintaining traceability of safety critical components was inadequate (paragraphs 198 to 203, see paragraph 225, **Recommendation 1**).

Previous RAIB recommendations relevant to this investigation

220 The recommendation made by RAIB as a result of its investigation into the incident which resulted in extensive track damage between Ferryside and Llangennech, Carmarthenshire, on 30 October 2017 (RAIB report 17/2018), has relevance to this investigation. It is described in paragraphs 112 to 122, along with the subsequent actions taken by the various parties.

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

Actions reported that address factors which otherwise would have resulted in a RAIB recommendation

221 ORR reports that it has carried out an internal review of its approach to the maintenance of freight wagons and locomotives.

222 The outcome of this review was a risk-based inspection protocol for 2021-22, based on a strategy that aims to:

- undertake supervision of freight duty holders' arrangements for the maintenance of freight rolling stock (without duplicating the surveillance work that is undertaken by ECM accreditation bodies);
- examine aspects of maintenance management that have been identified in previous ORR and industry investigations;
- consider how duty holders assure themselves that freight rolling stock is safe to re-enter service following maintenance; and
- where appropriate, sample duty holders' arrangements for the identification and management of brake system defects, including dragging brakes, as an indicator of systemic problems affecting individual wagon fleets.

223 The objectives of this intervention are for ORR to assure that the selected duty holders:

- are complying with relevant legal requirements;
- have appropriate arrangements in place for the maintenance of locomotives and rolling stock; and
- ensure that rolling stock is returned to the network in a safe condition.

224 The inspections that ORR plans to undertake will cover:

- all freight operators who also have ECM status;
- standalone ECMs involved in the maintenance of wagons that carry dangerous goods (including Touax);
- freight operators that do not hold ECM certificates in their own right and use third party suppliers of locomotives and rolling stock; and
- a sample of third-party maintainers (e.g. workshops) that carry out work on behalf of ECMs and freight operators.

Other reported actions

225 Touax has stated that it has taken the following actions:

a. Completed an inspection of the ex-GERS wagon fleet, with verification of the integrity of brake system components. One wagon was found to have a slightly loose relay valve. Washers were present on the relay valve retaining studs, on all wagons.

b. Issued a National Incident Report (NIR) on 18 September 2020 advising ECMs that an examination of the brake equipment on its wagon had revealed that the relay valve was loose and two small 'O' rings were displaced, one of which had migrated and wedged between two larger ports, possibly creating a pathway for an unsolicited brake application. Touax reported that it was carrying out an immediate safety check of its TEA fleet to check for mechanical security and air loss on relay valve connections using a soapy water test when a wagon was charged with air. The NIR advised other ECMs to carry out an immediate safety check for mechanical security and a check for air loss on the relay valve connection.

c. Issued an interim update of the maintenance specification for the affected wagon type, to include additional requirements for the fitting of relay valves.

d. Drafted a revision to its maintenance manual DT 432 version A to revision B (issued 27/11/2020) to cover both distributor valve and relay valve fitting. The document has not been published, as OEM documents were found to provide contradictory guidance. At the time of publishing this report Touax is in discussion with Wabtec Faiveley to resolve this issue.

e. Terminated its contracts with third party maintainers for repair and overhaul of Sab Wabco brake components. Overhauls are now contracted to Wabtec Faiveley, the original equipment manufacturer.

f. Proposed a common working group with DBC (UK) Limited to identify safety critical maintenance activities and identify risks.

g. Introduced a risk assessment process to define 'Safety Critical' components in the Touax fleet, as defined by the ECM Regulation 2019/779. The assessment will be validated by a designated body within the United Kingdom.

h. Supplied new relay valve components (washers, nuts and studs) to DBCM and AFSL in the event of parts being identified as missing or damaged.

i. Updated the original NIR, on 16 February 2021 to include the amended maintenance requirements for the security fastening of the relay component issued by Wabtec Faiveley.

j. Developed a risk assessment process for the introduction of safety critical components onto the TOUAX fleet.

226 Belgorail reported that it had undertaken an audit of Touax in December 2020.

227 Wabtec Faiveley re-issued its relay valve mounting instructions document (reference 01031-E01TLF) on 17 December 2020 to enhance the instructions for the detachment and mounting procedure. The tightening torque was reduced to 28 Nm (+/- 4 Nm), and the application of witness marking to the two nuts was introduced.

