RAIB
Rail Accident Investigation Branch

Rail Accident Report

Collision with the gates at Lydney Town level crossing
15 August 2007

Department for Transport

Report 14/2008
July 2008

This investigation was carried out in accordance with:

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

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Introduction

1 The sole purpose of a Rail Accident Investigation Branch (RAIB) investigation is to prevent future accidents and incidents and improve railway safety.

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

3 Access was freely given by the Dean Forest Railway to their staff, data and records in connection with the investigation.

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

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

Summary of the Report

Key facts about the accident

5 At approximately 14:40 hrs on Wednesday 15 August 2007 a special passenger train from Norchard to Lydney Junction on the Dean Forest Railway (DFR), struck a partially open gate at Lydney Town level crossing, detaching the gate from its mountings. The gate struck and seriously injured one of the two *crossing keepers*. No other person was physically injured, and there was only superficial damage to the train.

6 The location of the accident is shown in Figure 1.

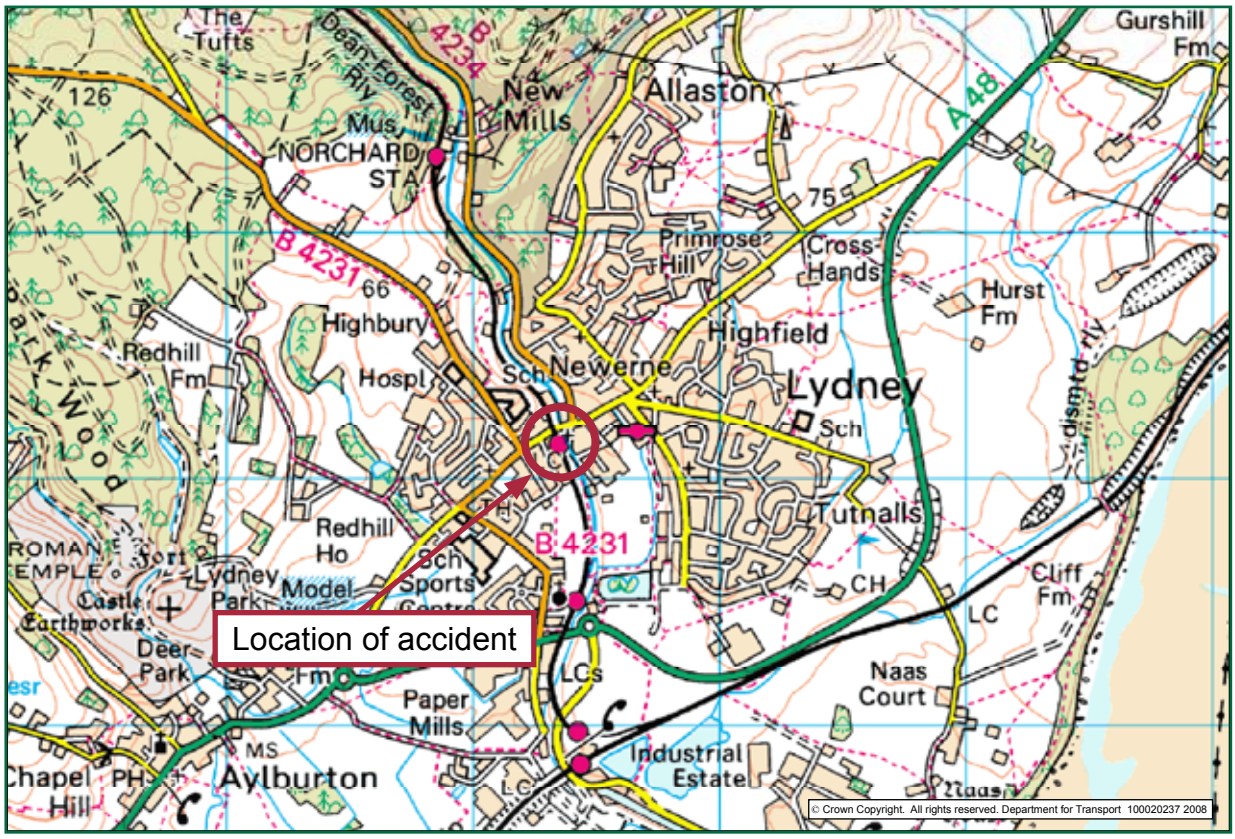

Figure 1: Extract from Ordnance Survey map showing location of accident

7 The immediate cause of the accident was that the driver of the train was unable to stop it before reaching the stop board at Lydney Town crossing and having passed the stop board, was not able to stop the train before striking the crossing gates.

8 The following factor was considered to be causal to the accident:

a. the excessive speed of the train as it approached the crossing.

9 The following factors are considered to be contributory to the accident:

a. the locomotive crew's lack of training and experience in controlling the *auto-train* in conditions of poor adhesion;

b. the wet condition of the rail head;

c. the low position of a warning *treadle* arm;

d. the DFR had not repaired the known problem with the warning buzzer and light; and

e. there was no effective system for informing train crews that the warning system was not working.

10 The following factors may be contributory to the accident:

a. not having working *sanding equipment* on the train;

b. the noise from passing traffic, in particular heavy goods vehicles; and

c. the DFR's response to pressure from road users to minimise traffic delays.

11 Recommendations can be found in paragraph 123. They relate to the following areas:

- the speed of trains approaching Lydney Town level crossing;
- adherence to speed restrictions;
- braking and sanding systems on the Dean Forest Railway;
- procedures for operating the Dean Forest Railway safely in a degraded mode;
- maintenance of treadles to a recognised standard;
- knowledge and experience of footplate crews;
- appointment of a health and safety adviser;
- notification of accidents; and
- age-related standards for train drivers.

The Accident

Summary of the accident

12 A passenger train consisting of a former Great Western Railway (GWR) steam *tank locomotive*, propelling a GWR *autocoach,* left Norchard station at 14:40 hrs. On board were the driver, the fireman, the guard and a private party of passengers consisting of five adults and five children.

13 The train, which was on its second run of the day, approached and struck the partially open northern *secondary gate* at Lydney Town level crossing. The gate became detached and struck and seriously injured one of the two crossing keepers. The train continued through the crossing before being brought to a stand alongside the Lydney Town station platform

14 Damage to the infrastructure was minimal and confined to one of the four crossing gates.

15 Rolling stock damage was limited to minor marking on the leading end and side of the autocoach.

Location

16 The DFR is a standard gauge single track heritage railway 4.25 miles (6.84 km) in length, operating from Lydney Junction northwards to Parkend in Gloucestershire.

17 The line from Lydney Junction, which was last used by British Railways (BR) in 1976, was reopened by the DFR as far as Norchard in 1995, and to Parkend in 2006.

18 The line has six stations and five level crossings, including the Lydney Town level crossing at which the accident occurred (Figure 2).

Parties involved

19 The Dean Forest Railway is operated by Dean Forest Railway Co Ltd, which is a wholly owned subsidiary company of Forest of Dean Railway Limited, whose shares are held by the Dean Forest Railway Society and private investors. The railway is operated entirely by volunteer staff.

20 The locomotive and autocoach involved in the accident are privately owned.

21 The DFR has a *Safety Case* covering its operations, which was accepted by Her Majesty's Railway Inspectorate (HMRI) in 2004 under the Railways (Safety Case) Regulations 2000. The Safety Case is currently being updated to bring it into line with the DFR's current management arrangements, and in preparation for the need to obtain safety certification from ORR (HMRI) in accordance with the requirements of the Railways and Other Guided Transport Systems (Safety) Regulations 2006, from 1 October 2008.