228 DBCM reviewed the Ferryside recommendation and has now (June 2021) commenced a complete review of the Touax maintenance procedures. This review has incorporated observations and task analysis of the practical application of the DT 432 manual. DBCM has reported the review has been extremely useful and identified issues it was not previously aware of. DBCM is currently awaiting instructions from Touax on the findings from the review.

229 Dyfed Powys local resilience forum has sent an accident response debrief report to the Cabinet Office with recommendations for national circulation.

230 Network Rail has reported that the following actions have been proposed:

a. A trial of the use of thermal radiometry cameras located in the cess / lineside to monitor passing trains, using 4G network to remotely access the thermal recordings and surface temperature data.

b. A review and risk assessment of the current locations and positioning of lineside hot axlebox detection equipment to understand and, if necessary, increase, upgrade or decommission equipment.

c. A review of the categorisation of operational incidents where brake dragging, locked wheels or high temperatures are recorded in axles and wheelsets, to be recorded on SMIS.

d. A review of the value of including specific dangerous goods events on the national operations centre (NOC) log.

e. In collaboration with the freight sector, introduced radio frequency identification (RFID) tags on rail vehicles that can be read by lineside technology.

231 RSSB has reported the following actions:

a. It has commissioned Newcastle University human factors research department to identify common freight vehicle event causes via the interrogation of reports (using data sources including SMIS, CCIL, and NOC) using specific modelling techniques.

b. RSSB's data insight team are remodelling both CCIL and SMIS incident data and working on the collation and development of the data into a new freight platform.

232 The National Freight Safety Group (NFSG) has reported that it has continued with a programme to address the risk of freight vehicle condition. This programme, known as 'Condition of freight vehicles on the rail network' (CFVN), will focus upon the following areas:

a. understanding and prioritising risks in train preparation

b. collaboration with RSSB on linking fault types and groupings within SMIS

c. building the project plan in key areas relating to vehicle condition which will encompass maintenance, ECM responsibilities, asset management systems, reliability, remote condition monitoring, staff resourcing and competence, training and development, and supervision and audit.

Recommendations

233 The following recommendations are made:[23]

1 *The intent of this recommendation is for Touax to validate, and where necessary improve, the way it manages the risk associated with its maintenance responsibilities for freight wagons operating in the United Kingdom.*

Touax should commission an independent review of the actions it has taken to improve its management of maintenance following the accident at Llangennech and assess their completeness and effectiveness. In particular, this review should address:

a. the effectiveness of the processes that have been put in place to ensure that safety critical systems and components are fully and correctly maintained by those contracted to do so;

b. the appropriateness of current instructions concerning the inspection, maintenance, removal and reattachment of safety critical components;

c. the traceability of safety critical components;

d. its processes for learning from the experience of its own people and other maintainers;

e. the dissemination of safety critical information including the reporting of dragging brake events and similar irregularities affecting the safety of its freight wagons; and

f. the extent to which its staff understand their maintenance responsibilities and are competent to perform them.

The findings of the review should be fully assessed and implemented to the extent necessary to reduce the risk of accidents linked to the condition of wagons.

(paragraphs 213a.ii, 213a.iii and 219).

[23] 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, recommendations 1 to 4 and 6 to 8 are addressed to the Office of Rail and Road, and recommendation 9 is addressed to the Department for Transport to enable them to carry out their duties under regulation 12(2) to:

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

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

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

2 *The intent of this recommendation is to identify and mitigate the risk associated with the maintenance of safety critical components on freight wagons at Robeston.*

Touax Rail, in conjunction with DB Cargo Maintenance, should carry out a task analysis of the processes that are used for the maintenance of fuel tank wagons operating out of Robeston terminal, taking full account of the risk associated with tasks being completed incorrectly and the working environment at the site. A time-bound plan should be developed for any necessary improvements that are identified (paragraph 213a.ii)

This recommendation may also apply to other ECMs.

3 *The intent of this recommendation is to mitigate risks involved in the overhaul of the safety critical components of freight wagons maintained by Arlington Fleet Services Ltd.*

Arlington Fleet Services Ltd, in conjunction with Touax Rail, should review and improve its quality management arrangements for maintaining and overhauling safety critical systems and components of wagons at Eastleigh works. This should include completing a task analysis of the processes that are used for undertaking and verifying the work done in accordance with Touax's work instructions. It should also check that the instructions issued to staff are complete and suitable for the task. A time-bound plan should be developed for the areas of improvement that are identified (paragraph 213a.ii).

4 *The intent of this recommendation is to validate the design of the interface between the relay valve and the pipe bracket on the GF4-SS1 brake group.*

Wabtec Faiveley should use the findings of this investigation to review the design of the interface between the VCAV relay valve and GF4-SS1 pipe bracket and implement any necessary improvements. This should include a review of the position of the equipment on the vehicle, the type and number of fastenings, specified torque values, related instructions for the detachment and reattachment of a relay valve, and how the security of safety critical component fixings is monitored. A time-bound plan should be developed for any necessary improvements that are identified (paragraph 213a.i).

5 *The intent of this recommendation is to improve the surveillance and certification processes of entities in charge of maintenance (ECM) of wagons carrying dangerous goods.*

BELAC, the Belgium National Accreditation Body, should use the findings from this report to carry out a review of the processes that are used to assess certification bodies who apply for or undertake surveillance and assurance certification of entities in charge of maintenance of wagons transporting dangerous goods.

Any areas for improvements that are identified should be incorporated into the surveillance and certification process (paragraph 213a.iv).

This may also apply to the arrangements which the United Kingdom Accreditation Service (UKAS) has for accreditation of bodies engaged in certification of entities in charge of maintenance.

6 *The intent of this recommendation is to provide practical guidance on good practice in wagon maintenance.*

RSSB, in conjunction with the National Freight Safety Group and entities in charge of maintenance (ECMs) with UK certification, should commission guidance on the practical application of the ECM regulations in the freight sector. This guidance should provide existing and new ECMs with examples of good practice that can be adopted to meet the legal requirements for all four ECM functions. It should also document ORR's regulatory strategy for freight wagon maintenance and its reasonable expectations of ECMs when operating in the UK, particularly in respect of outsourced maintenance delivery activities (paragraph 218).

7 *The intent of this recommendation is to reduce the risk that wagons will continue to run with undetected dragging brakes or locked wheelsets.*

Network Rail in conjunction with RSSB and the National Freight Safety Group should review the technology and systems currently being used in the UK and other European countries to identify how improvements can be made to the railway's ability to alert a train driver, signaller or control room to a wagon defect that may lead to a derailment, such as dragging brakes or an axle bearing failure. This review should include consideration of:

- the use of existing or new trackside equipment that is designed to detect overheated wheels and transmit an alarm; and
- equipment installed on wagons that is capable of detecting a safety critical fault and transmitting an alarm.

A risk-based plan should be formulated for the introduction of such improved systems, that accounts for the likelihood and consequences of a dangerous goods train derailment (paragraph 213b).

8 *The intent of this recommendation is to improve the management of wagon maintenance on GB railways. This recommendation should be implemented in parallel with the existing programme of work for condition monitoring of freight wagons on the network (CFVN) and any actions taken in response to recommendations 1, 2, 3 and 4.*

The National Freight Safety Group and the Freight Technical Committee, in conjunction with Network Rail and other industry stakeholders should develop a comprehensive programme of measures designed to promote the improvement of freight wagon maintenance in the UK. The programme should address all areas of significant risk, and aim to address the following issues:

a. how to capture and record high quality data relating to events which are recognised precursors to accidents, such as dragging brakes, to enable the better identification of the root causes and trends;

b. how to encourage the effective sharing of safety related information between wagon owners and maintainers;

c. the promotion of improved maintenance instructions, equipment, working conditions, methods and levels of compliance;

d. quality and management assurance processes that encompass ECMs, workshops, contractors and suppliers of specialised services; and

e. how to develop the competence of those undertaking maintenance of freight wagons, including the ability to spot defects that may affect the safe operation of freight wagons.

Once developed and agreed by stakeholders, the programme of measures should be implemented and progress monitored by the National Freight Safety Group (paragraphs 213a.iii and 214).

9 *The intent of this recommendation is to address a gap in the regulatory oversight of freight wagon maintenance.*

The Department for Transport and the Office of Rail and Road should jointly review the current arrangements for the oversight of entities in charge of maintenance (ECMs) and certification bodies that are not based in the UK. As a minimum the review should include consideration of:

- the effectiveness of current arrangements for the oversight of ECMs that are not based in the UK;
- current barriers to effective engagement with ECMs and certification bodies that are based outside the UK; and
- avenues for closer engagement with EU national safety authorities on matters related to rolling stock maintenance.

The outcome of the review should be used to inform any necessary changes to policy or legislation in this area (paragraph 215a.).