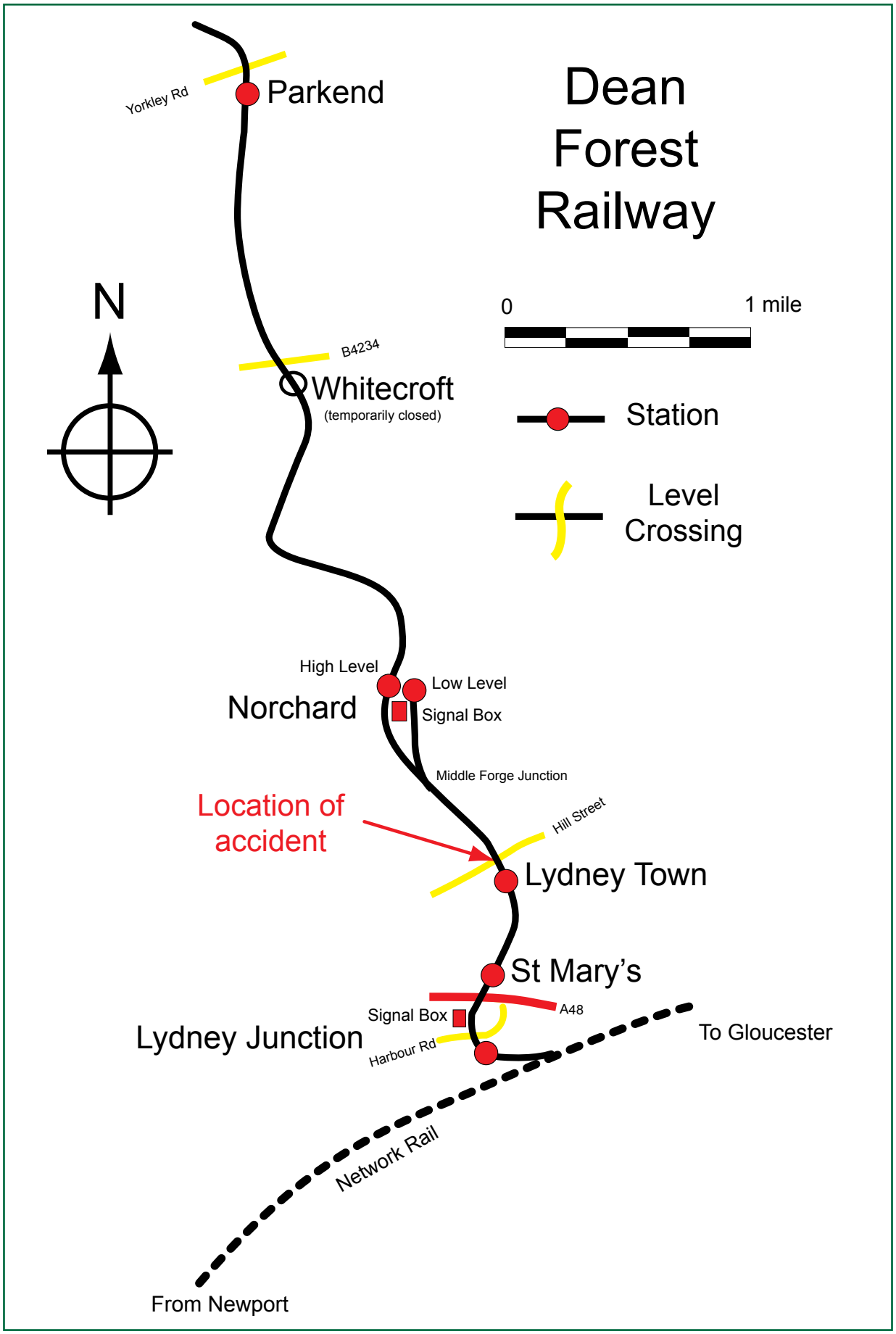

Figure 2: Map of the line

22 Six members of the DFR's operational staff were involved in the train movement. These were:

a. The driver, in the cab at the leading end of the autocoach, who was 71 years old, and had over three decades of driving experience. The driver had retired from regular driving as he was over 70, which is the maximum age for DFR drivers permitted by the company's rules, but was called in to drive special trains or to cover when the railway was short of staff. He had driven on a few occasions in 2007 before the accident.

b. The guard, travelling in the saloon of the autocoach, who was an experienced member of the railway staff and had been qualified to act as guard for several years;

c. The fireman, located on the footplate of the locomotive, who was 19 years old and had been qualified as a fireman for eight months, after spending twelve months as a cleaner. The fireman had fired the locomotive on six days previously. Two days had involved auto-train working, both with someone else on the footplate. The 15 August was the first day on which the fireman had been alone on the footplate when the driver was at the other end of the train.

d. Two crossing keepers at the Lydney Town level crossing gates, who both had more than three years experience of operating the crossing.

e. The signalman at Norchard station signal box, who was an experienced member of the railway staff.

23 All of the DFR staff members involved in the accident had been assessed as competent in the skills required to undertake their duties in accordance with the DFR's requirements. The DFR's rules specified that drivers should have a medical examination every five years, and every year once they were over the age of 60, but the company's management were only requiring such examinations every five years for all staff, regardless of age. The driver had last been medically examined in 2003, four years before the accident.

24 There is no evidence that any of the staff involved had had inadequate rest, or were otherwise fatigued.

The infrastructure

25 Lydney Town level crossing is a gated crossing on Hill Street, which is the main road through the centre of the town of Lydney (Figures 3 & 4). Before the Lydney by-pass was built in the 1980s, Hill Street was part of the A48, and although it is no longer a classified road it still carries substantial road traffic. When the crossing is closed to the road to allow a train to cross, road traffic quickly backs up on both sides.

26 The crossing has operated on the same basis (gates operated by railway staff which swing alternately across the road and railway, fencing the railway from the road) since the line was opened as a railway in 1869, successively under the ownership of the Severn & Wye Joint Railway, British Railways and the DFR. As its method of operation has not been upgraded it is not subject to a *level crossing order*.

27 Because the road is wider than the single track rail line, requiring a width of gate to close the road significantly greater than that required to close the railway, the crossing gates overlap when closed to the railway. The gates which are closed across the road first to stop the traffic, hinged on the right hand side of the railway as seen from approaching trains, are known as the primary gates.

28 To operate the gates as swiftly as possible, the DFR normally allocates two crossing keepers; each one has to open both gates on the same side of the road. The primary gates are opened by the two keepers at the same time, stopping the road traffic in both directions. The other gates, known as secondary gates, are then closed to fully fence off the railway from the road.

Figure 3: Lydney town crossing looking south

Figure 4: Lydney town crossing looking north (secondary gate missing following accident)

29 The line approaching the crossing from Norchard station (the north) is single track on a 1 in 128 falling gradient. There is a right hand, 300 metre radius, curve on the northern approach to the level crossing (Figure 9). There are trees intermittently in close proximity to both sides of the track throughout the approach to the crossing.

30 When they are on duty, but there is no train approaching, the crossing keepers occupy a small building immediately west of the line 15 m north of the crossing (Figure 5).

31 From the north crossing gates the crossing keepers can see a train approaching from the north a maximum of 128 m away.

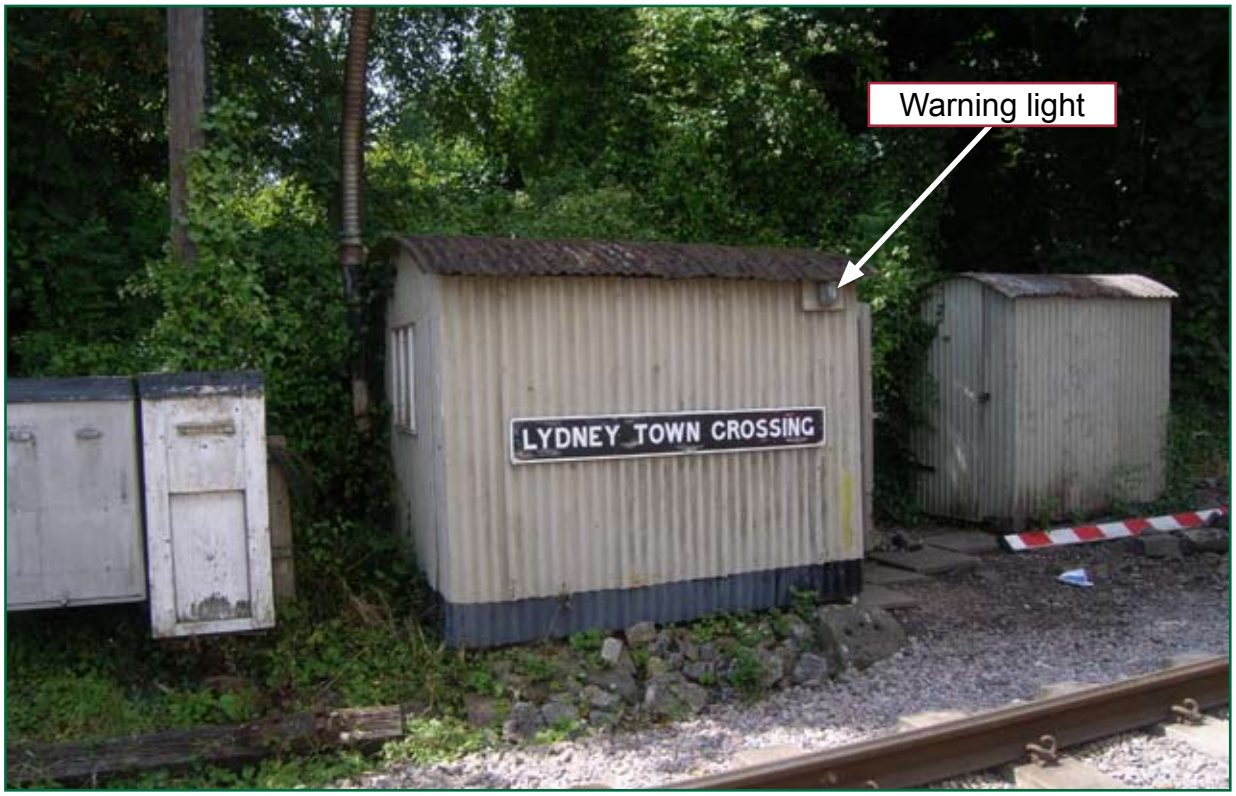

Figure 5: Crossing keeper's hut, showing warning light for approach of trains

32 In order to warn the crossing keepers of approaching trains there is a treadle placed 455 metres (500 yards) north of the crossing (Figure 6). Operation of this treadle by a train causes a buzzer to sound, and a light to flash, at the crossing keepers' hut.

33 The driver of a train approaching Lydney Town level crossing from the north should take the following actions (all dimensions given are measured from the line of the northern crossing gates when closed against the railway):

- Reduce speed to 10 mph (16 km/h) at a speed indicator board. This is located to the left of the line, as seen by a train driver, 183 metres (200 yards) from the crossing (Figure 7).
- Sound a warning at a 'Whistle' board (denoted by the letters 'SW') located close to the speed indicator board (Figure 7).
- Look out for the crossing gates and any hand signal from the crossing keepers. The gates come into the driver's view when the train is 119 metres from the crossing.
- Be prepared to stop at a board 24 metres before reaching the crossing, unless the crossing keepers give a proceed signal (Figure 8).

34 Vegetation to the left of the line obstructs the view of the stop board until the driver is some 40 metres from it, but for a train travelling at 10 mph on a dry rail this provides sufficient stopping distance.

35 Figure 9 shows schematically the position of the features in relation to the crossing gates.

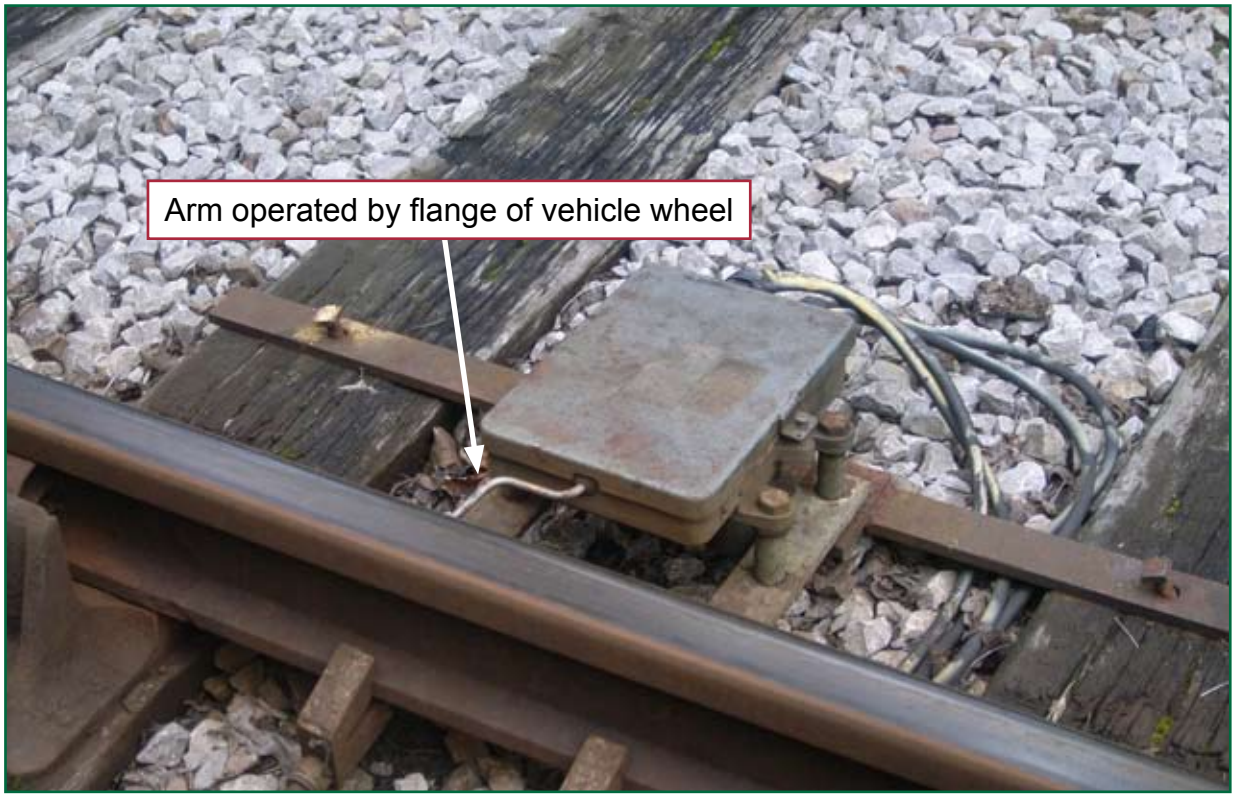

Figure 6: Treadle

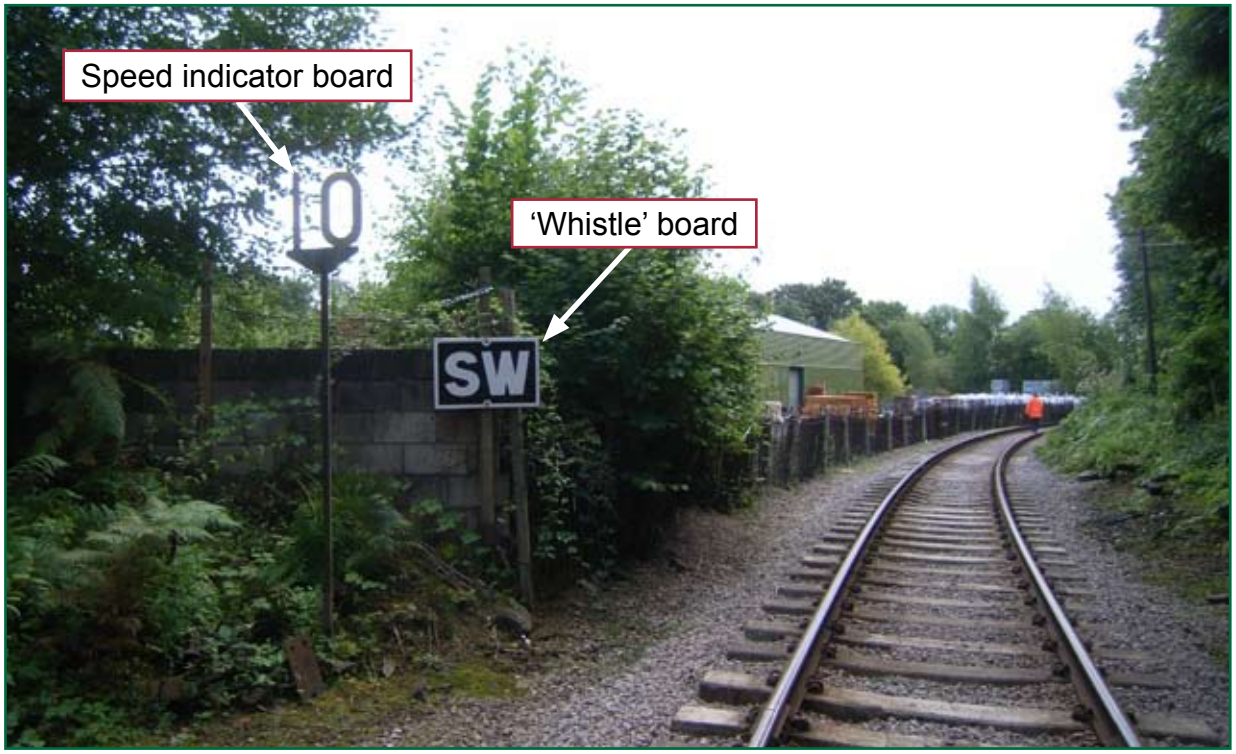

Figure 7: Speed indicator board and 'Whistle' board

Figure 8: Approach to Lydney Town crossing, showing 'Stop' board

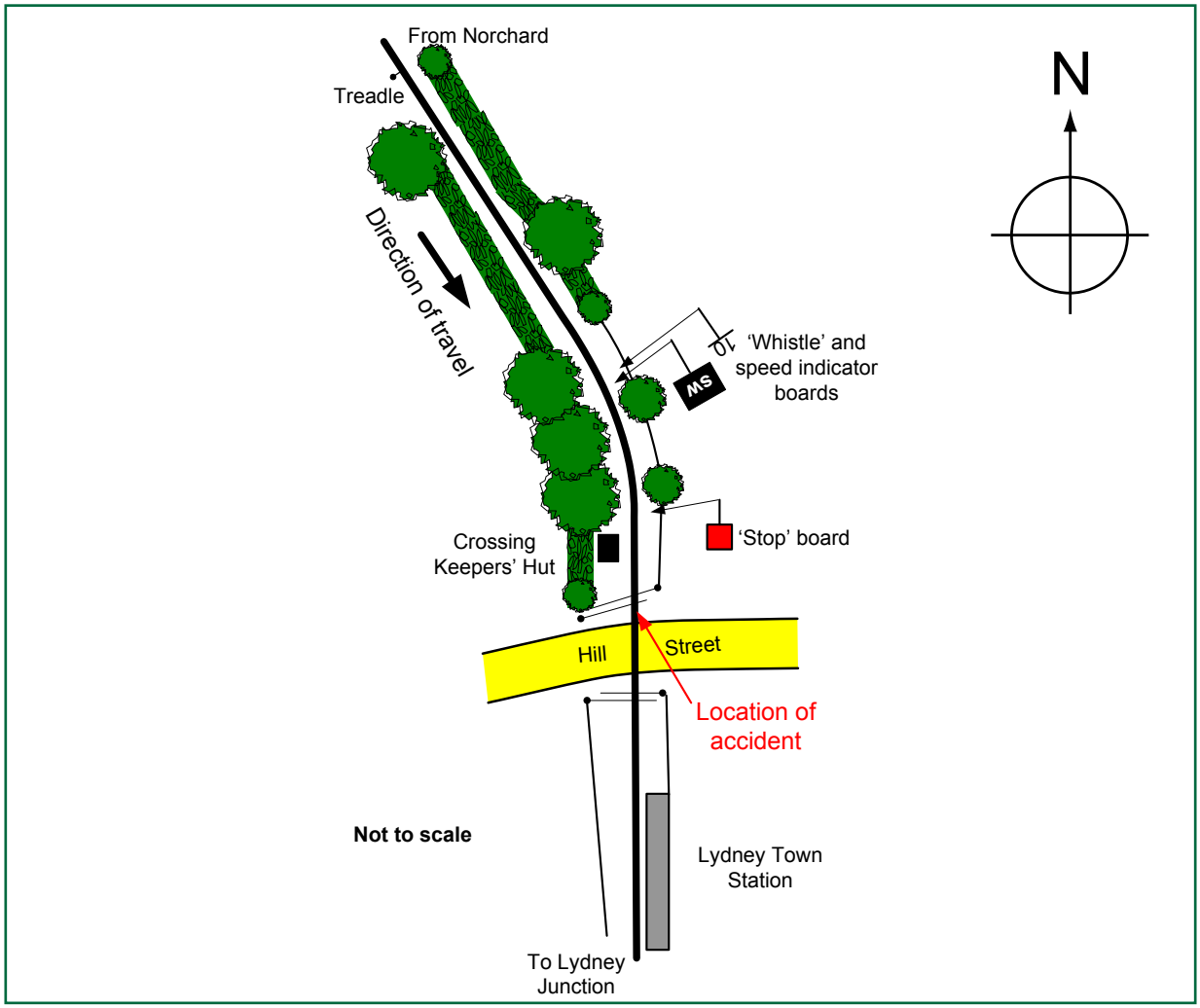

Figure 9: Plan of approach to Lydney town crossing

Operation of the approach to Lydney Town crossing

36 The process of operation of Lydney Town crossing is described in the DFR's General Appendix to their rule book, part II, Section 5. Under normal circumstances the operational sequence is:

a. The signalman at Norchard station gives a warning to the crossing keepers that a train is leaving the station southbound by ringing a telephone bell. There is no requirement for the crossing keepers to confirm that they have heard this warning.

b. The two crossing keepers move into position at the crossing.

c. The train operates the treadle, which warns the crossing keepers that a train is approaching by means of the buzzer and flashing white light.

d. The crossing keepers, using hand signals, stop the road traffic and begin to open the four gates to the railway.

e. The train driver reduces speed as necessary to ensure that the train's speed is 10mph at the speed indicator board.

f. At the whistle board the train driver blows the train's whistle to confirm to the crossing keepers that the train is approaching.

g. The driver controls the train's speed on the approach to the crossing on the basis that the gates will be closed and that the train must stop at the stop board.

h. The crossing keepers secure the crossing gates and, when the line is clear, one keeper signals with a green flag that the train can proceed through the crossing.

i. In poor visibility, or if the gates are closed or not fully open when the train rounds the curve, the driver must stop at the stop board, and wait there until the crossing keeper gives permission to proceed.

j. If the driver can see that the line is clear, and if the crossing keeper has given a green hand signal, the train crosses over and clears the crossing.

k. Once the train is clear of the crossing the keepers then close the four gates across the railway and permit road traffic to resume.

External circumstances

37 The weather on 15 August 2007 was reported as being poor with significant rainfall about the time of the accident.

38 At the time of the accident, the track, including the rail head, was wet. Water was probably still falling from the trees onto the track after a recent heavy shower.