Appendices

Appendix A – Glossary of abbreviations and acronyms

CCIL	Control centre incident log
CCTV	Closed circuit television
ECM	Entity in charge of maintenance
HABD	Hot axle box detector
LRF	Local resilience forum
NOC	National operations centre
OEM	Original equipment manufacturer
ORR	Until 1 April 2015, ORR was known as the 'Office of Rail Regulation'. It has used the name 'Office of Rail and Road' for operating purposes since 2015.
OTDR	On-train data recorder
PPM	Planned preventative maintenance
RAIB	Rail Accident Investigation Branch
ROGS	Railways and Other Guided Transport Systems (Safety) Regulations 2006
SMIS	Safety management information system
VIBT	Vehicle inspection and brake test

Appendix B – Investigation details

RAIB used the following sources of evidence in this investigation:

- information provided by witnesses
- examination of the brake components to establish the mechanism for the unintended brake application
- reconstruction tests using new and the accident components
- review of the maintenance history of wagons GERS 89005, 89014 and 89026
- review of the OEM technical documents and Touax maintenance instructions and procedures for the brake group components
- examination of the damaged wagons
- information taken from the train's on-train data recorder (OTDR)
- closed circuit television (CCTV) recordings taken from stations and a level crossing on the route
- site photographs and measurements
- weather reports and observations at the site
- analysis of the accident components and bolted joint commissioned by RAIB
- analysis of the brake system components commissioned by RAIB
- a review of previous RAIB investigations that had relevance to this accident.

Appendix C – Urgent Safety Advice

Urgent Safety Advice 02/2020: Maintenance arrangements for wagons that primarily carry dangerous goods

Published 5 November 2020

1. Safety issue

Suitable processes, facilities, tools and equipment may not be in place to prevent safety critical system components becoming unsafe due to insecure fastenings.

2. Safety advice

Entities in Charge of Maintenance (ECMs) should review their system of inspection and maintenance for wagons that primarily carry dangerous goods, to ensure that they have appropriate arrangements in place to manage the safety risk associated with malfunction of the braking system. This should include an assessment of the adequacy of:

- facilities, tools and equipment at all maintenance locations
- systems for assuring the competence of those involved
- management systems and instructions for assuring the quality of work undertaken
- methods for initial and ongoing assurance of the security of fastenings
- processes for the identification and tracking of safety critical components.

This assessment should take into account the particular hazards associated with conveying dangerous goods

3. Issued to:

ECMs responsible for the maintenance of wagons which primarily convey dangerous goods in the UK.

4. Background

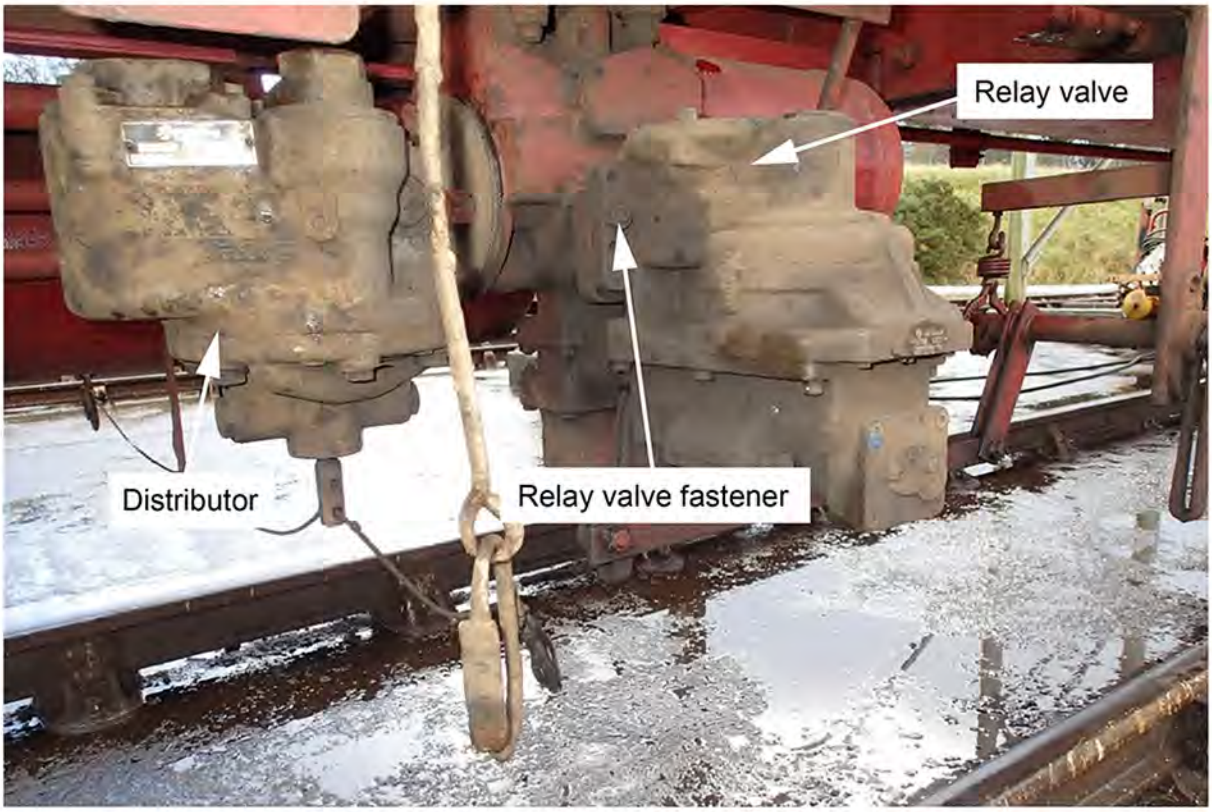
At about 23:15 hrs on 26 August 2020, train 6A11, the 21:52 hrs freight service from Robeston (Milford Haven) to Theale, conveying 25 tank wagons, each containing up to 75.5 tonnes of diesel or gas oil, derailed on the 'Up District' line near Llangennech, in Carmarthenshire. The derailment and the subsequent damage to the wagons resulted in a significant spillage of fuel and a major fire. Subsequent examination of the site revealed that a total of 10 wagons (positioned 3rd to 12th in the train) had derailed, and that around 330,000 litres of fuel had been spilt.