39 The weather did not reduce visibility at the crossing during the accident below that which would be available on a clear day.

40 There was traffic using the road either side of the crossing before the accident and background noise at the crossing could have been high.

Locomotive and rolling stock

41 The auto-train involved in the accident consisted of a steam locomotive and an ex-GWR autocoach. The locomotive propelled the autocoach when travelling north to south, as was the case at the time of the accident, and pulled it when travelling south to north.

42 The locomotive and its footplate arrangement are shown in Figures 10 and 11. Locomotive 1450 was built by the Great Western Railway in 1936. It is a four-wheels-coupled tank engine with trailing carrying wheels, 29' 11" (9.12m) long, and weighing 41 tons.

43 The GWR autocoach and its driving cab are shown in Figures 12 and 13. It was built in 1930 and is 66' 6" (20.3 m) long, and weighs 30 tons. Both the locomotive and the autocoach are fitted with sanding equipment. Together they make up a type of auto-train that was used by the GWR and British Railways from early in the 20th century until the end of steam operation on the main line in the mid-1960s. The purpose of the arrangement in which the driver can drive from the autocoach is to enable trains to operate in both directions without the locomotive having to change ends (run round) for its return journey. In order to achieve this, the main locomotive controls are duplicated in the autocoach cab. The controls are linked between the two vehicles by means of long rods running underneath the autocoach and locomotive. There is an electric bell by which the driver can signal to the fireman, who remains on the footplate of the locomotive. It is possible for autocoaches to be coupled on both ends of the locomotive.

44 The train is fitted with a *continuous vacuum brake*. When driving from the autocoach, the driver can apply the train brakes by admitting air to the *train pipe* using the valve in the cab, but cannot release the brakes once applied. If the train is stationary, or moving slowly, the brakes must be released by the fireman, on the footplate of the locomotive, using the *ejector* to recreate vacuum in the train pipe. There is a vacuum pump on the locomotive, which is effective when the train is moving at more than about 15 mph. The *steam brake* on the locomotive is controlled through a *combination valve* linked to the vacuum system, so that the locomotive brakes are applied at the same time as those in the rest of the train. The locomotive is also fitted with a vacuum reservoir to the combination valve (Appendix D), which provides a more sensitive application of the steam brake on the locomotive, to reduce the likelihood of a skid. This reservoir is fitted with a release valve, which can be used to release the steam brake on the locomotive if creation of train pipe vacuum has not been fully effective in doing this. The effects of operation of the various controls (with particular reference to the circumstances of this accident) are summarised in table 1 (paragraph 94).

45 When the driver wishes the fireman to release the brakes by creating vacuum, he should give two rings on the electric bell between the autocoach and locomotive to tell the fireman to release the brakes. The bell was not in working order on the day of the accident, so the engine whistle (operated by a wire from the cab of the autocoach) was being used for communication instead.

46 There was no speedometer, and no on-train data recording system, fitted to the locomotive or the autocoach. This was normal practice for rolling stock built before the second world war.

Figure 10: Locomotive 1450

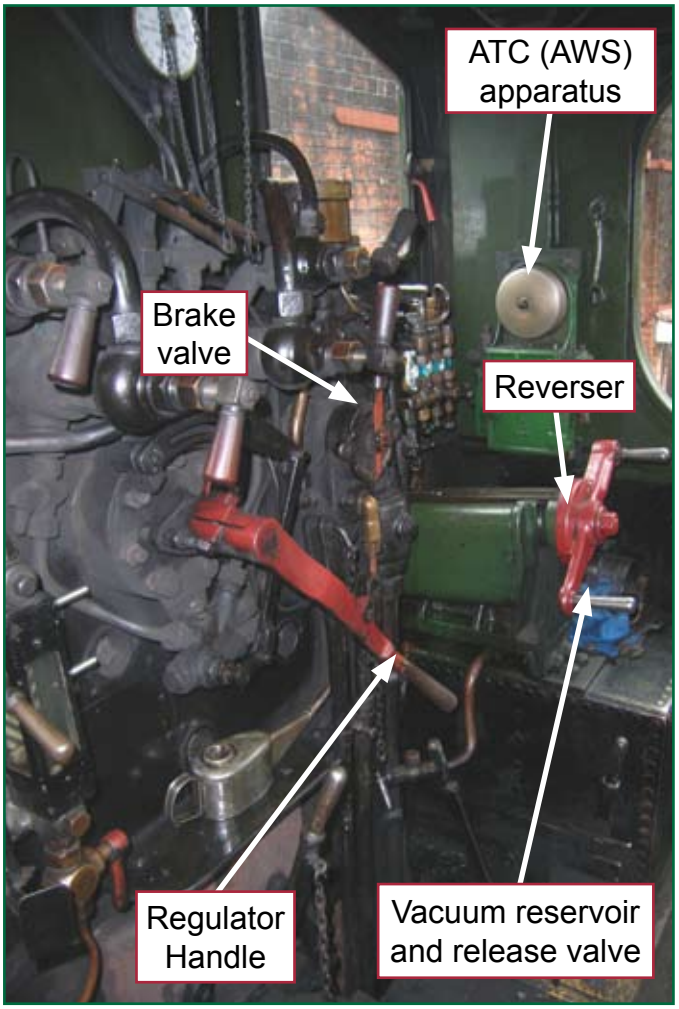

Figure 11: Driver's side of cab of locomotive 1450

Figure 12: GWR autocoach

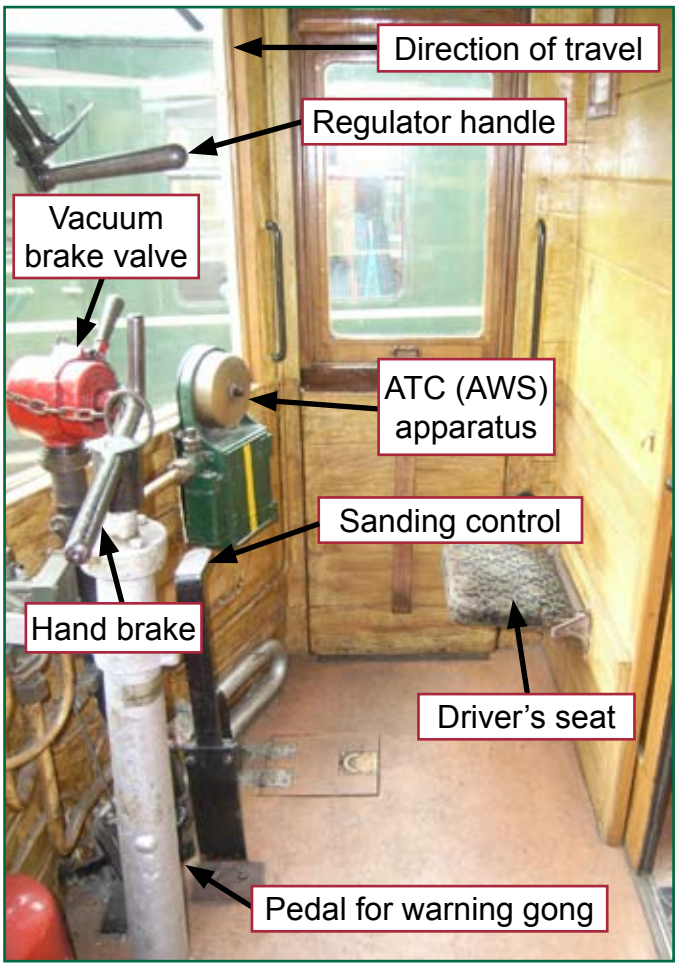

Figure 13: Driver's position in Autocoach. Bell and whistle controls are above front window, to left of picture

Events preceding the accident

47 The treadle operated warning buzzer at the crossing keepers' cabin had been failing intermittently for several months. Four days before the accident the signalman at Norchard had reported that it was not working, by making an entry in his signal box register. The DFR operations manager had discussed the matter with the signalling and telecommunications director. They had agreed that the treadle should be replaced, but this had not been done by the time of the accident because staff were not available.

48 Signalling maintenance on the DFR is carried out by volunteers, most of whom are in full time employment, and they can only attend the DFR when their employment permits. This limited their availability to attend to reports of faults.

49 On 15 August the driver and fireman prepared, checked and brought into service both vehicles of the train in accordance with normal DFR practice; they were already aware that the electric bell communication between the locomotive and the autocoach was not working, and they identified no other problems with the train during the preparation work. It was not the DFR's practice to use the sanding system, so there was no sand in the sandboxes on either the locomotive or autocoach. The driver briefed the fireman on what actions to take if the train's brakes locked up during braking: he said that the release valve on the vacuum reservoir in the cab (paragraph 44) should be operated to equalise pressure in the reservoir and train pipe, and thus release the brakes.

50 The driver and fireman undertook *static brake tests* and considered the brakes to be in good order.

51 They brought the train from the siding at Norchard, and into service, at approximately 12:10 hrs. The train was to take a private party to various locations along the line. There was also a public passenger train running that day, which passed over the Lydney Town level crossing twice in each direction before the accident occurred.

52 The first run from Norchard to Lydney Junction and return was, in the view of the train crew, without incident.

53 None of the operating staff on duty on 15 August had been told that the level crossing warning light and buzzer were not working. However, the crossing keepers observed that the flashing white warning light did not work during the first passage of the train. They attempted to verbally warn the driver that the treadle system was not operating correctly, but the driver did not hear them.

54 Between the first and second trips of the auto-train from Norchard Station to Lydney Junction the weather deteriorated and there was a heavy shower of rain (paragraph 38).

55 At approximately 14:40 hrs, when the train departed from Norchard for the second time, the signalman there belled the crossing keepers at Lydney Town level crossing using the normal internal telephone system. The two crossing keepers heard this warning and moved into position on the crossing looking north towards Norchard.

56 The train passed over the treadle (paragraph 32) but the warning buzzer and light, the primary means of alerting the crossing keepers, did not operate. The crossing keepers therefore had no warning that they had to begin closing the crossing to road traffic and start opening the crossing gates.

57 As the train approached the whistle board the driver sounded the whistle from the autocoach cab. Witness evidence indicates that there was a lot of noise from road traffic, and the crossing keepers did not hear the train whistle.

58 The train passed the 10 mph speed indicator board at a speed that was subsequently estimated by a witness to be approximately 20 mph (32 km/h). At some point thereafter the driver made a slight application of the brakes, but not sufficient to greatly slow the train.

59 The crossing keepers saw the train approaching when it came into view, and began to stop the road traffic and open the gates.

60 As the train rounded the bend and approached the 'stop' board, the train driver saw that the gates were not completely open, and fully applied the brakes.

61 Witnesses stated that as soon as the brakes were applied the wheels of the locomotive and autocoach locked and the train started to slide.

62 The driver sounded the whistle. The fireman took the sounding of the whistle to mean that vacuum should be created, and operated the combination brake valve and the valve on the reservoir, as instructed by the driver that morning, but the train did not stop before it reached the crossing.

63 The leading end of the autocoach struck the partially open left hand side crossing gate (the secondary gate) on the northern side of the crossing. The gate was torn from its hinge post and was flung to the right across the crossing. The detached gate struck one of the crossing keepers, knocking him to the ground.

64 The train came to a stand with its leading end some 30 metres past the crossing, partly in the platform at Lydney Town station, with the detached gate lying on the ground to the right of the line in the direction of travel.

Consequences of the accident

65 The crossing keeper who was struck by the detached gate was seriously injured. He was treated by the emergency services at the scene of the accident before being taken to hospital.

66 The other crossing keeper, who was trying to open the gate that was struck, jumped clear and did not suffer any physical injury.

67 A number of the passengers and staff were shocked by the event but did not require any medical treatment.

Events following the accident

68 The DFR reported the accident to the Gloucestershire Police and to the Office of Rail Regulation (HMRI). Gloucestershire Police took control of the site, and informed the RAIB of the accident.

69 The DFR did not notify the RAIB of the accident by phone until the morning of the next day, 16 August 2007, contrary to Regulation 4 of the Railways (Accident Investigation and Reporting) Regulations 2005, which require railway operators to verbally notify the RAIB of serious accidents as soon as possible. The DFR notified the RAIB in writing on 20 August, five days after the event, and outside the RAIB's guidelines that such written notification should be received within three days of an accident.