RAIB's preliminary examination found that, although all the wheels of the train were probably rotating freely when the train left Robeston, at some point during the journey the brakes on all wheels of the third wagon of the train had become applied, and remained so until the derailment. Although their brakes were dragging, three of the four axles of this wagon continued to turn. At some point in the journey the leading axle ceased to rotate altogether, as evidenced by a CCTV camera located at Pen-y-Bedd level crossing (12 miles (19 km) from Morlais Junction), and marks on the railhead.

CCTV image showing the third wagon passing Pen-y-Bedd level crossing

The locking of the leading axle of the third wagon caused the development of a flat spot around 230 mm long on both of the wheels on this axle. This in turn created substantial 'false flanges' (raised lips on the outer side of the wheel treads). When the train reached the crossover at Morlais Junction, travelling at about 30 mph (48 km/h), the false flange on the right-hand wheel caught on the converging stock rail and distorted the track, leading to derailment of both wheels. Around 100 metres further on, the partly derailed wagon encountered facing points set to route the train to the right. The locomotive and the two leading wagons went to the right and the derailed third wagon went straight ahead. The third wagon turned over onto its right-hand side and became detached from the wagon in front of it. This caused the points and the track beyond them to be destroyed, and derailment of another nine wagons followed.

Examination of the brake group on the third wagon (TEA wagon GERS89005) found that the relay valve was loose on the pipe bracket. A sealing ring from one of the ports in the mating face had migrated to a position where it lodged between two other ports, distorted the sealing rings of those ports, and probably created a route for air to pass directly from the auxiliary reservoir to the wagon brake cylinder. This would have had the effect of applying the brakes on the wagon, producing the result described above.



Brake group on TEA wagon

The ECM for the wagon was unable to identify with any degree of certainty where and when the fastenings of the relay valve had last been disturbed. However, this may have taken place during routine repairs in the sidings at Robeston terminal or during scheduled maintenance elsewhere. There was no record of any check on the tightness of the fastenings ever having been made, and no process requiring such checks or provision of any measures, such as witness markings, which would have indicated that fastenings were becoming loose.

Appendix D – Fastener tests and analysis

D1. Testing and analysis was conducted to determine the relationship between the torque applied to the nuts and the clamping load that is produced. The testing and analysis produced the following results:

a. Tightening of the studs and nuts (without washers)[24] from the accident assembly to 29 Nm resulted in a low bolt preload, relative to capabilities of the fasteners, of 4.6 kN for the left-hand (LH) stud/nut and 7.1 kN for the right-hand (RH) stud/nut.

b. Tightening of studs, washers and nuts from a relay valve assembly removed from a wagon in service to 29 Nm, resulted in similar preload levels to the accident fasteners, specifically, 6.5 kN for the LH stud/washer/nut and 5.9 kN for the RH stud/washer/nut.

c. Tests were completed using new washers, retaining existing (used/old) studs and nuts in accordance with the manufacturer's current recommended maintenance practice. The preload values obtained in this situation were similar to those obtained by reusing the washer. Specifically, a new washer with the old LH stud and nut from the accident tightened to 29 Nm resulted in a preload of 5.7 kN and those from the RHS, 6.1 kN. For the LH old stud and nut taken from a relay valve assembly removed from a wagon in service and a new washer tightened to 29 Nm resulted in a preload of 8.9 kN, and those from the RHS, 8.8 kN.

d. Tests on assemblies consisting of new studs, washers and nuts resulted in a higher preload than the previously used fasteners. Based upon a sample from 10 tests, the preload results were higher and varied from 12.2 kN to 17.20 kN.

e. Tests on assemblies consisting of new studs and nuts (with no washers applied) also resulted in a higher preload than with previously used fasteners, and similar to when a washer was used. Based upon a sample from 10 tests, the preload varied from 15.5 kN to 17.90 kN.

f. Tests were also completed using new washers and new nuts, retaining the existing studs (used). The preload values obtained in this situation are similar to those obtained by reusing new studs, new washers and new nuts. Specifically, a new washer and nut with the LH stud from the accident tightened to 29 Nm resulted in a preload of 16.3 kN and the stud from the RHS, 15.2 kN. For the LH stud and nut from a relay valve assembly removed from a wagon in service and a new washer tightened to 29 Nm resulted in a preload of 17.1 kN, and those from the RHS, 17.6 kN.

D2. In addition to these tests, analysis was completed on the joint. The analysis indicated that, assuming that the nuts had been tightened correctly, the likely cause of the nuts loosening on the relay valve involved in the accident was that the nuts had been re-used, and that the washers had not been fitted. The re-use of the old nuts was likely to result in a low initial preload in the studs. High relaxation losses from embedding can be anticipated in such circumstances due to the low amount of stretch (extension) in the stud. This, coupled with the forces acting on the joint, is the likely cause of the complete loosening of the nuts.

[24] The GERS fleet was checked after the accident which found one wagon with a loose relay valve. Wagon GERS 89005 was the only wagon with no washers applied.

D3. This analysis work, coupled with the tests, indicates that the re-use of a nut, even when a new washer is fitted, can result in the potential for joint movement to occur. The clamping force is needed to resist the shear loading acting on the joint, which is highly dependent upon the value of the static coefficient of friction between the joint surfaces.

D4. It was identified that the normal practice is for one person to detach and refit the relay valve. The shape of the relay valve and its weight (8.6 kg) makes this task awkward, and 'O' rings frequently fall out. To prevent this from happening, normal practice is to apply grease to keep the 'O' rings from falling out of their respective recesses. The consulting engineers who carried out this analysis concluded that it is reasonable to expect, without specific work instructions to the contrary, that engineering staff will not clean their hands after this process, and therefore grease deposits could contaminate the joint surface and the nuts and washers when the relay valve is secured. If this occurred, the friction between the surfaces could be significantly reduced requiring a higher clamp force to prevent slip. Based upon the analysis completed, with grease contamination, there is the potential for joint slip to occur that would compromise the 'O' rings and could result in the nuts self-loosening.

Appendix E – Other factors considered

The geometry of the track

E1. A visual examination and track survey of the accident site was undertaken separately by both RAIB and Network Rail.[25] The track geometry on the approach to the point of derailment showed no evidence of a fault that could have contributed to a derailment taking place.

The preparation and driving of the train, and overcharge of the brake system

E2. The purpose of brake pipe overcharge (during the train preparation procedure or during train movement) is to correct pressure imbalances that can occur within vehicle distributors, whereby the control reservoir pressures can be greater than the brake pipe pressure such that the distributors are induced to operate and produce brake applications.

E3. Pressing the overcharge button on the locomotive initiates an increase in the brake pipe pressure from the normal 'running' pressure (nominally 5.0 bar) to a higher figure (5.35 –5.47 bar), with this pressure being maintained for a period of approximately one minute. This higher pressure passes to the distributors on all the vehicles in the train formation, such that the pressures in the distributor control reservoirs are also increased. After the one-minute delay the brake pipe pressure is allowed to reduce back to the 5 bar 'running' figure but at a sufficiently slow rate that the distributors do not operate to apply the brakes, which permits the control reservoir pressures to reduce along with the pressure in the brake pipe.