70 The rolling stock was recovered from site later in the day and taken back to Norchard for examination.

71 The crossing was taped over and the line closed for the remainder of the day. A replacement for the damaged gate has subsequently been provided.

The Investigation

Sources of evidence

72 Evidence was gained from:

a. examination of the crossing;

b. observation of the operation of trains over the crossing after the accident;

c. examination of the train, the track, and the treadle operated warning mechanism;

d. interviews with staff and management of the DFR;

e. examination of DFR documentation; and

f. tests with the auto-train to establish how the handling of various controls affected the operation of the braking system and the stopping distance of the train.

Analysis

Identification of the immediate cause

73 The immediate cause of the accident was that the driver of the train was unable to stop it before reaching the stop board at Lydney Town crossing, and having passed the stop board, was not able to stop the train before striking the crossing gates.

Identification of causal and contributory factors

Estimation of train speed

74 The speed restriction on the approach to Lydney Town level crossing is 10 mph (16 km/h). General Appendix 1 of the DFR rule book states that any speed restriction applies 'at and between' speed limit marker boards. Therefore, the train should have decelerated to 10 mph by the board and not exceeded that speed as it came round the curve.

75 The train was estimated by witnesses to be travelling at a speed of approximately 20 mph (32 km/h) when it passed the speed restriction board. This cannot be corroborated further, as there is no speedometer or on-train data recorder fitted to the locomotive or autocoach.

76 Opening the gates to the railway takes about 30 seconds from the first movement of the gates to the time that they are open and fully secured. This time is increased if the crossing keepers have to wait for a suitable break in the flow of road traffic. There is a Fire Station adjacent to the level crossing, and crossing keepers are required to check that the beacon on top (which indicates that fire engines are being readied for deployment) is not alight before they open the gates. This can also delay the opening of the crossing to trains.

77 The train driver attempted to stop before the crossing, but the heavy brake application and the wet rails caused the train to slide. If the train had been driven a manner appropriate to the rail head conditions, and had been travelling more slowly, it would probably have been able to stop before striking the gates.

78 It is likely that the train was travelling at an excessive speed as it approached the crossing, and this was a causal factor in the accident.

Rail head and track conditions

79 The rail head was reported as being very wet, with heavy rain having stopped just before the accident. The actual condition of the rail head was not recorded following the accident (paragraph 69). For the wheels to have locked up the *coefficient of friction* between wheel and rail must have been lower than normal, as would have been the case with a wet rail. Tests carried out after the accident (paragraph 89) indicated that the train would have been able to stop before reaching the 'stop' board if the rail had been dry.

80 The driver did not anticipate the effect that the wet condition of the rail head would have on the braking performance of the train. This was contributory to the accident.

Infrastructure condition

81 The manually operated level crossing gates were functioning correctly.

82 The treadle operated approach warning mechanism was known to be faulty. This had been reported four days before the accident and the DFR proposed to rectify the fault, but had not done so by the time of the accident, and had not informed operating staff of the fault (paragraph 47).

83 The crossing keepers noticed during the first passage of the train earlier in the day that the treadle operated flashing light and the warning buzzer had not operated, and they only became aware of the approach of the train when they saw it coming.

84 Inspection of the system following the accident identified that the buzzer was faulty and not working at all. The treadle operated warning light was intermittent. The length of the warning given by the flashing light is a function of the train length and how long the treadle arm takes to return to the normal position once depressed by the wheel flanges of a passing train. The return motion is *damped* to extend the period of warning. At 20 mph, the wheels of the auto-train would depress the treadle arm for less than 3 seconds. If the arm is correctly adjusted, it should take between 6 and 8 seconds to return to its rest position. This gives a total length of warning of 9 to 11 seconds, which will be reduced if the arm is not set at the correct height (so that it is not fully depressed by wheel flanges) or if the damping not adjusted correctly.

85 The treadle was found to be in working order. However, it was not functioning correctly, because its operating arm had been positioned or displaced about 22 mm below the rail head (Figure 14). Network Rail company standards NR/GN/SIG/19046 and RT/SMS/TEST/044 give guidance on the correct method for setting up treadles, and the correct distance of the arm below the rail head for this type of treadle is 16 mm (+/- 1 mm). The lower position of the arm meant that it was being depressed a small distance, or not at all, depending on the actual depth of the wheel flanges (which have a nominal depth of 24 mm). Therefore the warning light was showing for a very short time, or not at all.

Figure 14: Displaced treadle arm

86 The incorrect positioning of the warning treadle arm was contributory to the accident. The lack of corrective action by the DFR after it became aware of problems with the buzzer and warning light was also contributory to the accident.

87 When they became aware that the warning system was not working, the crossing keepers attempted to alert the crew by shouting at the train as it passed. The driver did not understand what was being said. On previous days when the railway was operating and the warning system did not work, train crews had been notified of this and had taken special care on the approach to the crossing. However, the management of the DFR had not put in place a procedure for passing on this information and the method chosen by the keepers was ineffective. This was a contributory factor to the accident.

Train operation

Braking

88 The locomotive and rolling stock were prepared correctly before leaving the depot. There were no indications of operational problems with the rolling stock at the time of the accident, apart from the non-functioning electric bell communication, which the crew were aware of. Maintenance work had been carried out in April 2007 to take up slack in the braking system so as to ensure the correct response of the locomotive brakes.

89 Tests undertaken by DFR, under the supervision of the RAIB, on 17 August 2007, showed that the brakes functioned correctly. In subsequent tests on a dry rail carried out using a radar gun to establish speed, the train stopped from 20 mph (32 km/h) in 50 metres with a full application of the brakes.

90 Once the driver had applied the brakes he could not release them. The brakes had to be released by the fireman after communication via the bell/whistle arrangement (paragraph 45).

91 This configuration of the brake controls makes it more difficult to use controlled braking in an emergency. After making a full application of the brakes, the driver left the brake valve in the autocoach in the 'applied' position. There is some evidence (paragraph 62) that the fireman attempted to control the braking during the approach to the crossing, but this was not effective in releasing the brakes and the sliding continued.

92 The RAIB and the DFR carried out tests using the auto-train to establish how the braking system behaves in various different modes of operation. These tests confirmed that, once the vacuum brake has been applied, it is not possible to release it quickly: it can take up to thirty seconds to re-create vacuum using the ejector by placing the combination valve in the 'release' position. However, if the release valve in the locomotive cab is operated while the combination valve handle is in the running or release position, the steam brake on the locomotive will release very quickly. The tests also found that when the train brakes were applied on a wet rail, the autocoach wheels would slide, even though, in the test, the locomotive wheels did not.

93 The results of the tests showed that it is probable that immediately before the accident, the wheels of the autocoach were sliding, and the locomotive brakes had been released by the fireman's manipulation of the valve in the cab.

94 Handling the brakes on an auto-train requires skilled co-operation between driver and fireman. When these trains were in service on the GWR and BR this was recognised, and special instructions were issued for their operation (see Appendix D). These highlight the dual function of the valve on the vacuum reservoir in the locomotive cab. If the brakes do not fully release when vacuum is recreated after an application, use of this valve will equalise the reservoir and train pipe pressure and make the steam brake on the locomotive release fully, before the train brake. However, if a heavy brake application is required, including full use of the steam brake on the engine, the valve can be used to destroy the vacuum in the reservoir. It is important that the fireman is certain about what the driver is doing and which result is wanted before using the valve.

If the train is sliding in conditions of low adhesion, it is not likely that (in the speed range experienced on heritage railways) releasing and re-applying the brake on the locomotive will shorten the stopping distance. This is because the weight of the locomotive will continue to push the coach each time the locomotive brakes are released, and if the coach wheels are sliding the train will effectively be unbraked during this period. Table 1 summarises the effect of operation of the various controls on the locomotive and train brakes, in the sequence believed to have been involved in this accident.

Auto Coach Driver's Valve	Loco Combination Valve	Vacuum reservoir valve	Loco Brake	Train Brake
Run	Run	Closed	**OFF**	**OFF**
Brake	Run	Closed	**ON**	**ON**
Brake	Release	Closed	**ON**	**ON**
Brake	Release	Operated	**OFF**	**ON**
Run	Release	Closed	**OFF**	**OFF** (slowly)

Table 1: Simplified effects of operation of brake controls on locomotive and train brakes

95 The possible outcome of using the release valve needs to be fully understood by the railway and by individual drivers and firemen so that the brakes can be safely handled in all situations and proper training can be given to staff.

96 It became clear during the RAIB's investigation that the locomotive crews on the DFR had not practised handling the brake in emergencies, and may not have fully understood what to do. When the locomotive is propelling the coach, the fireman is alone on the footplate and unable to seek advice from the driver if unsure about what to do at any point.

97 The design of the braking arrangements and the crew's lack of training and experience in handling the train in an emergency may have contributed to the accident.