E4. In this case, data from the on-train data recorder (OTDR) on the locomotive indicates that after coupling the locomotive to the wagons, the brake pipe was charged to release the train brakes, with the maximum pressure of 4.9 bar being attained at 20:10:13 hrs.

E5. The OTDR data confirmed that after the brake continuity test (paragraphs 27 to 29) the driver initiated a brake pipe overcharge at 20:17:34 hrs with the brake pipe pressure increasing by 0.4 bar to 5.3 bar, which was attained by 20:18:27 hrs (figure 28).

E6. The train preparer reported that he waited at the rear wagon while this was done and made sure all the brake blocks had come off once the air pressure had built back up. He then walked around both sides of the wagons, left-hand side first and then the right-hand side, confirming that the brakes were released.

E7. Tests undertaken by RAIB showed that a loose relay valve is not readily detectable. The environmental conditions and noise (from the locomotive and the engine of the train preparer's own vehicle) may have also masked any noise from a potential air leak. As such, the fault may not have been easily identifiable during the pre-departure checks undertaken at Robeston.

E8. The OTDR data for train 6A11 shows that during the time that the full overcharge pressure was present in the brake pipe, at 20:17:50 hrs, the driver also applied power and the train began to move. This was most likely when the train preparer instructed the driver to pull up to the terminal gates.

[25] Evidence from the examination of the infrastructure and wagons involved was compared to Network Rail standard NR/L2/TRK/001/ mod11, issue 8, September 2015 and Railway Group Standard GMRT2466, Railway Wheelsets, Issue 4, December 2017.

E9. When the brake pipe overcharge was initiated the pressure rose from 4.9 bar to 5.3 bar which would, over the period that the overcharge was maintained at this figure (50 seconds) have caused the control reservoirs of the distributors on all the vehicles in the train formation to rise to 5.3 bar. When the brake was applied and subsequently released the control reservoirs would have remained at 5.3 bar. If, following the release of the brake, the brake pipe pressure had returned to the 'pre-overcharge' figure of 4.9 bar, the 0.4 bar pressure difference across the control diaphragms on the vehicle distributors could have resulted in dragging brakes throughout the train, which did not occur. Therefore, although the full overcharge system test was not fully completed, there is no evidence that the brake pipe overcharge feature had any effect on the accident. RAIB also examined the OTDR record for the train's journey, and the train driver's training records, and concluded that the driver's competence and driving technique was not a factor in the accident.

Other components within the relay valve and distributor

E10. The internal components of the relay valve and distributor were examined to identify any faults which might have been factors in the accident. The following possibilities were considered by RAIB in consultation with the manufacturer's technical experts:

- A foreign body becoming trapped between the two mating faces when the relay valve was fitted:

  An item becoming trapped between the faces of the joint during the tightening process during a maintenance examination would result in it not being possible to achieve sufficient torque in order to pass a pre-inspection brake test, and there is no evidence of this occurring before the last vehicle inspection and brake test (VIBT) on 18 June 2020.

- An 'O' ring becoming trapped (fully or partially) between the two faces when the relay valve was fitted:

  Witness evidence indicates that this had occurred previously, during both planned preventative maintenance (PPM) and VIBT inspections. It was also reported as having been identified during the final pre-departure brake test before a wagon was released back into operational service on the rail network. This would most likely have occurred following a general repair during which the wagon had been stripped down and components had been overhauled and refitted back onto the wagon. In the case of the wagon that derailed at Llangennech, microscopic examination showed no contact trace evidence on either mating face that would suggest that an 'O' ring had become trapped, was out of position or had been squashed during refitting. The wagon had also passed its brake test during two PPMs and one VIBT between January and June 2020.

- Defect in the relay valve:

  The main inlet valve (called a ‘rod’) slides up and down during operation of the relay valve, with the rod entering a ‘top cap’ or plug. If the rod had become contaminated it could have been prevented from moving. Under normal conditions the top cap is clean. However, examination of the rod and top cap from the relay valve from wagon GERS 89005 showed contamination was present, which may have restricted the movement of the rod and prevented it moving or working as intended. The contamination was analysed and found to be ‘carbonised’ material, which was probably burnt debris from the various ‘O’ rings that form part of the upper valve assembly. This contamination was also combined with zinc-based deposits, most likely to be burnt grease. After consulting the manufacturer of the relay valve, RAIB concluded that this contamination was almost certainly a consequence of the accident.