Wheel / rail sanding

98 Both the locomotive and the autocoach were fitted with sanding equipment, designed to allow the driver to lay sand in front of the wheels to improve adhesion for both acceleration and braking.

99 The DFR had no requirement for the train crew to check that the sand boxes for the locomotive and the autocoach were filled and operational. The DFR had never used sand and did not regard sanding gear as part of the day to day operational equipment of the railway and hence there was no requirement for the staff to ensure that the sanding systems were fully functional prior to going into service. Drivers and fireman were not accustomed to using sand, and the crew of the auto-train made no attempt to use it on 15 August 2007.

100 There is clear evidence that sanding can increase adhesion considerably when a train skids (see paragraph 45 of part 3 of the RAIB's report 25/2006 on adhesion in autumn conditions). Sanding equipment is required to be fitted to all passenger trains on the national network, and is in wide use on tramways and heritage railways. Not having working sanding equipment on the train may have contributed to the accident.

Driver's cab arrangement

101 The autocoach driving cab arrangement is shown in Figure 13. The driver is normally standing or seated towards the right hand side of the cab, looking forward. The views from the cab on the day of the accident were reported as being good with no observable windscreen contamination.

Road traffic issues

102 There is constant road traffic travelling up and down Hill Street. The noise from passing traffic, in particular heavy goods vehicles climbing the hill, could have contributed to the crossing keepers not hearing the warning whistle from the approaching train.

103 Crossing keepers reported that they were often subjected to verbal abuse by road users, and therefore they considered it important to minimise road traffic disruption. When the line was first re-opened by the DFR, the road (Hill Street) was still part of the A48 trunk road, and the railway company were required by Gloucester County Council to minimise delay to road traffic by completing the operating sequence of the crossing within three minutes, the approximate operating time of an automatic crossing. The DFR's response to this requirement, within the resources available to it was to retain the gates and install treadle-operated equipment to warn the crossing keepers when the train was approaching (paragraph 32). If the crossing had been closed to road traffic when the train left the previous station the accident would not have occurred, although road traffic would have been held up for several minutes. The DFR's knowledge of the need to minimise delays to road users may have contributed to the accident.

Previous occurrences of a similar character

104 An engineering train had hit the crossing gates at Lydney Town on 25 May 2006. The RAIB considers that this was an incident which under slightly different conditions might have led to a death, serious injury or extensive damage to rolling stock, and consequently should have been immediately notified to the RAIB under schedule 1(9) of the Regulations (paragraph 69). The DFR did not notify the RAIB of this incident. Failure to notify the RAIB of accidents is an offence under regulation 4(12) (**Recommendation 10**).

105 The DFR did notify the Office of Rail Regulation (HMRI) [ORR (HMRI)] of the incident on 25 May 2006. ORR (HMRI) investigated the incident for breaches of health and safety legislation, and found that it occurred when two unqualified volunteers moved a *loose-coupled* train without authorisation, and the train had insufficient brake force available to enable it to be safely controlled. These circumstances are not directly relevant to the accident on 15 August 2007. ORR (HMRI), while deciding not to take further enforcement action, were highly critical of the safety culture of parts of the DFR, and expressed their concern in a letter to the vice-chairman of the DFR Co Ltd dated 16 March 2007.

106 Following this, two enforcement notices were issued relating to other matters relevant to railway operations. On 5 September 2007 ORR (HMRI) issued a Prohibition Notice, preventing operation of trains on the DFR, because of the wide gauge of some parts of the track on the railway, and because there was an inadequate track maintenance regime to monitor the track and to rectify faults identified. The DFR took steps to address the issues raised, and ORR (HMRI) considered the prohibition notice had been complied with and allowed passenger train operations to re-start from 21 March 2008.

107 ORR (HMRI) issued an Improvement Notice on the DFR on 20 November 2007, relating to the management of safety on the railway, and requiring appropriate arrangements to be put in place for the effective planning, organisation, monitoring and control of the preventive and protective measures to ensure the safe operation of trains. This notice was complied with by the due date of 31 January 2008.

Management of health and safety

General

108 Responsibility for health and safety management is shared between the seven executive directors of the DFR Co Ltd, who are in charge of the locomotive (engineering), carriage and wagon, operations, signalling and telecommunications, permanent way, commercial and finance departments respectively. There are also two directors nominated by the DFR Society. A competent person to assist the company to comply with its obligations under health and safety law is required by the Management of Health & Safety at Work Regulations 1999. The company's Safety Case nominates the company Chairman to carry out this role. At the time of the accident in 2007, the Chairman had health and safety qualifications, but following management changes since the accident, the current Chairman is not experienced in this area, and the company has now appointed another suitably qualified director to act as health and safety adviser (**Recommendations 8, 9**).

Maintenance of signalling equipment

109 The limited resources available to the DFR means that its response to failures of equipment is slower than would be the case on a larger railway (paragraph 48). This makes it necessary to have procedures in place to inform staff that systems have failed or are operating in a degraded condition, and the arrangements for safe systems of work in these conditions (paragraph 87).

Competence of staff - Locomotive department

110 Steam engine footplate crews are selected from volunteer engine cleaners and are trained by the locomotive inspectors. They are assessed for competence to act as firemen, and in due course may advance to driver. Once certificated as competent to act in either of these roles, they may be rostered on any of the steam locomotives in use on the railway.

111 Drivers and firemen required to work on the auto-train were not specially selected, but worked alongside experienced staff for a few turns of duty before being allowed to crew the train unaccompanied.

112 The railway has not used written examinations to assess the competence of steam locomotive footplate staff, and has relied heavily on informal assessment by existing senior drivers and inspectors. The fireman involved in this accident had only had two days experience on the auto-train before the accident occurred, and had no training in or experience of the action to be taken in emergency situations.

113 The evidence given by the locomotive crew was confused as to the actions they took when the wheels of the train locked up. The driver, although very experienced, did not react quickly to what was happening, and the fireman was inexperienced. The RAIB is satisfied that once the train started to slide, their actions after this (in the absence of working sanding equipment), did not affect the outcome of the event. They may have resulted in the release of the locomotive brakes and consequently increased the stopping distance, given the railhead condition, likely overspeeding of the train and the short distance that was available in which to stop. It was common practice on British Railways to employ experienced firemen on auto-train duties, since they were on the footplate of the loco unsupervised by the driver, and controlled many of the safety critical systems. Using a recently qualified fireman, who had to be specifically briefed on the day about some aspects of auto working, was a contributory factor in the accident.

Observations

114 The driver was over the maximum age for driving laid down in the DFR General Appendix. The railway was not carrying out the policy on medical examinations for footplate staff laid down in that Appendix (medical examinations every five years up to age 60, then yearly up to age 70). Guidance on medical standards for staff on heritage railways was issued by the Heritage Railway Association during 2007 (**Recommendation 11**).

Conclusions

Immediate cause

115 The immediate cause of the accident was that the driver of the train was unable to stop it before reaching the stop board at Lydney Town crossing, and having passed the stop board, was not able to stop the train before striking the crossing gates (paragraph 73).

Causal factors

116 The following factor is considered to be causal to the accident:

a. The train was travelling at an excessive speed, both in terms of the permitted speed at the location and the rail head conditions, as it approached the crossing (paragraph 78, **Recommendations 1, 2**).

Contributory factors

117 The following factors are considered to be contributory to the accident:

a. The locomotive crew's lack of training and experience in controlling the auto-train in conditions of poor adhesion (paragraph 97, **Recommendations 6, 7**);

b. the wet condition of the rail head (paragraph 80);

c. the low position of the warning treadle arm (paragraph 86, **Recommendation 5**);

d. the DFR had not repaired the known problem with the buzzer and warning light (paragraph 86, **Recommendation 5**); and

e. there was no effective system for informing train crews that the warning system was not working (paragraph 87, **Recommendation 4**).

118 The following factors may be contributory to the accident:

a. not having working sanding equipment on the train (paragraph 100, **Recommendation 3**);

b. the noise from passing traffic, in particular heavy goods vehicles (paragraph 102); and

c. the DFR's response to pressure from road users to minimise traffic delays (paragraph 103).

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

119 The DFR has carried out an internal investigation into the accident, which has recommended the following relevant actions. The DFR has advised the RAIB that some of these actions have been completed, as described below:

a. review the speed limit for the autotrain approaching level crossings and signals (in progress);

b. ensure the proper operation of sanding equipment on all trains fitted with it, and that all crews are trained in its use (the equipment is now in use, and training is in progress);

c. repair the warning treadle (the treadle has been temporarily replaced by a track circuit until it can be demonstrated to be reliable);

d. implement a reporting system for treadle malfunctions and ensure appropriate staff trained in its use (completed);

e. ensure an adequate operating procedure in the event of the treadle not working (being developed);

f. review the size and sighting of the stop board, and clarify the rules relative to its operation (completed); and

g. ensure the electric bell system in the autocoach is working correctly (completed).