- Other potential failure modes associated with the relay valve and distributor, relating to an unsolicited brake application or the wagon’s inability to release its brakes were also considered. These were:

  i. the pilot pressure was not exhausted from the pilot chamber

  ii. the pilot pressure piston, balance lever or main piston was jammed and could not move

  iii. the exhaust circuit was blocked

  iv. the distributor valve initiated a brake cylinder pressure with no pressure drop in the brake pipe.

E11. RAIB, in consultation with the manufacturer’s technical experts, reviewed the evidence and these possible failure modes and found no evidence that they were factors.

Appendix F – Entities in charge of maintenance (ECM)

Note: The legal arrangements described below applied up to 31 December 2020 and were therefore in force at the time of the accident at Llangennech. Since 1 January 2021, EU regulation 2019/779 was revoked by the Railways (Miscellaneous Amendments, Revocations and Transitional Provisions) (EU Exit) Regulations 2020. Although the concept of an Entity in Charge of Maintenance has been retained, ECMs are no longer obliged to apply the four maintenance functions unless the registered rolling stock travels outside the UK.

F1. Regulation 18A of the Railways and Other Guided Transport Systems (Safety) Regulations 2006 requires each ECM to ensure that, through a system of maintenance, a vehicle for which it is responsible is safe to run on the mainline railway. The system of maintenance is required to include the maintenance file for that vehicle and the applicable maintenance rules.

F2. All ECMs placing a rail vehicle in service or using it on a mainline railway need to hold a valid ECM certificate. The ECM must also be registered on the national vehicle register. According to article 1(1) of EU Regulation 2019/779, which laid down detailed provisions for the certification of ECMs, the maintenance system was required to be composed of the following four functions, defined in article 14.3 of EU Directive 2016/798:

a) Management.

b) Maintenance Development.

c) Fleet Maintenance Management.

d) Maintenance Delivery.

F3. The management function (function a)) requires the ECM to supervise and coordinate the maintenance functions referred to in functions b), c) and d) and ensures the safe state of the vehicles on the railway system. The function also includes the following responsibilities:

i. the development and implementation of the maintenance system to ensure continuous improvement and effectiveness

ii. a structured approach to assessing risks associated with the maintenance of freight wagons, including those directly arising from operational processes and the activities of other organisations or persons, and to identify the appropriate risk control measures

iii. a structured approach to ensure that risk control measures are in place and working correctly

iv. a structured approach to analyse information gathered through regular monitoring, auditing, or other relevant sources (such as information from the investigation of accidents and incidents) to learn and adopt preventive or corrective measures in order to maintain or improve the level of safety

v. a structured approach to defining the responsibilities of individuals

vi. a structured approach to ensure that employees have the competences required in order to achieve the organisation's objectives safely

vii. a structured approach to ensure that important information is available to those making judgments and decisions at all levels of the organisation

viii. a structured approach to ensure the traceability of all relevant information

ix. a structured approach to ensure that subcontracted activities are managed.

F4. European Union Regulation EU/1078/2012 established a common safety method (CSM) for monitoring, enabling the effective management of safety of the railway system during its operation and maintenance activities. In relation to the use of contractors by ECMs, an ECM was required to ensure that:

- the risk control measures implemented by contractors were monitored using the process in the CSM; and
- contractors applied the same process through the contractual arrangements.

F5. An ECM must report, in its annual maintenance report, on its experience of applying the CSM for monitoring, including the strategy or actions taken and completed with reference to previous incidents. This information is to be made available to the bodies who are required to undertake certification and annual surveillance visits on an ECM (paragraph 128).

ECM certification

F6. The ECM certification process required each ECM to have an ECM certificate issued in accordance with Regulation (EU) 445/2011 or 2019/779 by a body accredited to do so by a national accreditation body. The application of a system of certification[26] of entities in charge of maintenance for vehicles was governed by Article 14 of Directive EU 2016/798 and Regulation EU 2019/779.

[26] The standards supporting the accreditation process of ECM certification bodies and ECM certification are:

- EN ISO/IEC 17065:2012 Conformity assessment- Requirements for bodies certifying products, processes or services
- EN ISO/IEC 17021-1:2015 Conformity assessment- Requirements for bodies providing audit and certification of management systems –(part 1)
- EN ISO/IEC 17025:2005 General requirements for the competence of testing and calibration laboratories
- EN 17095 Railway applications – Rolling stock maintenance- Maintenance records
- EN 17023 Railway Applications-Railway vehicle maintenance- Creation and modification of maintenance plan.

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