120 In addition the DFR has carried out the following relevant actions:

a. relaid the track under the treadle, thus improving the security of the fixing of the treadle;

b. tested and proved the wiring circuits from the treadle to the crossing equipment box;

c. replaced the battery that powers the buzzer and the white light at the crossing;

d. moved the 'stop' board at Lydney Town to a greater distance from the crossing; and

e. issued a reminder to all drivers of the need to observe the published speed limits.

121 The DFR proposes to upgrade the electricity supply to the battery at the crossing to increase the reliability of its charging.

122 The DFR has appointed a suitably qualified person to act as health and safety director for the company.

Recommendations

123 The following safety recommendations are made[1]:

Recommendations to address causal and contributory factors

1 The Dean Forest Railway should review the system by which trains approach Lydney Town level crossing from the north so as to verify that the speed limit allows trains to stop before reaching the crossing in all cases of degraded braking and poor rail head conditions. The speed limit should also take into account a driver's ability to achieve the desired speed in a locomotive not equipped with a speedometer (paragraphs 116, 119a, 120d).

2 The Dean Forest Railway should introduce a process to formally and periodically instruct all drivers of the importance of adhering to all published speed limits (paragraphs 116, 120e).

3 The Dean Forest Railway should put in place systems to cover the provision, maintenance and use of the sanding systems on locomotives, autocoaches and (where appropriate) brake vans in use on the railway (paragraphs 118a, 119b).

4 The Dean Forest Railway should amend its procedures and rule book such that in the event of signalling system malfunctions there are adequate degraded safety mode procedures in place. The systems should also include a process for formally warning ground based operational staff and train crew when a safety system has been degraded (paragraph 117e).

5 The Dean Forest Railway should set up a system for the setup and maintenance of the treadle mechanism on the approach to Lydney Town level crossing, in accordance with a recognised industry standard (paragraphs 117c, 117d, 119c).

6 The Dean Forest Railway should document the optimum procedure, and train and assess footplate crews in the action to be taken, to stop an auto-train quickly in poor railhead conditions and other emergency situations (paragraph 117a).

continued

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

Additionally, for the purposes of regulation 12(1) of the Railways (Accident Investigation and Reporting) Regulations 2005, these recommendations are addressed to the Office of Rail Regulation (Her Majesty's Railway Inspectorate) 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 167 to 171) can be found on RAIB's web site at www.raib.gov.uk.

Recommendations to address other matters identified in the investigation

7 The Dean Forest Railway should appoint a competent person to advise the company on the steps needed to comply with health and safety law (paragraphs 108, 122).

8 The Dean Forest Railway should, with advice from a suitably qualified person, review its safety management arrangements and implement any changes that are found to be necessary (paragraph 108).

10 The Dean Forest Railway should implement procedures to ensure the RAIB is notified of accidents or incidents in accordance with the requirements of the Railways (Accident Investigation and Reporting) Regulations 2005 (paragraph 104).

11 The Dean Forest Railway should take appropriate steps to bring its practice on the employment of drivers over 70 years old into line with its policies relating to medical fitness (paragraph 114).

Appendices

Appendix A - Glossary of abbreviations and acronyms

AWS	Automatic Warning System
ATC	Automatic Train Control
BR	British Railways
DFR	Dean Forest Railway
GWR	Great Western Railway
HMRI	Her Majesty's Railway Inspectorate
ORR	Office of Rail Regulation
RAIB	Rail Accident Investigation Branch

Appendix B - Glossary of terms

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

Autocoach	Term used by the GWR to describe a passenger carriage with a driving cab at one end, designed to be coupled to a specially equipped steam locomotive, allowing the driver to control the train without needing to be located in the cab of the steam locomotive. This eliminated the need to run the locomotive round to the other end of the coach at the end of each journey.
Auto-train	The GWR name for the combination of one or more autocoaches and a locomotive fitted with the necessary equipment to operate with the driver in the cab of the coach. Known on other railways as a push-pull train.
Coefficient of friction	The ratio of the force that maintains contact between an object and a surface and the frictional force that resists the motion of the object.
Combination valve	A valve that enables the driver to control both the locomotive steam brake and the train vacuum brake by movement of a single handle.
Continuous vacuum brake	A brake system that operates simultaneously throughout a train, and applies itself if vehicles become uncoupled, powered by the pressure difference between atmosphere and a partial vacuum.*
Crossing keeper	The person who operates a Level crossing from a gate box.*
Damped (arm)	The arm of a treadle device that has been mechanically designed such that its return from the depressed position takes place in a controlled timed manner (usually slow).
Ejector	Steam-operated device for creating a partial vacuum by use of the Venturi effect, used for creating and maintaining vacuum in a train's braking system.
Level crossing order	An order made under the Level Crossings Act 1983 specifying in detail the method of operation and control of a level crossing.
Loose coupled	A train with no automatic brake of kind, whose constituent vehicles are connected together using Instanter couplings or three link couplings.*
Safety Case	A document setting out the arrangements which a railway company has put in place for controlling the risks created by its operations, required by the Railways (Safety Case) Regulations 2000.
Sanding equipment	A means of delivering small amounts of sand onto the rail head near the driving wheels of a traction unit in order to improve adhesion in areas of very poor rail head conditions.*
Secondary gate	At a level crossing with overlapping gates, the gates which are hinged to the right of the railway (as seen from an approaching train) and are the second set of gates to be closed to the road.

Static brake test	A test which is performed when a locomotive is coupled up to a train to ensure that the train brakes are working correctly.*
Steam brake	The service brake on a steam locomotive, operated by steam from the boiler acting on a piston which applies brake blocks to the wheel treads via rodding. On ex-GWR passenger locomotives the steam brake is controlled via the driver's vacuum brake control valve.
Tank locomotive	A steam locomotive fitted with an integral water tank and, generally, an integral coal bunker. The alternative is a tender engine.*
Train pipe	In a train fitted with continuous vacuum brakes, the pipe which runs the length of the train connecting all the vehicles and is used for charging the vacuum cylinders on the vehicles and controlling application and release of the brakes.
Treadle	An electrical switch with an actuating lever operated by the wheel flanges of passing rail vehicles.*

Appendix C - Key standards current at the time

SIGNTAN046 (formerly RT/E/C/19046)	Treadles
RT/SMS/Test/044	Treadle timing and adjustment test

Appendix D - Working instructions (extracts)

from British Railways (Western Region) Regional Appendix to the Working Time Tables, 1960

ENGINES FITTED WITH VACUUM RESERVOIRS TO AUTOMATIC STEAM BRAKE ATTACHMENT

Auto Engines and engines having trip cocks or A.W.S. apparatus, when steam braked, are fitted with vacuum reservoirs to the automatic steam brake attachment. The automatic action is thereby made considerably more sensitive than usual, and the steam brake will be applied by ordinary leakage of the vacuum in the train pipe.

When running, the ejector must always be worked as on a vacuum brake engine, i.e. the brake must be blown off until the engine is moving fast enough to enable the pump to maintain the vacuum.

Should the brake fail to come off on recreating the vacuum after an application, a movement in either direction of the handle of the release valve on top of the reservoir will remedy this.

When there is a vacuum in the reservoir, an application of the brakes either by means of the ejector handle or otherwise, does not fully apply the steam brake. To apply the steam brake with full force the engineman should destroy the reservoir vacuum by means of the release valve in addition to putting the ejector handle into the full "Brakes on" position.

INSTRUCTIONS TO BE OBSERVED BY DRIVERS AND FIREMEN WORKING AUTO TRAINS WHEN THE DRIVER IS DRIVING FROM THE VESTIBULE END AND THE FIREMAN REMAINS ON THE FOOTPLATE

It is essential that there should be a proper understanding between the Driver and the Fireman as to the working of the engine.

The Driver should satisfy himself that the Fireman properly understands the working of the reversing gear, vacuum brake, lubricator and sanding gear, and the management of the fire and boiler.

On receipt of a signal to start from the Guard, the Driver must sound the whistle which the Fireman must acknowledge, and the Driver must not start until the Fireman has acknowledged his signal. Before acknowledging the Driver's signal the Fireman must satisfy himself that the brake is off and that the reversing lever is in the correct position.

When approaching signals or terminal stations, the Fireman must be on the look-out and be prepared to act in case of emergency from any cause.

If a Fireman discovers any fault in the working of the engine he must inform the Driver at the first stopping place, but if the fault is such that it is necessary to stop before reaching the stopping place the Fireman must call attention of the Driver by applying the vacuum brake.

The Fireman must not leave the footplate without the consent of the Driver.

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